An integrated and networked approach for the cultural heritage lifecycle management

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ABSTRACT

Cultural heritage is a complex and interconnected ecosystem requiring inno-vative methods and techniques to facilitate its management and valorization. From these assumptions, our research proposes a new, integrated and networked approach based on a three-level case study belonging to the archaeological context. In detail, the approach defines the lifecycle of an archaeological site, its processes and network analysis. It does this through the use of Business Process Management (BPM) and Social Network Analysis (SNA) techniques, taking the work of archaeologists at the Archeologia Ricerca e Valorizzazione s.r.l. (A.R.V.a) as a case study. The main objec-tive of the approach is to provide valuable insights to optimize the flow of data, gather information and share knowledge created during the archaeological process, starting from lifecycle management and carrying on with the processes modelling and identi-fication of roles and relationships among different stakeholders. The final aim is to im-prove the sustainable valorization of an archaeological site, facilitating value creation, strengthening the connections between culture and local development, and enabling a participatory governance of archeological heritage.

Keywords:

Cultural heritage

Lifecycle management

Business Process Management

Social Network Analysis

Valorization

Participation

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Introduction

"The community of heritage practitioners has long recognized the need for new approaches to conservation, which would reflect the increased complexity of their work and facilitate a positive interaction with the vast environment, with particular attention paid to local communities" (Romano, 2014: 3). Moreover, the need for new approaches can be extended to all of the lifecycle phases of cultural heritage (Bradshaw, Bryant & Cohen, 2011). In attempting to manage the complex ecology of a cultural system and cultural heritage (Holden, 2015), these approaches identify some important elements that should be taken into account, including the recognition of a distinct lifecycle, its phases and its stakeholders.

The concept of Cultural Heritage Management (CHM) (Willems, 2010; Mabulla, 2000) is not new anymore. It mainly concerns the legal and administrative requirements and a lot of bureaucracy. An integrated lifecycle management plan that involves all potential stakeholders can facilitate the conservation and valorization phases of the cultural heritage, increasing the positive impact on local communities. In literature, the discipline dealing with cultural sites management is also known as Cultural Resources Management (CRM). This includes cultural conservation practices, maintenance and preservation of significant cultural sites, restoration, museology, archaeology, history and architecture (Miller, Vandome & McBrewster, 2010; Latourelle, 2013). Due to the complexity of its management, the archaeological domain is the section that typically receives most attention (Talato & Cisco, 2014). Indeed, this domain is affected by the existence of a high number of threats (urban development, agriculture, absence of tutelage, etc.) and difficulties for the safeguard of the sites; furthermore, archaeology is a destructive process (Verhagen, Kamermans & Van Leusen, 2009). CHM was born with the rescue archaeology and urban archaeology undertaken in North America and Europe in the period of the World War II and the succeeding years. In detail, Archaeological Heritage Management (AHM) was theorized for the supervision of the processes of the archaeological sites (Smith, 1993).

Nowadays, the intelligent and integrated management of the overall archaeological heritage lifecycle becomes strategic (Resca, 2011) for two main reasons:

- It facilitates the stages of conservation and enhancement with the several external stakeholders engaged in the process.
- It justifies a multidisciplinary approach, which involves management engineering, technology, urban planning, and archaeology applied to cultural heritage.

The complex operation subtended at cultural knowledge, of its lifecycle and players involved in the process through alternative technical approaches, could be a tool for the enhancement of players themselves, in correlation with the process of conservation of heritage. These actions, together with the protection of heritage, are fundamental concepts in specific legislation, which guarantees the right use of cultural heritage in respect of future generations. Along these lines, the Italian Ministry of Cultural Heritage (MiBAC, 2011), for instance, suggests to pursue an integrated approach where the stakeholders and the involved structures interact with the subjects of the territory. Cultural heritage represents a real inexhaustible resource for local development, a valuable cultural asset, to be transmitted from generation to generation. Moreover, cultural heritage safeguard, conservation and valorization require a great effort in terms of time, costs, skills and people involved. Indeed, the cultural environment should be studied, evaluated, and defined both in terms of historical and present-day relevance, from the point of view of a wide network including suppliers and users. In order to improve and

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optimize the management of the whole cultural heritage lifecycle, professionals (architects, archaeologists, planners, etc.), public administrations, local authorities, public and private companies, associations, and citizens should work together on joint initiatives, in order to encourage the value creation and to reinforce the link between culture and economy.

This paper aims to systematize these concepts in order to optimize processes and to identify the best areas of improvement. The research question is: how can we standardize and simplify cultural heritage management lifecycle through the analysis of the relations existing in the ecological cultural network, in order to optimize the stakeholders' participation? To answer this question, we have employed a case study methodology, starting from the reconstruction of processes, information flows and players involved during an archaeological excavation. In detail, we intend to contribute to the improvement of cultural heritage management in two ways:

- providing an integrated methodology for managing the whole lifecycle, through standardization and digitization of procedures and documents;
- studying relations, information flows and outputs for identifying the role that each stakeholder can have along the whole archaeological lifecycle.

The study starts with general considerations on the Product Lifecycle Management (PLM) approach, usually used in manufacturing domains. Then, we applied the BPM approach for the reconstruction of processes and activities carried out, and the SNA technique for the identification of roles and relations among the people involved. Furthermore, we defined some strategical steps in order to encourage community engagement and participation. Finally, the main aim of this research is to provide both technicians and citizens with an integrated approach to increase sustainable valorization and fruition of the archaeological site as part of the global cultural domain. This work aims to facilitate the value creation and to strengthen the connections between culture and local development through the optimization of management and monitoring of new or existing cultural resources.

Background

Cultural and archaeological heritage complexity

Over the years, the cultural environment has been interested by a wave of change under the technological and methodological perspective. The tendency to merge different disciplines has opened new visions about the concept of culture and related domains. In this context, archaeological heritage is part of the most global cultural environment – including different disciplines (as anthropology, environment, technology, etc.) – whose attention is moving from structural features to external elements, such as knowledge, data, information and stakeholders, which are able to integrate the set of well-defined activities, processes and roles typically carried out during an archaeological investigation (Brogiolo, 2007; Manacorda, 2008; Volpe, 2008; Volpe & Goffredo, 2009). A global trend emphasizes the role of cultural landscape as an element that can integrate cultural lifecycle as a whole, as well as its typical phases of knowledge creation, protection, fruition and valorization. In this way, it is possible to enhance the link between landscape and people and to characterize the role of cultural resources in terms of key parts of the global territorial development, which also facilitates communication and access to outcomes and findings for different target audiences. This tendency highlights the need to work on the definition of a global approach able to manage the complexity inherent to cultural heritage. This will help face the administrative and bureaucratic criticalities and the lack of optimized methodology for knowledge sharing and management, inside and outside the complex network of players involved in the creation, protection, fruition and valorization of an archaeological site (Volpe, 2014).

