Thinking data. Integrative big data approaches towards an 'introspective' digital archaeology in the ancient Mediterranean

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Abstract

Archaeological data is what economists call a 'non-rivalrous' good: it can be processed again and again with no diminishing of its value. The proliferation of surveys and excavations, coupled with the large-scale adoption of digitalization in archaeology, exponentially increased the amount of data. Instead of keeping isolated 'data silos', one of the current challenges is the aggregation and correlation of archaeological data in the 3V's perspective of 'Big Data': high volume, high velocity and high variety.
Archaeologists make traditionally use of SQL RDBMS databases, although the rising importance of Big Data in Computer Science has recently brought to our attention a new typology of Database Management System: the NoSQL. This typology of database can much more effectively handle Big Data by preserving a 'more human' approach through dynamic queries and enhanced functions of data visualisation. In this perspective, NoSQL may prove to be a fundamental tool in moving from 'data silos' to a more complex strategy of data management. This paper explores the potential of a specific type of NoSQL Graph database (Neo4j) of handling archaeological 'Big Data', through the discussion of a specific case study in Bronze Age South-western Cyprus.

Keywords

Big Data, data integration, data management, SQL, NoSQL, Bronze Age, Cyprus, Eastern Mediterranean

1. Introduction

As archaeologists, we are well aware that many of our primary field methods are generally destructive and that our field results cannot be replicated by future generations. Once we have dug a site, sampled a filling or emptied a grave, its research potential is substantially already decided; even when we survey a field, the picture right in front of us will never be the same again. As archaeologists we know that it is of primary importance to keep a comprehensive record of our work and that our field notes, labels, pictures, drawings and maps will be probably much of our winter duties, to develop our analysis and to plan the next stages of our fieldwork.[1]

In a regional and landscape perspective, we started to accumulate a significant amount of quantitative data at least from the 1960s and the 1970s, when regional studies progressively acquired an important and autonomous position in the archaeological agenda, as the emergence of the so-called 'New Archaeology' and 'New Geography' determined the adoption and the development of new techniques for field and lab research. Until the 1980s, however, the vast majority of archaeological data was created and stored on paper, according to very patchy and heterogeneous organizational schemes. It's only from the following 'New Wave' that computer technology spread and analytical tools improved.[2] From the 'digital turn' of the 1980s onwards, in fact, an ever-growing amount of data has been collected, produced and processed using new digital techniques and analytical models, while advanced computer-based technologies and tools have been largely developed inside and outside archaeology.

2. Thinking (big) data in Mediterranean archaeology

Archaeological data is what economists call a 'non-rivalrous' good: it can be processed again and again with no diminishing of its value.[3] There is no doubt that archaeology is going digital, as demonstrated by the proliferation of surveys and excavations over time, and this process has exponentially increased the amount of data at our disposal. While the 'computational turn' appears to be nowadays a consolidated practice,[4] one of the current challenges is to replace the isolated *data silos* with advancements in data aggregation and correlation through the *3V's* perspective of 'Big Data': high volume, high velocity and high variety.

Since the well-known 2002 workshop at the University of Michigan, and its resulting volume 'Side-by-side Survey: Comparative Surveys in the Mediterranean World',[5] the debate about working in a comparative format has progressively gained popularity in Mediterranean archaeology,[6] so that today an increasing number of scholars is aware about the urgency of combining local datasets in order to produce wider landscape narratives.[7] This is not only a theoretical issue but also a tangible necessity: urban and rural changes are strongly transforming our territories and frequently the only legacy at our disposal is a very heterogeneous *corpus* of old reports, survey projects, casual discoveries, rescue excavations and grey literature.

It is unquestionable that a remarkable number of surveys has been operating in the last decades, with a large variety of theoretical backgrounds and survey methodologies. Consequently, this implies that data comparability is often a problem that archaeologists have to address. The heterogeneity of regional datasets does not mean that archaeological legacies are useless or incomparable; it rather means that researchers must be aware of how, when and why data has been collected, paying a particular attention to their own research methodologies, techniques and objectives.[8]

Before even beginning a second-generation analysis, a striking doubt rises at the centre of the methodological issue: can we rely on datasets collected in the past by someone else? And – if yes – how can we

1 Allison 2012.

2 Cherry 1994.

3 Gattiglia 2015, p. 1.

4 Huggett 2016.

5 Alcock, Cherry (eds.) 2004, pp. 1-9.

6 See several papers in Smith (ed.) 2011 or the recent volume by Cadogan et al. (eds.) 2012.

7 Kintigh 2006.

8 Allison 2008; Kantner 2008.

aggregate geographically and/or temporally circumscribed datasets in a wider and cross-disciplinary 'Big Data' and 'Linked' perspective? Unfortunately, this point is frequently a deterrent and interesting soon-to-be comparative studies cease to exist even before birth. The 'either go big or go home' mantra,[9] in fact, largely conflicts with a perceived impression of data fetishism, with a general lack of collective awareness about Big and Linked Open Data, with a generalized resistance to data sharing and with a substantial deficiency of theoretical and methodological tools to synthesise and analyse information.[10]

One of the preliminary problems, in fact, is the incontrovertible difficulty in aggregating and correlating data of heterogeneous provenience. On top of that, archaeological legacies are frequently formed by grey literature that makes datafication and computational analysis even more difficult.[11] The inclusion of low quality data, for example, can support the reprocessing of legacy datasets to explore new research topics and to reach a level of granularity and detail that sampling strategies cannot provide.[12] As Newhard recently argued, «archaeology is a place within the social sciences and Humanities where the nature of the work deals with Big Data».[13] Given this inherently heterogeneous nature of archaeological data, we must accept messiness as an inevitable characteristic of the archaeological inquiry and we need to collectively (re)think the data quality question, designing methodologies that can support scholars in evaluating data metrics.[14]

9 Wesson, Cottier 2014, p. 1.

10 Boyd, Crawford 2012.

11 Evans 2015.

12 Gattiglia 2015, p. 2; Van Eijnatten, Pieters, Verheul 2013, p. 59.

13 Newhard 2013. For a critique to archaeological data as 'Big Data' see Huggett 2016.

14 Bevan et Al. 2013a, 2013b; Costas et Al. 2013; Crema 2012; Crema, Bevan, Lake 2010; De Runz et Al. 2007; Habert, Huc 2010; Jaroslaw, Hildebrandt-Radke 2009; Lawrence, Bradbury, Dunford 2012.

3. Data storage in archaeology

'What is data?' is the question every scholar, not only archaeologists, tries to avoid for their whole life. Philosophers do not agree about a unique definition, because probably there is not a single meaning, and centuries of speculation provided grand theoretical scenarios but little practical help. Etymologically 'data' comes from the Latin *datum*, which means 'given'; it could be so described as an 'information which is given' from one to another, as the verb 'to give' needs the existence of a receiving partner. If we accept the Latin etymology, the nature of data lays in the existence of an external relationship, in the existence of a 'giver' and of a 'receiver'. On the contrary, our traditional way to acknowledge data surprisingly focuses on the properties of the observed reality, which means that it focuses on internal factors that belong to the observed entity itself, rather than on the external factors that belong to data usage. The Cambridge Dictionary provides a very concise and stringent definition for data: «information collected for use», which reinforces the perception that usage constitutes the very nature of data.[15]

3.1 Setting the question

Generally speaking, «a database is a collection of information that is structured and recorded in a consistent manner [...] to store and retrieve data records in the most efficient way possible».[16] Burrough and McDonnel listed four 'famous' specific functions that a Database Management System (DBMS) should provide: quick access to data, facility for inputting/editing/updating data, ability to define rules to ensure data consistency and ability to protect data.[17] This extreme flexibility and efficiency, coupled with the development of the Relational Model in the 1970s, made DBMS an essential technology in the hands of archaeologists.

15 Cambridge Dictionary 2017.

16 Conolly, Lake 2006, p. 51.

17 Burrough, McDonnel 1998, p. 50.

While there is not a single data model of recording archaeological data, there is an implicit 'internal' agenda that every archaeologist is asked to adhere to, in order to organize and manage collected data in the most efficient way. Completeness, correctness, accuracy, consistency and structure are the five 'magic words' to fix in the mind when designing our databases and conceptual models. Moreover, Berners-Lee provided us with the famous '5 stars' goal to produce fine datasets for the Linked Open Data (LOD) realm and the Semantic Web.[18]

Within the life-cycle of archaeological data (creating-processing-analysing-preserving-giving access-reusing), it is significant that emphasis is traditionally – and maybe unconsciously – placed in the phases of data-collection and database design. Yet the life-cycle contains further additional stages, including data reuse, even if it still remains rare.[19] As the Archaeology Data Service correctly argued, «imagining data being reused by someone else may cause you to approach the creation and design of your data in a new light».[20] A recent study developed by the ARIADNE project revealed that Academic archaeology is surprisingly lagging behind Heritage Management in developing a Linked Data approach: diverse organisational settings in charge of data collection and management, project-oriented data management practices and a general low level of open sharing of research data are among the present unfavourable conditions that impede the uptake of the Linked Open Data approach.[21] Moreover, the results of the AthenaPlus project's 2013-2015 survey revealed that, despite a general awareness about LOD, there is a persisting lack of experience and engagement with LOD projects.[22]

Yet, in recent years, a growing set of data sharing infrastructures has been developed. New infrastructures (e.g. ARIADNE, MedArchNet) have been created in order to share data, theories and knowledge; several international (e.g. JOAD Dataverse, Archaeology Data Service, Figshare, Open Context, tDAR, Zenodo and UCL Discovery) and national (e.g. Arachne in Germany, DANS in the Netherlands, Mappa in Italy and SnD in Sweden) data repositories can support the sharing of existing datasets among current and future scholars nowadays. Despite Linked Open Data still miss to break the resistance of Academic archaeology, data sharing appears to be one of the Gran Challenges of twenty-first century archaeology, to create interconnected sets of information, hub of knowledge and opportunity to explore new trajectories in research.[23] The 'don't publish, push!' model can certainly improve data quality through the integration of private editorial feedback and public version control; it can open new analytical and comparative research avenues, encouraging a greater dynamism and new collaborations among researchers and institutions.[24]

