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MAPPAproject Methodologies Applied to Archaeological Potential Predictivity

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This initial online publication is an extract from the project forms submitted to Regione Toscana under the PAR FAS Regione Toscana Action Line 1.1.a.3. call. It has been partially reviewed and adapted for a less technical reading. We believe that it is important to publish the project extract in order to provide details on the project objectives, the instruments that will be applied to achieve the objectives, the products that will be developed and the methods for disseminating the results.

Keywords: open data, archaeological potential, predictive archaeology, GIS, geology, mathematics

1.Scientific and technical quality

1.1 Philosophy and objectives of the proposal

Like many other Italian cities, Pisa is a settlement that goes well back into history. Its subsurface conceals the remains of walls, floors, tombs and roads, as well as the fragments of tiles, vases, lamps and sculptures: briefly, the more or less solid traces of the lives of the people who have inhabited the city over its almost three thousand years of history. By studying the city's archaeological artefacts and its pollen, coal and human/animal bone remains and by analysing the area's geological and geomorphological features and its resources, it is possible to reconstruct the landscape, or better the landscapes, that have evolved over time and have influenced the city's economic and cultural development, and in turn have been influenced by them.

The ground on which we walk, build and live today is an extraordinary palimpsest where uncountable traces that have been left by our predecessors evolve, merge and overlap. Yet since these traces lie under the ground, the vitally important needs of the city's life and development need to be taken into account: safeguarding archaeological heritage does not mean fighting development, on the contrary, sustainable management models should be proposed and solutions should be studied which do not simply safeguard but enhance archaeological heritage in terms of cultural enrichment and of further development of the supply of tourism services. They should also aim to recover technological experience and rediscover traditions and trades which could be extremely helpful to today's community.

The "Map of Archaeological Potential" is an answer to the problem of finding appropriate tools for making archaeological research demands coexist with present day and future needs. The Map of Archaeological Potential is the technical but above all conceptual development of common archaeological maps. All the information taken from excavations (casual or planned), ancient literary sources, archive documents, and aerial and satellite photographs are included in an archaeological map (and in the database connected to it). Archaeological maps, therefore, are of key importance in providing an overview of the knowledge already acquired about an urban or rural

area yet they are of no use for studying areas (either in cities, the countryside or periurban areas, in particular, with their greater demands for the construction of new neighbourhoods and infrastructures) where there is no information available whatsoever.

The "Map of Archaeological Potential" overcomes this limit. The map stems from the common archaeological map and combines archaeological-historical information with data resulting from geological and geophysical surveying and prospecting, geomorphologic reconstructions, historical mapping and registers, toponymic data, and analysis of urban construction elements. Further processing, carried out on the basis of coded interpretative models, allows us to make assumptions on the greater or lower chance of archaeological remains in areas of which we have no existing information today.

In other words, the map is a predictive map. Evaluation of the possibility that certain areas may conceal archaeological remains of which we have no news is achieved by projecting knowledge regarding neighbouring areas on them, with a degree of approximation that varies according to the quantity and quality of data available. It can be said, therefore, that the Map of Archaeological Potential is a new-generation tool that helps gain knowledge of the local area and whose advantages cover many scopes of application.

Research. The Map of Archaeological Potential is an incredible instrument for historical-archaeological research purposes since it provides a rather well-defined picture of space organisation during various historical ages. As a result, it allows research fieldwork to be planned (geophysical prospecting, core samples and archaeological excavations) at key sites and research issues to be solved with considerable saving of time and resources.

Planning and protection. As a consequence of the entry into force of the Law on preventive archaeology (Italian Legislative Decree 195/2006), evaluating archaeological potential has finally become a key issue. It guides operational decisions during work on sites involving construction or environmental transformation: knowledge of the area's archaeological potential (i.e. the chance that sites may conceal archaeological remains underground) allows the authorities responsible for protecting the territory (Superintendencies) and for planning its development (Municipalities, Provinces and Regions) to provide more knowledgeable opinions and to immediately inform the interested persons on the chances of finding buried remains during excavations. When an area has a high archaeological potential, the person in charge of approving a land development project may, for example, preventively prescribe a number of diagnostic surveys or even archaeological excavations. On the other hand, whoever intends building on an area with high archaeological potential will be informed in advance of the need to carry out archaeological investigations and, if necessary, to modify the original project. This can all be done "before" opening the building site, without stopping the building works or definitely blocking any projects already under way.

Unfortunately, archaeological discovery is still seen as a highly-expensive obstacle to the development of the urban fabric and entrepreneurial activities connected to it. Local administrators and entrepreneurs struggle daily all over the country (especially in historic urban centres) with the difficulty of conciliating expansion and restructuring with the time and costs connected to archaeological investigation. This difficulty, which often leads to the illegal removal of archaeological deposits and the loss of a site's historical memory, could be overcome by adopting a tool that preventively assesses a development project and its real feasibility.

The project has a wide range of aims and will have a highly positive impact on the activities carried out by various Institutions and the University. This has already been demonstrated during the competition of ideas called by the Comune di Pisa for requalification of the Santa Chiara Hospital Area, when the Dipartimento di Scienze Archeologiche (in collaboration with the Soprintendenza dei Beni Archeologici della Toscana) assessed the archaeological potential of the area within the hospital's perimeter. The Comune provided the results, including planimetric information of the areas with higher or lower archaeological potential, to the participants who were thus able to use this information tool for their strategic and functional decisions when planning buildings and structures with different intended uses.

A further aspect must not be underestimated: the creation of a Map of Archaeological Potential is not only a vital tool to learn and safeguard archaeological heritage and to fully enhance its resources; it is also the first step to raising new collective awareness of the importance of becoming familiar with this heritage, which is imperative to any kind of archaeological protection. In other words, the Map of Archaeological Potential is capable of triggering a vicious circle and affecting any activity carried out throughout the territory: an example is the possibility of using any investigation technique used during public and private works (which are certainly not few in a Municipality) for archaeological purposes, such as excavations, core samples and surface geomorphological studies, thanks to which archaeologists are able to collect important information.

To this end, the project also envisages the implementation of "procedural protocols", which formalise the procedures and allow archaeologists to access and process information gathered from different activities which are useful for continuously updating the historical framework at the basis of the Map of Archaeological Potential.

The project, however, will expand in two directions so as to move beyond the simple implementation of a Map of Archaeological Potential of the city of Pisa.

1. Technological innovation. The few examples of existing Maps of Archaeological Potential are based on the statistical analysis of known data from which

predictive data on archaeological potential are inferred non-empirically and non-systematically. Highly advanced mathematical theories, which are mature enough to significantly contribute in areas commonly considered as falling outside their scope of application, have never been used or have been unjustifiably used so far in many research sectors (especially in the field of historical-archaeological studies). This is also due to the general difficulty of communication between experts belonging to different disciplinary areas and, consequently, to the scarce amount of inter-disciplinary research activities. In most cases (meteorology, medicine, etc.), prediction is a task entrusted exclusively to mathematicians who work without actually relating to the experts in the area.

Integrating the various skills will instead be one of the project's strong points. Starting from WP2, they will work side by side to organically and systematically define the theoretical principles upon which the prediction of archaeological potential must be based, so as to codify the procedures and eliminate (or at least minimise) subjectivity.

2. Creation of an operational model. Given its historical, topographic and dimensional features and due to the methodological approach of the project, Pisa is an excellent case study for testing operational methodologies and instrumentation, with the purpose of creating an operational model with well-defined operational procedures that may be applied in city/town centres having the same features both in Tuscany and other Italian regions.

In harmony with Regional Programming objectives, we believe that it is crucial to promote the communication and diffusion of our research results, with a view to developing a truly free and democratic knowledge-based society. With this purpose in mind, the project's core philosophy is to make public data (now difficult to retrieve) of archaeological investigations carried out in the sample area of Pisa accessible. An online open data system will ensure the sharing of a common historical heritage. It is exactly for this purpose that the project activities for disseminating the results (WP13) will start from month 2 of the project. A project website will be set up to collect all the research reports and products that are gradually developed and will be updated throughout the entire project.

We will also focus on what we consider to be a serious lack of scientific-methodological discussion on the above described issues. Unlike famous international examples, research dealing with these problems and their focal issues is highly disadvantaged in Italy. Although many projects have been funded over the past years regarding the introduction of highly advanced technologies (especially in the area of musealisation and virtual heritage environments), a common and systematic multi-disciplinary approach has not yet been developed which aims at "managing" buried archaeological heritage in terms of planning and safeguarding. Our intention is to promote an innovative approach by combining the work of archaeologists, geologists, geomorphologists and mathematicians. Indeed, we are convinced that it is possible to attempt to develop a scientific-mathematical model that can be applied to Italian urban centres. A network of systems and procedures that will provide Regione Toscana with a single and highly-competitive system, placing it at the forefront in this field.

In brief, the general philosophy of the project is to implement a product created at university level which has a double aim: on the one hand, the progress of historical-archaeological knowledge of the history of Pisa, and on the other, the implementation of innovative techniques for the design and development of this kind of knowledge-based tool. Yet the project also intends going beyond the boundaries of university laboratories and interacting on an ongoing basis with the Protection Authorities (Direzione regionale per i Beni culturali e paesaggistici e Soprintendenza per i Beni archeologici) and Planning Authorities (Municipalities). The aim is to use skills belonging to areas that are not strictly related to university research yet particularly aware of the demands of civil society, and at the same time to allow the research products to be instantly brought to the attention of whoever may be interested in them and to be immediately applied to everyday life. In this way the funding that has been granted can be best used with the widest positive outcome.