The archaeological domain represents a complex field of research characterized by different phases including administrative procedures, practical activities, research, publication, communication and valorization both of theoretical outputs and archaeological evidences. The main criticalities of archaeological heritage focus on the conservation and integrated management of data, from rescue to interpretation. In this sense, the importance of digitizing the information is a well-known issue (De Felice &

Sibilano, 2010), even if there is a huge fragmentation of methodologies and tools aimed to solve different unconnected issues (Ryan, 2001). Based on these assumptions, it is essential to focus on the upstream and downstream activities of the archaeological heritage lifecycle, because the former are the starting point for the following elaboration and representation, and they are strictly linked to the latter, which in turn constitute the basis for implementing strategical fruition, communication and valorization actions. According to Manacorda (2008), detailed documentation can guarantee the conservation of the widest number of information. Nowadays it is fundamental to ensure real time access to data and information both for technicians – for them to gain access to analytical data and to verify the qualitative relevance allowing different interpretations on the basis of their own expertise) (Semeraro, 2009) – and for final users – to easily access data and information from multiple devices. In this sense the web provides the opportunity to share, spread and make use of culture, and it represents the point of contact between technicians (acquisition, storage, and data management) and final users (sharing, communication and valorization) coexisting with different roles within the same environment. The importance of the web has required revising the way in which archaeological data and information are collected, managed, manipulated, communicated and valorized; and it has highlighted the role of each player within the same network. The presence of all these elements led to consider this domain suitable to propose a flexible model for managing the methodological and procedural complexity endogenous to the microcosms within the global cultural environment.

Another important issue concerns the long tradition in terms of preservation in archaeological, cultural and creative domains, compared to the lack of economic and human resources committed to the safeguard and valorization of cultural heritage[1] at large. The intense legislation has often generated misunderstandings about roles and responsibilities, and the consequent need to define structured processes and to identify the stakeholders involved in order to optimize the whole lifecycle. The post-Malta archaeology is unanimously recognized as a phase of growth that led to several advances in terms of deep knowledge about the past, most efficient protection guidelines, increased and improved communication, and fruition and valorization of the archaeological sites. "In 'post-Malta' archaeology, the financial, human and technical resources allocated to archaeology have enormously increased but at the same time, these resources have had to be spent both effectively and efficiently. Therefore, why not create and use tools that will allow us to do so?" (Verhagen, Kamermans & Van Leusen, 2009: 19). This consideration points again to the need to optimize the management of archaeological heritage under a number of perspectives contributing to the evolution of this complex system.

Product Lifecycle Management and Business Process Management

A large number of studies has been carried out in order to define methods, tools and technologies to support the management of historical memory and cultural heritage, by adopting theories and practices from the manufacturing sector, which is characterized by interaction and management models that can be replicated in various entrepreneurial contexts. Cultural heritage management presents dynamics not so far from that of other industrial sectors. The main difference is to be found in the poor development of such dynamics, which in this sector remain prerogative of the academic knowledge of the involved actors (Hervy et al, 2013). In this context, questions related to knowledge management in archaeological processes become relevant, because the valorization process of cultural heritage is strictly related to the correct management of informative flows and knowledge. If we consider the significant information on cultural heritage, the adoption of a new managerial approach to its lifecycle, supported by technologies, could allow the identification of innovative methods of management and fruition.

A PLM system is a collaborative backbone allowing people throughout big enterprises to work together more efficiently (Saaksvuori & Immonen, 2008). An archaeological excavation is a system of complex and heterogeneous activities that involves a multidisciplinary team composed by actors with different responsibility levels and skills. Knowledge management in the archaeological process can be optimized through the digitalization of data, whose properly utilization strongly depends on their analysis and interpretation (Privitera, 2011). In the manufacturing sector, the adoption of the PLM logic is mainly focused on time-to-market, that is to say, on the capability to accelerate the fruition time, in order to increase the efficiency of the intervention, and to rise the control, security and safety of processes and activities carried out (Ameri & Dutta, 2005). In the cultural heritage sector, where many different actors communicate, this approach works properly for information management (Ding et al, 2007). The main issues concern the knowledge extraction methods, the data visualization and the flow of information. Hervy et al (2013) have recently proposed the application of PLM to the management of historical and artistic knowledge in museums. They argued that the increase of cultural knowledge is the main motivation that makes necessary the adoption of

1 For more information, see the European Convention on the Protection of the Archaeological Heritage (Revised), Valetta, 16.I.1992, and the Legislative Decree 22 January 2004, nr. 42 "Cultural Heritage and Landscape Code".

a PLM system inside museums. During the five-year research carried out inside the Nantes History Museum, in which various professionals were involved (historians, engineers and curators), all the available knowledge has been collected and the virtual links between the data have been created. The result is a system of virtual augmented reality based on real objects. The web-connected system allows both experts and common people to enrich the knowledge database with contents that include geographic information, semantics and historical links between the points of interest.

"THE DEEP STUDY OF THE PROCESSES ALONG THE CULTURAL HERITAGE LIFECYCLE IS PARTICULARLY IMPORTANT BECAUSE IT FOSTERS THE STANDARDIZATION OF PROCEDURES AND ACTIVITIES THAT GENERATE THE DATA OUTPUT"

Starting from this considerations, it is possible to assert that the deep study of the processes along the cultural heritage lifecycle is particularly important because it fosters the standardization of procedures and activities that generate the data output. Furthermore, it allows identifying each actor involved in the process and the criticalities in the procedures that would be otherwise hard to identify. The digitization of the processes can be realized through the BPM approach (Van Der Aalst, Ter Hofstede & Weske, 2003), which sees processes as important assets of an organization that must be understood, managed and developed. The approach closely resembles other total quality management or continual improvement process methodologies, and it can be supported or enabled through technology (Thiault, 2012). The information technology research and advisory company Gartner defines BPM as "the discipline of managing processes (rather than tasks) as the means for improving business performance outcomes and operation agility. Process span organizational boundaries, linking together people, information flows, systems and other assets to create and deliver value" (Gartner, n.d.). In this sense, one of the first experiments was conducted by a team at the University of Salento (Corallo et al, 2015a). More specifically, the collaboration between a team of archaeologists (A.R.Va – Archeologia Ricerca e Valorizzazione S.r.l., a University of Salento spin-off) and a group of researchers of the Engineering of Innovation Department generated one of the first examples of archaeological processes (figure 1). In this case, the mapping has been carried out on the basis of the manual

