Strategies and technologies for the knowledge, conservation and enhancement of a great historical settlement: Chan Chan, Perù

Francesca Colosi\textsuperscript{1}; Roberto Gabrielli\textsuperscript{1}; Eva Savina Malinverni\textsuperscript{2}; Roberto Orazi\textsuperscript{1}

\textsuperscript{1} CNR, Istituto per le Tecnologie Applicate ai Beni Culturali, Monterotondo (RM), Italy; \textsuperscript{2} Università Politecnica delle Marche, Dipartimento di Ingegneria Civile, Edile ed Architettura, Ancona, Italy

1. Introduction
The Italian Mission in Peru (MIPE) has been working on the archaeological site of Chan Chan from 2002 in collaboration with the Ministerio de Cultura of Peru. The first task it was the documentation and restoration of Palazzo Rivero, the smallest and the most recent of the great monumental enclosures that characterizes the ancient town, with the aim of both studying the organization and function of this specific type of architecture and to expand the touristic area of the archaeological site. Soon, however, we realized that the problems related to the archaeological complex are varied and it is not possible to address the issue of the conservation and enhancement of a single monument without considering all the elements that compose the urban structure and the surrounding territory. In fact, although it is inscribed in the UNESCO World Heritage List, Chan Chan is suffering from a structural deterioration due to its building technique (mud brick or adobe), but also from an equally dangerous degradation due to the rapid urban growth of the nearby town of Trujillo and to migratory movements, still difficult to control.

In an attempt to stop the degradation of the complex, the Peruvian government, pressed by UNESCO, in 2000 approved the Plan Maestro de conservación y manejo del Complejo Arqueológico Chan Chan, redact by Instituto Nacional de Cultura, (today Ministerio de Cultura). The Plan Maestro has a number of projects and sub-projects aimed to enhancing the complex and its territory with the purpose of helping the socio-economic development of the population. The MIPE intends to support the actions foreseen by the Plan Maestro participating to its revision and updating and following three main objectives: the planning of the Archaeological Park of Chan Chan, the restoration and the virtual visit of Palacio Rivero and other peculiar architectonic typologies and the baking of local handicraft and tourism by mean of training courses arranged also with the help of the international cooperation. In order to achieve these objectives, taking into account the impressive dimensions of the site, it was very important to take advantage of the potentiality of new methodologies of investigation: the remote sensing techniques and the ICT processes to organize and archive the geodatabase; the modern acquisition techniques, such as laser scanner, to arrange a 3D surveying, to reconstruct in virtual way the emergencies and by means other multimedia solutions to spread the whole site by virtual visits.

In the paper, after a first part devoted to the description of the site, we will illustrate the work of the MIPE in relation to the above-listed objectives, describing the results achieved and the future prospects of research and planning.
2. The archaeological complex and its territory

2.1 The urban structure

Chan Chan, the greatest settlement of Latin America built in adobe, was founded during the IX century A.D. and represents the most important material expression of the Chimú culture, one of the various civilizations that arose along the northern coast of Peru before the Incas conquest (1475).

The town occupies a very large area of the Moche valley, at about 600 km north of Lima, and it is placed on a natural terrace that decreases towards the ocean (from 40 to 20 m above the sea level) (Fig.1).

The agriculture was the main source of sustenance and its diffusion was assured by a highly developed irrigation system. A series of channel transversely connected the various rivers that from the mountains flow into the Pacific Sea and distributed the water to the fields, winning the desert and bringing prosperity and wellness.

At the height of its expansion the city spread over 20 Km², out of which only 14 Km² are preserved today. Of these, 6 Km² belong to the urban zone, where nine palaces or ciudadelas were built, as well as numerous semi monumental complexes, known as elite compounds, five huacas or temples in the form of stepped pyramids and four extensive popular quarters constructed with a building technique named quincha, which consists in a mixture of mud on a structure of reeds and wooden posts [Moseley, Kent 1982; Kolata A.L., 1990, 107-144; Campana Delgado 2006].

