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DISCOVERING CHAN CHAN: MODERN TECHNOLOGIES FOR URBAN AND ARCHITECTURAL ANALYSIS

1. Introduction

Chan Chan is situated about 550 km North of Lima along the northern coast of Peru. The territory is characterized by mild temperature despite its position between the Equator and the Tropic of Capricorn because of a cold water stream (the Humboldt stream) running along the coast of a great part of South America and producing a sea with plenty of fish and rich in plankton. Unfortunately, when warm water streams come in, there is a rise in temperature, which causes abundant rain and floods. This phenomenon, which usually takes place near Christmas time, has been called *Niño*. It was already known by the population of Chan Chan since they positioned their buildings and houses on an alluvial platform in front of the sea. As such, the town has rarely been touched by the water floods. It is also protected by a stone wall built between the town and the mountains (Piminchumo Hurtado, Galvez Mora 2003).

Chan Chan was the political, administrative and cultural capital of the Chimu Empire, one of the various civilizations that arose along the Peruvian coast since the beginnings of our era and which represents the greatest pre-Columbian settlement built in mud bricks or *adobe*. Agriculture was the main source of sustenance, and its diffusion was assured by a highly developed irrigation system. A series of channels transversely connected the various rivers that flow from the mountains into the Pacific Sea and distributed the water to the fields, challenging the desert and bringing prosperity and wealth to the town.

The town of Chan Chan was built around the 850 A.D. and continued to prosper for over six centuries, reaching its maximum expansion in the last historical phase (1300-1470) with a population of about 35,000 inhabitants. The capital was conquered by the Incas around 1470 A.D. Its population was decimated and the city was abandoned. Michanzaman, the last ruler of the dynasty, was conducted to Cuzco together with the goldsmiths, the administrators and the most important officials. When the *conquistadores* arrived on the site, the powerful Chimor Empire was reduced to a local chiefdom tributary to the Incas. Though it is inscribed in the UNESCO Word Heritage List, Chan Chan is suffering from a dramatic material and urban decay. This process is not only a result of natural causes, such as its proximity to the sea, the presence of marine salts, strong blowing winds, but it also due to human factors, such as the activity of the *huaqueros* (grave robbers) since colonial times, the continuous invasion of the site by *campesinos* and especially, the

uncontrolled growth of the nearby city of Trujillo, which is encroaching more and more onto the archaeological complex.

The various operations of conservation conducted by the Ministerio de Cultura (Ministry of Culture) are summarized in the *Plan Maestro de conservación y manejo del Complejo Arqueologico Chan Chan*, approved by the Peruvian Government in the year 2000. The *Plan Maestro* is organized in 7 programs and 153 projects related to the investigation, conservation, valorisation, protection and promotion of the site and its territory with the aim of supporting the socio-economic development of the local population.

The Italian Mission in Peru (MIPE) of CNR-ITABC has been operating in Chan Chan in collaboration with Ministerio de Cultura since 2002 with the aim of fighting the architectural and territorial decay and favouring the archaeological, economic and social valorisation of the site together with the development of tourism. In this regard, the MIPE has been pursuing three main objectives: the planning of the Archaeological Park of Chan Chan, the restoration and the virtual visit of Palacio Rivero and the support of local handicraft and tourism by means of training courses organised with the help of international cooperation.

In order to achieve these objectives, while taking into account the impressive dimensions of the site, it was very important to take advantage of the potential of the new methods of investigation, such as remote sensing techniques, ICT processes to organize and archive geographical data, and the modern techniques of speed and three-dimensional survey. The integration of different methodologies of analysis and the joint work of specialists of different disciplines have strongly encouraged our research, allowing us to compare a variety of data and leading to new and interesting interpretative hypotheses. The use of new technology has also favoured other operative aspects, such as the planning of the Archaeological Park or the creation of the three-dimensional model of Palacio Rivero.

2. Chan Chan, a prehispanic settlement

2.1 *The archaeological site*

The most populated part of Chan Chan covers approximately 6 km², but the whole urbanized territory, which included urban and suburban paths, cultivated fields, walls and channels, spreads over more than 20 km², producing an extremely complex and articulated urban structure that reflects a high level of social and economic organization (Fig. 1). The central area presents nine monumental enclosures named palaces or *ciudadelas* and five *huacas* or stepped pyramids. Inside the *ciudadelas*, there were wide ceremonial squares, small courtyards decorated with niches containing a small U-shaped room

Fig. 1 – Chan Chan. An aerial view of the monumental site (photo Consorcio Chimú, Odebrecht – Graña y Montero 1990).

with a presumable ceremonial role (*audiencias*), a great number of warehouses and, in an internal and isolated area, the tomb of the sovereign, or *Plataforma de Entierro*, which also has the shape of a stepped pyramid.

The *ciudadelas* perimeter walls exceed, in some cases, 10 m in height and 700 m in length. All the enclosures are always aligned in a N/S direction, with an entrance door generally located at the centre of the northern side. Starting from 1100 A.D. (Chimu Medio), the enclosures assumed a typical tripartite plan that characterizes, more or less unchanged, all the palatial complexes until the construction of Palacio Rivero, which is the most recent palace of the *ciudadelas* of Chan Chan (Kolata 1982).

The *huacas* were constructed with mud bricks and stones and normally located inside fenced areas. The biggest ones can be found in Toledo and Obispo. However, both of them were destroyed in the time of the *Virreinato*, and therefore, it is impossible to reconstruct them. As regards their function,

the discovery of rich graves within their structure has suggested that they might have been elitist *plataformas de entierro* or monumental religious buildings. Numerous small *huacas* are widespread in the eastern part of the territory being probably connected with the cultivated fields and the *huachaques*. Though located near the sea, the latter are fields sunk in fresh water, which, by exploiting the natural depressions of the terrain, are fed directly by subsoil humidity (Fig. 1, lower part of the picture). In the *huachaques*, the *campesinos* cultivated the *totora*, which is a typical reed used for the construction and fabrication of small boats called *caballitos de totora* (Campana Delgado 2006).