Cyberinfrastructures such as Open Context move in this direction by providing access to primary data from multiple projects and making them re-analysable and comparable through the adoption of controlled vocabularies and ontologies, the rigorous review of internal consistency and the provision of accompanying metadata.[25] The entire workflow of these infrastructures, that aim to transform multiple sets of primary data into annotated products ready for analysis, emphasises and optimises the idea that data is a dynamic product, the very nature of which is not fixed or static and the scientific capability of which is not limited to a defined number of uses.[26] Additionally, many project-specific data sharing facilities such as the Çatalhöyük database can provide a fundamental contribution in supporting second generation analysis, even if they are not readily scalable and comparable with external datasets, unless they conform to the specific recording systems.[27]

In particular, the increasing availability of complex sets of primary data can positively support the dissemination of NoSQL-based analysis, providing

18 Berners-Lee 2009.

19 Wallis, Rolando, Borgman 2013.

20 Archaeology Data Service 2014.

21 Geser 2016, pp. 43-46.

22 AthenaPlus 2015, pp. 7-12.

23 Huggett 2015b.

24 Kansa E.C., Kansa S.W., Arbuckle 2014.

25 Kansa 2010.

26 See footnote 1.

27 Engel, Grossner 2015; Lukas, Engel, Mazzucato 2018.

a native data complexity and heterogeneity that can capitalize the horizontal mechanisms, the flexibility and the relationship-based structure of NoSQL. As successfully demonstrated, published primary data can improve data reuse and re-examination, increasing the overall quality of legacy datasets and supporting new interpretations and more detailed thematic narratives.[28]

Hopefully, in the next decade LOD and data reuse practices will have greater impact and diffusion, going beyond Heritage Management and directly entering the archaeological discipline. Rewarding mechanisms, credit systems, reducing barriers to public participation, new data modelling practices and a collective recognition of data reuse as a professional goal will certainly minimise the current reluctance to share data.[29]

Berry and Huggett have recently advocated a 'third wave' in the use of digital technologies in the Humanities, including Archaeology, arguing that it's time to collectively examine the result of this 'going-digital' process and, in particular, to focus on the impact of the digital transformation on our process of knowledge creation.[30] The use (and reuse) of archaeological data can not miss the chance to play a vital role in this 'third wave'.

3.2 Comparing, replacing or integrating SQL and NoSQL (R)DMBS?

It is necessary to take a step back and cut our minds off from the traditional idea of 'database' (shaped by a long-term engagement with the SQL language) to acknowledge the difference between SQL and NoSQL.

Commonly, Structured Query Language (SQL) Relational Database Management Systems (RDBMS) are organised according to a certain oversimplification of the process of data collection and knowledge creation, which is reduced to a two-fold system based on standardized set of columns and rows, where data needs to be preliminary structured and grouped into *schemata*. By the logic of SQL, emphasis is placed on categories, that are generalized and predefined typologies that can aggregate fragmented data through a set of complex relationships, defined by the user according to the limits of the machine. Archaeologically speaking, scholars have a good grasp of SQL databases as they are traditionally used in structuring organized collections of archaeological data in a day-by-day perspective. Data organization passes through the schematization and abstraction of the body of information (e.g. chronology, function, artefacts assemblage, etc.) where data complexity is deconstructed and reconstructed.

NoSQL DBMS are built upon a different approach, which aims to save the complexity of data without oversimplifying the process of knowledge creation. They support the storage of unstructured data across multiple nodes, with no need to organize data into *schemata* and fixed tables.[31] This horizontal scaling mechanism help to accelerate the whole workflow and to handle 'Big Data', a vast range of heterogeneous datasets that the SQL rigid and vertical structure can hardly manage. In contrast to RDBMS that generally adopt SQL language for querying and maintaining the database, NoSQL databases use many typologies of language to support different strategies and preferences in data collection and processing.[32]

Generally speaking, NoSQL databases are progressively reaching the level of the famous SQL relational databases such as Oracle and mySQL in terms of their wide distribution. Fig. 1 displays the adoption of the main NoSQL databases according to the general families described by Yen.[33] In our opinion, Document Store databases and Graph databases are of great interest as they can provide an innovative contribution to the 'introspective' discourse of Digital archaeology, in particular concerning our reflexive engagement with data and the process of knowledge creation.[34]

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[28] Atici et Al. 2013.

[29] Harley 2013; Kansa E.C., Kansa S.W. 2013; Piowar, Vision 2013.

[30] Berry 2011; Huggett 2015a.

[31] For a general overview see Strauch 2009.

[32] Several classifications can be found in Cattell 2010; North 2009; Popescu 2010; Strauch 2009; Yen 2009.

[33] Yen 2009.

[34] Huggett 2015a.

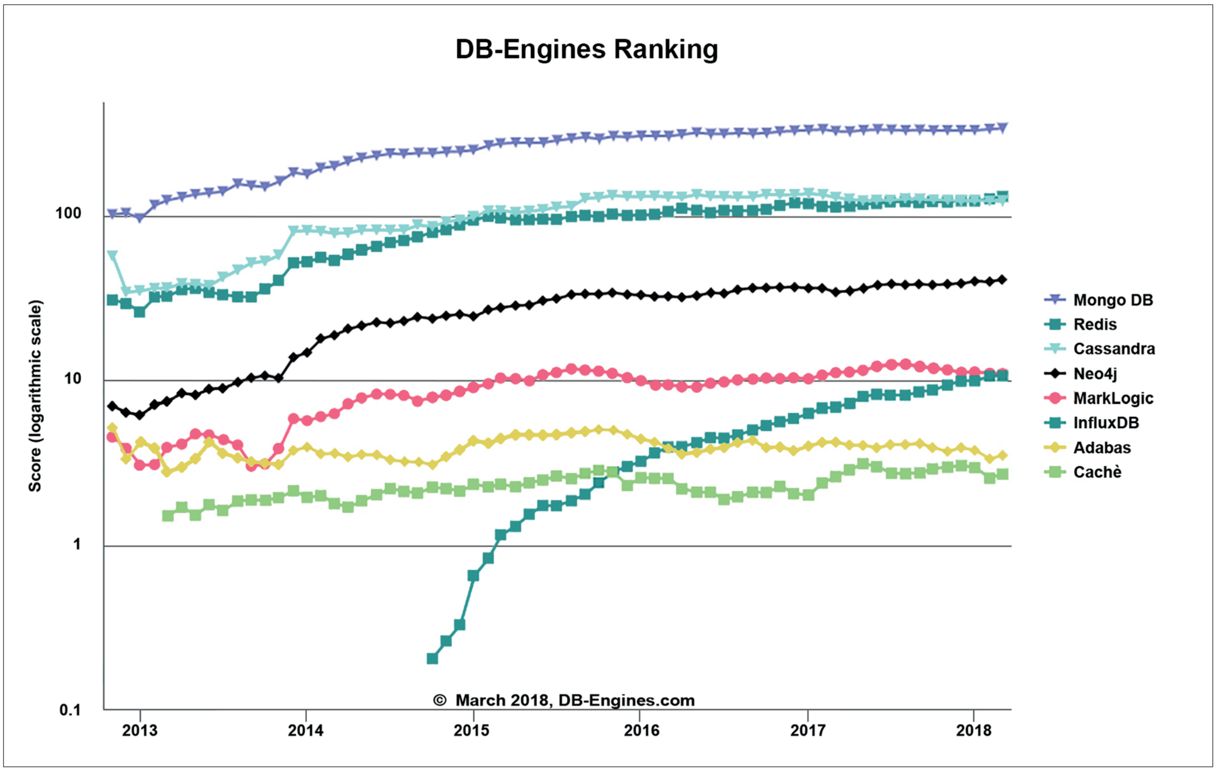


Figure 1
Graph displaying the diffusion of the main NoSQL DBMS; for every main family (as described in Yen 2009) the commonest software has been included in this graph. Ranking values are updated at March 2018 (© DB-Engines.com)

Instead of splitting information into tables and rows, Document Store databases such as MongoDB are able to store data belonging to different text formats, thus supporting the maintenance of data complexity, the distribution of information across multiple servers and the movement/replication of entire objects. Entries can differ from one another in terms of their content/structure (in this case the two elements fully coincide) as they are totally free from the limitative scheme based on tables and columns. This type of NoSQL database seems to be particularly suitable for archaeological research as it permits scholars to aggregate diversified legacy datasets such as, for example, the results of surveys carried out back in time, with variable methodologies, sampling strategies, theoretical backgrounds and historical questions. Diversified datasets can be correlated without requiring a secondary standardization, as requested by SQL databases, thus maintaining the overall complexity of legacy data. Similarly, Graph databases such as Neo4J can provide a significant contribution to archaeology, particularly by improving the traditional techniques for data visualization. Graph databases permit users to split data into two different types of information, namely nodes (data itself) and their reciprocal relationships. Nodes and relationships are defined by properties set by the user in order to ease data storage and analysis. The main benefit is represented by the relationships themselves; while they operate as simple joins in SQL RDBMS, in NoSQL databases they possess a defined set of properties that contain a meaningful part of the information.

Certainly, we need to consistently advance in digital technologies for archaeology in order to fully introduce NoSQL databases into our traditional toolbox. One of the main concerns is the limited capacity of NoSQL to integrate with Geographic Information Systems (GIS), that have been developed within the SQL relational structure.[35] The synergy with the main GIS desktop software is very experimental and still in progress, such as in the case of the integration between MongoDB and QGIS or of the Neo4J Spatial library.[36] Differently, SQL databases can be externally – but easily – related/joined to the main geospatial packages or they can even include a spatial extension into relational databases, such as in the case of the widely used PostgreSQL/PostGIS combination.

An additional and game-changing potential of NoSQL databases in archaeology is their usability in predictive modelling, addressing large-scale settlement dynamics through stochastic processes. In a comparative perspective, for example, NoSQL DBMS (particularly Graph databases) are currently used in intelligence-related studies (e.g. in advanced data mining on social networking[37]), but unfortunately scientific literature about their application in history-related studies is still missing. As demonstrated by Durand, Belacel and LaPlante[38], Graph NoSQL DMBS such as Neo4j can be successfully employed in Learning Path Prediction, where the inductive nature of retro-simulative environments suggests that similar techniques can also support the investigation of historical processes, including predictive modelling in archaeology.