The traces of the strong relationship between the town and its territory are still recognizable in a network of very long and pedestrian paths, often elevated and still in use, which allowed the functional distribution of the urban settlement and connected the town with the sacred areas, the cultivated fields and the huachaques.

These last are sunken fields near the sea that, exploiting the natural depressions of the terrain, are fed directly by the subsoil humidity (at the bottom in Fig.1). In the huachaques the campesinos cultivated the totora, a typical reed...
used for the constructions and for the fabrication of mats, baskets and small boats.

2.2 State of conservation
As mentioned above, the structures of Chan Chan have been suffering a continuous deterioration in these last centuries, due to human and natural factors. From the colonial period some “Companies for the exploitation of the Huacas” were founded and regulated with a Royal Decree in 1570. The “legal” work was then flanked by the huaqueros or grave robbers (still at work), while other damages are deriving from an uncontrolled agricultural activity inside and outside the palaces.

For what is regarding the natural factors, the main dangers are represented by the salts which are affecting the walls of Chan Chan and by the phenomenon of “el Niño”, a warming of ocean currents that produces high evaporation and very heavy rainfall.

At the territorial level, a very big problem is represented by the uncontrolled growth of the nearby city of Trujillo. The economy of Peru, which in recent years has been characterized by an increase of approximately 6% concentrated around the major urban centres, has caused the displacement of the inhabitants from the remote villages of the sierra and selva to the urban suburbs. A series of abusive agglomeration named pueblos jovenes were formed, without any type of service such as running water or the collection of garbage. In the area between Trujillo and Chan Chan the pueblos jovenes are in contact with the perimeter of the archaeological area, especially along the north and north east part of the complex.

3. Territorial analysis and GIS
The process of conducting an archaeological survey as investigative method, is dependent upon context. It requires the ability to accurately record field observations and their geographic location. Recent technological innovations in GIS, satellite imagery and mobile technologies have allowed for greater precision and efficiency in reporting. This part of the research presents the integration of GIS technology with archaeological survey. The GIS data arrangement, aided by different type of data processing, has allowed, during the research, to obtain a dedicated cataloguing to manage the data for the publication of different products, multimedia too. The improvement of the GIS data stored has allowed additional analysis, to retrieve new information about environmental and human settlements, discovering the relationships with the other heritage goods close to the site, increasingly the knowledge of themselves and introducing these information to the community of visitors.

The method for collecting data has been determined by a variety of factors, which can be chosen to balance the necessity to identify accurately the archaeological elements but also to make efficient and satisfactory the survey of the site. To take into account the intensity and the extent of a wide archaeological area it was necessary to organize the survey in units which can be natural field boundaries, roads, terraces, changes in vegetation, building ruins and so on. Not always it was easy to establish survey units on the ground. When
the time changes the aspect of the territory and the site is wide it is difficult to reconstruct accurately irregular units into a mosaic of coverages. The aerial photogrammetric surveying, made of Harvard University (Moseley, Kent 1982) (Figure 1, on the right) and the updated knowledge by the Quickbird image have been an important aid to guide the surveying on field and to recognize some archaeological emergencies. The different coverages have been organized in GIS layers with attributes. First of all the Amortiguamiento and the Intangible define the boundaries of the archaeological area and hold its presences. Following the Caminos localize, when it is possible, the ancient paths (roads), sometimes sacral, useful to analyze and understand the dynamic of growth of the different urban structures of the ciudadela. The hard work has been the surveying (till in updating), by a mobile DGPS, of many Estructuras arqueologica characterized by different uses. The list includes: Huachaques, Cementerio, Barrios Populares, Plataformas, Palacios, Residencias Elite, Huacas (Fig.2).