The population of Chan Chan lived all around the *ciudadelas*, with different residential accommodations that revealed their social status. On the basis of the hypothesis of some experts at Harvard University, the aristocracy occupied some big complexes, defined elite compounds, which are in quite degraded condition today (Klymyshyn Uliana 1982, 119-120).

On the contrary, the common people lived in popular quarters constructed with *quincha*, a building technique that required a mud mixture on a structure of reeds and wooden posts. The excavations made by Harvard University archaeologists in the 70s showed that these rooms, called SIAR (Small Irregularly Agglutinated Rooms), were mostly destined for an urban proletariat engaged in handicraft activities, such as metallurgy, weaving and carpentry (Topic 1982). The different elements that constitute Chan Chan and enrich its territory are interconnected through a dense network of often elevated pathways that crossed the cultivated fields in order to reach some strategic points which were particularly important from a practical or ceremonial point of view. The routes directed to the N (*Camino Viejo y Camino Ceremonial*) led to the large channels of irrigation, whilst several paths connected the centre of the city with cultivated fields and gardens and with temples and *huacas* distributed throughout the area.

Therefore, the monumental complex of Chan Chan is characterized not only by an extraordinary extension, but also by an internal organization and a richness of architectonic and decorative elements that make it one of the most important archaeological sites of Latin America.

2.2 *Technologies of analysis*

A specific GIS was implemented to study the wide area of Chan Chan and to provide a plan for site maintenance. Year after year, many surveying campaigns have collected a lot of information by means of different surveying techniques: remote sensing, photogrammetry, laser scanning, GPS and other integrated technologies. The interaction between the collected data and the geographical information tools in a multidisciplinary approach has been

useful for the study and management of the archaeological complex and its territory. The mapping core is based on the historical archives of maps and aerial images and new remote sensing orthoimages with different spatial and radiometric resolutions. The conceptual model has put in relation different kinds of data and several archaeological objects and has defined the performance of GIS according to a range of topics.

Many acquisition steps are already present in literature: GPS surveying, line plotting coming from aerial images, DTM and the orthoimage draped on it by digital photogrammetric procedures, automatic land use classifications (unsupervised and fuzzy) coming from the Quickbird image analysis (Fangi, Malinverni, Schavoni 2005; Galli, Fangi, Malinverni 2005; Malinverni, Fangi 2009). The remote sensing automatic classification was useful to investigate the land use of the archaeological area at large and to analyze urban growth dynamics with respect to the cultivated area in order to plan the "intangible" area of the Archaeological Park. Furthermore, by classifying the features of the archaeological structures, it was possible to discover new findings inside the intensive cultivations, such as the probable remains of a typical *huaca* (Fig. 2). On field, we used integrated surveying techniques, such as traditional measurements by a tachometry and GPS (DGPS) acquisitions by a mobile device using a Stop&Go kinematic method, placing the master station on the roof of the Chan Chan museum. The survey was also integrated by means of the photogrammetry.

All the coordinates were referred to the ellipsoid WGS84 and subsequently transformed to the UTM reference system (zone 17S) and Provisional South American Datum (PSAD) 1956, Peru. The ellipsoidal heights were corrected to gravimetric elevations by subtracting the constant value of 10,147 m.

The survey assessment and continuous updating were done by superimposing the data on the satellite image in the GIS. The GIS layers collect and organize the data related to the archaeological structures and the attributes define their spatial characteristics and different uses. First of all, the *Amortiguamiento* area (buffer zone) and the *Intangible* area define the boundaries of the archaeological complex. Then, the *caminos* localize the ancient paths (roads), sometimes of a sacral character, useful to analyze and understand the dynamic growth of the town. The list of the principal archaeological emergencies includes: *Huachaques*, *Cementerios*, *Barrios Populares*, *Plataformas*, *Palacios*, *Residencias Elite*, *Huacas* (Fig. 3).

The spatial and thematic organization of each entity is useful to document and analyze the structures, and overlay mapping has allowed us to study the relationships between them and the landscape. This is useful to highlight different topics in order to discover new historical dependencies, assess the correctness of data input, suggest some remarks, and involve the use of a new multidisciplinary methodology (Fig. 4).

Fig. 2 – The fuzzy unsupervised classification evidences the archaeological structures and the findings of one typical terrace pyramid (*huaca*) inside an intensive cultivation.