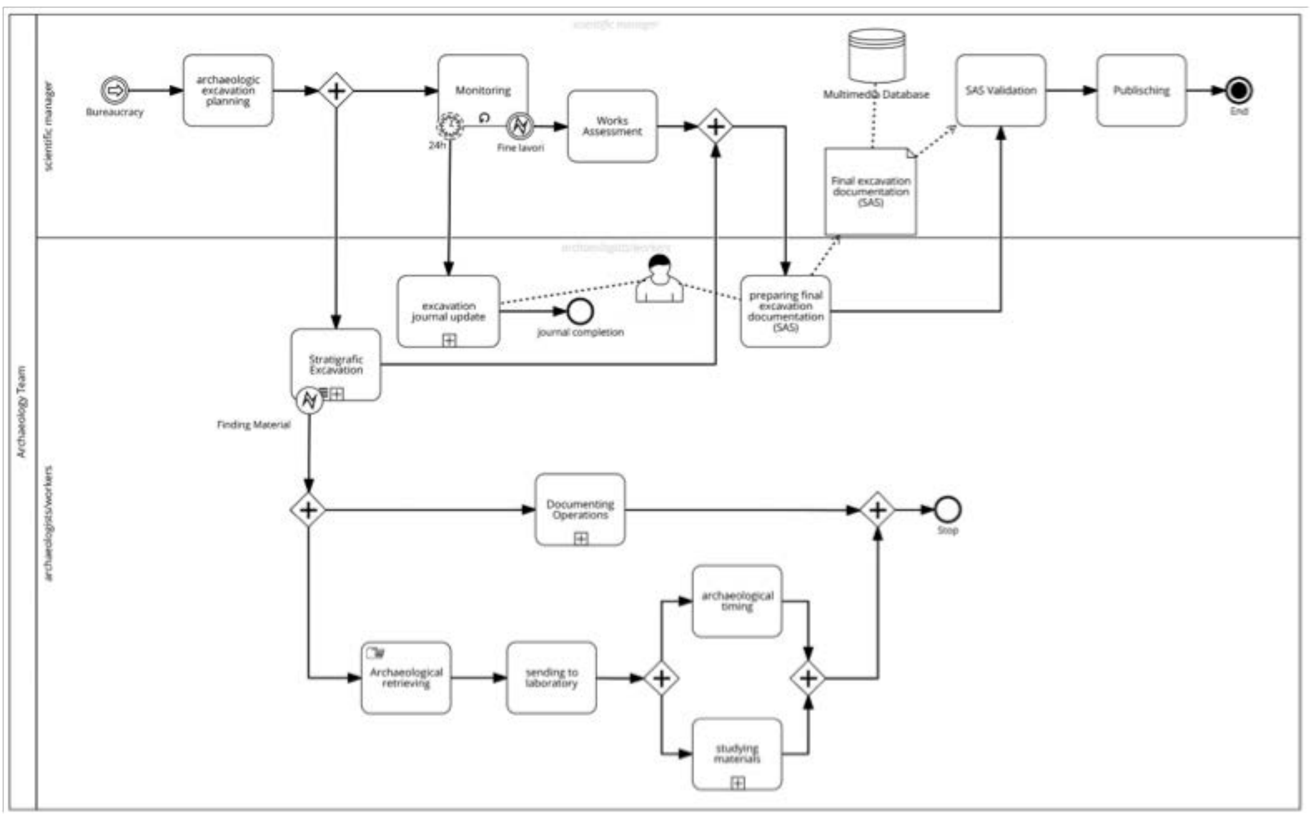

FIGURE 1. ARCHAEOLOGY EXCAVATION PROCESS (elaborated with Signavio BPM Academic tool)
Source: Corallo et al (2015b).

Process mining: discovery, conformance and enhancement of business processes (Van Der Aalst, 2011). The result, even though still acerb and in need of optimization, has clearly evidenced the complexity of the information and communication flows among the actors involved, opening the way to future research and demonstrating the validity of the approach, described as an opportunity to increase the value of the information provided.

Social Network Analysis

The main holders of the knowledge are the same main actors of the communication exchanges. "A significant component of a person's information environment consists of the relationships he or she can tap for various informational needs (…) who you know has a significant impact on what you come to know, as relationships are critical for obtaining information, solving problems and learning how to do your work" (Cross et al, 2001: 100). For this reason, most organizations recognize the importance of SNA as a powerful diagnostic method used to analyze the nature and pattern of relationships among members of a particular domain. One means of understanding knowledge flows or bottlenecks that slow down business processes is "mapping" the relationships between employees, with whom they communicate and how often (Busch, 2008). According to Burt (1992), a social network is a group of collaborating entities (actors) that are related to one another. Mathematically, the SNA result is a graph wherein each participant in the network is called an "actor" and depicted as a node in the network. Actors can be persons, organizations, groups, or any other set of related entities. Relations between actors are depicted as links between the corresponding nodes. Many social network relations are due to joint participation of actors in business or social activities, or membership in collectives. Their common activities create a network of ties among different participants. There has been an increased interest in this methodology to analyze the nature and role of informal relationships among individual members in formal business organizations (Cross & Prusak, 2002).

Software such as Ucinet, Jung, Pajek, Condor and Krackplot provide a graphic picture of the relations of people, teams and organizations. Moreover they allow the user to create visual maps, movies and adjacency matrices, and permit to calculate indicators of collaboration between actors or groups within a communication network (Hanneman & Riddle, 2005). With these techniques, SNA resolutely helps in identifying employees as well as work groups who play central roles in the organization; at the same time SNA is quite capable of discerning holes or bottlenecks in a communication network (Serrat, 2009). Through a better understanding of the formal and informal networks existing in an organization, it is possible to identify the tasks that employees effectively undertake and, consequently, to better map the business processes.

The application of network mapping and its characterization is recent but not completely new in the cultural field. Its recent use is mainly due to the actual availability of cheap and potent computing power especially suitable for large networks. Hewison, Holden and Jones (2010) described a level of connectivity of a cultural organization, the Royal Shakespeare Company (RCS). They analyzed informal and formal networks of the organization in two different periods and evaluated the variation of the network density in order to obtain information about the compactness of the working relations around the RSC. They also found the central node of the network in order to identify leadership and evaluate the consistency of the relation between leadership and organization. Moreover, they established how evident was the division between different organizational functions (artistic and administrative) in the networks. Jackson (2011) used the SNA to measure the extent to which connections in the sector had changed during and through the application of a visual arts strategy. The work showed clear growth in the connections between organizations and individual artists before and after the strategy, with a small number of individuals and teams that were the most connected, playing a pivotal role.

In the archaeological field, many analysts have been strongly influenced by SNA in our archaeological network (Brughmans, 2013). In the last 15 years, the SNA measures applied to archaeology concerned especially the construction of networks related to the ancient populations. Bernardini (2007) tracked the local movement of pottery among Hopi villages and mapped the interaction among them; Jenkins (2001) analyzed the network of 54 sites connected by Inka roads, like administrative centers, productive enclaves or storage sites; Graham (2006) analyzed a network of Roman towns connected by the routes. SNA centrality measures were used by Isaksen (2007) to explore aspects of the Roman transportation or communication systems in southern Spain, and by Mizoguchi (2009) to identify a centralized hierarchy between social groups in the initial Kofun period in Japan. Hart and Engelbrecht (2012) used SNA to determine whether pottery collar decoration data best fit the evolution of the Iroquoian ethnic landscape. Another study of ceramic networks in the Late Hispanic US Southwest (Mills et al, 2012) mapped the flows of information, the transfer of ceramics and distribution practices. Methods derived from SNA have been also used to examine temporal changes in the distribution and centralization of socio-political interactions of the Classic Maya (Munson & Macri, 2009).

