Aggregation of historical cartographic assets and development of intelligible structures and knowledge multipliers in library environment, with implementation in the 'AUTH Tricoglou Collection'

Final Report

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Abstract

Historical maps in manuscript or printed form, independent or embedded in books or atlases are important part of the world's cultural heritage. At the same time, they consist an important tool for researchers coming from different disciplines, particularly the humanities, since they provide an image of the past at specific time periods and the ability to study changes in the environment, intrinsically linked to the human activity, taken place in the area over time. Important role in the extraction of this information from historical maps plays the development of digital technologies and new computation methods and techniques that broadens the cartographic research and offers new tools to study and analyse historical maps. At the same time, it provides new computational methods and practices to be applied on the research in the field of humanities in digital environment (Digital Humanities).

This cartographic material is mainly located in map collections or libraries, an important part of the humanities infrastructure, since they provide wealth of information and stored knowledge. In Greece, contrary to what is happening abroad, important historical maps are in a state of complexity in libraries, they remain unknown to researchers and the general public and they have not been studied or utilized in any way, in order their value to be shown.

This research is focused on the collection, documentation, organization and management of the cartographic material found in Ioannis Tricoglou collection (Tricoglios Library)[1] of the Library and Information Centre of the Aristotle University of Thessaloniki (AUTH Central Library), with main goal to transform this material into intelligible structures that have the capacity to act as information and knowledge multipliers, not only for researchers but also for the general public, utilizing and promoting, at the same time, the importance of the rare cartographic inventory of Tricoglios Library.

Acknowledgements

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The cartographic material located at the AUTH Library & Information Centre has not been documented and studied properly in all its size and its cartographic wealth has not been employed in library's environment until the cooperation of AUTH Central Library and the AUTH CartoGeoLab, sponsored by the AUTH Research Committee. This research was conducted in the frame of this cooperation and it was implemented on Ioannis Tricoglou collection, which belongs to the Library. Thanks are due to the President of AUTH Central Library, Prof. Ioannis Tzifopoulos and the Head of the Central Library Directorate, Ms. Ekaterini Nasta for their continuous support and to the Library's staff for its assistance.

[1] Tricoglios Library (Ioannis Tricoglou Collection), Library and information Centre, Aristotle University of Thessaloniki https://www.lib.auth.gr/en/trikoglou-ioannis-collection.

[2] CartoGeoLab - Laboratory of Cartography and Geographical Analysis, Aristotle University of Thessaloniki, http://cartography.web.auth.gr/cartogeolab/.

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1 Introduction

Historical maps, in manuscript or printed form, independent or in map series, loose or bound in books, depicted in a variety of supporting materials such as parchment, paper or other writable or engravable material consist the historical cartographic wealth, which is an important part of the world's cultural heritage (Livieratos, 2008b) that belongs to UNESCO and can be safeguarded by it (Novotna, 2016). These cartographic items play an important role to researchers coming from different disciplines, especially the humanities, since the depiction of the geographical space over time is a valuable source of information showing changes of natural and man-made environment, proving the close relationship between space and time. This is really important, especially when these changes are only apparent through maps and no other written source exists (Tsorlini et al., 2017). In addition, historical maps can help in research areas dealing with historical, archaeological, sociological, political, demographic, toponymic and other issues. The prerequisite, however, is to ensure the correct reading and use of these maps, as well as to compare them with the modern maps (e.g. Boutoura and Livieratos, 2006, 1986; Livieratos, 2006; Tsorlini et al., 2010), so as to provide researchers, students and those dealing with them, accurate and meaningful results.

In recent years, mainly due to the evolution of digital technologies, there has been an increase in activity in the field of so-called Digital Humanities, a diverse and newly emerging field involving research in the field of humanities through digital technologies, applying different approaches and exploring digital models and tools to broaden the research (Schreibman et al., 2008; Svensson, 2010). The recent study of historical cartography and historical maps in a digital environment is among the interests of Digital Humanities and Scientific Cartography (Michev, 2016) and its development in recent years with the use of digital technologies and the application of new computational methods has given a new a dimension in the research of 'cartographic heritage' (Livieratos 2006, 2008b, 2016). This can be proved by the 15-years activities and achievements of the ICA Commission on Cartographic Heritage into the Digital[3], which was established in 2005 by International Cartographic Association[4], to deal with the digital technologies in cartographic heritage.

Historical maps, atlases and other related cartographic material are located in smaller or bigger collections mainly in libraries worldwide, which are important parts of the infrastructure of humanities, since they are centres of information and knowledge management (Svensson, 2010). Thanks to the development of digital technologies and their inclusion in library's functions, the libraries have now new options and directions to manage and retrieve knowledge (Kriezi et al., 2005) by digitizing all their deposit, giving access to researchers, students as well as the general public, to study and mine information from it. In this frame, the digitization of cartographic assets existed in libraries and their inclusion and provision online in digital form are very important, since they offer new tools for researchers of many disciplines, particularly the humanities, to expand the scope of research, giving them the opportunity to use new data extracted from the old maps (Tsorlini et al., 2017).

The existence of important library collections in libraries shows the necessity of strategy development for the utilization and emergence of the library's cartographic inventory. In many

[3] ICA - Commission on Cartographic Heritage into the Digital, http://cartography.web.auth.gr/ICA-Heritage

[4] ICA - International Cartographic Association: http://icaci.org

libraries in the world, there are special sections dealing with maps and other cartographic material that require specialized knowledge and engagement with the object. In Greece, despite the existence of great collections, the value of this cartographic heritage wealth has not been promoted in the degree it deserves. Rare historical maps, which are stored in libraries, remain almost unknown to the academic community and the society. Sometimes, there are difficulties even to detect them in the library's system, because they are documented and recorded following specific rules related mainly to traditional descriptive methods applied in book-keeping and book-archiving (Boutoura et al., 2015; Boutoura, 2014). As a consequence, there are important maps, who haven't been studied or analysed until today and their value has not been reclaimed yet in library's environment. For this reason, it is essential to provide solutions to this problem, given the digital capabilities currently provided by the new technology for the evaluation and utilization of historical maps and documents in library's environment, which are extensively used by international community of researchers in humanities.

The biggest academic library in Greece and the second in size after the National Library is the Aristotle University of Thessaloniki Library and Information Centre (AUTH Central Library), in which a big number of collections are kept. One of the most important collections exists in the library is the Ioannis Tricoglou collection[5], the *Tricoglios Library*, containing a large number of historical books, documents, maps and atlases. This material has not been documented and studied properly in all its size, since only a part of it has been digitized. As a result, the library has not reclaimed the cartographic wealth of this collection in library's environment, something which started with the strategic cooperation of the AUTH Central Library and the Laboratory of Cartography and Geographical Analysis, realized in 2016.