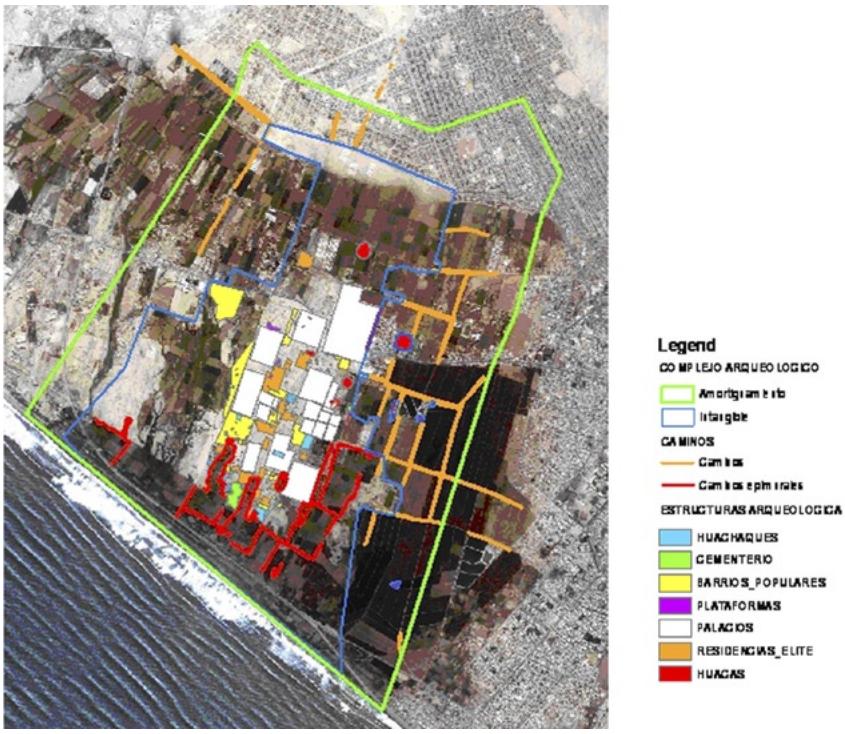

Fig. 3 – GIS of Chan Chan.

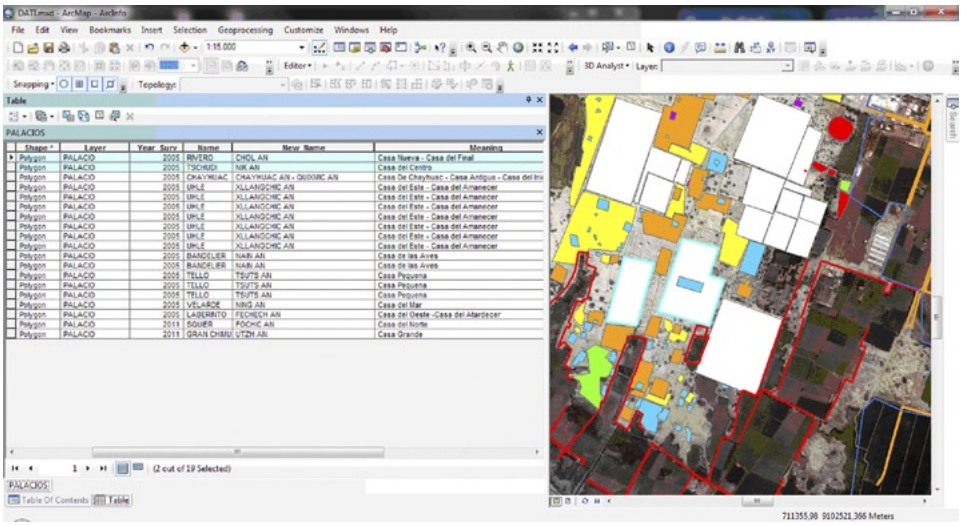

Fig. 4 – Spatial selection of two "Palacios": Rivero and Tschudi and their attributes.

Furthermore, the geo-database can be opened to a web solution in the future. In fact, in order to allow the widest possible dissemination of information, it is advisable that the system is accessible on the network, not only to share the knowledge among other scientific users but also to promote tourism.

2.3 *Data interpretation and urban structure*

The archaeological territorial investigation and topographic surveys of Chan Chan helped us to hypothesize a structural organization of the town, which was then clearly revealed by GIS processing (Fig. 3). We know from past investigations and literature that the town had three different periods of development, during which *ciudadelas* and *huacas* were constructed in different parts of the territory without any definite connection among them (Kolata 1990). The city was clearly built without a unitary plan. There were no perimeter walls, no main squares and, except for the *Camino ceremonial*, which connected the sea with the sacred peak of Cerro Cabras by means of one direct axis, there was no main urban landmark. In the absence of common areas of aggregation, all the political, commercial or religious functions were carried out within the walls of the *ciudadelas* and in the context of the emerging families.

Nevertheless, we can notice the agglomeration of specific architectural structures in some parts of the territory, such as the elite compounds

in proximity of the palaces, the *huacas* in the northeast part of the city and the necropolis areas in the southern part, just in front of the sea (in green in Fig. 3). The location of the necropolis is particularly important since it shows that the Chimu did not use to bury their dead inside the town since they had destined for this purpose a specific zone at the extreme limits of the urban area.

All the stepped pyramids (in red in Fig. 3) are located northeast of Chan Chan, immediately attached to the paths leading to the cultivated fields and in direct contact with the places of production and sustenance, indicating a close link between agricultural production and the probable propitiatory rituals celebrated at the beginning of the good season (Campana Delgado 2006). The popular quarters (in yellow in Fig. 3) are distributed predominantly on the western border of the town and along the *Camino ceremonial*, while some other small agglomerations of popular houses are spread on small reliefs of the urban territory in a slightly predominant position. Those houses were placed on an artificial platform and belonged to a middle class population connected with the life of the palaces such as ritual kitchens or artisans' laboratories (Topic 1982).

In order to remember the importance of fresh and drinkable water, we have to consider the wide distribution of wells and cisterns, also called *huachaques*, in different parts of the town. They were often fenced and protected by a guardian living in a small hut nearby. A dense network of paths (in orange in Figs. 3 and 4) linked the city with the cultivated fields to the E, the areas planted with the *totora* reed to the S (*caminos epimurales*, in red in Figs. 3 and 4), and the sacred peaks to the N. Therefore, we can assume that the town had a widespread urban plan, which, beside the urban area, had other small aggregates, as evidenced by the analysis carried out through regional satellite images and data fusion techniques. On that occasion, we found traces of buried structures positioned outside the intangible area and with an urban plan comparable to that of an elite compound (Colosi *et al.* 2009, 31).