Compared to these previous works, which used SNA to interpret networks related to archaeological findings, this work wants to focus on the extraction and analysis of the networks linking those who are responsible for such findings: the archaeologists. This paper aims to obtain a juncture between the management of the archaeological processes, the capture of knowledge flows and the analysis of human relationships, in order to obtain a detailed comprehension of archaeological processes through the analysis of human processes.

Research methodology and case study

Based on the general methodological approach and the continuous evolution of the different microcosms merging within the most general cultural heritage field, there are evident criticalities in managing in situ archaeological investigation. In a nutshell, the main problem lies in the gap existing between the technical archaeological investigation and the systematization of documents, data and information needed to make outcomes and findings available to other stakeholders and to the public at large. In this sense, the main solutions are aimed at providing technological tools for the data management, acquisition and elaboration, in order to support the data encoding in real time with the consequent distribution of information in a short time. With this aim, the upstream analysis of flows of information and players involved allowed to identify the main criticalities of the process of archaeological investigation and to provide ideas for improvements and optimization.

This research is part of the DiCeT-Inmoto project[2] and arises from previous assumptions in the field of the archaeological research, which consists of activities involving different methodological approaches. In addition, due to the complexity of the archaeological excavation dynamics, it is possible to integrate the analysis to better incorporate any other enhancement process and the digitization of the general cultural heritage. The tools and methods previously described are the basis of the research methodology and support the implementation of the case study. The innovation of the methodology consists in the application of methods widely known and applied in the literature within the manufacturing and business domains to the archaeological domain. The purpose is to optimize processes, activities and routines carried out, to identify strengths and weaknesses of existing networks, and to support the improvement of the flow of information through the creation of a virtuous cycle of knowledge co-creation and sharing.

The methodology is organized in different phases: archaeological site lifecycle; processes analysis, and network analysis. The outputs of each phase represent the inputs for the following one. In particular, we interviewed the group of archaeologists of A.R.Va s.r.l. in order to collect data and information both on the activities and on the types of relations developed among the different players involved on a specific ar-

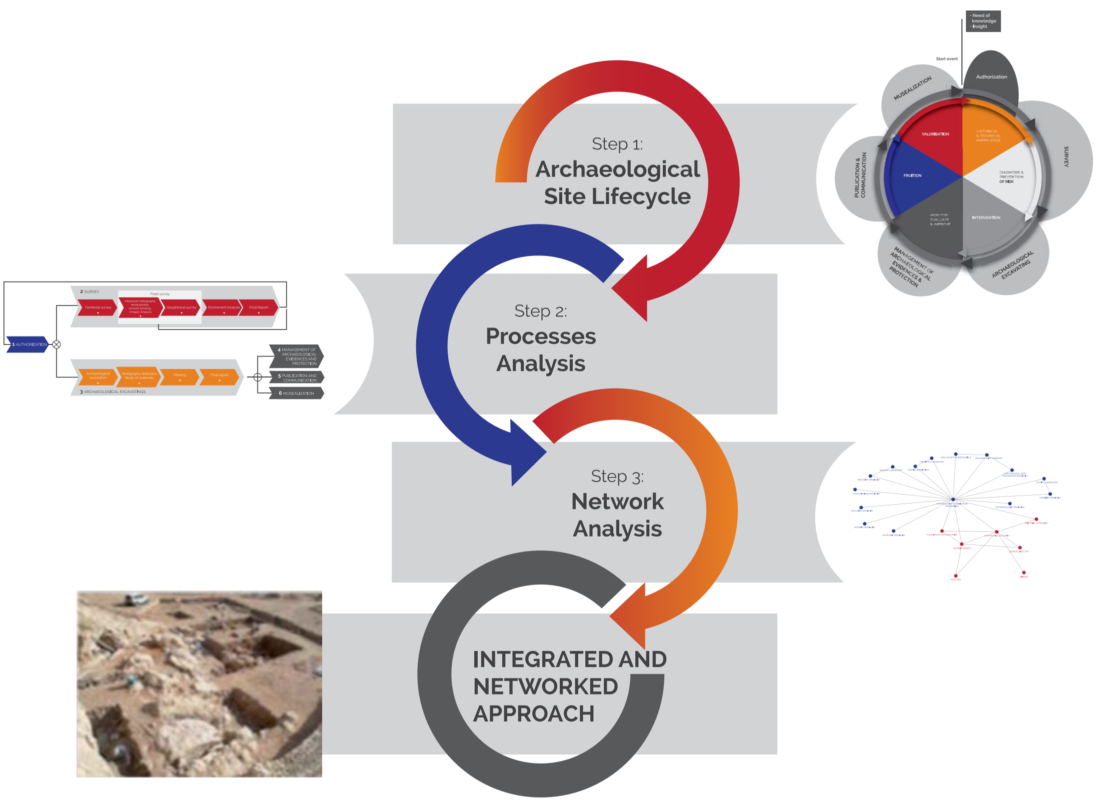

FIGURE 2. PHASES AND OUTPUTS OF THE METHODOLOGICAL APPROACH
Source: Authors' own elaboration.

2 For more information, see http://imagelab.ing.unimore.it/imagelab/project.asp?idprogetto=44

chaeological site. In this way, we were able to recreate the logical operation patterns of the archaeological site and to connect inputs and outputs to the different phases mentioned above. The main objective of the methodology is to provide an integrated and networked approach to overcome the limitations of fragmented views that tend to consider a single perspective and neglect other aspects which are crucial for reaching common goals within the cultural heritage ecosystem. Figure 2 summarizes the phases of the approach proposed. Each phase is described in detail in the next sections in order to facilitate the understanding and demonstrate the effectiveness of the approach.