In the frame of this cooperation, having in mind the situation in our country as well as good practices applied in similar situations in other countries, where the cartographic heritage is treated in the way it deserves in special map sections of the libraries, this postdoctoral research was carried out, focusing on:

- *the collection and the appropriate documentation of Tricoglios library cartographic items*, which are in a stage of disorganised complexity in the library, being documented following specific rules applied in book-keeping and book-archiving,
- *the transformation of the data to information* exploring methods for the aggregation of the historical cartographic assets in intelligible structures, sustainable, easy to use and friendly for the users and the library's staff, and
- *the organization and management of this information through a system*, so that the aggregation of the cartographic wealth in the system consists information and knowledge multipliers for researchers, the library's staff and the public as well as examples of good practice for other applications in library's environment.

[5] The collections of the *Tricoglou Library* in the AUTH Library consists of over 10.000 of books, 3500 works of art, such as paintings, engravings and lithographs, various personal items and precious objects, as well as a large number of maps, rare atlases and books with cartographic content.

2 Theoretical Background

Tricoglios Library in AUTH Central Library consists of a large number of historical maps in manuscript or printed form, individual maps, map series and maps embedded in books. Aforementioned, this cartographic material has been catalogued by the librarians according to traditional rules for books' cataloguing, without taking into consideration the special characteristics of the maps, as special entities. This is very common in Greek libraries mainly due to the lack of 'cartographic culture' in Greece, a country which is still trying to develop its mapping and cadastre infrastructures and the associated geospatially-related operational systems and functions according to the relevant European and international advanced standards, for the benefit of the society and its growth (Livieratos 2007, 2008a, 2009). As a result, the cartographic heritage wealth existed in academic and other public libraries is not employed sufficiently and it is not promoted to researchers and the public, something which fortunately does not happen with some private collections, which have been documented and shown to the public (Tolias, 2008; Soucacos, 2015).

The unknown cartographic inventory, even if it is documented by the librarians, it is not organized properly, it is located in different places inside the library and it has no cohesion. It is in a stage of 'disorganized complexity' with chaotic characteristics, which makes this material extremely vulnerable to changes in the original conditions (physical location, preservation issues, as well as their location on the library's digital system, connection with related cartographic material). As a consequence, it is not easy to detect historical maps, individual or in map series, in the library's digital system; to distinguish their physical properties and thematic content; to search for related material or to extract useful information from them, transforming them into 'intelligible' and 'understandable' forms of knowledge for future specialized or generalized use (Nanetti et al., 2017a, 2017b). This makes them complex 'data' systems without structure and organization due to the lack of reference and interpretation, thus they are individually useless and worthless. In order this 'data' to be useful, relevant and valuable, it must be appropriately processed, organized and structured, so that the provided information gains importance for a particular purpose or a specific reference framework (Rowley et al 2006).

On the basis of organizational knowledge management, in which data is transformed into information and then, into knowledge and other higher-order concepts, Davenport and Prusak (2000) claimed that there are five value-adding processes in transforming data to information: 'condensation', where data are summarized in a more comprehensive form; 'contextualization', in which the purpose of data collection is known or understood in advance; 'processing', in which useful information is exported from the data and direct or more generalized metadata are created; 'categorization', where the data is categorized and finally, the 'correction' of data, in which any errors existed on data are eliminated.

In order to convert the historical maps and other cartographic material of Tricoglios Library into understandable structures, it is necessary to recorded and document them properly in order their 'complexity' to be eliminated, to classify, organize and manage them through an information system. Important role on this procedure plays also their correct digitization, taken into consideration the physical characteristics of the maps (e.g. maps embedded in books) and the condition they are preserved (Daniil et al., 2003, Tsioukas et al., 2006), as well as their geometric properties and thematic content (Boutoura et al., 1986, 2006; Livieratos, 2006). This

process is demanding and requires specialized cartographic knowledge, because every historical map is unique, belongs to a certain time period, it is designed by different cartographers following different cartographic standards (Tsorlini, 2011; Tsorlini et al., 2010). For this reason, each map should be at first studied individually based on its physical properties and content and then, documented and classified in such way to be able to turn into an understandable structure, which can provide information by itself, sufficient and helpful for the transition at the highest level, that of knowledge (Wallace 2007).

In order to highlight the importance of each historical map, it is necessary to combine it with other information related somehow to the particular map. The re-organization and classification of this information and their aggregation, in order to enhance their understanding and awareness, leads to knowledge (Kyparissidis, 2000). Historical maps have the potential to be related with other textual or pictorial sources of information or knowledge, enriching the existing knowledge, which can be 'explicit', easily communicated, expressed in a typical language and shared with others, or 'tacit', which is endogenous, depending on each person's experiences, personal beliefs, prospects and values, therefore difficult, if not impossible, to communicate (Kyparissidis, 2000; Nonaka, 2007). The linking of historical maps with other sources of knowledge, explicit or tacit, could be considered particularly important and reasonable in the case of historical maps in libraries due to the wealth of information and stored knowledge they can provide. The spatial reference is the connective link of the existing textual knowledge with the geographic space depicted on the maps.

Condition for the implementation of this procedure to a library's cartographic inventory is the existence of specialized knowledge on history of cartography and cartographic heritage and the appropriate know-how, so that the historical maps become cognitive multipliers in various uses in libraries and the combined knowledge is presented and promoted to researchers and the public.

3 Methodology and Implementation to Tricoglios Library cartographic material

The methodology developed to transform the data - the historical maps and other cartographic material in Tricoglios Library – to information and knowledge, is divided in four main stages (Figure 1) and includes:

a. *collection and processing of data*, which consists of the collection of historical maps, their accurate documentation, classification and organization based on their physical properties,

b. *transformation of data to information*, containing the configuration of data and its transformation into intelligible structures, capable of transmitting information,

c. *correlation and combining of historical maps and the information they transmit with other textual or pictorial sources of knowledge* in order to aggregate the information and to develop a dictionary system that enables easier detection of the maps and relevant information about them and finally,

d. *development of appropriate tools to provide researchers and the public online access to this combined knowledge, reclaiming, presenting and promoting in this way the cartographic wealth of the library*.