To conclude, currently we can not entirely replace SQL with NoSQL databases (assuming that this is our final goal) as we have a lot of ground to cover before fully integrating NoSQL databases with GIS and before elaborating an archaeology-based body of theoretical and methodological literature. We can certainly combine SQL and NoSQL databases in order to successfully manage an increasing amount of heterogeneous archaeological (Big) legacy data and to effectively progress towards a proper data-driven approach.

What follows is our preliminary experiment in this direction, aiming to combine SQL (PostgreSQL/PostGIS) and NoSQL (Neo4j) databases in a strictly GIS-based (QGIS) archaeological research. The selected case study is a discrete test area in Bronze Age Southwestern Cyprus.

4. A case study from Bronze Age Cyprus

Cyprus is the third largest island in the Mediterranean Basin, as well as an extraordinary case study given its ecological diversity and long-term trajectory in human history. Located in close proximity to the Levantine and Anatolian coastline, Cyprus was an active crucible of ideas, technologies, goods and ideologies throughout Mediterranean Prehistory and Protohistory.[39]

The Bronze Age history of Cyprus can be generally described as a complex and gradual route from a relatively egalitarian, insular and village-based organization in the Early and Middle Bronze Ages (2000–1750/1700 cal. BC) through to the hierarchical, urban and internationally-connected society of the Late Bronze Age (1750/1700-1300 cal. BC).

4.1 Trends in Cypriote archaeology

When one googles 'Cyprus crossroad', approximately 528,000 results come into view: from the 2011 exhibition at the Smithsonian Museum entitled *Cyprus crossroad of civilizations* to thousands of recent articles in geopolitics that emphasize the role of Cyprus as a 'crossroad of three continents'. From the archaeological perspective, Cyprus is paradoxically located in a position of academic isolation: it is neither part of Aegean nor of Near Eastern archaeology. Much vaunted as a crossroad of cultures, Cyprus is tossed from one academic sector to another: Aegeanists and Orientalists consider Cyprus as one of the latest islands along the cross-Mediterranean trade route, depending on whether it started, whether from the East

35 Bennett 2015; McCarthy 2014.

36 Altaweel 2016. See also Schutzberg 2011 about the use of NoSQL for geospatial tasks.

37 Corbellini et Al. 2015.

38 Durand, Belacel, LaPlante 2013.

39 Knapp 1986, 1993; Manning, Hulin 2008; Sherratt S., Sherratt A. 1993.

or from the West. Therefore, ironically, the archaeology of Cyprus progressively became a discipline in its own right and a certain sense of insularity became the backbone of several studies about Cypriote past.[40] 'Insularity' and 'connectivity' are recurring words in Cypriote archaeology, frequently used in a constant tension between the island and what was located beyond its coastline.[41] In this way, Cyprus started to be delineated as a single monolithic block, different from what was positioned around/beyond/close to it. Under some points of view, this dichotomy has flattened our analytical perspective and the island's complex ecosystem turned into a geographically homogeneous mass, saturated by copper in every square kilometre. Excluding some chronological stages or specific themes, the regional scale of analysis has been omitted, at least, until the last decade.[42] The repeatedly mentioned Early and Middle Bronze Age Cypriote regionalism, for example, has resulted in a proliferation of typologies of material production – especially ceramics – while several topics related to the territory (e.g. settlement pattern, natural resources, economic organization) still persist in a substantial island-wide perspective. Despite this fragmentation in our knowledge, new interesting insights about the 'divergent trajectories' in Cypriote Prehistory and Protohistory have been recently provided by Webb and Frankel, tracing a new route in regional studies.[43]

4.2 Addressing the problem of data integration in the Southwest of Cyprus

There is currently no body of data allowing a complete and regional-based comparative analysis about Bronze Age Cyprus, and, excluding few important exceptions, there is not a comprehensive diachronic study at a regional scale of analysis.[44]

The archaeological legacy from the Southwest of Cyprus is the product of more than fifty years of research projects and a century of antiquarian interest. Under the supervision of the local Department of Antiquities, six foreign survey projects recorded and mapped the archaeological heritage of the Southwest (fig. 2); namely these are: the Canadian Palaipaphos Survey Project (CPSP), the Kent State University Expedition at Episkopi *Phaneromeni* (KSU), the Kouris Valley Project (KVP), the Sotira Archaeological Project (SAP), the Sotira *Kaminoudhia* Survey (SKS) and the Western Cyprus Project (WCP). Rescue and research-oriented excavations provided a further impressive sequence of datasets, exploring the life at the Bronze Age communities of Sotira *Kaminoudhia*, Erimi *Bamboula*, Episkopi *Phaneromeni*, Erimi *Laonin tou Porakou* and *Pitharka*, Alassa *Paliotaverna* and *Pano Mandilaris*, Prastio *Mesorotsos*, Kouklia *Evreti* and *Asproyi*, Maa *Palaeokastro* and Kissonerga *Skalia*.

It is a matter of fact that regional and landscape studies have a proud and successful tradition in Cypriote archaeology. Thanks to the pioneering and multi-thematic approach by Gjerstad and the Swedish Cyprus Expedition, Cypriote archaeology was permeated by a wide-ranging theoretical and methodological focus from the 1930s onwards, with the important surveys directed by Dikaios and Catling.[45] Systematic surveys in Cyprus underwent a successful period of flourishing from the 1970s onwards, thus producing a remarkable quantity of collected data that constituted a solid basis for several studies about the local settlement pattern.[46] In 1974 the Turkish invasion of the north of the island suddenly interrupted the activities by the local Survey Branch of the Department of Antiquities, and archaeological projects shifted from the northern part of the island towards the south coast and the southwestern region of Paphos.[47] Nevertheless, the new regional focus of the 1970s inspired foreign institutions to organize new projects on the

40 This is rather common for insular cultures; see Vogiatzakis, Pungetti, Mannion (eds.) 2008.

41 Held 1993; Knapp 2007, 2008.

42 See Barlow, Bolger, Kling (eds.) 1991 for regionalism in pottery production and distribution, and Webb, Frankel 1999 concerning the passage from the Late Chalcolithic period to the Philia phase.

43 Webb, Frankel 2013.

44 See Georgiou 2006 for a territorial-based comparative discussion about Bronze Age Cypriote regionalism.

45 Gjerstad 1926, p. 1; Gjerstad, Lidros, Westholm 1934, p. xiv; Catling 1962; Stanley Price 1979, p. 51.

46 Very successful examples are Merrillees 1973 and Frankel 1974.

47 Hadjissavvas 1977.

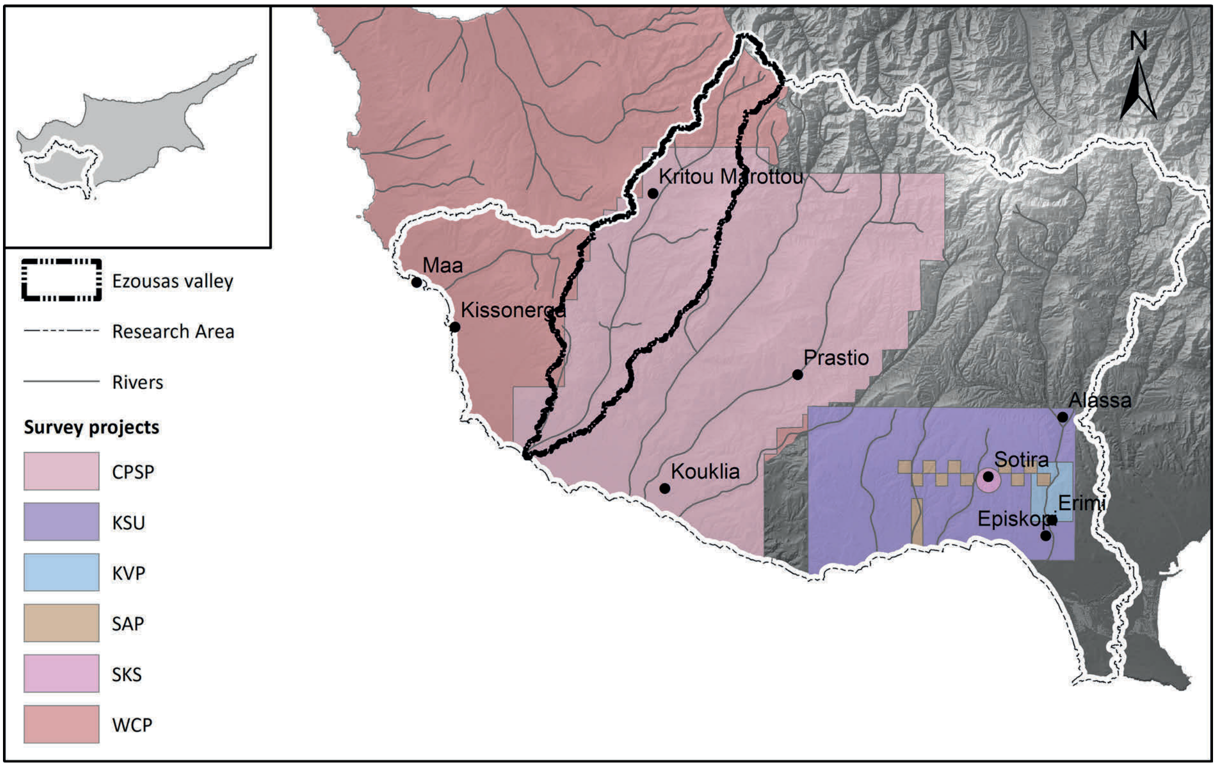


FIGURE 2
Spatial distribution of the six foreign survey projects in the Southwest of Cyprus and the location of the original research area and of the selected test area (the Ezousas river valley)

island, such as the Kent State University Expedition at Episkopi *Phaneromeni* (KSU), the Sotira *Kaminoudhia* Survey (SKS) and the Vasilikos Valley Project (VVP).[48] In this period the debate on data collection methodologies developed in parallel with the emergence of new interpretive frameworks. At least until the end of the 1980s, with the development of surveys as a stand-alone practice, it was rather common to notice that data collection strategies were changing from year to year, even within the same survey project. This process is clearly exemplified by the Canadian Palaipaphos Survey Project (CPSP), where a site-oriented project turned into a large-scale survey.[49]