Phase 1: archaeological site lifecycle

The definition of the archaeological site lifecycle begun with a first round of interviews aimed to identify the *modus operandi* of the archaeologists on the field. During this stage, it emerged that, apart from the onsite work, there is a large amount of upstream activities linked to administrative procedures that can influence the following steps. This phase was a prerequisite for each following phase because it aimed to give an order to the *chaos* caused by the complexity of the work needed to be done and by the wide numbers of players with different backgrounds involved. The endeavor was undertaken to provide a model of archaeological site lifecycle starting from the existing literature (Bradshaw, Bryant & Cohen, 2011) on cultural heritage lifecycle models. That first bibliographic review provided many insights but required some customization due to the variety of cases embraced within the cultural heritage context. Based on these assumptions, we took as starting point the phases of the process of CHM elaborated in the IT@CHA project, from which we worked on the adjustment required to build the archaeological lifecycle, considering also the information collected during the interviews. In more detail, the phases of CHM can be summarized as follows:

- *Historical and technical knowledge*: cognitive analysis of technical data and information through literature review, desk and field analysis, etc.
- *Diagnosis and risk prevention*: in situ recognition aimed to identify the *living conditions* of cultural resources, and analysis of problems linked to structural and functional conditions.
- *Intervention*: activities needed to be carried out on the basis of the outputs of the previous two phases and the features of the resources (e.g. maintenance, restoration, excavation, etc.).
- *Monitoring, evaluation and improvements:* monitoring of direct and indirect impacts on cultural heritage, evaluation of cultural outcomes, improvement of systems, programs and operational plans, etc. This phase is continuously repeated along the whole lifecycle.
- *Fruition*: to make the cultural heritage available to public at large (e.g. through formal reporting processes) (Bradshaw, Bryant & Cohen, 2011).
- *Valorization*: open communication with external communities and stakeholders (e.g. museums, cultural associations, research centers, and citizens, etc.) (Bradshaw, Bryant & Cohen, 2011).

The following step was to recognize the phases of the archaeological research lifecycle based on the interviews with the A.R.Va. s.r.l. team. Drawing on that, we established the correspondence between each phase of the CHM lifecycle and the phases of the archaeological excavation. In detail, the data collected revealed the presence of a lifecycle starting with an event that corresponds to a need of knowledge or insights, derived from the interest to investigate of research centers, local authority, etc. Following the start event, we identified the phases below, which correspond to one or more phases of the general CHM lifecycle, even if there is not always a one-to-one correspondence (see figure 3):

- *Authorization*: corresponding in part to the start event and in part to the technical knowledge reconnaissance phases. It includes the process of obtaining permits for archaeological investigations and can differ on the basis of the purpose of the investigation, from authorizations or concessions for excavation/survey (by research centers), to opinions expressed in the case of the preventive archaeology.
- *Survey*: corresponding both to the historical and technical knowledge acquisition carried out through desk research, and the diagnosis and risk prevention phases implemented through non-invasive technical surveys, which allow guaranteeing the acquisition of a huge amount of data on the contingent existence of an archaeological site.
- *Archaeological excavation*: corresponding to the intervention phase. It is carried out to identify, analyze, provide documentary evidences and characterize all the elements of an archaeological site. In particular, this phase aims to go back in time to the age of the site, and to understand its function and relations in a wide historical and territorial context.
- *Management of archaeological evidences and protection*: this phase can be partially linked to the monitoring, evaluation and improvement phase, because, on one hand, it is aimed to plan and implement protection measures both in the field of the administrative procedures and as regard to technical activities (e.g. restoration work, conservation, etc.). On the other hand, this phase is also dedicated to the management of data (documents and knowledge base) coming from

the previous two phases and consequent phasing activity .

- *Publication and communication*: corresponding to the fruition phase. Its aim is to make the results of the different phases available through communication tools such as scientific or informative publications or materials (e.g. brochure, virtual reconstruction, web, etc.). This phase could not be linked to the material fruition of the site.
- *Musealization*: corresponds to the valorization of the archaeological site, findings, and other outputs through strategies addressed to the public enjoyment that are often able to network these cultural resources and foster community engagement in the context of territorial development.

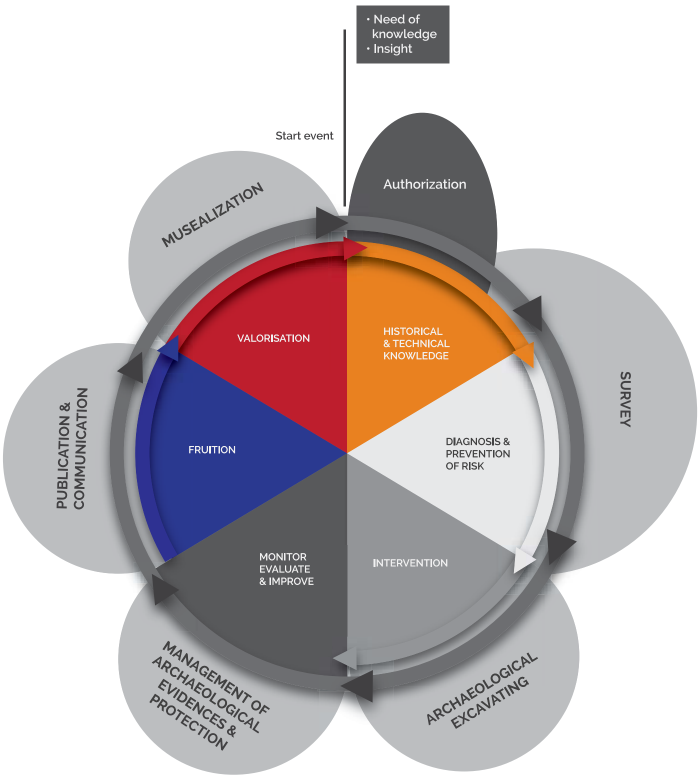

FIGURE 3. CHM LIFECYCLE AND ARCHAEOLOGICAL SITE LIFECYCLE CORRESPONDENCE
Source: Authors' own elaboration.

Phase 2: processes analysis

The second phase corresponds to the process modelling based on the archaeological site lifecycle. Through the application of the BPM approach we aimed to provide a snapshot of the current situation (*as-is*, as opposed to the *to-be* or desired condition) by identifying processes, activities, data and information exchanged, as well as players involved in each phase.

This phase of the research was organized in two main sub-phases:

1. *Requirements analysis*: carried out through a second round of face-to-face interviews to A.R.V.a s.r.l. archaeologists in order to define the requirements of excavation activities and to investigate the criticalities to be revised.

2. *Process mapping*: which allows a detailed representation of processes, activities, time and people involved in each phase.

Figure 4 represents the logical flow of the processes carried out during each phase of the archaeological lifecycle. In particular, the diagram shows the activities launched from the start event. After the authorization, the process can follow the sequence enumerated from 1 to 6 or, under particular conditions, it can follow an alternative pattern, also from 1 to 6 but skipping phase 2. This can contribute to generate differences as regard to the legislative procedure, documentation, operations, and stakeholders needed to be involved.

Phase 3: processes analysis

As reported in the background section, SNA is a methodology used for social relations analysis. The basic idea is that every individual or group of individuals (network actors) are interdependent rather than independent, they are a social interacting unit rather than an autonomous unit (Wasserman & Faust, 1994). Therefore, it is reductive to base the analysis of an actor only on parameters that characterize him as autonomous unit. Relational ties (linkages) between actors are channels for transfer or flow of resources (either material or nonmaterial). For this, SNA theorists deem important to look at the interactions between the network members as variables responsible for a precise behavior and decision-making. Network models are focused on describing the structure of relationships between actors in order to see the impact that this structure has on the functioning of the network and its influence on individual actors, in terms of providing opportunities or constraints. Calculating the density of social networks, the number and relations between clusters, the relation type between actors and the centrality of key nodes allows network analysts to explore the structure of resources flow.