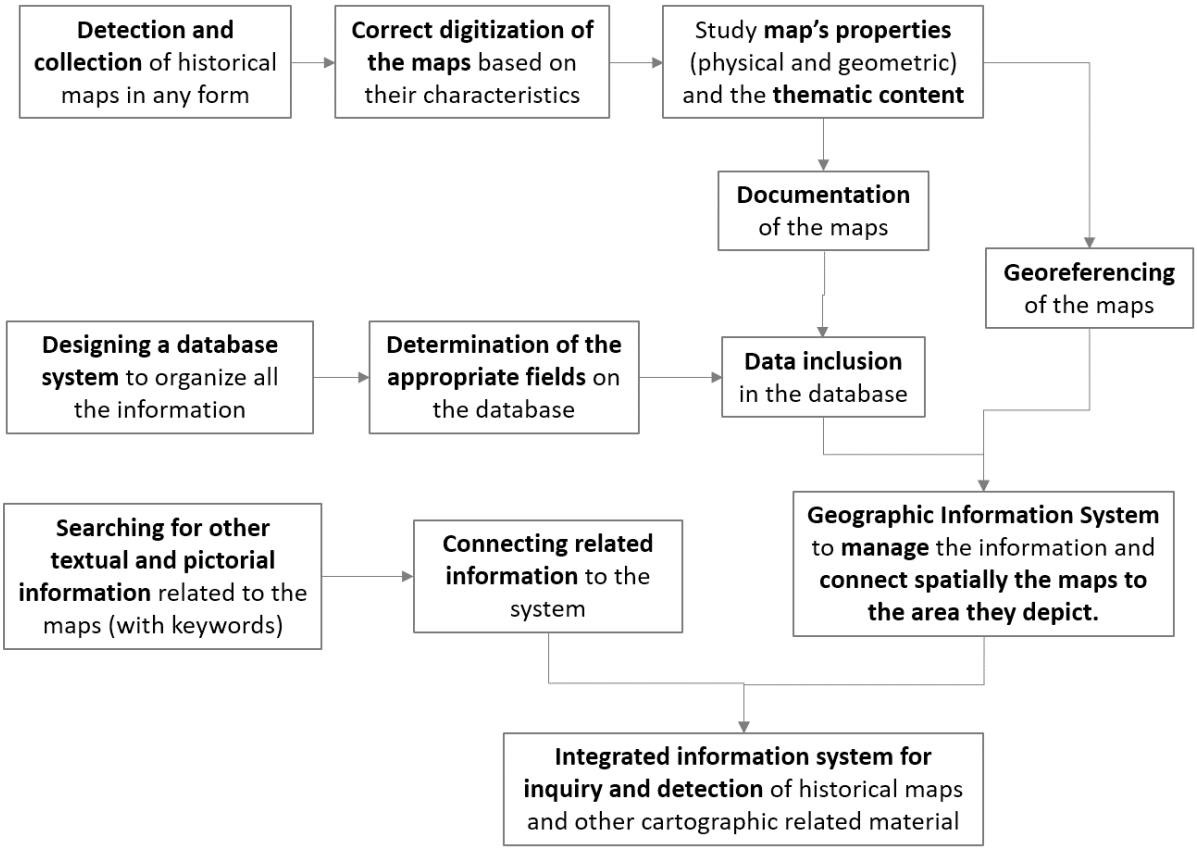

Figure 1. The methodology diagram followed in this study

In the next paragraphs, each stage of the procedure is analysed in detail, together with the problems and the difficulties appeared during the procedure and the solutions proposed in order the problems to be overcome.

i. Data collection and processing

The first step was to **find and collect the cartographic material**, i.e. historical maps in manuscript or printed form, loose or bound in books, atlases and other related material from the library's digital searching system. The inquiry in the system was not so easy. Although in some records, there was a note mentioning the existence of maps, there is not a specific section in the system dedicated on the maps, so we had to use different keywords relating to them, in order to detect them. Since the maps could be also recorded as plates, plans or even gravures, it was necessary to check all the possible keywords mainly in different languages (mainly Greek and English) to find them.

Through this inquiry, it was confirmed that maps were treated and recorded following the rules related mainly to traditional descriptive methods applied in book-keeping and book-archiving, having as a result important information concerning the design and production of the map to be totally ignored. For the independent maps, although there were several mistakes on the information provided through the existed system, their detection was a bit easier compared to the maps which belong to atlases or maps embedded in books.

These maps can be of different sizes, fitting to the size of the page or being larger than that, thus folded inside the book. The most difficult task in detecting them is that most of the times, the only existed evidence is a reference mentioning that there is a map inside the book, without any reference to the map's exact location inside it. Additionally, there are cases in which there is no reference to a map inside the book, but the title of the book shows that it is possible to contain maps. Taking into consideration that only a part of the collection is digitized, in order to find the maps, we had to search page by page the books which are not correctly or not at all digitized, since most of the times the folded maps inside the books were digitized without being opened to their full size. From this inquiry, rare historical maps, atlases and a big number of books including important maps were detected and gathered on a table, together with information existed for them in the library's system, in order to be studied and further analysed.

The research on the searching procedure and the way the maps are provided to the users was also expanded to other digital libraries and web providers of cartographic material. Searching for maps in books in different digital collections and libraries, helped us to determine the shortcomings on archiving maps and other cartographic material and to define finally the fields which are necessary to exist in our system based on the digital cataloguing of other libraries worldwide, which are regarded to be examples of good practice in this field (e.g. David Rumsey Map Collection[6]), due to the completeness of information and functionalities they provide to users to study the included maps.

Based on them, it is possible then to propose solutions to overcome these problems and improve the AUTH Library system concerning the cataloguing and archiving of the cartographic deposit, giving in this way access to more unknown maps and promoting the cartographic heritage wealth stored in the library to researchers and the general public. The results of this research were analysed in detail in a paper presented at the 13th ICA-Commission Conference on Digital Technologies to Cartographic Heritage organised by the ICA-Commission of Cartographic Heritage into the Digital, in Madrid (Tsorlini et al., 2018b) and on an invited speech about modern methods in geographic information management, organized in Athens by the Libraries and Information Centres of Harokopio University of Athens and Aristotle University of Thessaloniki (Tsorlini, 2018).

The next step of the procedure is the **digitization of the maps**, which should be conducted taking into consideration the special characteristics of the maps, their dimensions, age and condition (Daniil et al., 2003). Particular attention was given to the maps that were embedded and folded into books in order to avoid any possibility of greater deterioration in the digitization process. For these reasons, each map was treated separately as a special case of digitization. Based on the dimensions and the condition of the maps, as well as the digitization speed, the quality and resolution of the digital files, three different contactless, high quality digitization systems were used[7]. Most of the map which are embedded on books were smaller than the size of the book and they were digitized on a small-size, high-precision scanner; maps which are folded in books, or maps in atlases with maximum size A2 (60cm x 42cm) were digitized on

[6] David Rumsey Historical Map Collection, Stanford University Library, https://www.davidrumsey.com/.