In the 1990s, important projects operated throughout the island, such as the Sydney Survey Cyprus Project (SCSP) that aimed to investigate «the relationship between the production and distribution of agricultural and metallurgical resources» in a wide *terra incognita*.[50] The diachronic approach and the noticeable interconnections between environmental factors and socio-cultural interactions completely fit into the landscape paradigm characterizing the 1990s. This attempt to comprehend a particular geographical area in a more detailed and comprehensive way progressively produced a narrowing of survey areas also in Cypriote archaeology.[51] Examples of this 'high-resolution wave' are two recent projects carried out in the Southwest of the island: the survey in the surroundings of Prastio *Mesorotsos* and the Kouris Valley Survey Project (KVP).[52]

48 Held 2003; Swiny 1979; Todd 1996, 2004.

49 Sørensen, Rupp (eds.). 1993; Rupp, Kling 1983.

50 Given, Knapp, Coleman (eds.) 2003, p. 1.

51 The 'Mediterranean Myopia' according to Blanton 2001, p. 68.

52 Jasink et Al. 2008; McCarthy et Al. 2010.

4.3 Methodology

Whilst Cypriote archaeology proudly experienced a long history of successful landscape studies and survey projects, surprisingly there is a general lack of web-platforms and repositories for sharing and comparing datasets.[53] This evident discrepancy points to the necessity to promote a new season of data management and to engage in a better understanding of the theoretical and methodological implications of the overall 'going-digital' process.

This paper presents just a preliminary test about the integration of SQL and NoSQL databases. Chelazzi recently re-processed a large amount of archaeological legacy data from southwestern Cyprus, setting an effective – but simple – method to manage different datasets.[54] Her methodology was shaped according to the characteristics of the Bronze Age Cypriote archaeological record, but it originated from the evaluation of wider theoretical issues that are not limited to this specific spatial and temporal focus.[55] The use of data quality estimation procedures supported the characterization of the overall archaeological legacy in terms of periods, regions, sites, typologies of artefacts that are more or less reliable. This research largely made use of PostgreSQL/PostGIS where data was structured according to the traditional RDBMS framework, based on tables using columns and rows.

With this paper we aim to go one step further and to test the integration of NoSQL databases in this specific case study. In particular, we tested the use of the commonest type of Graph database, Neo4J, which can provide a remarkable contribution to data visualization and is easy to use on web browser, even when offline. To develop a coherent and rigorous test analysis, we defined a subset of the original research area, that coincides with the Ezousas river valley (fig. 2), where evidence of human occupation is documented at least from the Aceramic Neolithic at Kritou Marottou *Ais Yiorkis*.[56]

[53] See Kydonakis, Chliaoutakis, Sarris 2013 for the GIS-based application for the management of the archaeological heritage in Cyprus.

[54] Methodology is broadly described in Chelazzi 2016, pp. 44-93.

[55] See footnote 15.

[56] Simmons 2005.

Neo4J has a very intuitive – for being a NoSQL database – structure, even if the entire process of data entry needs to be carried out through command-strings. Although this can appear to be an obstacle at first, command lines facilitate the control over data structure. The database is organized according to two types of features, where nodes and relationships constitute the technique to add information as each of them is accompanied by a rather infinite and fully editable set of properties.[57] According to Neo4j syntax, a node is the simplest form among the available sets of information: it can be a substantive, a person's name or – in archaeology – the name of the site or its identity document (ID). Additional sets of information can be placed both in the node's label or as properties. Nodes are thus correlated through relationships that do not operate in a standardized way but rather as a dynamic component that can be fully customized by users and adapted to *ad hoc* needs.[58] Nodes, labels, properties and relationships create a dynamic and potentially infinite network of relationships. The process of data query can be structured on this network, which – despite the standard language – facilitates the creation of semantic queries. Thanks to its elevated level of customization, this database allows users to visualize not only specific data or data collections, but also to create new relational data. The entire process is performed through a graph system providing data with its own visual evidence, which was what the column/row structure of SQL RDMBS obscured.[59] Graph databases, including Neo4j, are traditionally classified as highly flexible but highly complex; their own set of given features, however, was considered as a crucial benefit in the performance of this test analysis.[60]

Keeping in mind what we achieved with the SQL-based representation of the archaeological record in the Ezousas river valley and aiming to create the most consistent and coherent comparison between the two typologies of DBMS, we decided to run our comparative NoSQL test using the same categories previously employed in the PostgreSQL/

[57] Baton, Van Bruggen 2017.

[58] Hunger 2014.

[59] Robinson, Webber, Eifrem 2015.

[60] Popescu 2010.

PostGIS database.[61] This permitted us to accelerate the whole process without limiting its performance. Nodes included ID of sites, their function, their periods of occupation, their geographic location and the occurrence of the most common ceramic wares of the Cypriote Bronze Age. This approach allowed us to create a heterogeneous set of 'nodes' which contained the basic set of information concerning every archaeological site; in our opinion this set of data constitutes a solid base to create a consistent network of relationships. This last point, stage by stage, resulted to be the main strength of the graph database. From a purely theoretical point of view, in fact, this system is virtually boundless and consequently it allows the database to avoid any loss of semantic value for each single entry. The system is so data-oriented that it supports also the creation of 'weighted relationships' to increase the network's information capacity.

4.4 Discussion about data

A test of the real consistency/scalability of the node/property structure was not among the main objectives of this preliminary study, thus we decided to bound our discrete test of relationships. In particular, test query#1 focused on the 'attributed-to' relationship, which describes the hypothesized periods of occupation at each site, and on the 'found-in' relationship, which indicates the collected material assemblage.

Given the selected set of variables, the test explored the local material assemblage and, in particular, two distinctive Middle Bronze Age local ceramic variants of the island-wide Red Polished ware: the Drab Polished Blue Core and the Red Polished Punctured wares.[62] Generally speaking, the Drab Polished Blue Core belongs to a ceramic tradition of southwestern Cyprus as it is documented by the extraordinary occurrence of this ware in the area of Kissonerga *Ammoudhia* and *Skalia*, where it accounts for more than 70%.[63] At the same time, the Red Polished Punctured ware characterizes part of the ceramic production along the south-central coast. Already Åström attributed the production of this ware to the South of the island and more recently Herscher hypothesized its production at Episkopi *Phaneromeni*, renaming this ware as the 'Episkopi ware'.[64] This ware has been broadly recorded not only along the Kouris valley but also at several sites in the Southwest.[65]

Once we structured the database, we run the test through the use of the NoSQL main tool: the query. Our first test concerned the co-occurrence of both these ceramic wares in the Ezousas valley, aiming to map the convergence of ceramic traditions both from the coastal Southwest and South-centre of the island. In the SQL environment, this test is based on a very simple query that every archaeologist is familiar with: we used the SELECT clause (which is the most complex statement in SQL) for the 'site number', 'Drab Polished Blue Core' and 'Red Polished Punctured' fields. Our main condition was the WHERE clause which links the occurrence (YES clause) of the 'Red Polished Punctured' or (OR clause) the 'Drab Polished Blue Core'.

```
SELECT * WHERE "Red Polished Punctured"
OR "Drab Polished Blue Core" = YES
```

The result of this query included five sites where both the wares are documented, one site which provided only the Drab Polished Blue Core and three sites where only the Red Polished Punctured was collected.

We ran the same test in the Neo4j environment. The software uses the Cypher language which needs to perform a type of statement using both nodes and relationships.

```
match(b:pottery)-[r:FOUND_IN]->(a:site),
(b:pottery) -[x:ATTRIBUTED_TO]-> (c:period)
where c.name="MC I" XOR c.name="MC II"
XOR c.name="MC III" XOR c.name="LC IA"
return a,b,c,r,x
```

61 Chelazzi 2016.

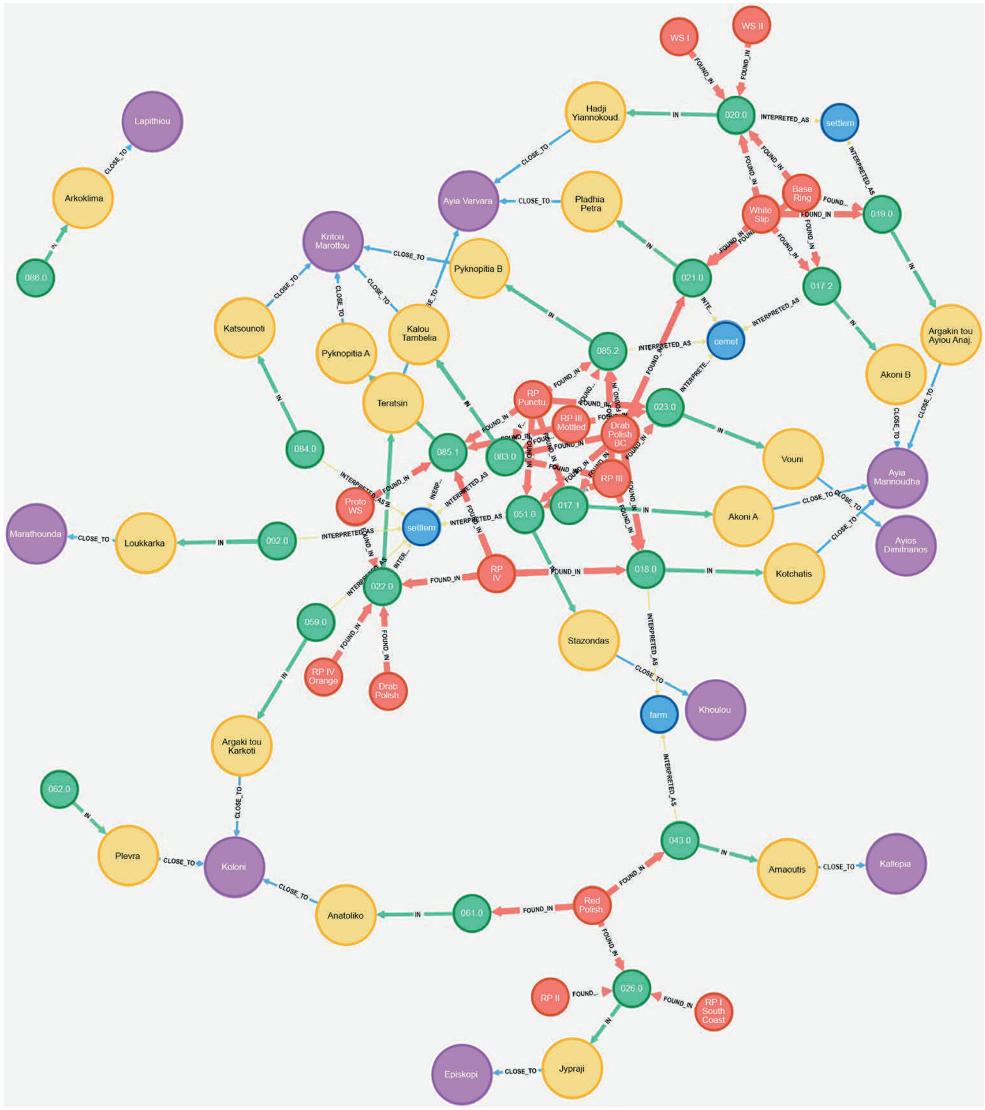
62 Åström 1972, pp. 83-84; Carpenter 1981, pp. 61-64; Herscher 1976, 1991, 2003; Swiny 1979, pp. 232-236.