The *network density* is one of the main descriptive statistics, often used as the primary indicator of the degree of network cohesion. This index allows to detect the participation and the involvement in the social ties construction and to evaluate the compactness of the network. It is defined as the fraction of the maximum possible number of edges in the network that is actually present (Newman, 2010). Numerically, the density is a value between 0 and 1: "0" when edges

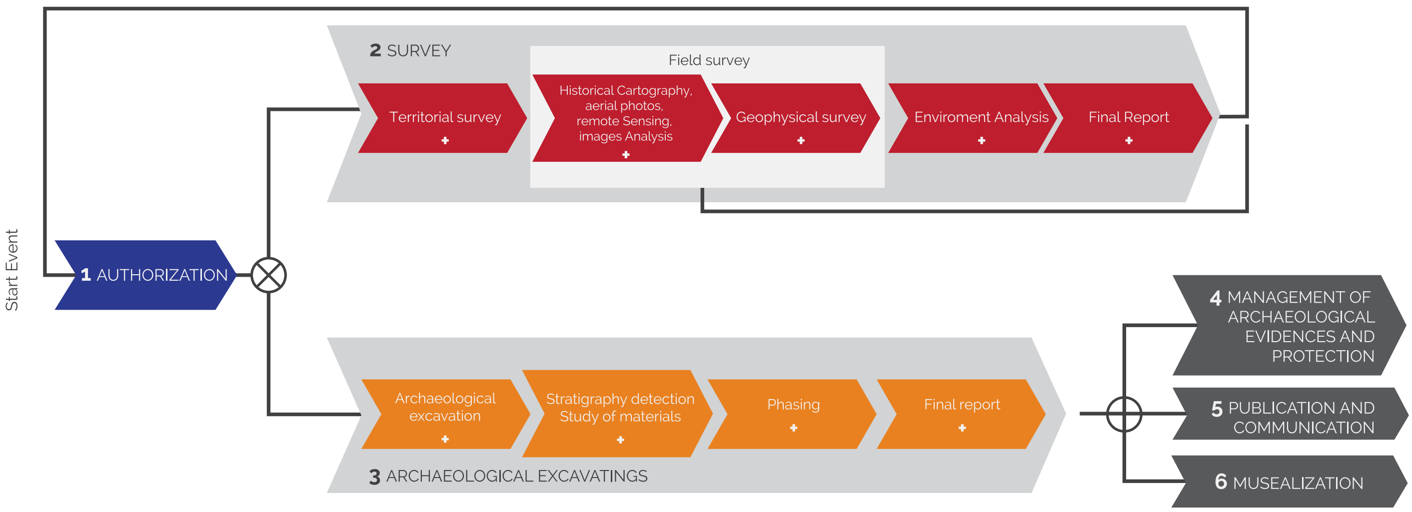

FIGURE 4. ARCHAEOLOGICAL EXCAVATION PROCESSES
Source: Authors' own elaboration.

are not available – i.e. the network is empty, and "1" when there are all the edges possible – i.e. the network is complete. In a low-density network, actors have few contacts and sparse information/resources flow, while in a high-density network, actors maintain links with a high number of people.

In SNA, *centrality measures* – degree centrality, closeness centrality, betweenness centrality (Freeman, 1979) – make it possible to identify the nodes that have a central position and therefore a better access to information/resources. Their position enhances opportunities to spread information and resources. To understand network structures, the natural tendency of real-world networks to form *clusters* has been pointed out. Clusters are groups of nodes densely connected among them, with sparser links to the rest of the network (Gentile et al, 2014). The importance of these applications has recently led to the intense development of algorithms, aiming to automatically solve the detection of communities, or to check for the *clusterability* of the network (Fortunato, 2009). Specially for small networks, fine grain algorithms exist, in particular those involving metrics at the node/edge level that aim to a precise assignment of the single nodes to the various communities (Gentile et al, 2014). A perfect example of an algorithm feasible to be used straightforward for small networks is the Girvan-Newman (GN) method, based on the edge betweenness (Girvan & Newman, 2002).

In a social network, it is possible that the actors belonging to a particular group or cluster tend to focus only on their cluster activities and ignore what happens in the others. In terms of exchange of information between the different groups, this situation generates holes in the social structure, defined as structural holes (Burt, 1992). In SNA, the so-called *brokers* are key actors that build a bridge between these groups and they are in a *brokerage position*. The broker is an actor that, holding a strategic position in the network structure, could provide access to diverse and heterogeneous knowledge and resources and enables or improves the resources flow between nodes otherwise unconnected (Burt, 1992). Its importance will be higher, the lower the number of players who can fill his position. The lack of a position of brokerage involves the dissemination of information and knowledge only within each group of the network, but the groups remain isolated from each other and does not exist the opportunity to knowledge recombination.

In SNA, a relation between two kinds of different entities is called a two-mode interaction, represented by a two-mode affiliation matrix (A), whose elements (aij) indicate if an entity i is in relation with the entity j. In particular, in this paper we have analyzed the relationship between information flow and archaeologists. A key hypothesis for network analysts is that, whenever two entities i and j participate in the same activity or share some information/resource x, this indicates the real or potential existence of a bond between them. Relations between actors are depicted as links between the corresponding nodes. Conversion into two one-mode data sets is the most direct approach to handle two-mode data (e.g. users-resource), and examine relations within each mode separately. This approach is appropriate in this study, because of the interest in focusing on just one of the modes: the N actors. We have created a data set of actor-actor ties, measuring the strength of the tie between each pair of users as proportional to the number of times they worked on the same activities (Corallo et al, 2015a). As starting point, a 1-mode matrix A is defined so that its elements aij=1 if user i performs at least one activity (or share at least one information/resource) with person j. Using the sums of cross product, a method of the tool Ucinet (Hanneman & Riddle, 2005), we defined the weights of the 1-mode matrix. The use of these techniques of SNA allow analyzing and revisiting the information and communication flows between the actors involved in all lifecycle phases of an archaeological excavation, and its consequent improvement.

Preliminary results

The first preliminary results show the graphic representation of the archaeological lifecycle with the integration of the different players involved in each phase (figure 5).

ing the third phase to the archaeologists involved in the excavation process and on the analysis of official documentation related to this process – the presence of some key figures (actors of the process) was extracted. Table 1 contains the list of these actors in order of appearance in the archaeological lifecycle and the description of their role.