[7] During this research, I guided also the implementation part of the Diploma work carried out by the students Poseidon Kotsiou and Nikos Ioannidis in AUTH CartoGeoLab as part of the interuniversity cooperation project agreement (2016) between the AUTH Library & Information Centre and the AUTH CartoGeoLab sponsored by the AUTH Research Committee. (Kotsiou et al., 2017)

a medium size scanner; and large maps were digitized in a large format scanner. From this procedure, a big number of maps, independent or embedded in books were digitized and **their physical and geometric properties and thematic content were studied** in order to proceed to their documentation and inclusion to a geographic information system, which was developed in the next stage. Additionally, the digitized images of the map were included in the system to give the opportunity to researchers and users to download them and use them for further studies.

For the **documentation of the maps**, it is important to determine the information which will be collected while studying the maps' properties and it will be later used for the definition of the table fields included in the database. Important role in the definition of the information which will be collected played the previous research in digital libraries worldwide on the information they record in each case for their items. Among the information provided to users were the identification number, the full title, the authors, engraver and the publisher of the map, the publication date and location, the scale of the map and its original dimensions, the type of the map, a reference to the thematic content of the map, the area it depicts, as well as information which connects the map with the book it belongs, such as the title and the author of the book, its location inside the book and an image of its front page. Based on this information, it is possible then, to categorize and organize the maps according to their common characteristics, bringing them out of the disorganized complexity and giving them the opportunity to provide correct information to the users.

ii. Transforming data to information

Based on the documentation of the maps and the analysis of their geometric properties, the next step is the **georeferencing of the maps** which gives them the opportunity to be connected and correlated with the geographical space they depict. The georeferencing of each map, which is important in order to bring each historical map to its physical dimensions, eliminating possible geometric deformations induced by scanning, depends on the geometric properties of the map (Tsorlini et al., 2015; Tsorlini et al., 2013). If the map is drawn on a specific coordinate system and there is a grid on it, it is possible to reconstruct the grid on the coordinate system of the map and then, georeference the map it its coordinates. Then, in order to bring the maps in one to one correspondence with the modern background, the georeferenced historical maps were converted to the modern's map projection system giving the opportunity to be compared to each other. On the other hand, if there is no coordinate system on the map, the map is best fitted to current data using as control points characteristic points of the map and the current data. The georeferenced maps in a specific format were also included in the designed database and used for the proper and complete development of the system at the end.

For the data organization and management, the **designed database** includes the necessary information for the external recognition of the maps. Based on the information collected for the maps during their documentation, two main tables, one for the maps and one for the books, with the appropriate fields were defined in the database (Tsorlini et al., 2018b). Having designed the database, the next step was the inclusion of the information came out from the maps documentation procedure, as well as the information recorded by the librarians in the library's system. This step of the procedure is also essential, because the information from these two sources needs to be unified, in order to be integrated in the database and the

mistakes should be corrected, in order reliable information to be provided to the users. Additionally, the integrated data should be formulated following specific standards and instructions such as AACR2 (Anglo-American Cataloguing Rules, second edition) or RDA (Resource Description and Access, the successor of AACR2) to create library and cultural heritage resource metadata that are well-formed according to international models for user-focused linked data applications (Togia et al., 2015).

During this process, possible improvements on the way the information could be stored in the database were explored to make the database more functional, especially in the retrieval of combined data from different fields through queries in the database. Through this procedure, some fields which were regarded unnecessary were deleted and their information was added on other fields, while the information of some other fields was split into two fields. This was done in order to facilitate the creation of the queries and their application to the data. Moreover, in the database, appropriate forms were connected with the tables and the queries to present in a better way the information and an initial page (Figure 2) was prepared, so that the database works autonomously internal in the library.

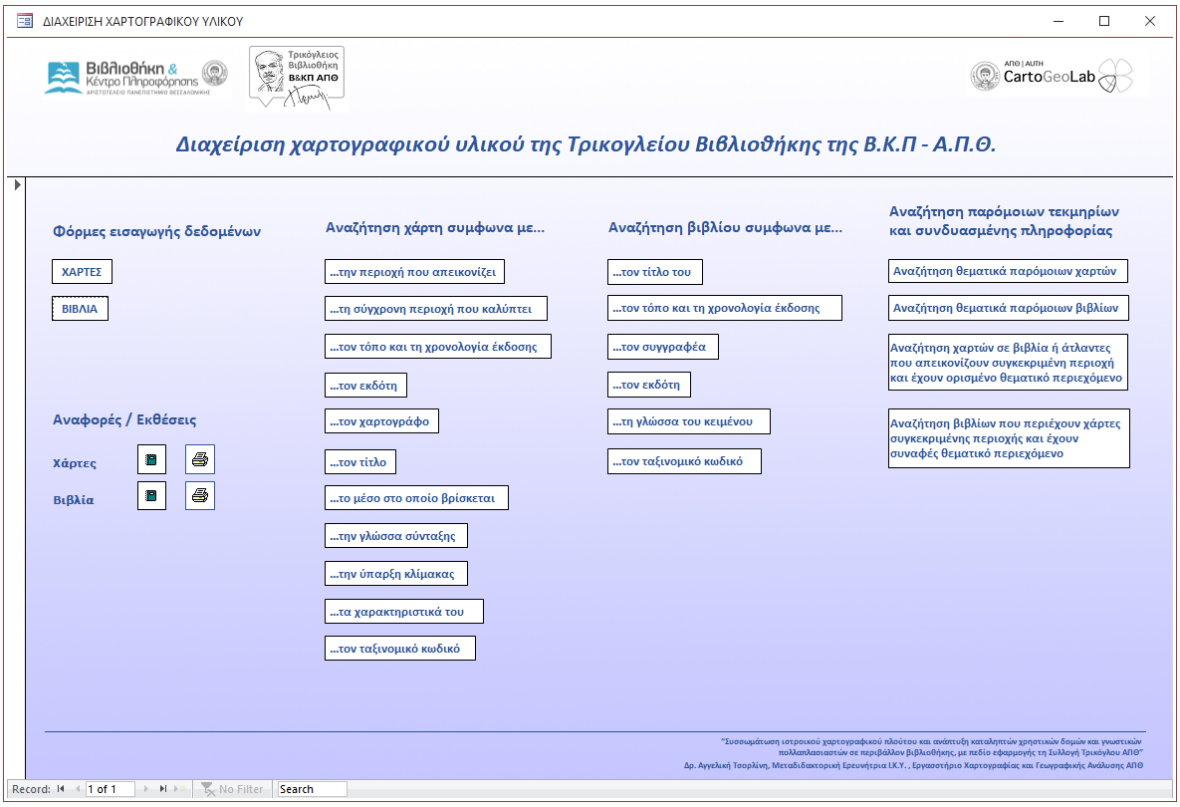

Figure 2. The initial page of the database, from which the searching procedure can start.