The first topographic surveys, the use of high-resolution satellite images, the geo-referencing of the key features of the territory and the analysis of the anthropic settlement by means of a specific GIS give us an idea of extensive irrigation systems, large agricultural areas, elevated routes surrounding the *huachaques* and different architectural elements of the town. All these characteristics, even in the absence of a specific urban design, are evidences of an extremely organized and efficient territorial planning which, together with the organization of the local resources and the exploitation of the rivers descending from the Andes, have rightly allowed scholars to define the Chimor Empire as «the most powerful hydraulic State that the ancient Peru has ever known» (Lavallée, Lumbreras 1986).

3. Architectural investigation: the ciudadela Rivero

3.1 *The spatial organization of the palace*

Rivero or Chol-An, according to recent re-nomination, is the smallest and the most recent palace of Chan Chan and has the typical tripartite spatial distribution that characterizes the majority of *ciudadelas*. The palace consists of a northern public sector, a central sector reserved for the king and his burial and a last southern sector, free from construction and occupied by wells for water supply and by areas for small orchards.

Among the palaces of Chan Chan, all surrounded by a wall, Rivero is the only one to have a double perimeter wall (Fig. 5, C). The outermost is in *adobe*, and the innermost is in *tapia*, which is a conglomerate of stones and highly compressed earth, the same high-resistance construction technique of the *plataforma de entierro*.

The most significant elements of the first sector are the large square, located near the entrance and used in public ceremonies, and the *audiencias*, covered by a gabled roof and dedicated to administrative or religious ceremonies (Andrews 1974; Fig. 5, A). The second sector is characterized by the presence of the king's burial site, containing the graves of his concubines and closest servants. This sector also consists of a smaller second square where burial ceremonies were possibly held and a series of warehouses for storage of surplus production.

Finally, another feature of Rivero is the perimeter corridor between the two high walls surrounding the palace with a width of 3.5 m and a length of nearly 400 m (Fig. 5, C). We cannot imagine any other function for that empty and ugly space but that of a first moat for defending the palace or an accidental consequence of different chronological changes (see § 3.3).

3.2 *The architectural survey and the process of knowledge*

3.2.1 Total Station and DGPS survey

The first activities of the Italian Mission in Chan Chan were regarding the architectonical survey and study of Palacio Rivero with the main objective of its restoration. In the beginning, a 2D survey was carried out by using an electronic total station (Colosi, Orazi 2003, 2004). Since the decay of the upper parts of the structures had settled along the base of the walls, it was often impossible to identify the original architectural alignments. Therefore, the total station was used to record the coordinates of those walls whose connection with the ground was clearly visible. This type of survey, using traditional topographical instruments, was crucial to highlight some asymmetries in the distribution of the rooms and especially the strong misalignment of the ceremonial square with the external walls of the palace. This different

Fig. 5 – Palacio Rivero. A) Aerial view of the palace (Quickbird image 2003); B) A view of the internal structures; C) The survey of the double perimeter walls.

alignment, as we shall see, has produced a series of irregular spaces, which suggest a planning obliged by the presence of existing reference elements.

The great deterioration of the walls has created in Chan Chan an almost lunar landscape characterized by the slight undulation of the surface from which the high walls of the perimeter are emerging (Fig. 5, B). Therefore, in order to carry out a complete survey of Palacio Rivero, it was necessary to take into consideration this typical conformation of the ground by creating a 3D survey of the monument. In fact, by only registering three-dimensional data that could document the morphology of the terrain, showing even the minimal variation, it was possible to locate and document some much damaged structures which were hardly visible.

In order to perform this kind of 3D survey, we have used different types of technologies in the course of time. In the first two years, we created a contour survey by means of a differential GPS used in cinematic mode. The great quantity of data which were gathered in this way allowed us to draw the 3D shape of the surface and to enrich our information about the palace. In the ceremonial square of the N sector, for instance, the contour lines evidenced

some regular structures probably belonging to little subsequent constructions and a kind of platform at the centre of the open space with a clear ceremonial character. In the area, at the extreme E of the first sector, the contour lines have revealed small little warehouses that had not been detected previously (Colosi, Orazi 2004).

3.2.2 Photogrammetric and laser scanner survey

These first encouraging results convinced us to create a three-dimensional reconstruction of the building by experimenting advanced photogrammetric and topographic methods in an integrated way. In order to survey the external walls of the building we used a photogrammetric technique based on triplets of images (Menci Software-ZScan) acquired by a camera that moves with regular intervals on a graduated bar (Fig. 5, C). However, in order to detect the very articulated first sector of the building full of small rooms arranged in an irregular manner, we preferred to apply a new aerial photogrammetric method. This is based on the use of three cameras shooting simultaneously by means of a remote control and hanging from an aerostatic balloon (Menci Fly-Scan system). Three operators control and direct the balloon by means of three long cables that are unrolled up to an altitude between 50 and 60 m above ground level. Each shot covered a large area of about 850 m². The connection between the images of different portions of territory, originated from a series of three photographs, was carried out by more than 600 targets placed on the ground and detected with the total station. In this way it was possible to obtain an aerial view of the monument which, in the case of the "rounded" structures of Rivero, was particularly effective and also subsequently useful to produce a 3D reconstruction of the first sector of the building (Colosi *et al.* 2011) (Fig. 6).