63 Crewe et Al. 2008; Graham 2012; Philip 1983.

64 Åström 1972a, p. 95 Type VIII B; Herscher 1976, 1991.

65 Bombardieri et Al. 2012, pp. 96; Guldager Bilde 1993, pp. 6, 18-19, pl. 1.

Figure 3
Test query#1:
the Neo4j graph



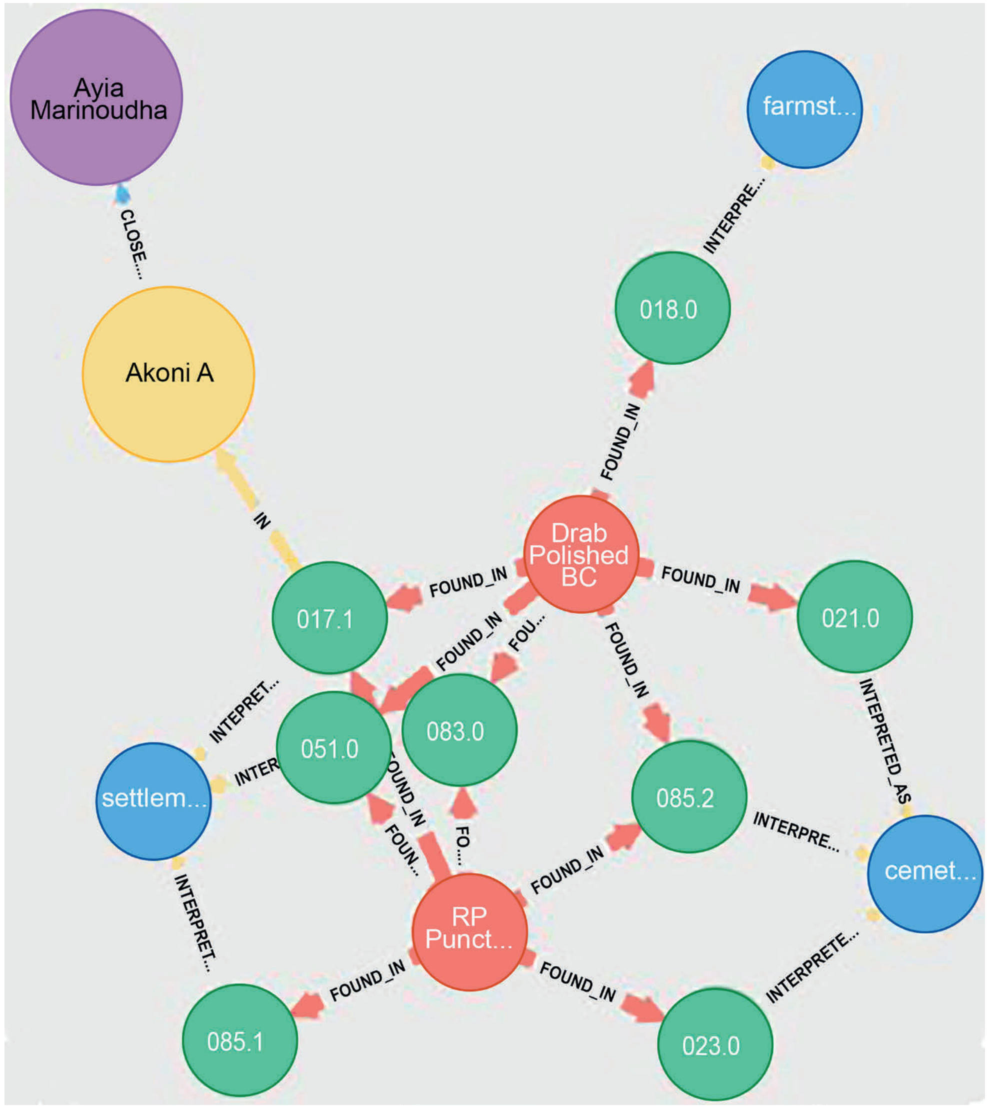
To perform this very simple query, Cypher was used in its simplest performance potential as the 'search, find, elaborate and display' query basically matches the SQL statement. In short, we asked the database to elaborate and visualize (match) all the possible relationships between the ceramic assemblage (b:pottery) and their corresponding location (a:site) in a time span (c:period) which stretches from the Middle Bronze Age I (MC I) to the Late Bronze Age IA (LC IA) (c.name). Besides the specific Cypher clauses (match, where, XOR, return), we requested the software to create two new relationships (r:FOUND-IN) and (x:ATTRIBUTED-TO).

The outcome was, in fact, a nuclear graph, where a radial pattern based on chronological periods organized the information in a meaningful way. Fig. 3 displays the created network in relation to the specific sites' functions and IDs, the chronological periods and the two selected ceramic wares. This complex network was rather unexpected and it provided a certainly more meaningful information when compared with the traditional SQL-based query.

Beyond the impact of this small test in the archaeological discourse, the main difference among the SQL and the NoSQL approach is self-evident. Queries performed in Neo4j and Cypher do not request the user to restrict the analysis to pre-iden-

Figure 4
Test query#2: the Neo4j graph

(for reasons of simplification and data readability, relationships related to place-name are visible only for site ID 017.1 by example)



tified typologies of results (which is the preliminary *condition sine qua non* of the SQL language). Instead of (pre)imagining the result in order to build the query, we actually asked the software itself to produce data: in short, we asked the database not only to answer to our initial question but also to contextualise its result, thus producing new archaeological data. When compared with the 'comfortable' SQL inductive process, NoSQL queries are much more complex but they provide an unexpected support for producing new data and new relationships.

To conclude our test, we asked Neo4j to relate the test query#1 results with the hypothesized function of each site (f:INTERPRETED_AS and d:function). The goal was to visualize if there was any meaningful association between pottery distribution and site classification.

optional match (a:pottery)-[r:FOUND_IN]->(b:site), (c:site)-[f:INTERPRETED_AS]->(d:function) where a.class="Drab Polished Blue Core" XOR a.class="RP Punctured" return distinct a,r,b,d,f

The outcome of this test query#2 was a nuclear graph, displayed in Fig. 4, where settlements and cemeteries (shown as blue nodes) were almost equally documented in terms of the occurrence of the Drab Polished Blue Core and Red Polished Punctured wares, while farmsteads were remarkably less 'proximal'. Even during this second test, the NoSQL query provided new data, as the software did not require any pre-existing criteria.

5. Conclusions

In the light of the recent claim for an 'introspective' and reflexive discourse about the use of digital technology in the Humanities, including Archaeology, this paper explores the semantic and functional transformation of archaeological data through new logics of data storage and mining. We developed a comparative integration between the traditional SQL RDBMS and the NoSQL DBMS. Despite the NoSQL/GIS integration is still experimental, the underpinning logic of NoSQL databases facilitates not only the preservation of a more complex approach to archaeological data but also the aggregation of legacy data without the requirement of secondary processes of data standardization, such as those demanded by SQL databases. This comparative test has been performed on the archaeological evidence from a discrete area of Southwestern Cyprus, the Ezousas river valley, where a previous PostgreSQL/PostGIS-based study already provided interesting preliminary data. The replication of the SQL-based queries in a NoSQL environment (using Neo4j) permitted us not only to replicate the results but also to generate new networks of information without the need of over-imposing (pre)defined analytical conditions.

The research potential of this integrative methodology is particularly compelling, especially because NoSQL Graph databases enhance visual functions and provide unexpected associations in an immediate and particularly explicit way. The main aim of this test study is to invite the archaeological community to experiment innovative strategies of data mining and to explore their theoretical implications and methodological novelty.

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The Crisis Areas Archaeological Database (CAAD): a WebGIS for monitoring and safeguarding archaeological heritage

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Abstract

The current political instability in the Near East is at the heart of complex issues of management and protection of local archaeological heritage. In the last century, many archaeological sites have been victim of conflicts, which caused huge damages. Although it constitutes a well-known problem inside the international community, a consistent and reliable report on damage is still missing.
The Crisis Areas Archaeological Database (CAAD) aims to create an online open source database, a WebGIS platform, for collecting data relating archaeological heritage in Near Eastern crisis areas, monitoring their status in real time and documenting the extent of the damage suffered by them with photos, maps and, where possible, a comparison with existing archaeological documentation.
The data collected will be accessible through a dynamic, searchable and interactive on-line maps, which, will allow access to several data such as name, geographical references, date of survey, presence of regular excavations/restorations, type of damage, date of damage and eventual multimedia contents of the site.
At present, a demonstration version of CAAD WebGIS regarding southern Levant is under construction. The goal of the project is the creation of a WebGIS available and updatable by all the scholars who, in their work, encounter damage to archaeological heritage in crisis areas and in all the Near East.