Cataloguing the maps in this way, **organizing and managing them through this database system**, gives the opportunity to the users, researchers, students or library's staff, to find easily maps and the books they belong, to get information about them and to retrieve combined information for them through proper queries in the database. An example is shown on Figure 3. In this figure, a query, which leads to the detection of maps in the area of modern Greece, was applied to the data and one of the maps that came out, is presented on the user through

a form, designed for this reason. The information, the user gets about the map is recorded on relevant fields, together with an image of the map, its georeferenced version showing the map over the geographical space it depicts and links to this item in the library's digital system and to its full digitized version, if it exists. In case this map belongs to an atlas or it is embedded in a book, there is a reference which connects the map with the atlas or the book.

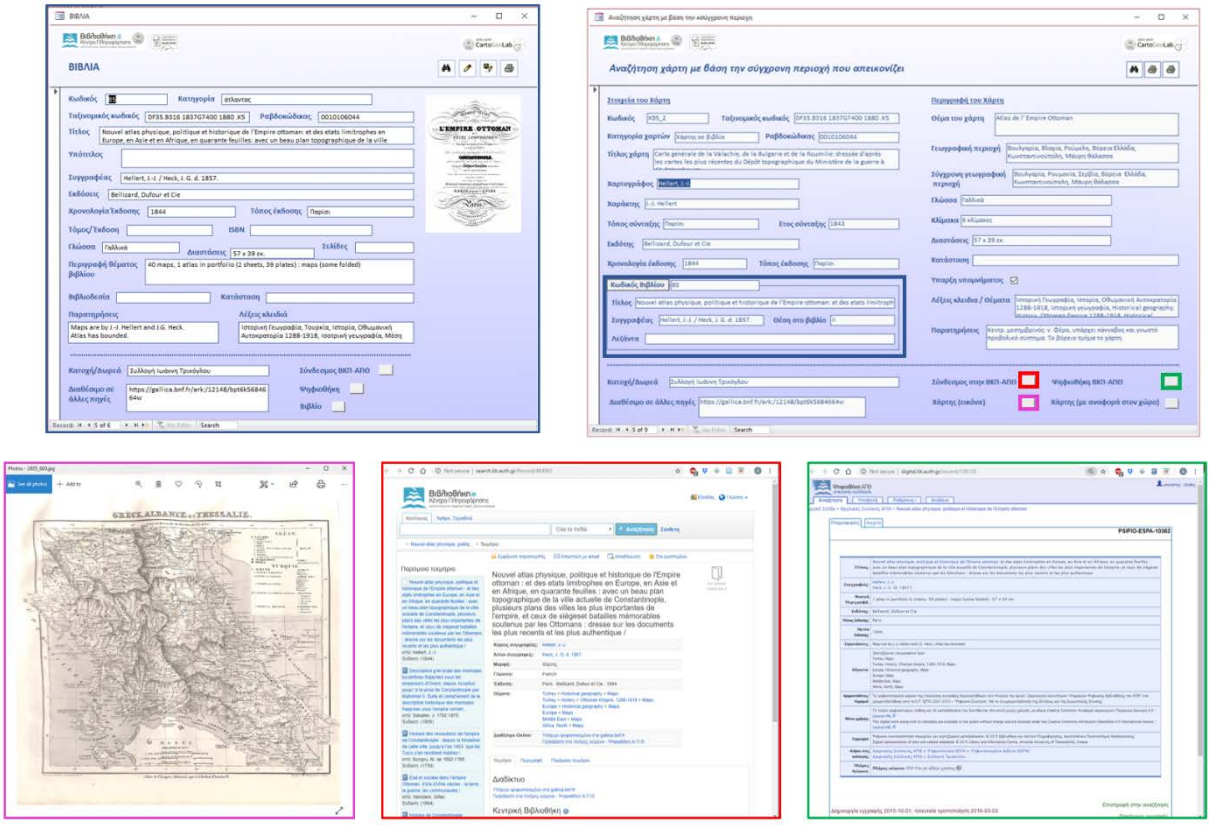

Figure 3. The information provided for each map with the appropriate links to the image of the map (purple), to the record (red) and the digitized item (green) in the library's digital system. This map belongs to an atlas and it is connected to it through a unique code, with which the atlas is recorded on the respective table.

The next step of the procedure is the joining of **the georeferenced maps with the information stored for them in the database.** This can be done through a geographic information system and a geospatial database, which will be developed to include and connect the spatial information coming from the maps with the descriptive information existed in the database from their documentation. In this way, through spatial queries, it will be possible to see the area each map covers, to compare it with other maps in the same area or to find which maps depict / contain (Figure 4)/ intersect with particular area and to get combined information about them through the geodatabase. The geographic information system can also work autonomously in library's environment providing the users, researchers or the library's staff, access to the cartographic inventory and giving them tools to search and detect easily maps and other related material on the geodatabase.