1.1.1 General objectives

The project intends to achieve the following general objectives:

1) Enhancing the development and research of archaeology by fostering collaboration with experts from different research sectors (earth sciences and mathematics). By developing a common language and observing from different perspectives, the project will especially aim at achieving a methodological development of the issues tackled in the project and at increasing the progress and competitiveness of the individual disciplinary sectors. Within this context, we seek to develop and test predictive mathematical models applied to archaeology which will have a social impact in terms of archaeological heritage protection, territorial planning and historical knowledge.

2) Creating a repeatable model that may be applied to all multi-layered urban centres in order to facilitate land use decisions regarding archaeological heritage management and protection issues. This will mitigate impact on heritage and promote the sustainability of territorial planning processes. We firmly believe that university research must be at the service of civil society and provide its results in the form of exploitable tools, with effects both on local governmental institutions – therefore on citizens – and on ministerial protection institutions – therefore on cultural heritage.

3) Making all primary data from archaeological investigations available. The publication of such data

is often disregarded or incomplete, and rarely swift. The damages that this deep-rooted habit can cause to research development, which feeds on comparison and creation of new data, is quite evident. The project proposes that after acknowledging authorship of the data, the latter shall be made publicly available and easy to consult (open data), in line with the purposes of Action Line 1.1.a.3.

4) Training and professionally qualifying new R&D experts with a multi-disciplinary approach in order to develop a competitive system model. We aim to create new experts with strong specific skills but at the same time capable of speaking a common inter-disciplinary language, thanks to the methodological approach at the basis of the project. This will be achieved by implementing activities targeted at diffusing the experimental progress of the sciences and technologies acquired during the various project steps and in the diverse disciplinary areas, and by making the know-how progressively acquired by the research team constantly available. We firmly believe that this is a qualifying element for the professions involved in the project and for the development of a knowledge-based society that is capable of integrating topics that differ by scientific approach and method, and of developing a highly competitive system model.

Scientific objectives:

The project intends to achieve the following scientific objectives:

1) Creating a mapping and monitoring tool for the **knowledge** and **protection** of Pisa's archaeological heritage, developed according to a repeatable methodological model for multi-layered urban centres. The tool has been conceived with the aim of both:

- s**haring the knowledge** acquired and placing it at the disposal of institutions dealing with territorial government and protection and;

- developing and optimising historical and archaeological **scientific research** relating to urban settlement dynamics.

2) Developing multi-disciplinary scientific research by combining different specialised expertise to achieve a common objective. The aim is to deliver quality results that are more reliable than those reached by studies conducted independently by each single expert.

3) Defining a **predictive and repeatable** mathematical model of archaeological potential. We believe that the promotion of scientific progress, on an experimental basis, will place Tuscany at the forefront in the sector of cultural heritage technologies and in the development of an integrated system aimed at the conscious use of cultural heritage knowledge by the public.

Technological objectives:

1) Creating different Archaeological Maps for the various historical periods (in the case of Pisa, from prehistory to post-medieval times) and geomorphological and palaeographical maps of the urban area, which represent the knowledge base required to implement a **Map of Archaeological Potential**: knowledge of the site's environmental evolution, and of the development of human settlement and landscape elements throughout the historical phases, allows assumptions to be made on the archaeological potential in various city areas. Consequently, both public and private development projects will be able to count upon broad predictive knowledge and to assess beforehand any impact on archaeological heritage, already during the planning phase.

2) Creating an urban planning tool that may be included, as an integral part, within the Municipal Strategic Plan of Pisa and, more in general, of Municipalities with multi-layered historical centres, and at the same time providing a standardised protocol of Operational Guidelines, drawn up with measurable and repeatable criteria. A further objective consists in providing local governmental and protection institutions with an integrated "package" that will make urban planning easier during the planning phases and optimise both financial resources and implementation time. The system also represents a valid tool for supporting private development projects since it facilitates archaeological impact assessment procedures and safeguards cultural heritage.

3) Creating a standardised, digital and user-friendly (i.e. open-data and online) archaeological data archiving model, which may be applied to all Tuscan and Italian urban contexts after it has been tested on samples in Pisa. The implementation of a system such as this (the only one in the country to date) will promote the communication and diffusion of the research results and the direct transfer of technological innovation through the network.

4) Pisa has a very special environmental context, characterised by numerous watercourses and wetlands which have frequently changed over the centuries and significantly altered the territory. For this reason, we believe that a detailed geomorphological reconstruction is of vital importance, especially with regard to the diachronic migration of natural watercourses in the urban area and identification of the artificial canals connected to them. Furthermore, it will help us interpret the dynamics of urban settlement over various historical periods.

From a technological viewpoint:

- using advanced and innovative remote sensing techniques will help receive precise information on subsurface data and provide a more reliable and accurate palaeographic reconstruction of the various settlement phases.

- using differential GPS will make georeferencing of the archaeological, geological and geomorphological data, and their integration in a data bank, a highly effective tool for interpreting the relationship between these data.

1.1.2 State of the art

Needless to say, archaeological mapping has grown in importance over the past years. Various branches have recently developed relating to mapping issues: **archaeological maps** that record archaeological finds in a certain area; **period maps** that visualise data referring to a certain historical period and help study the development of that chronological period; **deposit thickness maps or sections** that help provide a more accurate time and costs estimate; **function maps** that provide synchronic or diachronic information on the type of settlement; **maps relating to trade**, the circulation of materials and products, viability and routes, and the dynamics related to the location of sepulchral areas; lastly, **maps of risk or potential** that define areas of archaeological interest under protection. Any of these maps may be applied and developed within an urban context, but cannot remain isolated and be an end in itself. Cities are live and busy places that continuously develop and change; for this reason, they need special care and attention that must take into account the coordination between protection, territorial planning and research.

The last map, the "map of risk or potential", will be analysed in detail. The term "risk" refers to the danger represented by archaeological remains for public or private development projects or, on the other hand, the harm that the development projects could cause to the remains and traces of the past. The term "potential", which should be preferred to the former, sends out a more positive message, since referring to potential as a site's wealth and resources. The map of archaeological "potential" is neither an archaeological map for recording data nor a historical map: it is a synthesis of both because in addition to combining information and approaches, it summarises the results of further new data. The map of archaeological "potential" is used by people working in the archaeological heritage protection sector. It provides a topographic view of the archaeological potential and interested areas with different levels of intensity. This first application, that is, gathering provisions and indications from the map on the archaeological work to be conducted, is quite fruitless if not supported by an adequate legislative framework. The integration of maps within the P.R.G. (General Zoning Plan) and Municipal Strategic Plans could become a useful planning tool for professionals working in this field during the entire planning phase, ranging from general urban development guidelines to more specific building interventions. It will also offer the opportunity to make the administrative process transparent, especially planning permission procedures.

This application will lead to a great economic advantage for both administrations and single entrepreneurs: the opportunity to plan and work upstream with the Superintendencies and so estimate the time and costs required, may ensure a better result for all parties involved as well as for territorial management, entrepreneurial development, and archaeological protection and research.

Last but not least, the map of archaeological potential, featuring a diachronic set-up and without criteria of hierarchy, simplifies archaeological research planning and fosters the definition of accurate issues and improved strategies using invasive and non-invasive diagnostics. This consequently leads to enhancing the multi-disciplinary and all-purpose use of the map, which must also be a tool of public use, capable of reaching all categories operating throughout the territory for different reasons, including the citizens themselves.

What has been described as a list of maps that may be developed and applied to an urban context such as Pisa, will be implemented according to a rather standardised practice in archaeology: the creation of digital archives for storing archaeological data, whether textual (reports, context recording sheets, dig diaries), graphical (images, planning of context, sections) or digital (database, CAD, GIS, etc.).

Over the past years, archaeology has undergone significant progress and the first examples of open access and open data systems are beginning to flourish. Whilst open access simply proposes free access to electronic scientific information (Gruppo Laser 2005: 77-78), the open data philosophy aspires to the free use of raw data (especially non-textual data) and their reuse, although monitored by specific licenses. Open access and using the web as a means for publishing entire excavations is certainly an important achievement. It ensures wide-ranging distribution and reduction of printing costs, but can offer even more: according to the open data approach, the free use of raw data will ensure further progress to archaeology.

The future of archaeological research is strictly connected to data storage and free reuse of data for further investigations and analysis. The reasons are detailed below.

1. An archaeological excavation or survey basically consists in documenting and recording in detail all the evidence found during the excavation and survey in written, graphical and photographic form. This archaeographic process (Moberg 1981, Guidi 1994) allows persons who did not directly carry out the work to interpret the records and experts to reuse the fieldwork documents for further assumptions and historical reconstructions (D'andrea 2006: 130). In fact, just as good critical reasoning cannot be performed without a good factual description of initial data, so archaeology cannot be performed without archaeography (Mannoni 2000: 217).

2. Archaeological excavations, and in part surveys, are non repeatable. The only item that can be reproduced and re-analysed is the raw archaeographic data. Sharing these data allows scientific communities to understand and reread the interpretation process, and also to reuse the data on different grounds and for further investigations. Raw data are truly archaeology's only source code.

3. The great majority[1] of archaeological interventions in Italy are not strictly related to research, yet to rescue archaeology (real preventive and/or salvage archaeology) especially with regard to urban contexts.

4. The great majority of archaeological interventions remain unpublished (Brogiolo 2000: 354)[2] and this is especially true for rescue archaeology.

5. It is common practice for archaeologists to create digital archives (that are often insecure) for storing data and to acquire part of the information directly in digital form;

6. The creation of online digital archives allows data to be preserved;

7. The availability of online archives containing raw data facilitates research, territorial planning policies[3] and the enlargement of the scientific community, thus overcoming local and regional barriers.