According to the information received during the interviews, the archaeological excavation process described in the previous section consists of administrative and/or technical activities. Each activity produces some outputs that will be, consequently, administra-

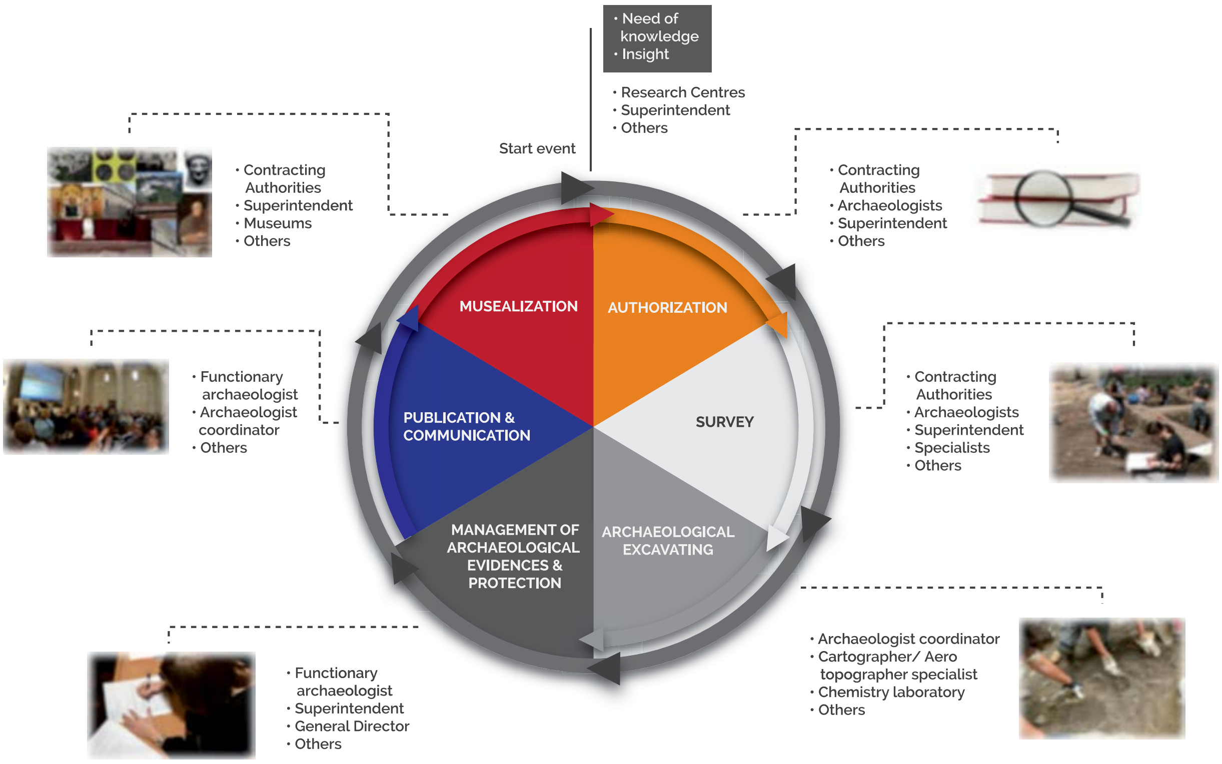

FIGURE 5. ARCHEOLOGICAL LIFECYCLE AND PLAYERS INVOLVED
Source: Authors' own elaboration.

The elaboration of the results of phases 1 and 2 of the research methodology revealed the existence of criticalities both in terms of scarce integration of standard procedures and in terms of innovative methods and tools for managing the archaeological lifecycle. In addition, substantial differences were underlined in the requirements expressed by different stakeholders involved in each phase, such as institutional operators, specialists, etc. That should be addressed to integrate their contributions to the whole process. In this sense, the analysis showed the patterns for digitalizing the processes of rescue and valorization, and the existence of a network of players that can actively participate and influence the outcomes. Following these phases – drawing on the interviews carried out dur-

tive (e.g. administrative documentation) or technical (e.g. technical documentation, findings identified, test samples, etc.). Starting from the information about the sharing of official documentation among actors during their activities, the two-mode matrix was created. This matrix represents links between archaeologists and shared resources (e.g. activity output like documentation or findings) and, using the sums of cross product method of the tool Ucinet, the one-mode (archaeologists-archaeologist) matrix was obtained. Using NodeXL[3], an add-in to the Microsoft Excel 2007 spreadsheet software, the archaeologists network based on the one-mode matrix was obtained (figure 6).

3 For more information, see http://nodexl.codeplex.com

Actors	Description
Superintendent	Representative of the Superintendence that assesses the project and archaeological documentation
Contracting authority	Generally government departments, research institutions or large groups (in the case of works promoted by multinationals)
General director	Role ratifying the declaration of cultural interest
Functionary archaeologist	Officer of Superintendence with jurisdiction in the working/research area
Scientific community	Research institutions or researchers interested in the investigation
Archaeologist coordinator/responsible	An archaeologist or groups of archaeologists with specialization and/or PhD. They can also be research organizations
Cartographer/aero topographer specialist	Archaeologist coordinator/responsible or archaeologist specialized in cartography/ topography/aero topography
Archaeologist operator	Archaeologist coordinator/responsible or archaeologist specialized in manual excavation or archaeologist scout
Study findings specialist	Archaeologist coordinator/responsible or archaeologist specialized in materials analysis, for each class of material
Geophysics specialist	Archaeologist coordinator/responsible or archaeologist specialized in geophysics
Botany specialist	Archaeologist coordinator/responsible or archaeologist specialized in botany
Chemistry specialized	Archaeologist coordinator/responsible or archaeologist specialized in chemistry
Geology specialist	Archaeologist coordinator/responsible or archaeologist specialized in geology
Zoology specialist	Archaeologist coordinator/responsible or archaeologist specialized in zoology
Anthropology specialist	Archaeologist coordinator/responsible or archaeologist specialized in anthropology
Physics specialist	Archaeologist coordinator/responsible or archaeologist specialized in physics
Area or sector responsible	Archaeologist coordinator/responsible or archaeologist responsible of the area/ sector
Chemistry laboratory	Specialized laboratories for chemical analysis
Physics laboratory	Specialized laboratories for physical analysis
Geology laboratory	Specialized laboratories for geological analysis
Museums	Institution that conserves artistic, cultural, historical, or scientific artefacts and other objects and makes them available for public viewing
Citizens	Individuals or communities, end users of archaeological results

TABLE 1.. EXCAVATION PROCESS ACTORS
Source: Authors' own elaboration.