The second and third sector are characterized by large open spaces, regular rows of warehouses in very bad condition and by the *plataforma de entierro*, which looks like a great mass of earth making it difficult to recognize the original shape. Due to the characteristics of these structures, it was decided to operate with a laser scanner Faro Focus 3D Multi Sensor 120, a high-speed instrument that takes only 9 minutes for each medium resolution scanning (one point each 6 mm at 10 m) and the contemporary acquisition of photographs. The compactness and lightness of this laser scanner (only 5 kg) makes it easy to transport it by plane in foreign country and to move it on rough terrain such as in the case of Palacio Rivero.

Even though the Faro has an acquisition range of 120 m, a maximum distance of 50 m was maintained for surveying the structures of the palace, according to the logistic situation and required resolution. In fact, the walls of Rivero, which were entirely built with earth, do not show any particular architectural details, but in certain areas a greater resolution is required to

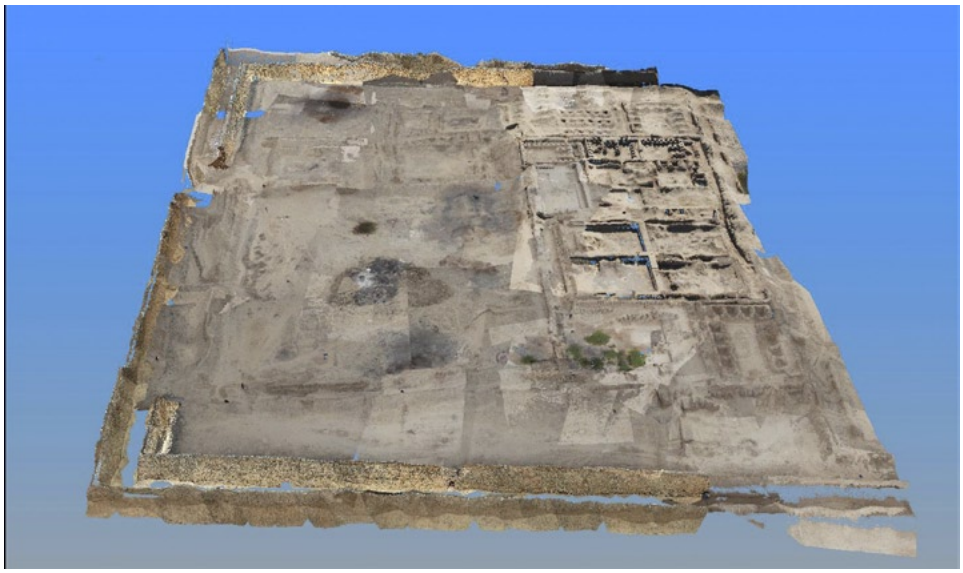

Fig. 6 – 3D photogrammetric survey of the first sector of Palacio Rivero (Colosi *et al.* 2011, fig. 6).

document the characteristics of the building and its state of conservation. The survey of the whole central sector was performed with about 160 station points, using two different reference targets to merge different point clouds. In the case of small and well defined areas, such as little squares or limited sectors of the *plataforma de entierro*, special spheres recognizable by the laser scanner were used (Fig. 7, A). In the case of larger areas, such as an entire block of warehouses, some targets placed on the walls were detected with the total station.

We are currently merging the collected data by using different methodologies. With the help of a total station, it has been possible to position the photogrammetric and laser scanner surveys in a single reference system. The data were processed by using the laser scanner software JRC 3D Reconstructor, which allows us to manage large volumes of data at high resolution and to transform the unstructured point clouds produced by the photogrammetric system to structured clouds with a topographic and structural standardization (Sgrenzaroli, Vassena 2007; Colosi *et al.* 2011).

The aero-photogrammetric survey, as mentioned before, provided satisfactory results especially in the case of many deteriorated structures not very high and without sharp corners that could create shadow zones. In fact, the 3D photogrammetric model is very impressive for an overview from above, but has gaps of considerable size for what concerns the restitution of high and vertical

A

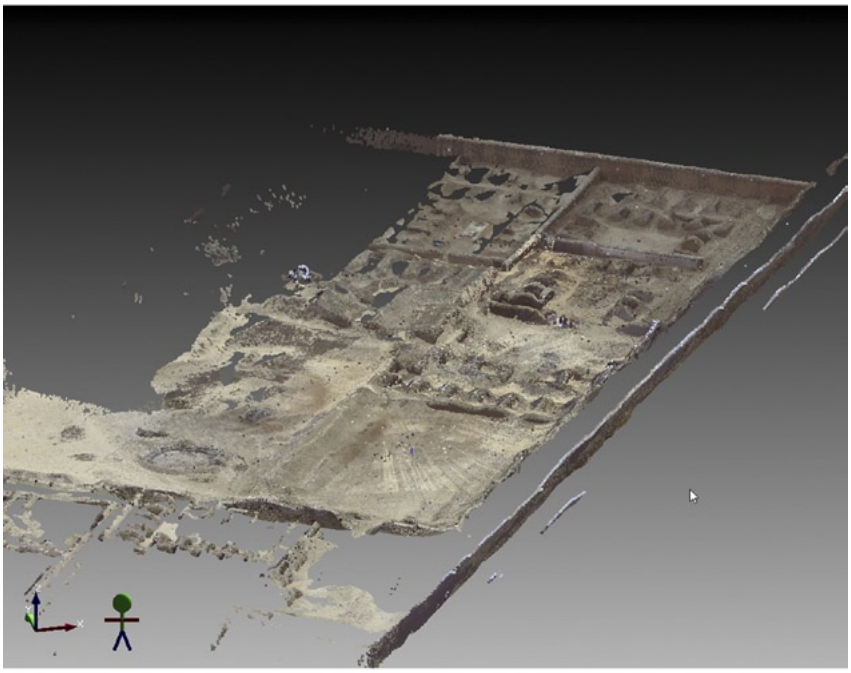

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Fig. 7 – 3D laser scanner survey of Palacio Rivero. A) First processing of the *Plataforma de Entierro*. In the image, the spheres that were used to merge the range maps are visible; B) 3D survey of some warehouses in the central sector.

walls. A second problem is the lack of uniformity of the 3D model surface. The aerial photos do not always have homogeneous brightness and contrast since the light conditions in proximity of the ocean may suddenly change. These differences cannot always be corrected during processing, with the result that the model shows sudden changes in colour and tone between the different shots.