As already mentioned, the creation of digital archives is common practice in archaeology. Alongside standards that regulate fieldwork recording, a series of good practice standards[4] need to be set up regarding the IT procedures to be used for protecting digital archive design, implementation and preservation. Standards, therefore, play a key role in computational archaeology and archaeology in general and, together with archive accessibility, are the keywords upon which the future of archaeology must be based (D'Andrea 2006:78). These issues have been primarily addressed by the *English Heritage Centre for Archaeology* (CfA) and the *Archaeology Data Service* (ADS) described respectively in Digital Archiving Strategy 2.0[5] and in *Digital Archives from Excavation and Fieldwork. Guide to Good Practice, Second Edition*[6]. Very briefly, the two manuals are useful tools for professionals working in either private or public fields who need to create digital archives. The manuals address topics such as obsolescence of chosen resources, long-term archive maintenance and protection procedures, and accessibility.

The main purpose of digital archiving is the storage of original records for future use. This must begin by clearly defining the nature, essential characteristics and authenticity of the recorded data, and also by depositing the data in a facility where they can become available on the Internet[7]. The proposed model envisages that the creation of an open digital archive will be carried out in agreement with appropriate national and international standards, fully documented to help ensure quality certification of the archives. The model also envisages that the diffusion of data must be supported by national institutions, leading to full integration and cooperation between national agencies and the international scientific community.

It is understandable that a considerable amount of human resources are involved in the maintenance of digital archives which guarantee assistance[8], a wide range of formats[9] for each dataset (so as to allow use by a vast array of users), and data maintenance[10]. Regarding the preservation of data, both the physical and structural characteristics of digital archiving must be considered. The documents should be saved in ASCII text, while the structures should contain information on the codification process adopted. Furthermore, data on provenance, background and inventories should also be available. Distinction is made between data that is created digitally and scanned data. Digital data acquired from external sources should contain explanatory documentation on the format used and on compliance with existing standards, data models and thesauri. All the data have an associated metadata record, whose purpose is to describe every set of information related to the stored

1 Although overall data do not exist at national level (which would be greatly needed), data relating to Pisa – where each single archaeological intervention that is known (554 archaeological works of various nature dating from 1520) has been recorded (Anichini, Paribeni 2005) – show how 83% of the works, including excavations and surveys over the last 20 years have been carried out by professional archaeologists and in any case not connected to University Departments.

2 Even in this case, there are no official statistics yet the data collected for Pisa reveal that only 20% of the works carried out over the past 20 years have been published and only a little above 1% has been published with a complete account of the excavations.

3 Reference is especially made to Italian Law no. 109 of 25 June 2005, articles 2-ter Preliminary assessment of archaeological interest and 2-quater Preliminary assessment procedure for archaeological interest.

4 Standards ensure compliance with restrictions on the form and contents laid down for codification and normalisation of categories of objects and attributes. Digital strategies enhance documentation, inventory and classification processes by making them simple and easy to use; this ensures future access to the archives and long-term storage of archaeological records (http://www.english-heritage.org.uk/publications/digital-archiving-programme/dapmanual-preservation.pdf, access 23 August 2011). The creation of standards, furthermore, fosters exchange of information and triggers intensive cooperation with supranational institutions engaged in the development of programmes aimed at diffusing standards and guidelines.

5 http://www.english-heritage.org.uk/publications/digital-archiving-programme/dapmanualpreservation.pdf (access 23 August 2011)

6 http://ads.ahds.ac.uk/project/goodguides/excavation/ (access 23 March 2010) created by Archaeology Data Service (ADS)

7 http://ads.ahds.ac.uk/project/goodguides/excavation/sect81.html (access 23 March 2010)

8 The ADS portal provides PATOIS: a series of tutorials to learn how to use online digital data http://ads.ahds.ac.uk/project/patois/module2/index.html (access 4 April 2009)

9 Projects regarding digital archive analysis also stemmed from problems related to the proliferation of "proprietary" software solutions, by nature incapable of ensuring data interoperability. In fact, it is usually suggested to use open source solutions when creating digital archives; indeed, "the greater open exchange formats are used, the freer working groups will be to use commercial or open programmes which better adapt to their needs, and both projects and data will be able to "migrate" more easily from one system to another; this aspect must not be undervalued given the continuous evolution of information technology" (Pescarin 2006:144)

10 Again, the model envisages the participation of the entire archaeological community to develop strategies aimed at the funding of IT infrastructures.

record. Data preservation strategies deal with storage format and supports requirements (longevity, capacity, viability, obsolescence, cost, susceptibility to physical damage), whereas accessibility strategies identify the criteria needed for long-term management (evaluation, ingest, migration[11]; refreshment).

There are currently no existing open digital archives in Italy[12]: the greatest problem lies in making the academic archaeological community accept such a revolutionary instrument, which is often more intent on protecting data for future publications. Furthermore, complete research on archaeological documentation is missing in Italy: although the methodological and procedural debates were definitely closed at the start of the 1990s, technical and IT progress, alongside the growth of professional archaeology, make them highly relevant. The increasingly varied archaeological community in Italy, which includes government agencies, research institutions and professional archaeologists, makes this issue an ever more urgent matter. It is sufficient to recall that the *Archaeological Data Service* (ADS), curated by York University, was developed thanks to the collective involvement of many different subjects working in the archaeological sector (although within a different regulatory and professional framework). Indeed, archaeographic data must be created by a plurality of subjects that must actively take part in the creation of good practices and standards for collecting archaeological data. Such standards represent the professional consent to common practices and are of use when checking the compliance of working and/or organisational processes within a professional community, at least on a national scale. Data sharing depends on standards (Gattiglia 2009).

1.1.2.a Regulatory aspects

The idiom "prevention is better than cure" can easily be transferred from the health sector to environmental and cultural heritage protection: in the latter case, prevention especially means using appropriate tools to protect our buried archaeological heritage, the most fragile we have inherited.

Although national regulatory instruments (Italian Legislative Decree no. 42/2004, the so-called Code of Cultural and Landscape Heritage) are available along with regional instruments which are partly structured around regulations and guidelines issued by national authorities (in Tuscany, recent Regional Law no. 21 of 25 February 2010, *Consolidated Act containing provisions for cultural heritage, institutes and activities)*, any action to protect cultural heritage by appointed Governmental Offices is still toilsome and highly ineffective. There is no true participation by Local Institutions entrusted with the planning and authorisation of public and private development projects.

Many private citizens – vaguely "warned" about possible archaeological risks – have the intelligence to plan the work to be performed. They contact the Superintendency and agree upon the operational procedures to be followed in order avoid risks for all parties involved: interruption of works and loss of the buried archaeological heritage.

Article 28 of Italian Legislative Decree no. 42/2004 contains the origin of preventive archaeological activities which was implemented by Italian Legislative Decree no. 163/2008, the Code of Public Contracts (articles 95 and 96). This regulation is still rarely applied in the context of public works carried out by Local Institutions and even of many national interventions.

The vast sector of private development projects, which are directly authorised by the Municipality they fall under, completely lacks any codified and uniform instruments. In some cases, municipalities have considered the archaeological potential of their territory by including a reliable knowledge-based tool (Archaeological Map) in their Strategic Plan and regulations/provisions in the relevant Zoning Plan. Successful results have been achieved although they may be improved. However, the majority of Municipalities have not taken charge of these issues in a responsible manner.

Activities must be improved upstream, i.e. by spreading knowledge of the heritage already acquired. This is the only way to develop a conscious-raising approach and effective assumption of responsibility at all levels by institutions acting throughout the territory.

In 2007, Regione Toscana issued a *Territorial Plan* and provided a *Map of Restraints* (which evidently included archaeological restraints), and also took steps to prepare a Landscape Plan in compliance with the law and with the criteria indicated in Italian Legislative Decree 42/2004. This resulted in the restraints imposed by the Italian Ministerial Decree regarding the areas of archaeological interest identified by law in accordance with article 142, paragraph 1, letter m). This procedure includes the Archaeological Resource Atlas which provides indications on archaeological finds throughout the region. The data are point positioned using a symbol that does not vary when a change in scale occurs. Colours vary according to the reliability of the autoptic positioning and each point is linked to a summary sheet. The limits of this tool

11 The Technology Watch establishes whether the original formats have become obsolete or if more appropriate formats are available. http://www.english-heritage.org.uk/publications/digital-archiving-programme/dapmanualpreservation.pdf (access 23 August 2011)

12 By way of example, the difficulty still encountered by the Soprintendenza per i Beni Archeologici della Toscana (Superintendency for Archaeological Heritage of Tuscany) to manage its paper archives. The Superintendency employs a researcher to identify the data needed, if existing (archaeologists are very reluctant to delivering their excavation documents since they fear they could be used by others). Archive management divides excavation documents into three different sub-archives: written documentation; photographic archive; graphical archive. There is also a strong risk of decline in sources: the graphical documentation preserved in the historical archive of Pisa (interventions before 2000) consists of just one map from the mid-1950s.

lie in the sources used (usually scale 1:100.000), nonetheless, the tool is implementable and could be improved in terms of positioning accuracy and information about the finds, through actions entrusted to Local Institutions which should produce more refined knowledge-based instruments.

The situation in Pisa (case study chosen for the project) is only apparently among the most fortunate. Two rulings (administrative protection provisions issued in compliance with Protection Law 1089/1939 by the Soprintendenza per i Beni Archeologici della Toscana, respectively on 10 April 1986 and 29 June 1993) determine the topographic limits of an area, corresponding to the area included in the perimeter of the city walls and to an external portion, designated as being of "important archaeological interest" since it was revealed to be (although always by chance) the area with the highest amount of archaeological discoveries relating to the Etruscan, Roman, Medieval and Post-Medieval city. In other words, protection has been governed by randomness rather than by research.