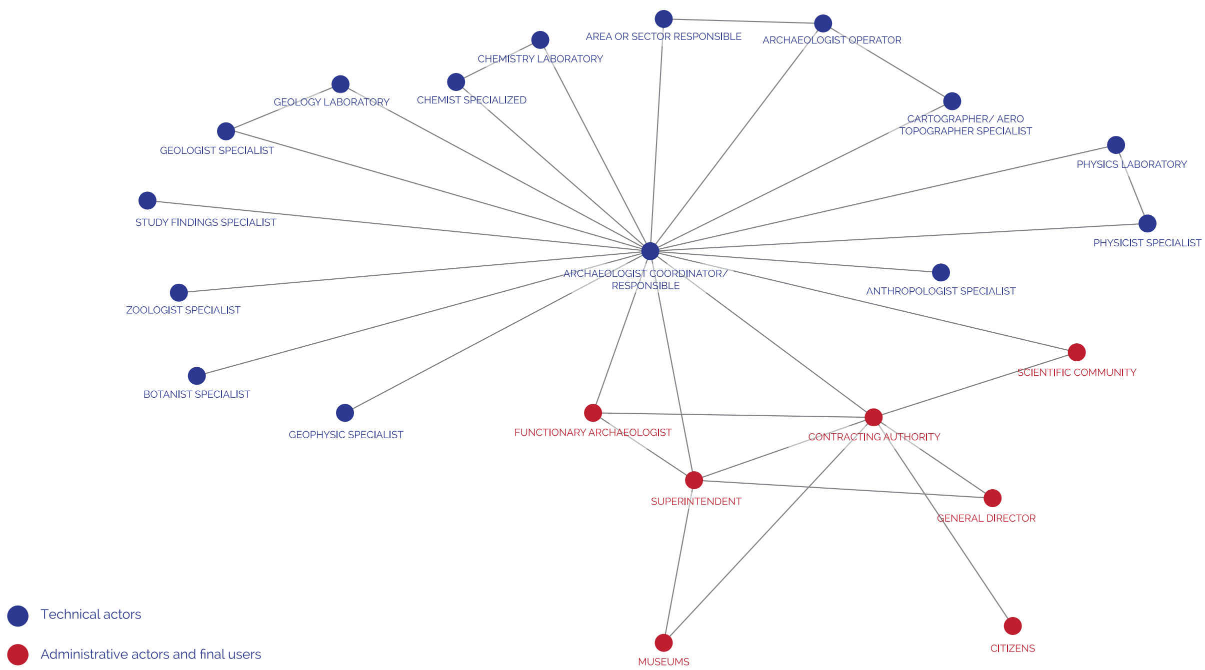

FIGURE 6. ARCHAEOLOGICAL SITE NETWORK
Source: Authors' own elaboration.

The application of the Girvan-Newman (GN) method permits to identify clusters within the network structure. The algorithm identifies two clusters represented with two colors: blue and red. By analyzing actors belonging to clusters, it is easy to interpret the presence of these two groups. The blue spheres represent the technical actors involved in the excavation process, the archaeologists, while the red spheres represent the actors involved in the administrative activities of the process. More specifically, this last cluster also contains nodes (citizens, museums and scientific community) that are not properly administrative but identifiable as final users. It is proposed, nonetheless, to let them in the administrative network to distinguish them from the technical actors.

The low network density detected (0.13) demonstrates that the network contains a small number of highly connected nodes and a large number of nodes with few links. This sparse network does not permit rich information/resources flow. The reason for this is explained by the betweenness centrality (BC) of the nodes. Actors with high BC are often found in the shortest paths that connect couples of other actors: they are gatekeepers. Identification of these people is very useful: these people should be contacted whenever it is required in order to facilitate internal communication, especially among people who have never done activities together. Notice that in this case the actor "archaeologist coordinator/responsible" is the one with the highest BC. All information, both technical and administrative, goes through him. The analysis of the *brokerage position* also shows that this actor is a *broker*. This strategic position of the actor archaeologist coordinator/responsible allows him to have an overview of the excavation process progress, both from the technical and the administrative point of view. In addition he is the one to which other archaeologists refer; there are few contacts among other technical nodes. His importance is remarkable, also he is the only one with a high value of brokerage. At the same time, his absence during the process may compromise the performance of the process as two clusters would be unconnected, interrupting the information flow. The final users of the archaeological results deserve a special mention – citizens, museums and scientific community. Beyond the only link between the scientific community and archaeologist coordinator/responsible, these final users are completely cut off from technical network. In our opinion, the presence of ties connecting end users with the technical cluster could give new life to the archaeological investigation, strengthening and improving promotion activities. In this sense, this analysis identifies the strengths and weaknesses of the existing network in order to optimize processes and activities carried out in the archaeological domain, to support the improvement of the flow of information through the creation of a virtuous cycle of knowledge co-creation and sharing.

"THE PRESENCE OF TIES CONNECTING END USERS WITH THE TECHNICAL CLUSTER COULD GIVE NEW LIFE TO THE ARCHAEOLOGICAL INVESTIGATION, STRENGTHENING AND IMPROVING PROMOTION ACTIVITIES"

Conclusions and future research

The main objective of the study was the identification of steps and methods to standardize and simplify the cultural heritage management lifecycle, optimizing the stakeholders' participation through the analysis of the relations existing in the ecological cultural network. With this aim, the analysis of flows of information, outputs, data, and relations among different entities converging within the archaeological environment suggested that the single parts require significant improvements in order to optimize the global ecosystem. Indeed, the communication and the integrated valorization of the archaeological evidences have been underlined in order to create a virtuous circle of knowledge sharing and co-creation by involving not only technicians and experts in the field, but also citizens and general users as the main consumers of culture. Through the proposed integrated and networked approach, we are able to analyze each single part and, at the same time, look at them jointly, with a more comprehensive view.

The attention to the methodological approach highlights the need to improve the upstream activities aimed to acquire and store data and information. This could help guarantee the correct archaeological heritage management, also supported by the information and communication technologies that can provide a number of advantages in terms of real time acquisition, storage, communication, publication and communication. In particular, the reconstruction of the archaeological heritage lifecycle allowed marking the standard logical pattern of operations (including methods, tools, and roles) to manage complexity during a multidisciplinary archaeological investigation. This standardization was reached thanks to the introduction of the process modelling approach through which we were able to define the current workflow and set the foundations for future improvements and processes reengineering. This leads to identify the set of methods and tools that can automatize a part of the activities and digitize the documents generated on site. Having identified processes and people, we paid attention to the ways to increase and optimize the communication among the different actors. With this aim, the SNA made it possible to clearly identify different roles and the weight of each actor within the network. This provided insights and guidelines for creating the right correlation between roles and responsibilities and making suggestions on how the activities carried out during the process can benefit from the improvement of communication among the different actors. In detail, the analysis shows that the current role of citizens is one of a mere receiver of the whole process.

Future research will be dedicated to define the *to-be* (desired condition) of the whole process based on the archaeological lifecycle identified. The reengineered process will be based on the new methodological assets identified in the present work and will be characterized by the introduction of technological tools enabling the automation of some phases (e.g. data acquisition, data extraction, visualization, etc.). In addition, the network analysis carried out in this work will be used to complete the optimization showing the added value for all actors during the global lifecycle, underlying the importance of citizens' active participation and community engagement in each phase identified.

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