The laser scanner restitution turned out to be more uniform since, working on the ground, it was easier to plan photographic acquisitions in similar light conditions. The survey of high structures and of articulated rooms shows greater accuracy and the gaps in the data are greatly reduced by careful planning of the scanning points. The survey of the *plataforma de entierro*, for instance, would not have been possible without the help of the laser scanner which, by rotating around the structure, allowed us to reconstruct its volume in detail. The survey shows the large number of cavities caused on the original stepped pyramid by the *huaqueros* and highlights some parts of the walls that still preserve their original shape (Fig. 7, A). Besides observing the 3D laser scanner data, we were able to distinguish some constructive features, which were not otherwise evident. For instance, we noticed an imperfect alignment of the warehouses of the second sector and their missing gable roofs, which are inferable from the shape and position of the upper part of the walls (Fig. 7, B).

However, the laser scanner provides a view from the ground that, in the case of Palacio Rivero, does not show the top part of the structures and especially the high perimeter walls in the best way. Then, to integrate the efficiency of this instrument with the advantages of an aerial survey, we experimentally mounted the laser scanner on a telescopic rod that can be raised up to 6 m.

3.3 *Chronological phases and historical hypothesis*

During the long process of survey and analysis of the degraded structures of Rivero, two questions remained unsolved for a long time: the great square of the northern sector is not aligned with the perimeter walls, and the palace is the only one to be surrounded by a double perimeter walls and by a long empty corridor which runs all around it. As we have seen, the external wall is built in *adobe* and the internal one in *tapia*. If we observe the building with more attention, we observe that the *adobe* and the *tapia* walls are on the E, W and N side of the palace, while on the southern side, the *adobe* one has not been built. Therefore, the corridor runs only on the E, N and W side, while the southern side is delimited by the high external wall in *tapia* and by a lower internal wall in *adobe*, which belongs only to the southern sector (Fig. 6). The latter is connected with the northern public sector by means of another corridor, which runs around the western side without any connection with the central sector. Most probably, it was necessary for the servants

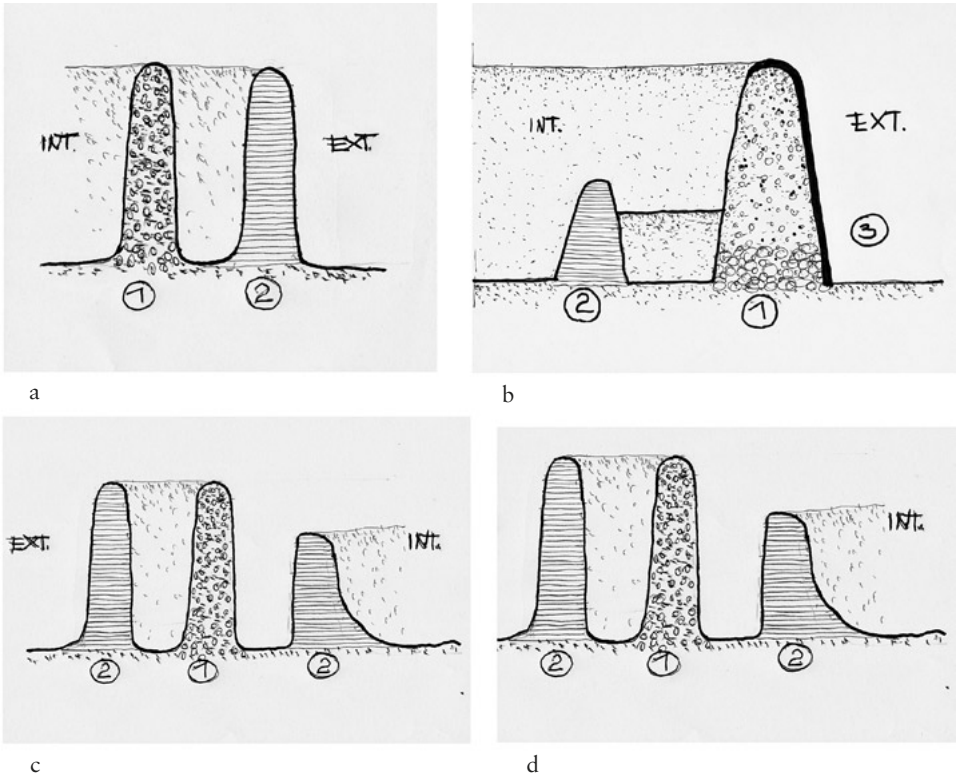


Fig. 8 – Schematic sections of the perimetral walls of Ciudadela Rivero (n. 1 *tapia*, n. 2 *adobe*, n. 3 *adobe* coating of the *tapia* wall). A) Eastern wall of the N sector; B) Southern wall of the S sector; C) Western wall of the central sector; D) Eastern wall of the central sector.