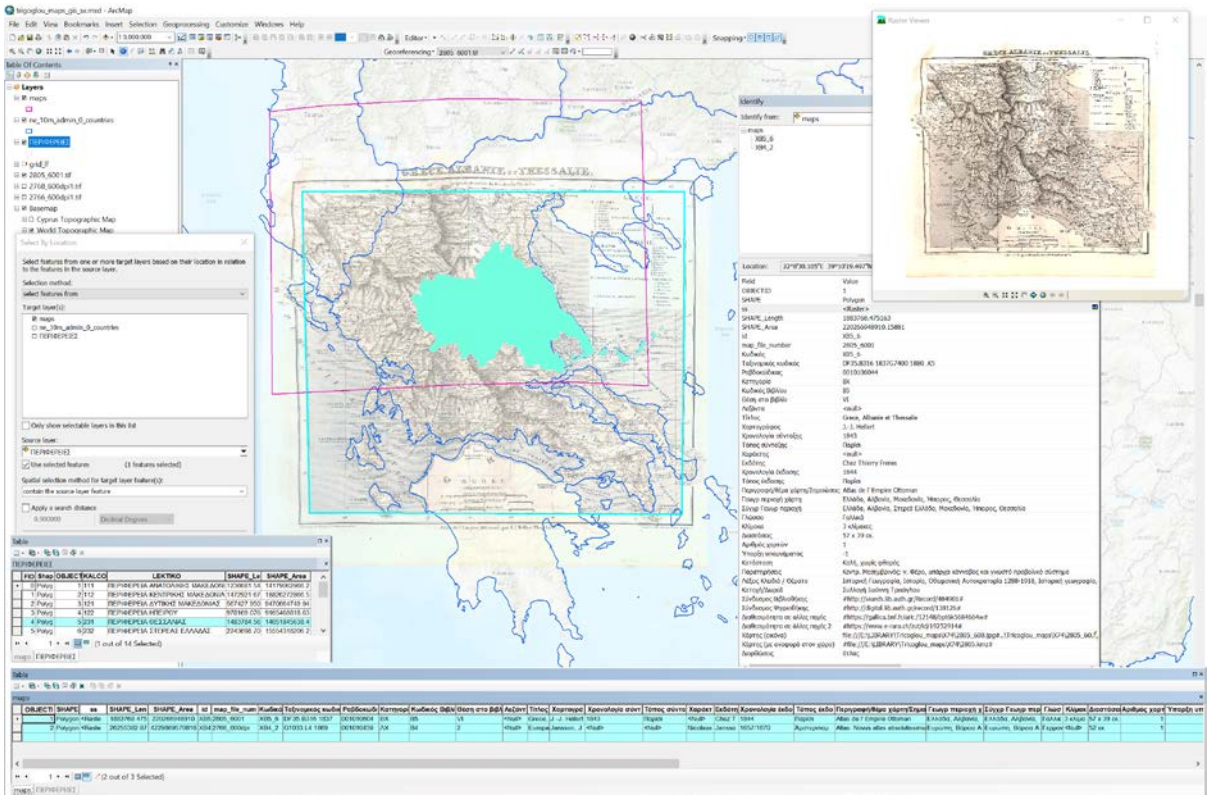

Figure 4. Spatial query in the geodatabase which shows which maps depict the whole Prefecture of Thessaly. On of these maps is selected in this image. The table on the left gives information about the map connecting it with the respective record in the database.

iii. Connecting maps with information from other sources

In the next stage of the procedure, **the information stored with the maps in the database** in the form of metadata, is **connected with other related textual and pictorial sources** existed in the library, enriching the information provided for the maps to researchers, students and library's staff. In this way, the combined information which leads to knowledge, is aggregated and it can be used as knowledge multipliers for the users and the library's staff in the library's digital environment.

The first step in this stage was to search in the database for maps and other cartographic material with same reference, as well as for other relevant textual and pictorial data/information, which can be joined with them. The next step was to explore the possibilities of connecting and correlating maps with textual and pictorial data in library's digital environment. This was a challenging procedure, especially in case of maps embedded in books, since they could be linked not only with textual data from different sources existed in the database (something that happens with all the maps), but also, they can be combined with relevant texts inside the book they belong. Prerequisite for this is the digitization of the whole book and the application of a text recognition procedure to it, in order to convert the text to an editable form, allowing the inquiry of words or phrases inside the text.

The joining of maps and the information they transmit, with other texts and images stored in the database can be done using appropriate keywords referring both to the texts and the maps (Simon et al., 2015; Simon, 2017). It is important in the keywords definition procedure to include words not only in Greek language but also in the language of the map, or even in English

language, in order to increase its detection's possibilities. This procedure leads to the definition of new fields in the two main tables of the database, which stores information about the maps and the books/atlases, that could be used as keywords for the searching procedure (Tsorlini et al. 2018).

These keywords concerning the maps may refer to the area depicted on the map, its thematic content or its cartographic standards and concerning the books, it refers to the general thematic category, which is already defined in the library's system. The main reason for using this information is to integrate more easily the developed system to the system which already exists in the library. Additionally, for maps which belong or are embedded in books, information about the location of the map in the book is added, such as the page and the caption of the map/image, if it exists. The recording of the caption may play later important role in detecting the texts referring to a map inside the books, since it will connect the map with relevant texts of the book. Setting similar keywords for map and for the thematic description of the books, it is possible then to combine the information for different sources setting proper queries in the database (Tsorlini et al. 2018). This will provide the opportunity to researchers to expand their scientific research and enrich it with new data, while at the same time the cartographic wealth of the library is presented and promoted through the researchers' work to the general public.

An example of the application of a proper query in the database is shown in Figure 5. In this case, we were searching for maps belong to a historical atlas depicting the modern area of Greece. The results from this query were shown in forms providing combined information about the map and the atlas to which the map belong.