Keywords

Database; WebGIS; cultural heritage; conflicts; Near East; looting

1. Introduction

In war theatres (civil wars, wars, unconventional conflicts, terrorist attacks), in addition to civilian casualties, cultural heritage is also subject to serious damage. The loss of cultural property and archaeological heritage is a serious problem during conflicts and post-conflict times. The situation is getting worse, especially in Syria and Iraq (not to mention Afghanistan or Yemen), but also in countries such as Lebanon, Israel and Palestine.

In this climate of high political instability, cultural heritage is damaged not only by acts of war – as the ones provided by the Islamic State – but also by negligence and lack of supervision by the local authorities and public institutions responsible for its protection.

We are witnessing a never-ending drain of cultural resources: in some cases, there are massive attacks against heritage, like in Palmyra or in Mosul, in other cases, such as in Israel and Palestine, the destruction is slower but unrelenting.[1]

There is a real risk that the Near East will lose it all in a short span of time.[2] Consequently, local people will be facing not only the usual post-war challenges of social and economic nature, but also the bewilderment caused by the loss of their own historical and cultural identity.

A people without its history cannot exist[3]; as written in the revision of the Burra Charter approved by ICOMOS in 2013 "Places of cultural significance enrich people's lives, often providing a deep and inspirational sense of connection to community and landscape, to the past and to lived experiences".

Current conditions of generalized and widespread crisis in the Near East require cultural heritage experts (from the Near East and from western countries) to develop new methodological approaches for monitoring and safeguarding cultural heritage (historical, archaeological, artistic and architectural heritage).

In this perspective, the CAAD project aims to develop a WebGIS in order to share data about the conditions of the archaeological heritage in the Near East. The data sharing will allow the monitoring of cultural heritage in crisis areas in real time.[4]

At present, the project is still in the early stages: we developed a CAAD WebGIS demonstration version in order to test the feasibility and its real potential toward a full development in the future.[5]

For this demonstration version we used a selection of data collected by Marzia Merlonghi for her PhD project about damages to pre-classical sites in Palestine and Israel.[6]

Several challenges with different problems and solutions will be addressed in the next years by experts of cultural heritage: from cultural genocide[7] to illicit antiquities traffic.[8] In this framework, it becomes necessary to safeguard archaeological heritage through a deep knowledge of the present conditions of the sites. Moreover, it is important to study

[1] The so called "second intifada" and the reoccupation of large parts of the West Bank in 2002 and 2003, the war against Lebanon in 2006, the periodic military operations in the Gaza Strip (Arrigoni 2009, *passim*) and the rockets of Hamas on southern Israel: all these episodes affect the conservation of heritage in southern Levant (Maniscalco 2005, p. 97).

[2] Nigro 2014, pp. 1-2.

[3] Maniscalco, Mengozzi 2002, p. 79.

[4] Currently, there are other projects that aims to monitor the state of conservation of archaeological sites in the Near East: the EAMENA database of the Oxford University (BEWLEY, R. ET AL., 2016), for instance, uses almost only remote sensing and satellite images. This method is very useful during wars since it is almost impossible go safely on the ground.

On the other hand, CAAD, a was born to order data collected during survey activity. Using mainly data "from the ground" involve a different method of observation and has different purposes: it is helpful in post-war situations, where there is a need to verify the situation together with local authorities and citizens. As far as we know, there are no other WebGIS programs developed mainly to order and collect data from emergency survey.

[5] Unlike most of this kind of projects, CAAD is not sponsored by a University or another institution.

[6] Merlonghi 2015. The database we are developing is mainly dedicated to the southern Levant because of personal experience. The relative safeness of the region (if compared with, for example, Iraq and Syria) and, at the same time, a situation of never-ending conflict, contribute to make it an ideal laboratory for developing techniques of intervention in post-war situations (Ruggiero Maniscalco 2014, pp. 93-94). All the data we are using are original and the collection method is explained in the next paragraph.

[7] This term, even if it is widely disputed, indicates the deliberate erasing of the tangible and intangible cultural properties tied to a specific people (Starrenburg 2014; Akhawan 2016).

[8] Yahya 2008, 39-55.

the anthropic[9] causes of decay and to find possible solutions.

An on-line database with as much information as possible about sites (documenting the extent of damage with pictures, maps, plans, videos) is key instrument for understanding typology and causes of damage and it will empower us to prevent them.[10]

The definitive goal of the CAAD project is to develop an online open-source application updated by all the scholars and local authorities who, during their work, encounter damage to archaeological heritage in Near East: it will thus be possible to acquire information on a growing number of sites in conflict areas, monitoring their changes across time.

2. Working method in post-war contexts: assessment of sites damage and data collection

In this regard, it is possible to define a working method in emergency survey and intervention. This method is based on the experiences of Fabio Maniscalco in Albania, Kosovo and Bosnia during the 1990s. Maniscalco, when he served as officer in the Italian Army, developed one of the first methodologies for monitoring and protecting cultural heritage in times of conflict.[11] In the early years of the new century he began working in Palestine but his premature death left this work unfinished.

Maniscalco's pioneering surveys and emergency interventions started a new phase of cultural heritage protection during and after conflicts. In the surveys conducted during the peace-keeping operations in Albania and Bosnia Herzegovina, Maniscalco used a schedule developed by himself, the "Form for the immovable cultural heritage in crisis areas".[12] This form allows the collection, during a preliminary visit to a monument, of the main information needed in order to check the state of historical buildings, monuments and archaeological sites (fig. 1). It was developed for the monuments and cultural properties in Bosnia and it formed the main tool for monitoring and safeguarding cultural property at the end of the Balkan wars: it allows an easy, fast and accurate check of the situation in order to pinpoint the main actions needed.

This form, with some changes due to the different operation set, was very helpful to check the situation of the archaeological heritage in Palestine-Israel.

In this case, the research started choosing a number of pre-classical archaeological sites:[13] the first step was to study the history of the archaeological researches in these sites and to find all the available bibliographic and photographic material about them (a sample of 101 archaeological sites).[14]

The second step was to conduct field assessment in order to check the transformations and the damages the sites had suffered in the last 50 years (from 1967[15] to today):[16] look at the way immoveable heritage changes through time (confronting historical pictures and bibliographic material with what we can see on the ground) can help to save, protect and even restore monuments. An archive of more than 5000 digital pictures (originals, taken by the writer on field between 2011 and 2016) was set up. Each site has a folder with pictures, joined with a digital copy of the form completed during the survey. This database is constantly updated.

9 We excluded all the natural causes since the main goal of this project is to focus on the political crisis and war situations.

10 The method for collecting this data will be explained in the next paragraphs.

11 Sudiro, Rispoli 2015, pp. 40-44. Maniscalco also introduced the protection of cultural heritage in the Italian army and trained a team of soldiers during the peace-keeping mission "Alba", in Albania in 1997, as an application of the 7th article of the Hague Convention for the Protection of Cultural Property in the Event of Armed Conflict, signed in the Hague in 1954 (Sudiro, Rispoli 2015, pp. 64-68).

12 Maniscalco 2007, p. 89.

13 Pre-classical sites are more fragile and exposed because of the materials used in these eras. Moreover, in historical Palestine, a main part of the ideological/political battles centre on the pre-classical period, especially the early Iron Age.

14 The sites were surveyed by Merlonghi during her PhD researches. The sample covers most of the territory of Historical Palestine (Israel and Palestine) from the Galilee to the Negev.

15 The 1967, the starting year of the Israeli occupation in Palestine (as stated by the UN Resolution 242) it is a symbolic date and marks a gap in the history of archaeology in southern Levant.

16 The fieldwork is very important in order to provide a better understanding of the problems. Infact, the development of solutions could be different for every single situation.

SCHEDA DEI BENI CULTURALI IMMOBILI IN AREA DI CRISI

LOCALIZZAZIONE

Coordinate: Lat. N **Long.: E** **Alt.: slm**

Stato: **Città:** **Provincia:**

Frazione: **Località** **Via:**

Data del sopralluogo: **Compilatore: Marzia Merlonghi**

MONUMENTO

Denominazione monumento:

Cronologia assoluta:

Cronologia relativa:

Tipologia:

- Costruzione/complesso sacro:
- Costruzione/complesso civile:
- Costruzione/complesso privato:
- Cimitero:

Appartenenza etnica:

Restauri/Rifacimenti:

Collezioni e beni culturali contenuti nel monumento:

MONUMENTO

I. Danni esterni: SI NO

a. danni di guerra:
1. Armi di piccolo calibro
2. Granate/Razzi
3. Artiglieria
4. Bombardamenti
5. Vandalismo
Altro:

b. incuria : c. incendi

II. Danni interni: SI NO

III. Furti:

IV. Responsabile presunto danni:

V. Responsabile presunto furti:

VI. Data presumibile dei danni:

VII. Situazione del circondario:

VIII.Descrizione stato del monumento:

FONTI DELLE INFORMAZIONI

1. Documentarie:
2. Autorità locali:
3. Civili:
4. Testimoni:
Nome
Cognome
Indirizzo
Attendibilità
Disponibilità a testimoniare SI NO

DOCUMENTAZIONE

a.Foto/video del compilatore:

b.Foto/Video di altri:

c.Doc. acquisiti sul monumento:

d."Scudo blu" apposto sull'edificio:

e.Apposizione conforme al regolamento di esecuzione della Convenzione dell'Aja del 1954:

OSSERVAZIONI

SITUAZIONE ATTUALE

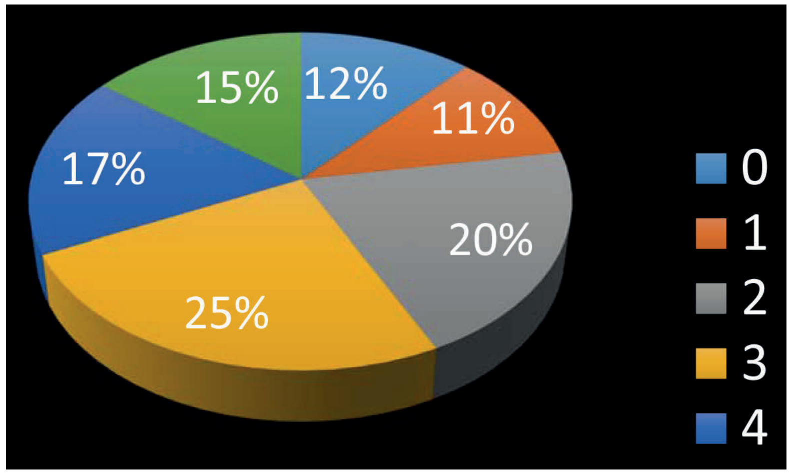
a. Restauri in corso: SI NO

b. Monumento in uso: SI NO

c. Luogo in cui i beni culturali mobili sono custoditi:

Figure 1
Form for immoveable cultural heritage in crisis area. (after Merlonghi M. 2016, p. 3)

FIGURE 2
Pie chart with percentage of the degree of damage in a sample of 101 archaeological sites (after MERLONGHI M. 2016, p. 4)



For the sake of accuracy damage is evaluated according to a numeric scale from 0 to 5 where the major score indicates better conditions:[17]

– **0**: the site disappeared or is inaccessible for military reasons;
– **1:** the site is in very bad condition and there is a risk to lose it;
– **2**: the site is in bad condition (missing parts of buildings, mud brick structures melted, widespread looting...);
– **3**: the site is in adequate condition but with some serious damage (the basic pattern of the site is still visible, some conservation damage is present or the overall environment has deteriorated);
– **4**: the site is in good condition with some minor damage;
– **5**: the site is an archaeological park or a protected area in a very good state of preservation.

Using this scale, it is possible to extract statistical data. For example, in the total sample of 101 sites almost 12% have grade 0, 11 % have grade 1, 20% have grade 2, 25 % grade 3, 17% grade 4 and 15% grade 5 (fig. 2).[18]

The second challenge was to manage all the data collected and create the CAAD.

From the survey emerged four kinds of damage: military or war damages, damage from modern constructions, damage due to illegal digging and general damage due to deterioration or missed restoration. Often a place can suffer from two or more different kinds of damage.

Finally, some interviews with local archaeologists and people living near sites (especially in the occupied West Bank) were collected in order to understand in greater detail the connection between population and archaeological heritage.[19] The interviews were briefly reported in a section of the form: they allow to figure out what was the main cause of damage. These interviews would also state the way the presence of experts (both native and foreign) can help to preserve the archaeological remains.

3. Four main categories of damage

Obviously, the division of in four main categories is instrumental to the analysis: the shades of a damage to an archaeological monument could be innumerable. A rough division is needed in order to have a first impression of the issue.[20] These

[17] This is very useful for statistical computing.

[18] Therefore, we can affirm that in Palestine and Israel, the conservation of pre-classical sites is not so good. Generally speaking, the causes are related to the situation of the occupation and to the ideological and physical struggle between Jewish and Arab population.

[19] This is useful in a second stage of work, when the experts going to start actions of rescue and preservation.

[20] In the form compiled during the survey is possible to find a more detailed description of every single situation.

main kinds of damage are the most common damage that occur not just in southern Levant but in every war theatre too.

1. **Military damages** are those related directly with a conflict situation, such as bombing, rockets, use of weapons on archaeological monuments, military installations on a cultural or archaeological site, occupied and closed areas. This kind of damage are widely spread, e.g., in Syria, Iraq[21] and Yemen. In addition, the damage caused by airstrikes and terrestrial attacks with mortars and artillery are very common. In Syria, Iraq and Afghanistan, we assisted to the intentional destruction of monuments using mines and various explosive devices. This is the worst kind of damage since a rocket or a mine can cancel in a few second an entire monument.[22] In our sample of 101 sites, just the 10% suffered direct military damage, especially sites in rural areas and near the "separation wall" (fig. 3).[23]

2. **Modern constructions** affect the conservation of archaeological sites especially in places where there is low attention to cultural heritage or where a central agency for building management is missing and there is a high rate of demographic increase.[24] Modern constructions are a common problem in the countries rich in archaeological remains or in places where a sort of sensitivity about the past is missing for social and historical reasons[25]. In the sample studied, 33% of the sites are covered by modern constructions such as houses, streets and infrastructures: one of the main causes is the high rate of population increase in a very small territory.[26] Other factors are, the military Israeli occupation of the West Bank and the construction of illegal settlements (fig. 4).[27]

3. **Illegal diggings** are widespread in all the Near East and, usually, they are due, mainly, to the request of the illegal market. The illegal excavations are common where there is need for money and where there are negative feelings (or not feelings at all) for the past among local population.[28] In a conflict area, the illegal traffic of ancient objects spreads whenever the national authorities are no longer able to control sites and antiquity shops. Illegal diggings are cause of the destruction of archaeological stratification and damage to the underground structures. Examples are Kamid el-Loz in Lebanon (Fisk 1989, 249-52), Nippur, Hatra and numberless places in Iraq and in Syria. These places were almost destroyed by looters (fig. 5). Remote sensing is very useful to investigate the presence of this kind of damage but only on-site assessment allows to understand the frequency, the deep of the excavations and the damage to the underground structures.

4. **General deterioration**: fires, vandalism and lack of conservation measures are the last kind of damages investigated. Some factors influence the politics of in situ conservation:[29] a value-based approach could penalize some sites just because they are not connected with the predominant stakeholder groups.[30] A correct

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21 Fales 2005.

22 Maniscalco 2007, pp. 67-96.

23 Maniscalco 2006, pp. 85-85.

24 Iwais et Al. 2010, *passim*.

25 In the case of Palestine it is possible to observe a real detachment from the pre-islamic heritage. The reasons are various but, basically, they are tied to the fact that archaeology in Palestine had a colonial approach from its start in nineteenth cent. (the Arab population was only marginally involved in the researches). Even now, a decolonization of the archaeology is still missing as underlined by Glock, Taha, Gori, and other scholars. See Glock 1994, Taha 2010, Gori 2013.

26 Especially in seventies and eighties the management plans developed by the Israeli military authority, the Civil administration for Judaea and Samaria, disregarded the archaeological heritage of the Palestinian hills, causing destruction of ancient landscapes and sites (Piccirillo 2002, 271-73).

27 Iwais et Al. 2010, p. 103. Frequently Israeli colonial settlements are near or directly above biblical sites such as Shiloh (Tell Seilun) or Hebron (Tell Rumeidah).

28 Sajey 2010, p. 62; Al-Houdalie 2010, p. 36; Yahya 2008, p. 498. In the mind of many Palestinians, archaeological sites relate to confiscation of land by the Israeli army. It is understandable that looting or destroying sites is a form of defence against expropriation.

29 Bandarin 2011, pp. 7-16.

30 Valentino, Misiani 2004, pp. 30-33.

Figure 3
Khirbet el-Makhruk, Jordan valley: firing position in concrete built directly on Iron Age remains (original picture taken by the author in 2012)

Figure 4
Hebron, Tell el-Rumeideh: a palace in the illegal settlement was built in 2004 directly on the ancient remains (original picture taken by the author in 2012)

Figure 5
Tell Kheila,
Hebron Governatorate:
debris from
an illegal excavation
(original picture taken
by the author in 2012)

Figure 6
Samaria,
Omri's Palace in 2014
(original picture taken
by the author in 2014)

approach to the heritage should underline the universal importance of the historical properties: the concept of shared heritage is a modern and valuable approach to the interpretation of a cultural site. Shared heritage concept applied to a post-conflict theatre allows avoiding possible vandalism and reprisal against the cultural heritage of the enemy.[31] The management of a site or a monument needs to involve all the communities living in the area, in order to get out of the ideological struggle.[32] Moreover, community based management can be a tool of micro-economic development in depressed areas: in many cases it was possible to develop very promising projects such as in the Samaria-Sebaste[33] and in Tell Balata.[34] The concept of shared heritage should point toward the intrinsic value of the cultural property (fig. 6) as a living place, a place that bears significance by itself for all the communities living in the area[35].

After identifying all the main damage, the last challenge was managing all the data collected. The better way to manage the complex situation, to study patterns for the various areas and to underline possible similarities between distant places seemed to create a WebGIS platform.

Thanks to interactive cartography is possible to understand general and specific problems of conservation in a crisis area, managing various typologies of data and identifying patterns in grade or in categories of damage. Since on line, these maps are a precious source of information for scholars all over the world: a tool to spread knowledge about cultural heritage in danger using a uniform recording system. This kind of tool is powered by WebGIS.

[31] Bandarin 2011, pp. 7-16.

[32] Valentino, Misiani 2004, pp. 26-27.

[33] Benelli, Hamdan, Piccirillo 2007.

[34] Van den dries, Van der Linde, 2012.

[35] Perring, Van der Linde 2009, pp. 197-200.

4. The CAAD WebGIS: a quick overview

A WebGIS is a geographic information systems (GIS) published on web. It is therefore an extension of the web application born and developed to manage digital cartography. A WebGIS project is distinguished by a GIS project for the specific purpose of information and communication sharing with other users. It is a really flexible platform, suitable for research and monitoring purposes.

For our project we want to develop a platform that is accessible to everyone, without restrictions by proprietary software license. According to open-source policies, in order to design and develop CAAD we chose resources and tools that respect this view. This choice is in accordance with the web services for making data available in conformity with the so-called Open Geospatial Consortium standards.[36]

The CAAD development must take into account the following criteria:

1: Low maintenance and development costs: one of the issues in managing a WebGIS is to have a server (hardware). Unfortunately, traditional servers are too expensive and wasteful at level of energy consumption. In addition, due to lack of funds, it is not possible to make use of cloud services, such as cloud storage for storing large amounts of data, making them available on Web. Similarly, is expensive to rent small servers in specialized datacenter. The ideal solution for ensuring cheap support for the CAAD could be provided by Raspberry Pi, a single-board, low-cost, but high-performance computer first developed in the UK by the Raspberry Pi Foundation.