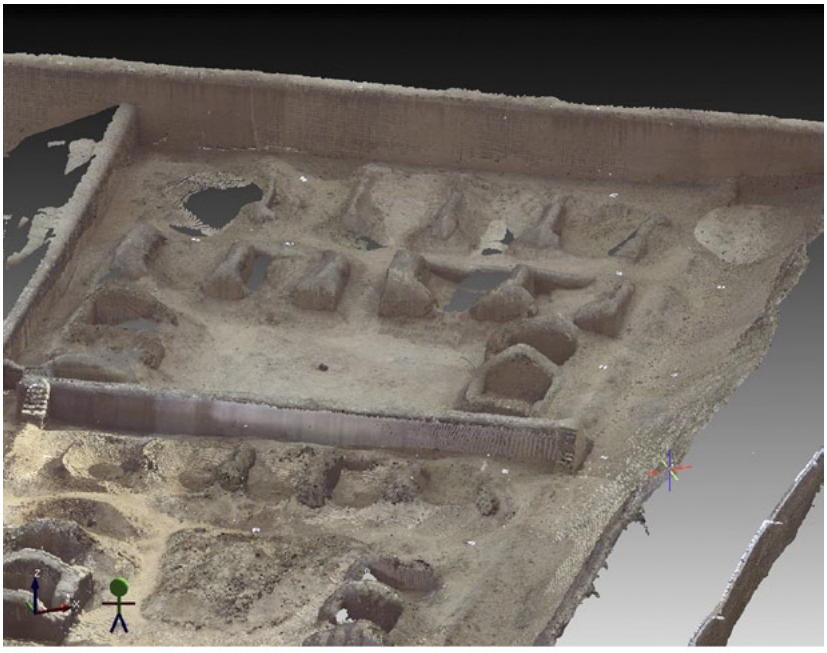
to pass from the northern public sector to the southern sector dedicated to water supply and cultivation without entering the central space reserved for the king and his family.

All these observations led us to presume that there were at least two building phases in Rivero. The first phase corresponded to the construction of the *tapia* wall, which could have been built for a different purpose (sacred enclosure, protected cultivated area, protected *huachaque*, etc.). At a later time, it was decided to build a palace and to use the existing structure for some new tasks by making some changes to it. Therefore, in order to make the new building like all the other buildings, a new *adobe* wall was built around the *tapia* one on the E, N and W side (Fig. 8, A), and the external side of the southern *tapia* wall was coated with *adobe* without adding any new structure (Figs. 8, B e 9).

Fig. 9 – The outside of the southern wall of Ciudadela Rivero: the original structure in *tapia* at the centre and all around it an *adobe* coating.

At the same time, a part of the northern side of the *tapia* wall was brought down in order to recover an open space and build the great ceremonial square. This, unlike all the other spaces, has an orientation which is substantially different from that of the perimeter walls, resulting in a series of irregular structures such as the long trapezoid square located to the W and other rooms in connection with the southern *audiencias* and the eastern warehouses (Fig. 5, A). Another large intervention was that of hiding the view of the rustic *tapia* wall from the king's sector. A new *adobe* wall was built on the W side creating a new corridor (Fig. 8, C), and another *adobe* wall was constructed very close to the eastern *tapia* one so as to leave an empty space of only 60 cm in width (Fig. 8, D). It is clear that this last structure was built only for aesthetic reasons since it neither creates any useful space nor does it have any structural function. Finally, in order to protect the privacy and beauty of the king's sector, its S side was delimited by an high *adobe* wall.

Lack of orthogonality stemming from a different orientation of the *plaza ceremonial* was noted, albeit to a lesser extent, also in other parts of the building. In the area of the warehouses located to the W of the *plataforma de entierro*, we could notice, with the help of the laser scanner survey, that individual blocks, covered with gable roofs, are not perfectly parallel (Fig. 10). This fact may depend on the construction technique. For what concerns the warehouses, i.e. narrower and shorter structures, attention was only given



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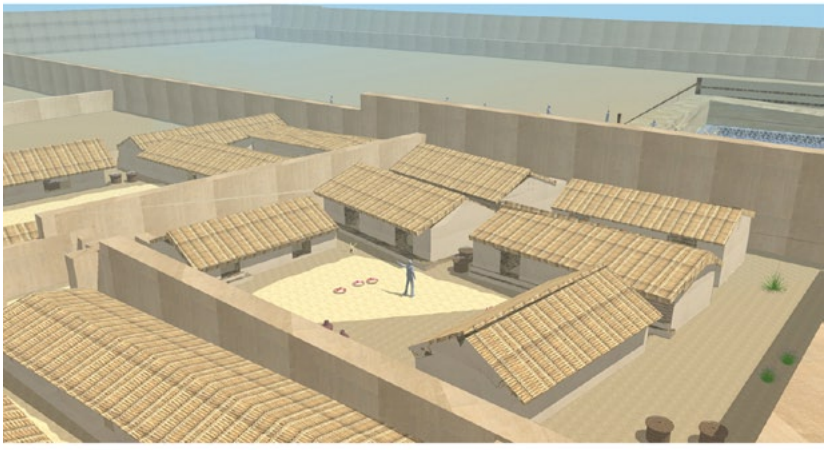

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Fig. 10 – Ciudadela Rivero: warehouses in the central sector. A) Laser scanner survey; B) 3D virtual reconstruction (elaborated by Vittorio Lauro).

to maintain the alignment of the single block without any concern for the parallelism of one another. On the contrary, the long perimeter walls were perfectly aligned and perpendicular since, in order to maintain the established alignment, tall reeds inserted in the masonry were used as references.

Among the various architectural features of the Rivero building, there is one last feature that characterizes the N sector. There is an E/W band of 50 by 100 m which, as mentioned above, is higher by about 2,5 m compared to the level of the rest of the building and in particular to the square from where it is possible to climb by means of a slightly inclined ramp. This raised sector is also characterized by the fact that it contains a considerable number of *Audiencias*. It can be assumed that this difference of level depends on the presence of underground structures, which could be prior or contemporaneous to the construction of this part of the palace. In order to verify this hypothesis, the geophysical prospecting could be one of the next cognitive campaign.