Municipal regulations have based themselves on this declaration of interest and so require that public and private development projects be subject to a single provision: approval by the Soprintendenza per i Beni Archeologici during the final phase of the approval process. It must be acknowledged, however, that the Superintendency is not provided with the suitable data organisation tools needed for performing such a delicate task and so, when assessing a project, finds itself choosing the safest strategy: preventive archaeological investigations for each project!

Although not required by law, yet suggested by wide national and international experience, the next step to be taken should be the creation of a tool that is capable of establishing the archaeological potential of the territory and of guiding the decisions taken by both public and private subjects.

1.1.3 Participants

Dipartimento di Scienze Archeologiche (Department of Archaeological Sciences)

Dipartimento di Scienze della Terra (Department of Earth Sciences)

Dipartimento di Matematica (Department of Mathematics)

1.1.4 External Collaboration

- Direzione Regionale per i Beni Culturali e Paesaggistici della Toscana (Regional Directorate for Cultural and Landscape Heritage of Tuscany)
- Soprintendenza per i Beni Archeologici della Toscana (Superintendency for Archaeological Heritage of Tuscany)
- Soprintendenza per i Beni Architettonici, Paesaggistici, Artistici ed Etnoantropologici per le Province di Pisa e Livorno (Superintendency for Architectural, Landscape and Ethno-anthropological Heritage for the Provinces of Pisa and Livorno)
- Comune di Pisa (Municipality of Pisa)
- Istituto Nazionale di Geofisica e Vulcanologia (National Institute of Geophysics and Vulcanology)
- Aerofototeca Nazionale (National Aerial Photograph Archive)
- Laboratorio di cultura Digitale – CISIAU Centro Interdipartimentale di Servizi Informatici per l'Area Umanistica (Digital Culture Laboratory – CISIAU Interdepartmental Centre of Information Services for the Humanities)

1.2 Quality and effectiveness of management and proposed work programme

The MAPPA project will be executed through a series of WPs that define the various project phases. The general strategy is the complete transparency of all management/administrative, methodological and technical working phases. The project is characterised by two transversal WPs that run along the entire project: WP1 and WP13. The former relates to project management and is transversal in terms of duration and activities to all WPs. This work package will deal with the planning, management and optimisation of all project implementation resources, schedules and costs, thanks to a project management committee coordinated by the Project Director (Dsa: Prof. Maria Letizia Gualandi) and composed of the scientific managers of the Departments participating in the project (Dst: Prof. Marta Pappalardo; Dm: Prof. Dario Bini), Prof. Sergio Steffè (Dm) and of Giovanni Sarti (Dst). The transversal approach of these activities is determined by its specific functions. The aim of the WP is to: coordinate project activities among participants; appoint the contact persons for the various WPs; ensure observance of the work programme for correctly synchronising the WPs and observance of both the milestones and general, scientific and technological objectives expressed in the project; promote project visibility by periodically updating work progress in order to disseminate the project beyond the scientific community, with effects at local and regional level; maintain contacts and relations with external project collaborators (Soprintendenza per i Beni Archeologici della Toscana; Direzione Regionale per i Beni Culturali e Paesaggistici della Toscana ; Comune di Pisa; Istituto Nazionale di Geofisica e Vulcanologia). The management committee will also ensure the correct administration of the project's financial resources, in direct contact with the project secretariat. The latter will ensure consistency of expenditure items and, together with the WP managers and project secretary, will prepare the six-month project reports assessing project work progress, as well as the final scientific report and the administrative and accounting statements for all project phases. Finally, it will be responsible for the purchases required for technological adjustments to the project's operational ma-

nagement centre. This activity clearly has a transversal and bonding role within the project, which is the reason for its duration, covering the entire length of the project. Likewise, WP13 which includes all training and dissemination activities has an equally transversal approach. It is directly related to WP1 yet is slightly shorter (23 months). Its transversal nature is due to the fact that it fully combines and performs all dissemination and training functions through the entire term of the project. The WP is considered a capillary and ongoing activity, a 'work in progress' and an open window on the project providing complete transparency, monitoring and diffusion of events connected to the achievement of each project step and related to every single WP. The website will be a real open window on the project: it will be created during the first month of this WP, hosted on the University's server and entirely translated into English. Networking the project will be an objectively verifiable event although not a real milestone. The website will be the container (again highlighting the project's transversal nature) of the project's technical reports, of the products/milestones implemented during the activities (all archaeological, geomorphological, palaeographical and potential mapping will be used via the web-GIS) and of the open digital archaeological archive. The project will be implemented at the "Laboratory of Methodologies Applied to Archaeological Potential Predictivity" (LabMAPPA), an open window and physical location for educational/scientific dialogue. Continuous, transversal and multi-disciplinary training and updating will be performed here. Training will consist in the gradual and ongoing transfer of know-how from the research team to students and future R&D experts. Updating will be carried out via workshops for non-university technical staff using the design/planning methodologies implemented by the project.

The remaining WPs, which aim at achieving the expected results and are strongly interconnected, are included within these two macro-activities. The starting point, therefore, is WP2, a short work package (1 month) which provides the methodological structure of the work. WP2 will provide a conceptual analysis of the meaning of archaeological potential and define the parameters needed for its determination, i.e. which items contribute to the calculation of archaeological potential in an urban area and how to translate these items into numerical components, at the basis of the subsequent mathematical study. This shared analysis, involving all participating subjects (Dsa, Dst and Dm), will produce a scientific report: the first milestone of the project, which will be disseminated through the website and allow its achievement to be verifiable. Three distinct work packages – WP3, WP4 and WP5 – will ensue from WP2, since a number of activities may be carried out in parallel during the first phase, mainly aimed at collecting the data needed for subsequent processing activities. WP3 will collect geomorphological and sedimentological data. This WP is a research activity that is preparatory to the creation of the Map of Archaeological Potential and has a direct impact on WP8. The long duration of this activity (11 months) is due to the need to collect existing data and a significant amount of new data. Indeed, WP3 deals, on the one hand, with detailed geomorphological surveying that is necessary for creating a high-resolution DTM by integrating LIDAR data, mapping data and data from the use of differential GPS. On the other hand, the WP will acquire existing subsurface data and, after analytically re-interpreting them, will handle them in GIS environment and implement 2D and 3D stratigraphic sections. This will allow a preliminary model of the stratigraphic-depositional architecture of the first 6-8 metres of subsurface to be prepared, as well as assessment (thanks to the joint work of geomorphologists and archaeologists) of key data acquisition areas in which to carry out further continuous core sampling activities. The data will be jointly read by geologists and archaeologists for the preparation of stratigraphic logs and collection of samples for lab testing, especially petrographic, pollen and radiometric tests. Petrographic tests will provide indications on the composition and provenance of sediments together with key paleohydrographic information. Pollen tests will provide details on climate incidents, including paleo-environmental information and connections between stratigraphic levels. C14 radiometric dating methods will restrict the correlation framework from a temporal viewpoint. Thanks to this new set of data and to implementation of the GIS project, further stratigraphic sections may be prepared and/or those already performed during the preliminary phase may be reviewed. Furthermore, a model for developing the stratigraphic-depositional architecture of the uppermost subsurface may be defined consistently with space-time evolution. The data obtained will be summarised in a final report and in a common methodological "action protocol" between geologists and archaeologists, which will provide guidelines for collaboration between different experts. Achievement of the objectives will lead to a milestone consisting of the creation of geomorphological and paleogeographic maps disseminated through the web-GIS available on the project website, and will allow verifiability of the milestone itself. The relational Database already used by Dsa will be checked during WP4 and will be adjusted to the new data collected throughout the project. Activities will include the creation of data archiving tables, normalisation of the different types of fields/data and compiling of thesauri. The limited duration (2 months) of this package is connected to the type of work envisaged: implementation of the RDBMS structure, created with an open and easy-to-integrate architecture and aimed at containing the greatest amount of information possible. A user-friendly interface will be developed allowing a variety of uses according to the user's computer literacy. The product developed at the end of the package, therefore, will be a complete and updated version of the previous RDBMS. WP5 also stems from the conceptual analysis of WP2. Its aim is to implement existing archaeological data records of Pisa by analysing publi-