3.1 GIS documentation augmented by virtual visits
To increase the possibility to explore the heritage site in each aspect, we also realized some hyperlinks in the GIS, to retrieve the summarized knowledge of the Chan Chan structures, coming from the Master Plan (Plan Maestro) documentation, approved by the Peruvian Government in the year 2000. This descriptive report sheets give a short description of the different aspects of the site, useful not only to the experts but also to have an overview for all the visitors (Figure 3). Another opportunity in the GIS it is the possibility to explore the site in virtual way. Some virtual tours can be showed by hyperlinks too. They, collected from different strategic point of views into the heritage site and geolocalized by a mobile GPS, have been realized expressly for a pre-visit of the
site. The virtual tours have been enhanced adding the descriptive report sheets told above, displayed in PDF format selecting the related hotspot (Fig.4). However there is also the necessity to introduce the heritage ruins directly on-site, because of these are not always accessible, the visitor route is sometime not safe or difficult to explore and the ways are long and dangerous. At this point the panoramic tour will be shared on web for a widespread dissemination of the information and will be located in the Museo de Sitio giving the better solution for a preview knowledge of the site for the visitors.

4. Architectonic analysis and virtual reconstruction of some structures
In relation to the task to have a greater knowledge about some archaeological emergencies, the choice to focus our attention on Palacio Rivero has been determined by two factors. The first, for all practical purposes, it is close to Palacio Tschudi, the only archaeological emergencies currently restored and open to visitors. The aims are to extent the visiting area and create another tourist pole within the site. The second factor is that Palacio Rivero, small and well-preserved, is organized according to a typical tripartite plan that is common to many ciudadelas of Chan Chan and it could represent a model for the
study of the Chimú organization and culture. For this reason we decided to create a three-dimensional model of the building that can be made available to scholars and tourists, also through virtual reality solutions. Moreover the three-dimensional documentation represents a fundamental element for planning the restoration works.

In order to perform the 3D survey we are using, in the course of time, different types of technologies. In the first two years of the research mission we realized a contour lines survey by means of a differential GPS used in cinematic mode [Colosi and Orazi, 2003, 465-474], while in the following years advanced photogrammetric and topographic methods have been experimented in integrated way. To survey the external walls of the building we used the close range photogrammetry by means of triplets of overlapped images, while to detect the very articulated first sector of the ciudadelas we preferred to apply an aerial photogrammetric method based on the use of three cameras shooting simultaneously and hanging from an aerostatic balloon (Menci Fly-Scan system) [Colosi et al., 2009, e27 – e34; Colosi et al., 2011, 244-251]. The second and the third sector of the palace are characterized by large open spaces, by regular rows of warehouses and by the plataforma de entierro, the tomb of the sovereign, which looks like a great mass of earth where it is difficult to recognize the original shape of the monument. Due to the characteristics of these structures, it was decided to operate with the CAM2 Laser Scanner Focus3D. Considering that the view from above provides the best results in the survey of the lunar landscape of Chan Chan, the laser scanner has been mounted on a telescopic rod that can be raised up to 5 meters (Fig.5, on the left). The survey has been carried out with about 160 station points whose range maps have been aligned by means of total station measurements and connected by targets with the topographic network of the first sector. In the Fig.5 (on the right) is represented the 3D survey of the Plataforma de Entierro that shows in detail the large number of cavities inflicted on the original stepped pyramid by the interventions of the Conquistadores and huaqueros and highlights some parts of the walls that still preserve their original shape. In Figure 6 the result of the 3D survey of a warehouses area as point cloud is shown; successively the virtual reconstruction of the warehouses of the second sector coming from

Fig.5 - Survey of the second sector of Palacio Rivero. The laser scanner has been mounted on a telescopic rod (on the left). 3D survey of the Plataforma de Entierro (on the right)
laser data and some historical information. For the same reason told above, we mean to create virtual reconstructions of the main architectural typologies of Chan Chan area, to show them in the Museo de Sitio, with the purpose to help the tourists to orientate themselves among the ruins, not always easy to read or find.