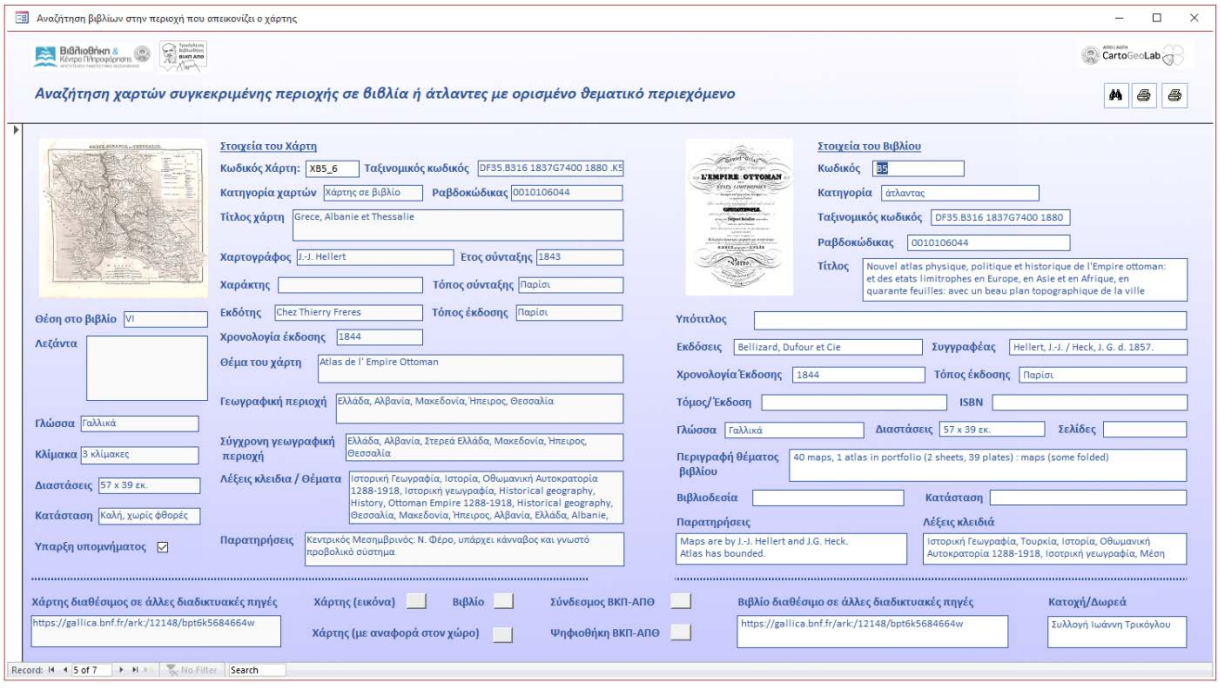

Figure 5 Detected map and the atlas it belongs with all the information provided for them through the database.

This part of the research was analysed in detail in a paper presented at the 15th National Cartographic Conference on Cartography of Crises, organized by the Hellenic Cartographic Society, in Thessaloniki and published in the Conference Proceedings (Tsorlini et al., 2018a).

iv. Reclaiming, presenting and promoting knowledge through the developed system

At the last stage of the research, in order to find the appropriate way to develop a user-friendly digital environment to provide access to this combined knowledge to researchers, the public and the library's staff, cartographic and web mapping tools and applications were explored based on their functionalities and the possibility to be easily integrated to the present digital library's system which is based on a database.

The research on these applications showed that the integration of the developed system to library's digital system could be more easily done, if the fields with the additional information from the developed system would be included in the library's system together with the proper queries which would provide combined information to the users. The interface of the library's digital system will change properly, in order to include the new documented information and appropriate corrections will be made to the mistakes existed on the already recorded information, due to the wrong documentation of the maps by the library's staff (Figure 6). Additionally, in order the maps to be connected to the geographical space they depict, they were converted to appropriate format, so that they can be opened to common-used applications such as Google Earth, where they can be compared to each other and to current data (Figure 7). This ability is given for each map through the database and it has been integrated to the developed integrated system.

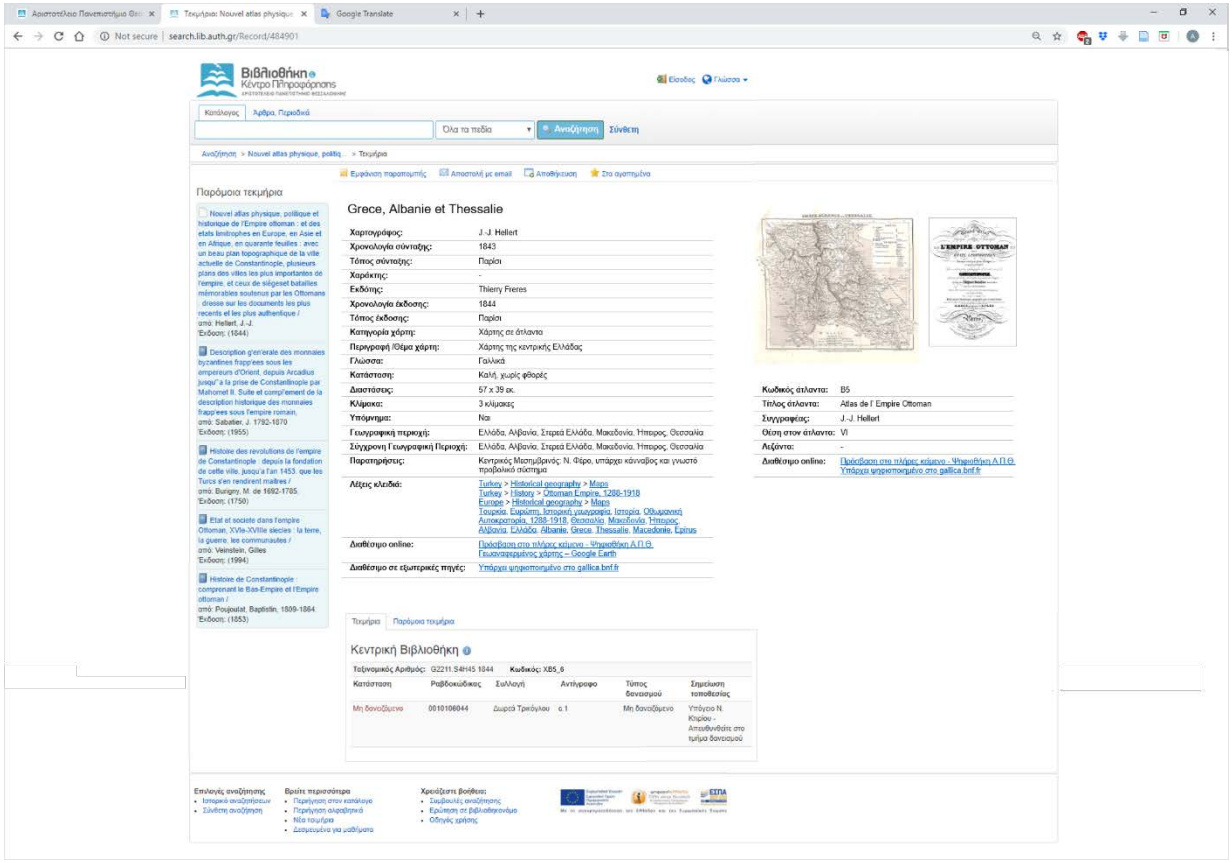

Figure 6. The adjustments of the library's digital system to include the additional information documented and recorded for the maps.