The possibility that the building has undergone several phases of construction, together with the interesting results deriving from recent excavation essays in Tschudi, raises some doubts over the theory that the palaces were built and inhabited by only one king so as to form an administrative and religious centre during his life and a place for funeral services after his death (Conrand Geoffrey 1982).

4. Suggestions for the operative actions

The analysis of Chan Chan's territory, which is being carried out by integrating different methods of investigation, has not only cognitive and scientific purposes, but it is also essential in terms of operating measures directed towards the conservation and valorisation of the archaeological site.

4.1 *The Archaeological Park of Chan Chan*

The primary objective of the Italian Mission is to plan the Archaeological Park of Chan Chan following the guidelines of the *Plan Maestro* and collaborating with the Ministerio de Cultura and the local and regional institutions. We believe that a monument of such importance deserves protection from the rampant urbanization that is affecting the area around Trujillo, and that the site must be promoted and publicized at international level. The complex of Chan Chan, if properly exploited, may be a significant source of wealth for the local population and an opportunity for socio-economic growth with clear occupational development.

The first step for planning the Archaeological Park was to define the limits of the intangible area (in blue in Fig. 3) and of the buffer zone (in green in Fig. 3) with the help of a differential GPS and the geo-referenced Quickbird satellite image. The polygon that defines the intangible area was approved by

law by the Peruvian government in the 60s, but its borders, no longer visible on the ground, were a constant reason for contrasts between the Ministerio de Cultura and the *campesinos* living in the area. The new boundary, equipped with absolute coordinates and positioned on the satellite image, was approved in 2008 by the Comisión Nacional Técnica de Arqueología and the Dirección Nacional of Ministerio de Cultura which now represents an effective tool for the protection of the site.

The buffer zone, already foreseen in the *Plan Maestro* and absolutely indispensable in a highly urbanized area, has the border at an average distance of 500 m from that of the intangible area, and its perimeter has been defined in accordance with the Ministerio de Cultura and the Master Plan office of Trujillo (PLANDET). The borders of the buffer zone were defined on the basis of the archaeological surveys and the analysis of satellite images that, as shown above, made it possible to trace the localization of many ancient paths and to identify the currently unprotected underground remains or archaeological structures. Together with the above-mentioned institutions, we are now working on land use standards and building restrictions for each of the six areas in which the buffer zone has been divided.

The primary objective of the design of the Archaeological Park is to define long distance itineraries that refer not only to the already existing preserved ancient paths but also to architectural emergencies that will be the points of attraction for visiting the complex. Some oases for rest will be placed in areas subject to reforestation and protection of the irrigation channels such as the natural area of Santa Maria, the *Mochica* channel (N), the *Reserva de Padre Abán* (S/W), the area of the *huachaque* Huamanchumo and the area of the *laguna* Toledo (E). At the same time, in connection with the above mentioned "points of attraction", some elevated points of view of the urban settlement will be raised using mud brick elements and the existing high walls in such a way so as not to disturb the original landscape without adding wood or metal structures.

Finally, a crucial part of the project is characterized by the general services, the information centre and some artisan workshops that will be concentrated where the present museum and the area for its future expansion are located.

4.2 *The restoration and valorisation of Rivero palace*

The masonry structures and, in particular, the basements of the walls in *tapia*, which are constructed with blocks of stone, show gaps and situations of dangerous instability given the imposing size of the walls. Therefore, in order to allow the tourist to visit the palace, the first intervention will involve consolidation of these basements with the addition of new stones to the missing

parts and the consolidation of the whole structure with the right kind of new mortar. Along with the consolidation of the structures, it will be important to highlight, also visually, the different phases of the construction which we described in the first part of the paper. For instance, some small areas of the *adobe* coating could be removed in significant points of the S external wall in order to display the underlying wall in *tapia*; we could also highlight, through panels, some evidences that led us to interpret the chronological changes (demolition of part of the *tapia* wall, different orientation of the ceremonial plaza and related irregular areas, points of connection between the *adobe* walls and the *tapia* ones, etc.).

These points of interest, along with the most significant architectural elements of the building, will represent a guided tour that will begin with the N door and end with the *plataforma de entierro*. The same view will be displayed in an interactive multimedia tour on which we are working at present. The tour will propose a reconstruction of the architectural landscape and some assumptions regarding the use of various spaces in order to form a pre-visit with historical notes and archaeological indications that will be visible on computers at the Information Centre of the Museum (Fig. 10, B).

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ABSTRACT

Since 2002, the Italian Mission of CNR-ITABC has been operating in the archaeological complex of Chan Chan (Peru), which is the largest pre-Columbian settlement entirely built with *adobe*. In 1989 Chan Chan was placed on the UNESCO World Heritage List. The main purpose of the work is aimed at the conservation, documentation and use of the site and of the territory that is related to Chan Chan from a historical and cultural point of view. The urban structure of Chan Chan, which is spread over a surface of 14 km^2, has a number of buildings which characterizes the town at both an architectural (*ciudadelas*, *huacas*, *huachaques*) and decorative level (bas-reliefs, geometrical motifs). In order to achieve our research goals, we had to arrange for the combined use of various analysis techniques that would provide both urban and architectural information about the town. The data we obtained allowed us to make a more up-to-date interpretation of the urban fabric and revealed intriguing details regarding the construction phases of one of its palaces which will be helpful both for the planning of the Archaeological Park and the restoration project of the Palacio Rivero.