shed data in literature and systematically studying the archives of the Soprintendenza per i Beni Archeologici della Toscana (SBAT) and the Soprintendenza per i Beni Architettonici, Paesaggistici, Artistici ed Etnoantropologici per le Province di Pisa e Livorno (SBAAAS). Existing archaeographic data (graphical, photographic and compiling documentation) referring to stratigraphic excavations in the urban area will be also collected in collaboration with SBAT. This work package also lasts 2 months (like WP4) since it stems from a consistent basis of data collected during previous research activities (degree and PhD theses) carried out by Dsa. It is important to underline the participation of Dm in these activities aimed at directly checking which type of data archaeologists use and which could be the most coherent methods for their mathematical calculation. The concurrent completion of WP4 and WP5 will lead to two different activities: WP6, a strictly archaeological work package, and WP9 relating to mathematical research. WP6 contains the activities required for drawing up the Archaeological Map. The data collected during WP5 will be entered in the relational database and will be analysed by archaeologists according to their historical periods. This package will also include data vectorisation in GIS environment and georeferencing of the photo-interpreted data, carried out with the help of Dst that has acquired notable experience in this field. All the data included in GIS environment will then be re-processed and summarised in diachronic form, and will lead to the Archaeological Map of Pisa. The importance of this step justifies its duration (5 months) and the man-hours involved. This step also represents the achievement of a milestone which will be verifiable through web-GIS publication on the project website where it may be viewed by a wide audience (WP13). The milestone will also be verifiable through digital publication – thanks to collaboration with Edizioni PLUS, the Pisa University publishing company – which will provide information about the project methodological steps and work carried out. The Archaeological Map is a vital issue for research and a useful knowledge-based tool: it will report all acknowledged archaeological data in the urban area of Pisa in diachronic terms ranging from pre-history to contemporary age. It should be recalled that the previous archaeological maps of Pisa, besides being obsolete, only reported archaeological data up to the Roman period. Publication in the form of numerical mapping means that it can be continuously updated, thus avoiding the risk of rapid obsolescence. The completion of WP6 represents the start of a new package, WP7, which includes: filing of published data, of archive data and of data resulting from building archaeology, and data georeferencing and vectorisation in order to understand urban fabric development and the level of architectural heritage preservation; the collection of written, published documentary sources with the aim to locate no longer existing place names, production activities, infrastructures and topographic structures; the computerised acquisition of historical mapping to trace urban transformation throughout the modern and contemporary ages; finally, mapping of stratigraphic gaps by recording (with the help of the Municipal Administration) the thick network of underground environments including cellars, garages, cisterns, basement areas, underground services, as well as the portions already subject to archaeological excavations which have led to the removal of stratigraphic deposits. The duration of this package is 5 months, twice as along compared to WP5. The high number of man-hours is due to the lower amount of data currently in the hands of Dsa. WP7 is, therefore, preparatory to WP8, into which the geomorphological and palaeographical data produced during WP3 will merge and will be disseminated on the website inside the web-GIS. WP8 has a double aim: to review the data entered in connection with the interpretation of settlement development over the various historical periods and to implement an urban Archaeological Potential prototype that will be subsequently tested. This is a key work package as confirmed by its length (5 months) and by the strict cooperation between Dsa, Dst and Dm. The first phase of the package envisages joint activities between archaeologists and geologists; by integrating archaeological data with geological/geomorphological data (through geostatistical analysis), a series of altimetric models (digital terrain models – DTMs) relating to the living standards of the various historical periods will be prepared. After a further interpolation process developed with software used for 3D rendering of the geological deposit, the DTMs will be overlapped to obtain a theoretical model of the volumetric consistency of the deposits during a specific period. This process will allow a more accurate assessment of the consistency of archaeological deposits in all those urban areas where no evidence has reached us to date. After this working phase has been completed, an archaeological review of the period-related data will be carried out to assess the potential of each single period. The assessment will be compared to the period DTMs and will allow analysis of geomorphological and environmental evolution as well as settlement evolution in topographic, typological and qualitative terms, for each single historical period. Subsequently, areas with higher or lower concentration of finds and areas featuring hypothetical urban/settlement development or the absence of anthropic living/settlement will be highlighted. At the same time, the type of finds will be analysed and classified according to variables in terms of mobility, possibility of being removed and monumental interest. All the data will merge in the individual maps of archaeological potential by historical period, which is the starting point for preparing the Map of Archaeological Potential for the entire city. After these activities have been completed, the core of the project will be dealt with: development of the prototypal Map of Archaeological Potential. This will be achieved both by means of a map algebra process in GIS environment by overlapping a series of spatial data such as the period maps of archaeological potential and the consistency of archaeological deposits (duly rasterised and re-classified on the basis of adequate parameters), and through application of the mathe-

matical function developed in WP9. The double calculation is necessary to check and analyse the two processes used and to fine-tune the mathematical function. WP8 must evidently be carried out in strict contact with the mathematicians who have analysed the mathematical models for archaeological potential predictivity in parallel, yet with ongoing dialogue, during WP9 (starting from WP5). WP9 includes the algorithm research phase which enables calculation of the archaeological potential. This is a long research activity (14 months) which starts by transforming the archaeological data studied in WP5, using the criteria developed in WP2, and by creating a numerical database. The mathematical models already existing in scientific literature will then be studied and analysed, and it will be assessed whether they are suitable for determining the archaeological potential of the urban area of Pisa. Finally, any existing models considered suitable will be integrated and new mathematical models will be developed for determining the archaeological potential. Among the approaches used, statistic methodologies, computerised methodologies and numerical methodologies will be considered. Rule-based and evolutionary algorithm approaches will also be used and the possibility of applying PageRank methodologies will be examined. Finally, algorithms seeking to solve the mathematical models will be developed and analysed. They will be identified by keeping in mind computational aspects such as calculation complexity, numerical stability and robustness. WPs 8 and 9 will produce the final project milestone: the prototype of the Map of Archaeological Potential. This milestone, given its prototypal nature, will not be published. Its achievement may be verified through the scientific report that will be drawn up and published on the project website. After the prototype of the Map of Archaeological Potential has been implemented, the first version of the operational guidelines (during WP8) will be drawn up by Dsa in collaboration with SBAT. These procedures integrate the determination of archaeological potential by providing indications on the activities to be carried out and on the calculation of the relevant archaeological risk, as well as on the standardised and shared methods for preliminary planning of the intervention. At the end of this important phase, WP 10 (3 months), WP 11 (4 months) and WP 12 (6 months) will commence. WP 10 will check the models produced by conducting experimental and instrumental tests. The actual predictive validity of the models of archaeological potential will be checked, with respect to data not yet known, through archaeological excavation surveying and core sampling. As a result, the value of potential attributed to the sample areas by the two models may be verified. Experiments will allow testing of guidelines and allow modifications to be made before the dissemination phase (WP13). The collected data will be analysed, in close cooperation between the three Departments involved in the project, in order to optimise the definite mathematical processing model for the Map of Archaeological Potential and to review the first operational guidelines drawn up. Since these are two project products, they will be disseminated through the website. The former will be published both via the web-GIS (accessible online) and in the form of a digital publication, in collaboration with Edizioni PLUS, the Pisa University publishing company. The publication will provide information about the project methodological steps and work carried out. At the same time, WP11 will be carried out under the guidance of Dm and in collaboration with Dsa. This work package will aim at implementing, validating and comparing the models via simulation techniques. A prototypal implementation will be provided to the various models analysed, upon which tests and comparisons will be carried out. The tests will be conducted using complete data assigned only partially to the algorithm. Finally, the model will be chosen and software will be developed that will be made available through open source licenses and disseminated through the project website. The decision will fall upon the model that has given best results in terms of adequacy and ability to predict potential with small margins of error, and which can be solved with low-complexity calculation algorithms. WP12 will be carried out together with the two latter WPs. WP12 is a package of key scientific and methodological importance capable of awakening the academic community from its immobility. Its aim is to create a digital archive in the form of an exportable, sharable and repeatable model for archiving stratigraphic documentation, to define reference parameters for sharing digital documentation and to draw up accurate standards as guidelines for using and compiling the computerised archive. This result will be achieved by analysing the regulatory framework applicable to archaeological data ownership and dissemination, carried out by Dsa (especially the Chair in Cultural Heritage Legislation), in collaboration with SBAT. The analysis will establish how to disseminate raw archaeological data and will define the conceptual structure for determining the assessment procedures necessary to establish whether certain archaeological data should or should not be stored inside the digital archive. Qualitative verification of the data available will also be performed during this phase. Alongside standards that regulate fieldwork recording, a series of good practice standards need to be set up regarding the IT procedures to be used for protecting digital archive design, implementation and preservation. Standards guarantee compliance with restraints related to the forms and contents necessary for coding and normalising categories of objects and attributes; digital strategies consist in valorising documentation, inventory and classification processes, making them easy and simple to use, so as to ensure future access to the archives and long-term storing of archaeological records. The creation of standards also facilitates the exchange of information. Data preservation strategies deal with storage format and supports requirements (longevity, capacity, viability, obsolescence, cost, susceptibility to physical damage), whereas accessibility strategies identify the criteria needed for long-term management (evaluation, ingest, migration, refreshment).

The majority of digital data will be developed with proprietary software. Although this choice may be questionable, proprietary software is among the most widely used software and must be taken into account when creating digital archives. Instead, open source software allows possible alternatives to be adopted. The concept at the basis of open data is not so much how the data have been developed but rather that the data are shared and made available to the entire community. The formats chosen to exchange this information, therefore, must focus on reaching as many users as possible. Licences (copyright/copyleft) will be defined for diffusing the raw archaeological data (archaeographic data) following verification of the regulatory framework. Publication of both the archaeographic data and interpreted data (archaeological data) must be guaranteed by maintaining a right of pre-emption for a limited period of time for the archaeological data and by making archaeographic data free for further analysis through specific licenses. The work carried out will lead to an archive of stratigraphic data applicable to Pisa, containing detailed documentation – context recording sheets, planning of context, Harris matrix, preliminary reports, findings quantification sheet and excavation images available – and accessible online through the project website.

The work plan has emphasised the critical issues in the final phase of the project. Basically, the data collection phase appears to be without risks. Critical issues may arise during the last three WPs, especially WP10 and WP11, during definite development of the archaeological potential, algorithm and application software. The risks could result from the need to perform more tests and fine-tuning activities before launching the final product. For this reason, WP10 and WP11 have, respectively, a 3-month and 2-month slack, thanks to which the time scheduled for the final product development may be increased by a half and by a third. Critical issues could result from the search for more effective regulatory procedures for licensing the archaeological data. Consequently, WP12 will not only be of considerable length (6 months) but will also have a further 1-month slack.

2. Project evaluation elements

2.1 Level of innovation of the project

M.A.P.P.A. is an ambitious and innovative project. Its main innovative features are described below.

2.1.1 Product innovation

The project intends to implement an open and systemic archaeological product accessible through the network, based on two key and complementary pillars:

a) the Map of Archaeological Potential and the open digital archive, which are intrinsically connected to archaeology and to the need to produce data of high scientific content;

b) the possibility for vast scientific and public audiences to share the data.

The Map of Archaeological Potential (still at an embryonic stage in Italy, as seen in the state of the art) is by itself a new product. However, the real innovation consists in automating the calculation of archaeological potential by developing a specific algorithm. The product will not only assure less subjective evaluations but will especially consider a wide range of parameters that would not be able to be otherwise handled.