2: Easy-to-use accessibility: operators and users should be able to consult and operate on CAAD by means of not high-performance devices or in areas where, for various reasons, high-speed internet connectivity services are not available. An accessible WebGIS must be well coded

[36] Castronova, Goodallb, Elag 2012. For more information: https://www.opengeospatial.org/standards.

well, easy to navigate, and working in everyone's browser without the need for additional plugins or special tools.

3: Simplicity and ease of use: we choose an intuitive user-friendly interface. It is not overly complex but is straightforward, providing quick access to common features and commands for average users.

In this regard, the final version of CAAD WebGIS will be developed on three access levels:

a) Occasional User: public access. The access will be public, and it will be possible to query the database with a specific widget, display the alphanumeric results and the associated media files in an appropriate form.
b) Registered User: private access. The user will be able to login only by personal credential to download multimedia file.
c) Administrator: private access. By personal credentials, the user be able to insert, delete and update the data inside the WebGIS.

This feature is not present in demonstration version, because it is not on line and it is working only on local server.

For coding the CAAD WebGIS we're using, for the server side, PHP scripts. PHP is a server-side scripting language designed primarily for web development. Through the coding languages server-side as PHP it's possible to query the database data needed for building dynamically web pages.

Indeed, for the client server, we're using JavaScript and HTML. For displaying map data in web browsers, with no server-side dependencies, we're using OpenLayer, a JavaScript library. To facilitate the interaction between Client and Server side we use JQuery, a multi-browser JavaScript library designed to simplify the client-side scripting of HTML.

CAAD WebGIS is developed using different tools:

1) Apache HTTP Server 2.4[37]: web server[38].
2) MapServer 7.0 GIS engine[39]: server for map production. MapServer manages WMS (Web Map Service)[40], WFS (Web Feature Service)[41] and WCS (Web Coverage Service)[42] standards for supplying through web of raster and vector cartography.
3) PostgreSQL: object-relational database (ORDBMS). It uses SQL language for data querying.
4) PostGIS: provides spatial objects for the PostgreSQL database, allowing storage and query of information about location and mapping[43]. It's able to handle both alphanumeric data and vector elements in the same record format.
5) Pmapper: offers widespread functionality and multiple configurations in order to facilitate the setup of a MapServer application based on PHP/MapScript[44].

The MapFile defines the relationships between objects, points MapServer to the pace data are located, defines how things are to be drawn and, how to create and use maps and their layers.[45]

The Template files are the common HTML pages provided with MapServer specific parameters and variables. They are what a user can watch on browser, so they are used to present maps and cartographic objects.

The CGI is the real engine of the CAAD WebGIS. It is started up by the web server, it processes both the MapFile settings and the template files defined by the user's parameters and returns the processed outputs as maps, cartographic objects, variables values and query results shown in the template files. Every CGI output is a temporary image or value updated at each CGI work session.

37 https://httpd.apache.org/

38 A web server is a computer system that processes requests via HTTP.

39 http://www.mapserver.org/

40 http://www.opengeospatial.org/standards/wms/

41 http://www.opengeospatial.org/standards/wfs

42 http://www.opengeospatial.org/standards/wcs

43 http://www.postgis.net/

44 http://www.pmapper.net/

45 http://www.mapserver.org/mapfile/

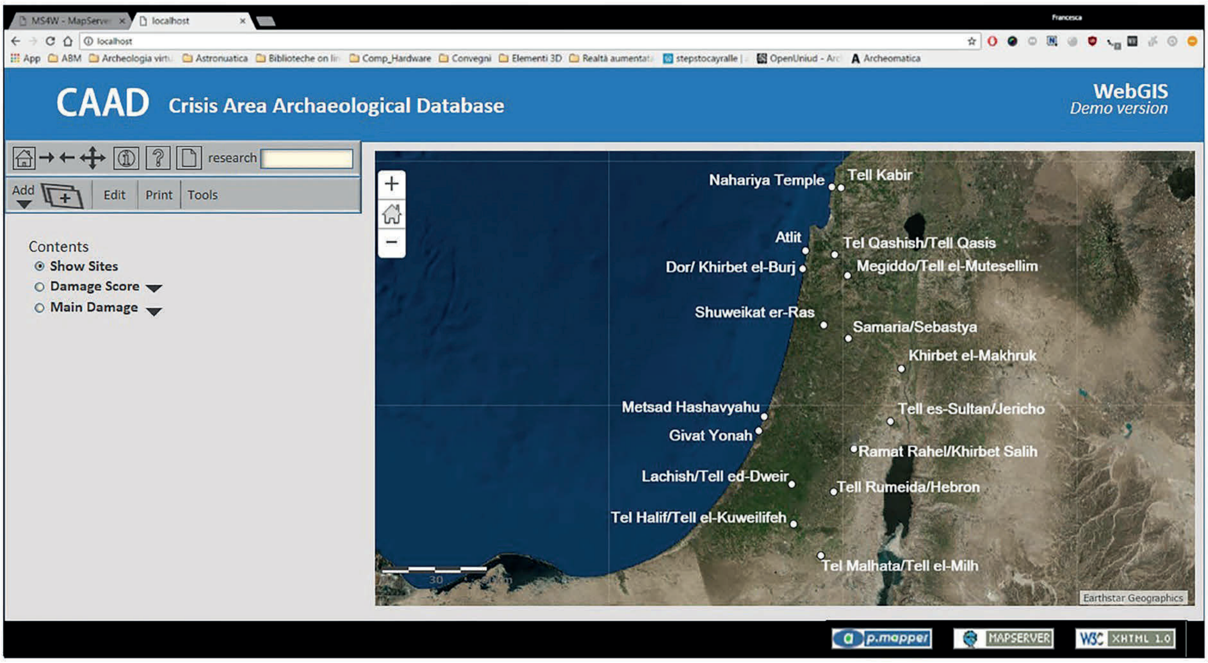

FIGURE 7
Home Page of CAAD WebGIS

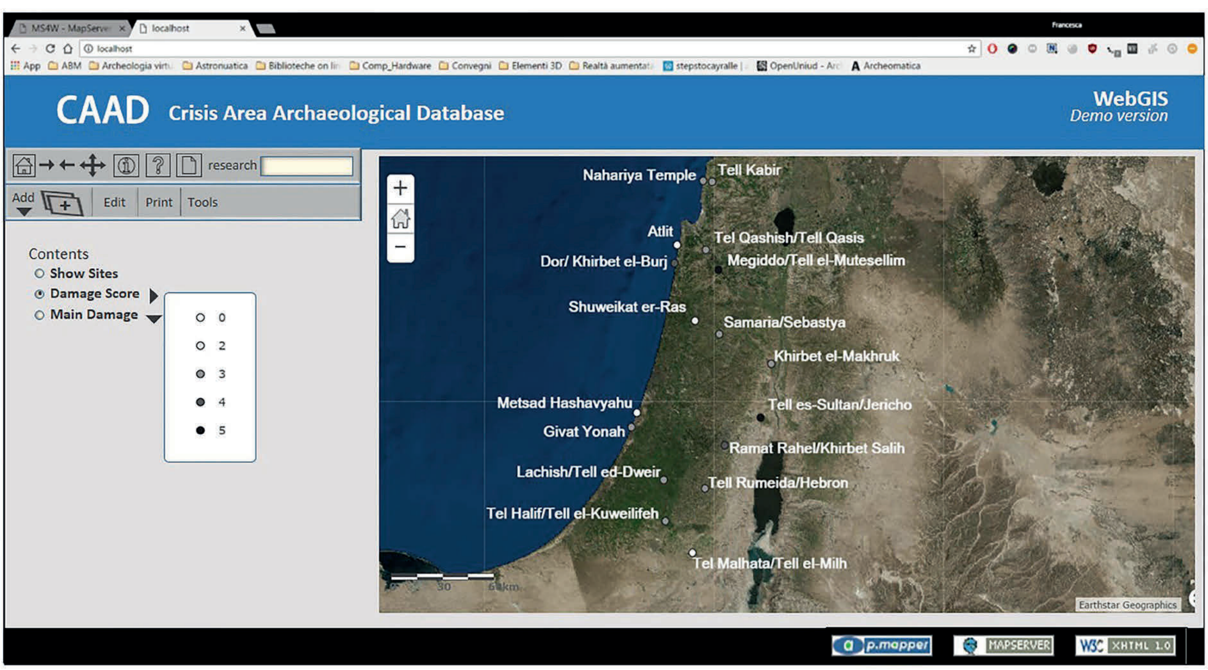

FIGURE 8
A sample query in CAAD WebGIS for looking at sites damage score

The data entered CAAD WebGIS for each site currently are:

- name;
- date of survey;
- last excavation year;
- main damage;
- other damages;
- score of the grade of damage;
- link to a folder with images and multimedia files;
- link to digitalized original schedules filled out during the survey.

From the home page the user has access to MapServer template files, in order to query and open the map (fig. 7). By clicking on each site is possible to read all the information about it. Changing the research parameters and the map layers, is also possible to see the archaeological sites as dots in grayscale, according to the level of damage severity, from 0 to 5 (fig. 8).

5. Conclusions

To summarise, CAAD WebGIS will allow to reconstruct information on a growing number of archaeological sites in conflict areas of Near and Middle East and monitor their changes through time.

As cultural heritage experts, we should improve the use of new technologies and web sharing instruments to strengthen our efforts in saving archaeological heritage in crisis areas. Keeping in mind that technology is no more than a useful instrument, it is of the utmost importance to investigate the real causes behind the destruction of cultural heritage in order to be ready to work, together with local populations, in post-conflict time. This would be the last step of the preservation work: the recovery of historical memory of a community through the protection of its cultural heritage. Working in crisis and post-conflict areas means especially to flank communities to restore dignity and to give the cultural property an active role in the reconstruction of society and economy.

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