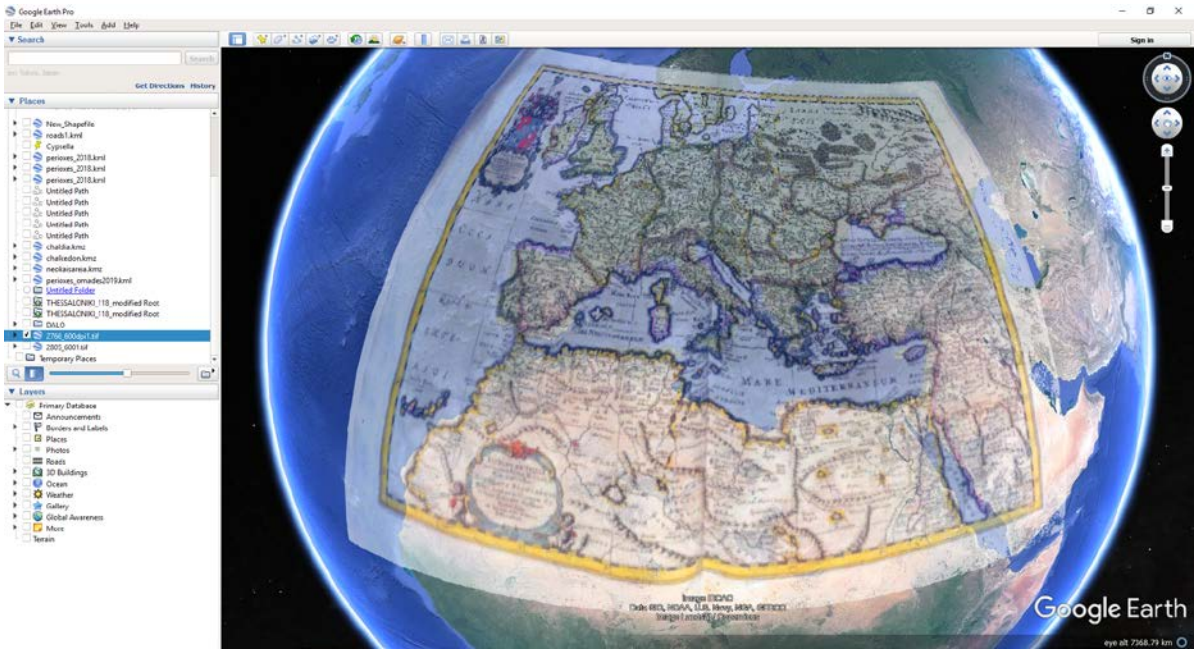

Figure 7. A georeferenced map displayed over current background in Google Earth.

The developed system and the results of this research will be presented next month at the **29th International Cartographic Conference**, which will be held in Tokyo, 15-20 July, organized by the International Cartographic Association (Tsorlini, 2019b).

4 Results - Conclusions

The availability of old maps, atlases and other related cartographic material in digital form in the web, by bigger and smaller providers such as public and private libraries, archives, collections and other institutions dealing with cartographic heritage is growing rapidly worldwide, with the providers to improve their digital environments with new functionalities and tools to make easier the detection of maps and the provision of completed information about them. In Greece, the situation is completely different, since the cartographic material in most libraries is not documented correctly, having as a result to provide limited or sometimes misleading information about the maps to the users, making difficult their detection in the library's digital system. As a consequence, the cartographic wealth of the library remains unknown to the academic community, which is expected since its value is not properly estimated by the library.

In order to change this situation, it is important to standardize the cataloguing and archiving of maps in the library's environment, so that the information provided to researchers and the public is complete and correct. Based on this information, an integrated system was developed with three main parts: a database with proper queries for the information management and retrieval; a geographic information system to connect the maps and information documented for them with geographic space they depict; and an online application which would give the opportunity to its users, to search in a user-friendly environment for historical maps and other cartographic related material and to find extensive information about them. Moreover, it will give them the opportunity to combine the maps and the information recorded about them with

other maps with common properties or with relevant information from textual or pictorial sources, enriching in this way their research with new data.

The research questions set at the beginning of this research, as well as basic issues concerning the special characteristics of the maps, which require particular treatment and make their cataloguing differ from the common standardised method applied in book-keeping and book-archiving, have been answered through the description of the main idea of this study and the methodology followed to reach the final outcome, which is the development of a system to improve the library's digital system, making easier the detection of maps and other cartographic material.

Through the developed system, which can also work as an example of good practice for other applications in the library, the cartographic material kept in different collections in the library and remained unknown for years to the academic community, will now have the opportunity to be accessible, studied and analysed properly, showing in this way its value to the public, something which has already started happening through map exhibitions listed in the next session, or presentations of the library's cartographic material through scientific papers in international and national conferences (e.g. Boutoura et al., 2018; Boutoura et al., 2019; Tsorlini, 2019; Voulgarakis et al., 2019; Yu et al., 2018).

5 Dissemination activities

The information system, which was designed and developed in this research, to include historical maps and other related cartographic material of Tricoglios Library, to provide information to users about this material and to combine this information with relevant information from other textual or pictorial sources, was used and tested its function during the preparation of map exhibitions, in the detection of cartographic material which will be presented. These map exhibitions were organized by the AUTH Central Library in cooperation with Laboratory of Cartography and Geographical Analysis, in an attempt to employ, present and promote historical maps and other cartographic material located in Library's collections to researchers and the general public. These exhibitions were:

- "Lefkada 38°.7N, 20°.7E. A beautiful surround between historical maps, coins and profitable balances". Art Gallery "Theodoros Stamos", Lefkas, 18.05.2017-06.06.2017.
- "220 years of Rigas Velestinlis Charta, 1797-2017. The two (plus) faces: another reading of the map". Teloglion Fine Arts Foundation of Aristotle University of Thessaloniki, Thessaloniki, 15.12.2017-14.01.2018 and Art Gallery "Theodoros Stamos", Lefkas, 20.05.2018-31.05.2018.
- "Archipelagos 1685-1687 on the maps of Louis XV". Teloglion Fine Arts Foundation of Aristotle University of Thessaloniki, Thessaloniki 14.2.2018-02.04.2018.
- "In similarity with the crescent moon. A trip with Santorini maps from the Aristotle University of Thessaloniki". Bellonio Cultural Center, Fira, Santorini, 29.9.2018-31.10.2018.
- "Archipelago runs into the moon: French maps and images from a past life in Archipelago". Central Library of the Aristotle University of Thessaloniki, Thessaloniki,

07.05.2019-02.06.2019. A cooperation between the AUTH Central Library and the AUTH CartoGeoLab with the General Consulate of France in Thessaloniki.

6 Publications and papers' presentation in scientific conferences

In the frame of this postdoctoral research, a number of scientific papers was presented at international and national conferences and seminars in Madrid, Spain; Athens and Thessaloniki, Greece. Some of these papers were also published in the Conference Proceedings and are mentioned in this report as references.

The final results of the research will be presented at the 29th International Cartographic Conference, which will be held in Tokyo, 15-20 July (http://www.icc2019.org/index.html). The title of this presentation is: "Organizing, utilizing and promoting the cartographic wealth of a library in digital environment" and its extended abstract can be found in the Appendix of the report.

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