Considering the recent regulatory framework applicable to archaeological impact evaluation (Italian Legislative Decree 163/2008) under which Archaeological Departments are also eligible for performing preliminary evaluations on public works, the possibility of easily drawing up a map of archaeological potential further emphasises the product's extreme innovation. Above all, the research carried out during the project will provide a more competitive tool for the development of a knowledge-based society. This tool will also give the Dipartimento di Scienze Archeologiche of Pisa University the opportunity to play a leading role in a strong and fast-expanding sector. The system also provides free access via the web to the map, thus guaranteeing a more effective and aware use and protection of cultural heritage. The need to create open digital archives on an open data basis is the future of archaeology. The innovative character of this project consists in providing a solution with a bottom-up approach capable of involving the entire archaeological community. The project will also focus on changing routine habits and imposing required standards (Gattiglia 2009), rather than waiting for the definition of standards and guidelines by institutions appointed with archaeological heritage protection and safeguarding, and their subsequent use by researchers (D'Andrea 2006:78).

The real innovation of the project consists in the spread of a large amount of raw data through an archive which may be traceable through the project website. Starting to share data means starting to reason upon standardisation procedures. It is also important to share them within a short time limit: data grow old and it is better to make them immediately available (without trying to further improve them) when the scientific community is more methodologically in tune with whoever has produced the data. A further level of innovation consists in making the academic archaeological community accept such a revolutionary instrument, which is often more intent on protecting data for future publications. The innovative path that intends being taken is to consider archaeography (whether associated to research structures or professionals working in this sector) always and in any case a research activity since it produces unique and unrepeatable data. Since research occurs only upon publication of the data, the sharing of raw data must clearly be considered as a real scientific publication, meaning that both knowledge and collection

must be protected. Publication of this information (archaeographic publication) and of the interpreted data (archaeological publication), therefore, must be guaranteed as joint curatorship between the Project Director and Principal Investigator and the subject that has collected and produced the archaeographic data. A right of pre-emption will be maintained for a limited period of time for the archaeological data, nevertheless, the archaeographic data will be free for further analysis through specific open licenses such as *Creative Commons Share Alike*. If the general criterion of assessment of competitiveness in scientific and academic institutions is exactly the amount of knowledge that a researcher is able to publish in articles and books in the shortest possible time (Gruppo Laser 2005:39), this criterion does not seem to be used by the archaeological world that prefers non-access to data than copyright: archaeologists tend to hold onto information so that they can publish them one day, thus hindering raw data sharing. Furthermore, the data will not be published in detail but used at most for summary works. In other words, therefore, the project will lead to a real progress in the diffusion of data and democratisation of research.

2.1.2 Process innovation

The multi-disciplinary methodological approach of the project is an innovation in itself. In Italy, issues related to buried archaeological heritage and especially to historic urban settlement reconstruction rarely involve the joint work of archaeologists, geologists and mathematicians. The predictive nature which is inherent to the Map of Archaeological Potential indeed requires an in-depth conceptual definition of the various items that intervene in the determination of the concept of "potential". The debate (WP2) that will be launched by the working group will be highly innovative, as too the creation of an accurate report that will provide all the items (in numerical form) identified at multi-disciplinary level, which contribute to the various levels of archaeological potential.

The impact of this cooperation will not only affect the purpose of the project, but will contribute to improving the knowledge of each single discipline and will lay the foundations for a common language that allows deeper dialogue and represents a new challenge for innovation. Specifically, an action protocol will be prepared integrating the various professional skills involved in the project, not only in terms of scheduling but especially in terms of the type and standard of documentation to be produced and of terms to be used. The protocol may be tested in this specific sector and transferred to other areas both within the scope of other research or territorial management projects. Collaboration between archaeologists and geologists is certainly not new at national level but has mainly been applied to the study of a single archaeological site. It has never (as in this case) been applied to a large city area characterised by an enormous variety of forever-changing environments and landscapes.

The involvement of mathematical disciplines, thanks to the cooperation of Dm, brings further innovation to the project. The archaeological data is rationalised as much as possible and reduced to an intrinsic subjective component. Mathematical models spread through the majority of scientific calculation problems and real world issues. They are highly diffused for geological purposes, such as the prediction of water and oil basins through the study of inverse problems. Although the study of archaeological potential may be associated to an inverse problem, mathematical models have not been widely diffused yet in this sector. Only partial studies exist in scientific literature which do not use the potential of modern mathematical theories. The innovative feature of the project consists in exporting advanced mathematical and algorithmic methodologies from well-established sectors to archaeological issues and, therefore, in promoting experimental technological progress for protecting and enhancing cultural heritage.

The desire to focus on the development of a multidisciplinary methodological approach is confirmed by setting up a "Laboratory of Methodologies Applied to Archaeological Potential Predictivity" (LabMAPPA) in Dsa's existing premises ("Marcello Cosci" Archaeological Photo-interpretation Department). The entire research team will have access to these operational premises, and educational/scientific training activities will be carried out for students from the three departments. Training will aim at transferring the experimental progress of the know-how and technologies acquired during the various project steps and at creating new R&D experts with strong complementary skills that may be applied to archaeological heritage protection and safeguarding.

Subsurface (stratigraphies, wells, penetrometries) and surface data (micro-relief, current hydrographic network, geomorphology), archaeological data (finds, contexts, etc.) and urban data (buildings, roads, underground services, etc.) will be integrated on the same GIS platform during the project. This strategy has only been applied in pioneering studies and will integrate data that is traditionally subject to separate analysis and representations. The combination of stratigraphic and geomorphological is particularly able to provide more in-depth and complete interpretation.

After performing a geostatic analysis developed in GIS environment, the integration of these different categories of data will be used to obtain a series of altimetric models (digital terrain models - DTMs) relating to the living standards of the various historical periods. After a further interpolation process developed with software used for 3D rendering of the geological deposit, the DTMs will be overlapped to obtain a theoretical model of the volumetric consistency of the deposits referring to a specific period. This process has never been attempted at urban level and will allow more accurate evaluation of the consistency of archaeological deposits in all those urban areas where no evidence has reached us to date. An innovative aspect consists in the integrated use

of leading-edge techniques, such as LIDAR images, remote sensing techniques and differential GPS, for the geological analysis of lowland urban areas, which represent a frontier for the geomorphological studies since characterised by ruined and hardly visible morphology which are often partially cancelled due to anthropisation. For instance, in a lowland area, such as that upon which Pisa is built, low differences in level that are currently hardly perceptible may be detected in detail using GPS and LIDAR images. These topographic variations are of vital importance not only for their geomorphological meaning but also for the effects that their presence has on natural run-off and on settlement choices: the study of a methodology aimed at identifying geomorphological contexts applicable to different types of population and land-use is consequently an innovation in the geomorphological field. In particular, analysis using both high-resolution (1 metre) aerial images (orthophotos) and satellite imagery with 30 metre resolution will be applied for identifying paleo-riverbeds. The following two factors will be taken into consideration: recognition of natural or anthropic objects with contiguous geometries and meandering or winding movement (e.g. wooded areas, cultivated areas, roads, etc.), and image processing using stretching or filtering techniques aimed at emphasising the object under examination. This first analysis will be performed only on the orthophotos, using appropriate visualisation scales according to the size of the object being examined. The second analysis will be carried out on grey-tone orthophotos and on both infrared and panchromatic bands extracted from the Landsat 7 ETM+ image. These bands are sensitive to moisture content and, thanks to their colour tone variations, provide useful indications on the presence of possible abandoned river beds. The subsurface data will be interpreted using high-resolution sequential stratigraphy principles (used in the oil exploration field) for the 3D detailed reconstruction of the subsurface depositional architecture and of the palaeographic evolution of the area under examination.

2.1.3 New standard procedures and protocols

The project will give great attention to the introduction of standard procedures and protocols. The main innovation lies in the procedural standards relating to the operational practices to be followed when evaluating archaeological impact and in the introduction of new standards for preserving and transferring raw archaeological data.

The project will define an operational protocol in cooperation with the Soprintendenza per i Beni Archeologici per la Toscana which rationalises both resource and timing requirements of archaeological surveys relating to public and private works, and allows the protocol to become an indispensable means for guiding planning choices. Based on the indications laid down in the legislation on preventive archaeology (Italian Legislative Decree 163/2008) – which lays down the fundamental principles for planning the collection of resources for evaluating the archaeological impact of a public work on a determined area – we believe that it is crucial to optimise a tool that is able to help subjects working in the urban development sector and provide them with targeted and geared indications according to the various levels of archaeological potential. The project will offer the public administration the opportunity to be provided with a well-calibrated tool for the specific needs of a multi-layered urban context, which – if adopted alongside the Strategic Plan (under review for Pisa) – will help local governing bodies. Thanks to this tool, the public administration will be able to offer a service to citizens and provide preventive indications to private individuals regarding the notice of commencement of works (Dia) and planning permissions, in order to facilitate accurate evaluation of the intervention area, make planning variations and estimate the cost of an archaeological investigation. This service will produce indirect cooperation between the public and private sector in the protection of archaeological heritage. Pisa will thus be able to test the application of a new method for local governing bodies. The reproducibility of the model in many Tuscan and Italian cities presenting the same problems will place Tuscany at the forefront in this sector.