5. Program for the enhancement of the monumental complex

In Chan Chan the tourist currently has only the possibility of a short visit to the Museo de Sitio and to Palacio Tschudi. The project of the Archaeological Park foresees, instead, that the tourist can spend an entire day in contact with the different aspects of the ancient town. The plan of the Archaeological Park wants to point out, therefore, the definition of a set of “constituent elements” that may become as many poles of attraction to discover the architectural and natural landscape. The Archaeological Park will be organized in order to highlight some territorial elements with specific functions (museum activity, observation points, reforestation areas, archaeological sites, recreational areas for children etc.) that will be connected through predetermined paths accessible by means of electric locomotion. The tour of Chan Chan could start from Huaca Obispo, a natural lookout of the whole complex, then could go to Huaca Olvido, a small sanctuary with an entirely reconstructable volume, proceed to the still intact warehouses of Palacio Laberinto and Palacio Uhle, pass through the Huachaques where the totora was cultivated, with a view of the nearby ocean, until arrive to the network of paths, often elevated with earth embankments on the surrounding fields, and to the Camino Cerimonial. An example of the same itinerary was made by the virtual visit, carried on in the course of 2012 and based on twenty-eight 360° panoramic views and will be showed in the Museo de Sitio.

The enhancement of Chan Chan is also related to the rediscovery and exploitation of traditional activities connected with the archaeological site, such as the cultivation of some species of plants or the development of the historic handicraft. In order to achieve these goals, the MIPE has promoted agreements between Italian and Peruvian organizations and has carried out, in collaboration with the Instituto Italo Latino Americano (IILA) and financed by
the Ministry of Foreign Affairs and by the Lazio Region, a program for the “Support to the socio-economic development of the area of the Archaeological Park of Chan Chan and its territory” which included training stages for experts in the field of cultural heritage and training courses for craftsmen of ceramics [Colosi and Orazi, 2001]. The courses were aimed at the refinement of the professional skills of young artisans working in ceramics, at the construction of a permanent handicraft laboratory and at the creation of a network of “quality pottery”. According to this perspective, the archaeological resource becomes a key element in the socio-economic and cultural growth of the La Libertad region.

Conclusions
The archaeological site of Chan Chan has such dimensions that cannot be studied and managed without the aid of modern analysis and management tools. At the same way, the construction technique of adobe involves considerable problems of documentation and conservation that can be partially solved through the integration of methodologies for the data collection and cataloguing. The remote sensing analysis has allowed identifying unknown archaeological remains and defining, on the basis of these findings, a wide buffer zone that must be protected and safeguarded. The management of the data within the GIS will be very useful for the officials involved in the protection of the territory. Moreover, the GIS is an important tool of analysis and research that has allowed us to reconstruct the planning scheme of the ancient town. The individuation of the different functional areas (residential quarters, popular quarters, agricultural areas, sacred structures, monumental tombs, cemeteries) and the reconstruction of the connecting roads between the religious, political and economic nucleus has shed new light on the social Chimú organization [Colosi and Orazi, 2011, 139-172]. A so articulated ancient urban centre cannot be quickly and partially visited as it is today. Palacio Tschudi represents only the 1% of the whole archaeological site and it cannot explain, by itself, the beauty of the monumental complex and the landscape. It is, therefore, necessary to plan new touristic routes and, with the help of the 3D surveys, to rebuild, in virtual way, the impressive architecture, now partially destroyed. Chan Chan is a fundamental resource for the La Libertad region, and then must be exploited and well introduced to the international community. The museum, from this perspective, must become a central reference to manage and connect each features of the territory where the tourist can be led to the discovery of a fascinating culture and of ancient traditions still living among the local population.

References
Colosi F., Fangi G., Roberto G., Orazi R., Angelini A., Bozzi C.A., 2009, Planning the Archaeological Park of Chan Chan (Peru) by means of satellite images, GIS and pho-
togrammetry, «JCH», 10, Suppl. 1, pp. e27-e34.