Alongside standards that regulate fieldwork recording, a series of good practice standards need to be set up regarding the IT procedures to be used for protecting digital archive design, implementation and preservation. Standards guarantee compliance with restraints related to the forms and contents necessary for coding and normalising categories of objects and attributes; digital strategies consist in enhancing documentation, inventory and classification processes, making them easy and simple to use, so as to ensure future access to the archives and long-term storing of archaeological records. The creation of standards also facilitates the exchange of information. Data preservation strategies deal with storage format and supports requirements (longevity, capacity, viability, obsolescence, cost, susceptibility to physical damage), whereas accessibility strategies identify the criteria needed for long-term management (evaluation, ingest, migration, refreshment). The majority of digital data will be developed with proprietary software. Although this choice may be questionable, proprietary software is among the most widely used software and must be taken into account when creating digital archives. Instead, open source software allows possible alternatives to be adopted. The concept at the basis of open data is not so much how the data have been developed but rather that the data are shared and made available to the entire community. The formats chosen to exchange this information (database, CAD, GIS, images, worksheets, texts, metadata), therefore, must focus on reaching as many users as possible. Licences (copyright/copyleft) will be defined for diffusing the archaeological data. Publication of this information (archaeographic publication) and of the interpreted data (archaeological publication), therefore, must be guaranteed as joint curatorship

between the Project Director and Principal Investigator and the subject that has collected and produced the archaeographic data. A right of pre-emption will be maintained for a limited period of time for the archaeological data, nevertheless, the archaeographic data will be free for further analysis through specific open licenses. The consequence of these new procedures is, on the one hand, the possibility to train leading-edge and highly-skilled archaeologists provided with greater competitive know-how in sectors dealing with the development of a knowledge-based society, not only at national but also at European level. On the other, the introduction of parameters for the verification of archaeological knowledge with a view to promoting experimental progress in cultural heritage preservation and valorisation fields.

3. Technical validity, economic validity, relevance and credibility of the project

3.1 Technical validity of the project

The technical validity of the project mainly lies in its innovative aspects from both scientific and technical viewpoints.

Scientific innovation. The Map of Archaeological Potential (still at an embryonic stage in Italy, as seen in the state of the art) is by itself a new product. However, the real innovation of the project consists in automating the calculation of archaeological potential by developing a specific algorithm. The product will not only assure less subjective evaluations but will especially consider a wide range of parameters that would not be able to be otherwise handled.

The Map of Archaeological Potential is a highly competitive tool for the development of a knowledge-based society and will give the Dipartimento di Scienze Archeologiche of Pisa University the opportunity to play a leading role in a strong and fast-expanding sector.

Cultural innovation. The system will provide free access, via the web, to the map which will ensure more effective and aware use and protection of cultural heritage. The need to create open digital archives on an open data basis is the future of archaeology. The innovative character of this project consists in providing a solution with a bottom-up approach capable of involving the entire archaeological community. The project will also focus on changing routine habits and imposing required standards, rather than waiting for the definition of standards and guidelines by institutions appointed with archaeological heritage protection and safeguarding, and their subsequent use by researchers.

Methodological innovation. The multi-disciplinary methodological approach of the project is an innovation in itself. In Italy, issues related to buried archaeological heritage and especially to historic urban settlement reconstruction rarely involve the joint work of archaeologists, geologists and mathematicians. The predictive nature which is inherent to the Map of Archaeological Potential indeed requires an in-depth conceptual definition of the various items that intervene in the determination of the concept of "potential".

Educational innovation. The project will set up a "Laboratory of Methodologies Applied to Archaeological Potential Predictivity" (LabMAPPA). The entire research team will have access to these open operational premises, and educational/scientific training activities will be carried out for students from the three departments (Archaeological Sciences, Earth Sciences, Mathematics). Training will aim at transferring the experimental progress of the know-how and technologies acquired during the various project steps and at creating new R&D experts with strong complementary skills that may be applied to archaeological heritage protection and safeguarding.

Procedural innovation. The project will give great attention to the introduction of standard procedures and protocols. The main innovation lies in the procedural standards relating to the operational practices to be followed when evaluating archaeological impact and in the introduction of new standards for preserving and transferring raw archaeological data. The project will define an operational protocol in cooperation with the Soprintendenza dei Beni Archeologici della Toscana which will rationalise both resource and timing requirements of archaeological surveys relating to public and private works. The project will allow the protocol to become an indispensable means for guiding planning choices and helping subjects working in the urban development sector, by providing them with targeted and geared indications according to the various levels of archaeological potential. The project will offer the public administration the opportunity to be provided with a well-calibrated tool for the specific needs of a multilayered urban context, which – if adopted alongside the Strategic Plan (under review for Pisa) – will help local governing bodies. Thanks to this tool, the public administration will be able to offer a service to citizens and provide preventive indications to private individuals regarding the notice of commencement of works (Dia) and planning permissions. This service will produce indirect cooperation between the public and private sector in the protection of archaeological heritage. Pisa will thus be able to test the application of a new method for local governing bodies. The reproducibility of the model in many Tuscan and Italian cities presenting the same problems will place Tuscany at the forefront in this sector.

Technical Innovation. Alongside standards that regulate fieldwork recording, a series of good practice standards need to be set up regarding the IT procedures to be used for protecting digital archive design, implementation and preservation. Standards guarantee compliance with restraints related to the forms and contents necessary for coding and normalising categories of objects and attributes; digital

strategies consist in enhancing documentation, inventory and classification processes, making them easy and simple to use, so as to ensure future access to the archives and long-term storing of archaeological records. The creation of standards also facilitates the exchange of information. Data preservation strategies deal with storage format and supports requirements (longevity, capacity, viability, obsolescence, cost, susceptibility to damage), whereas accessibility strategies identify the criteria needed for long-term management (evaluation, ingest, migration, refreshment).

The cost and scheduling estimate provided in the project feasibility study was based on the analysis and evaluation of the (little) experience already gained in Italy and Europe.

3.2 Scientific validity

With regard to the archaeological approach, the validity of the Map of Archaeological Potential has been directly tested by Dsa during the evaluation of the archaeological potential of the Santa Chiara Hospital of Pisa carried out on behalf of the Comune di Pisa . Regarding the geo-archaeological approach, the map has already been widely tested and used in the field of scientific research applied to the study and protection of archaeological, historical and artistic heritage.

3.3 Economic validity

The project will use well-established procedures and investigation techniques for developing the Map of Archaeological Potential. This will reduce the costs that would otherwise result from the need to test completely new and not necessarily reliable operating protocols.

The project also aims at overcoming the traditional lack of coordination between research institutions and territorial protection institutions which, as is well known, is the cause of expensive public interventions throughout the territory. The coordination between Superintendencies, Local Institutions and Research Institutions will have an impact on the preventive strategy that this project intends setting up, leading to lower costs for public and private urban construction works and general increase in effectiveness.

Furthermore, by combining urban demands with environmental protection needs, the project will provide a valid support to planning technicians so they may implement highly-sustainable intervention projects. Given these characteristics, the project has a strong economic validity, in direct and indirect terms. In direct terms, we refer to the excellent cost/benefit ratio of the project products; in indirect terms, we refer to the economic – intended as savings for the community due to cost reduction – and social impact resulting from the need to merge archaeology, archaeological heritage protection and development.

In brief, the overall project investment will be around 800,000.00 EUR and will include both regional funding and cost-sharing by the research institution. Cost-sharing represents around 30% of the total budget, thus illustrating the strong commitment by both staff (teachers and technicians) and structures (laboratories and libraries). The overall cost of the project is due to the strong research focus (archaeology, geology, mathematics) and, therefore, to the highly specialised manpower. Another reason is also the decision to make high-technology purchases so as to be provided with leading-edge technologies which will allow further development of the research field. At the same time, this means that only research sectors of limited economic impact and low investment value need to be outsourced.

As a result of this financial commitment, the expected results will:

- produce software that does not yet exist in the archaeological sector, capable of placing the proposing subject and Regione Toscana at the forefront in this field of research and development;

- create an archaeological heritage protection tool and management and planning instrument with a strong impact on economy and territorial management;

- purchase high-technology products which will be of use to the research institutions for continuing the research activities and guaranteeing system updating and validity even after completion of the project;

- extend training and dissemination opportunities by extending already existing laboratories, which will give rise to a new inter-disciplinary laboratory (LabMAPPA);

- democratically disseminate all the project results and products through the creation of a project website, its management and ongoing implementation.

Relevance of the project within the scope of regional policies. Given its inherent characteristics, the project is of relevance to at least three scopes of existing regional policies.

a) *Training.* One of the project aims is to train (using the M.A.P.P.A. Laboratory) university or post-graduate students who, consistently with their scientific skills, will be able to interact with colleagues from other research fields and who will have the ability to work in sectors dealing with the evaluation of archaeological potential: this is a sector that will need specialised workers in the future in all those areas where effective protection must be combined with correct territorial planning.

b) *Containment of costs for the implementation of private and public works.* The evaluation of archaeological potential allows favourable and ongoing coordination between heritage protection institutions and territorial protection institutions, significantly reducing costs related to construction or environmental interventions: prior knowledge of archaeological survey costs and the possibility to avoid work stoppages and changes in progress will be of great help to the relationships between private individuals and institu-

tions, in full observance of the rights and obligations of those concerned.

c) *Technological progress*. The development of a conceptual instrument that is able to evaluate archaeological potential on a standardised basis represents progress for scientific research and may find application in specific software for commonly-used systems dealing with territorial data management.

The project will achieve these objectives in a framework of financial sustainability since it avails itself of highly qualified personnel to achieve the project objectives who already work for Pisa University.

The relevance of the project goes beyond national borders: the definition of methodological and operational guidelines among the experts of different sectors means that the research product may be easily exported in many other multi-layered urban areas such as Pisa, in Tuscany and in the rest of Italy. The project is also of relevance to many other European cities, hopefully Mediterranean Countries where, as in Italy, archaeological remains must coexist with the progress and development of urban centres.

4. Capability of the project to create valid network relations

Project implementation and project products will create an operational network which involve the cooperation (each with specific purposes) of the research institution (Pisa University), protection institutions (Direzione Regionale per i Beni Culturali e Paesaggistici della Toscana; Soprintendenza dei Beni Archeologici della Toscana) and the local government, planning and valorisation institution (Comune di Pisa). This *modus operandi* will allow the methodological consideration, at the basis of all project phases, to consider the needs but also the diverse problems of all the subjects to whom the final product will be delivered. The basic idea is to test the effectiveness of the proposal also from this perspective: the operational model will be transferred to users who belong to the same sectors but are located in different geographical areas. This perspective could lead to both a scientific and technological exchange network, first with other cities within the region and then throughout the country.

The creation of a digital archive which is accessible online and useable over time will allow the exchange of information and data between research institutes, professionals working in these sectors and local institutions.

As already mentioned, multi-disciplinarity is a vital issue for the project. Enabling diverse and different disciplines, which rarely interface with human sciences, to consider issues regarding cultural heritage protection is already an important achievement for the project's inter-disciplinary approach. This aspect is further emphasised by the attention given to multi-disciplinary training that drives the project to further excellence.

5. Results

5.1 Expected results to be achieved according to the work programme

The final products (this definition excludes single WP products) that the MAPPA project intends implementing are: the Map of Archaeological Potential of Pisa; the predictive algorithm of Archaeological Potential and related software, i.e. the tool with which results may be replicated in other urban contexts; and the creation of an open digital archaeological archive, whose importance and innovation have already been widely examined. The work programme is divided into four different yet strictly interconnected phases: an archaeological and geomorphological phase aimed at collecting all the data required for describing both the archaeological and geomorphological contexts (WPs 3, 4, 5, 6 and 7); a mathematical phase including study, analysis, model comparison and research activities relating to the development of a predictive algorithm of archaeological potential, and software processing activities (WPs 9 and 11); a data synthesis and processing phase for the creation of the first prototypal products, their testing and adjustment to any changes needed for the subsequent licensing of the finished products (WPs 8 and 10); a dissemination phase that will use multiple paths to implement the open digital archaeological archive (WPs 12 and 13).

All the project phases are structured so as to achieve a series of intermediate results which will ensure work plan functionality and project progress, with a view to implementing the products within the project deadlines.

The four milestones are key aspects of the project: they establish objectives and strict deadlines and at the same time act as a litmus test for verifying the project results.

The first milestone is the definition of the parameters needed for determining archaeological potential: this step will be carried out in WP2 and is necessary for further project activities. The milestone will provide the shared conceptual analysis of the meaning of archaeological potential and define the parameters needed for its determination, i.e. how to translate the items that contribute to the calculation of archaeological potential in an urban area into numerical components. The multi-disciplinary approach that drives the project and determines its innovative profile is laid down during this phase. This first project phase lays the foundations for determining the research phases of the specific disciplines and for planning the training and professional qualification of the research team and external users (belonging or not to the university) receiving training. The project will be implemented at the "Laboratory of Methodologies Applied to Archaeological Potential Predictivity" (LabMAPPA), an open window and physical location for educational/scientific dialogue. Continuous, tran-

sversal and multi-disciplinary training and updating activities will be performed here. Training will consist in the gradual and ongoing transfer of know-how from the research team to future R&D experts and non-university staff as final users of the project products.

The second and third milestones are the creation of archaeological, geomorphological and paleogeographic maps. All the collected and analysed data relating to the city in archaeological and geological terms will be included in a single container; at the same time, the objective of fully diffusing the maps online in web-GIS and in digital publication (e-book) format will be achieved. This an important step that will allow common sharing and exportation of the initial methodological models and will foster an open dialogue with the national and international scientific community.

The last milestone (the fourth) is the development of the prototypal Map of Archaeological Potential. This crucial step is essential for verifying the previous working phases and preparatory to the overall achievement of several general project objectives. Prototypal verification will be performed through experimental and instrumental tests and will weigh up the actual predictive validity of the models of archaeological potential developed. Subsequent product adjustment and preparation of standard guidelines containing operational good practices will allow repeatability of the entire system in multi-layered urban centres presenting similar features. Impact on university research will ensue in the form of instruments that may be used both by local government institutions and ministerial protection institutions.

Last but not least, the creation of an open digital archive and the implementation of dissemination activities, transversal to the entire project and using different communication tools, will achieve one of the project's main goals: making primary data resulting from archaeological surveys in cities accessible and, at the same time, creating a standardised, digital and easy-to-use archiving model that may be applied to all Tuscan and Italian urban contexts.

The entire project stems from the attentive study of national and international research on the issues under examination. After examining the gap of Italian research in this field, British experience and models were especially analysed (see section 1.1.2. "State of the art").

The project layout has been planned so that each single step contributes to either partially or fully achieving the results that intend to be achieved and that are illustrated in section 1. We are convinced that our work programme will broaden the horizons of research and development and will create a common language fostering communication and scientific cooperation through the methodological and competitive development of individual disciplinary sectors. It will also contribute to opening the world of university research (which is often too isolated) to society by providing applications that will improve local governing procedures and by offering new instruments for the knowledge and safeguarding of a common archaeological heritage.

5.2 Dissemination of excellence, exploitation of results, diffusion of knowledge

We have already emphasised how the project aims at contributing to the development of training excellence through multi-disciplinary actions directed towards university education and training, and towards ongoing refreshment and training activities for experts in the specific disciplines and related sectors. These actions, listed in WP13 and already discussed in the work-plan, will be one of the main tools for disseminating the project's scientific and technological progress, and results.

At the same time, we believe multi-disciplinary methodological consideration, which can arise from both the intermediate project phases and final research results, to be a key issue, especially in the archaeological sector. We are indeed convinced that the development of true scientific debate can diffuse knowledge and is a tool for achieving excellence goals. The Italian archaeological research scenario has lacked tangible consideration on methodological issues for several years, due to the inadequate addressing and tackling of many issues related to the knowledge, protection and valorisation of Italy's immense national archaeological heritage. We truly believe that this project will be able to stir action and foster fruitful dialogue outside the proposing research group.

We believe the creation of a specific website at the start of the project is a key issue for the project, the first real Italian archaeological open data project. The project website will be vital for achieving the objective of spreading in an easy-to-use and democratic manner information about the city's archaeological heritage.

We are convinced that archaeological data are public data that can foster knowledge sharing and preserve common historical memory; for this reason, we believe that the network is the most effective tool for diffusing the project results and any difficulties and issues encountered during the research activities. We also consider it the quickest and most cost-efficient tool for reaching wide audiences. The project dissemination and transfer plan will be spread during the entire project through the network and will allow full access to data. Project activities may be checked with the aim to create a source of public information for subjects working in the same fields. Examples are the daily difficulties encountered by Italian archaeologists when accessing data for their work; these data, although of public property, remain closed in archives that are difficult to access or for the exclusive use of whoever has collected them, thus hindering the natural development of research and its intrinsic mission.

The website is also the area where three fundamen-

tal project milestones will be published: the Archaeological Map, the Map of Archaeological Potential of Pisa and the standards. The maps and standards will be accessible through the specifically-created web-GIS and through two e-books which may be downloaded according to the methods agreed upon between Pisa University and Regione Toscana.

The English version of the website and its contents focus on obtaining wide dissemination of the research results and data. The decision to publish the project results in English is based on the need for archaeological research, especially research related to methodological practices, to branch out towards the international scientific community. The national and international scientific community will, therefore, benefit from this, but also experts working in the sector, especially archaeologists and administration institutions, along with professionals, architects, engineers and urban engineers working in the urban sector.

The decision to make the operational guidelines available on the website allows the following consideration to be made: archaeological research does not focus on historical knowledge or heritage enhancement but leads to a direct impact on employment and on the programmatic decisions relating to the development of our towns and cities. This has not been fully understood yet and we believe that our work may contribute to its acknowledgement.

Lastly, we believe that the diffusion of our research and its results via the web could be of use to a wider audience: people who are interested or just curious about the project could become familiar with a new tool that will help them understand the city they live in.

Likewise, the software produced during the project may be used via the website and spread using open source licenses.

6. Ethical issues

The project will be the first truly open-data project in Italian archaeology: a series of problems ensue from this, which mainly regard the diffusion of the archaeological data.

As already mentioned, archaeologists often have the bad habit of considering fieldwork data, for which they are responsible or coordinators, as private property (although they are nearly always publicly funded) and of not informing the scientific community until publication. Unfortunately, the data are often published years after the investigation; they hardly ever include the raw data of the archaeological excavations but simply provide a historical reconstruction. As a consequence, it could be difficult to access certain archaeological data which are required for creating the Map of Archaeological Potential. In the specific case of Pisa, this risk is rather limited since most recent investigations have mainly been conducted by the project research team which will consequently provide all the information in its possession.

The project seeks to encourage "virtuous behaviour" by immediately diffusing excavation data: this is an essential prerequisite for knowledge of the territory and evaluation of archaeological potential, which are at the basis of safeguarding and correct planning. This does not mean, however, that the rights of whoever has produced the data with his/her own fieldwork must not be respected.

During the two-year term of the project, therefore, it will be important to consider the possibility of ensuring rapid and complete circulation of information, without damaging the study and development needs of researchers who must be able to formulate their historical reconstructions according to the deadlines and methods they consider more appropriate.

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Appendix

List of WPs (Work Packages)

WP	Titolo
1	Project management
2	Conceptual analysis and definito criteria
3	Paleogeographic reconstruction of the urban area of Pisa based on geomorphological and stratigraphic data
4	Relational Database
5	Collection of archaeological data
6	Development of Archaeological Map
7	Collection of historical mapping data
8	Development of prototype of the Map of Archaeological Potential
9	Archaeological potential algorithm research
10	Development of the Map of Archaeological Potential
11	Implementation of archaeological potential software
12	Open Digital Archaeological Archive
13	Dissemination and training