

## INTEGRATED SURVEYING TECHNIQUES FOR THE ARCHAEOLOGICAL PARK OF CHAN-CHAN IN PERU

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### ABSTRACT

An archaeological mission has been realized recently for the survey of the archaeological site of the Chan-Chan in Peru. The site consists in an archaeological area extended 18 km<sup>2</sup>s, the widest complex of the world for the constructions in raw earth. It has already been inserted in the lists of the patrimony of the humanity and in the one of the monuments at risk. Placed in the Northwest of Peru, next to the city of Trujillo, it is object of study by an Italian archaeological mission, led by the arch. Roberto Orazi of the CNR\_ITABC in Rome. The complex includes ten vast enclosures called "palacios", that were the regal residences of the Chimú sovereigns. In 1998, el niño, ravaged the much degraded archaeological area. The Unesco has launched therefore an alarm, taken back by the Peruvian government for its safeguard. The mission is developed in tight collaboration with the National Institute of Culture of Peru. As first assessments of the mission the survey was carried out. The survey was performed with multidisciplinary techniques say tachometry, terrestrial photogrammetry, low-altitude aerial photogrammetry, high resolution satellite Quick Bird imagery. The control network, inserted in the Peruvian national cartographic system, has been realized both with traditional tachometry techniques and with differential GPS. The intentions of the Italian mission, besides the study of a methodology for the maintenance of the site, is the creation of a center of documentation that can autonomously continue the activities of research and that can constitute an example of international cooperation, the formation of local technicians for the documentation, the catalogue and the exploitation of the monumental patrimony, the acquisition of suitable computer tools and the constitution of an operational nucleus for the creation of a Regional Center of documentation. By means of the high resolution image the aggression by urban constructions of Trujillo city and by agriculture fields has been revealed. The first activity is an example of survey of the Chan Chan architecture, the so-called Palacio Rivero. By means of a QUICKBIRD image it has been possible to analyse the whole archaeological site, with the aim of a better definition of its general features and of a contribution to the exploitation of the whole territory. The different kind of results are presented, the line plotting, the DTM, the orthophoto, the thematic classifications derived by the multi-spectral satellite imagery. The aim is to collect all these data in a dedicated Gis.

### 1. INTRODUCTION

The archaeological complex of Chan Chan extends on an area of about 14 Km<sup>2</sup> in proximity of the coasts of the Pacific Ocean, 600 km North of Lima (Peru). It is a site of exceptional historical-cultural value, since long time included in the list of the UNESCO World Patrimony. Its continuous decay, due to the atmospheric agents, to the uncontrolled agricultural activities and finally to the disfigurements of the so-called "tombaroli", gravemen. Therefore a plan of recovery and maintenance of the whole area is extremely urgent. Currently a study is undergoing, in collaboration between the Italian Mission in the Peru (MIPE), the Italian CNR, the Università Politecnica delle Marche (DARDUS-DISASC) and the Institute National de Culture Peruvian (Inc), aimed to a model of intervention for the documentation, the maintenance and the fruition of the archaeological complex. The first activity is the survey of the Chan Chan architecture, the so-called Palacio Rivero. After then, by means of a QUICKBIRD image it has been possible to analyse the whole archaeological site, with the aim of a better definition of its general features and of a contribution to the exploitation of the whole territory.

#### 1.1 The Archaeological area

The remaining of the city of Chan Chan, capital of the Kingdom Chimù, can still be admired near Trujillo, capital of the Department La Libertad. It rose on the right border of the Moche Valley and it extended on a surface of around 20 square kilometers with more than seventy thousand inhabitants. It was founded in the IX century AD. The Chimù Kingdom, become then a great empire, on the pacific coast before the Incas

domination in XV century. The city constitutes the greatest human agglomeration built in raw earth in Latino-America.

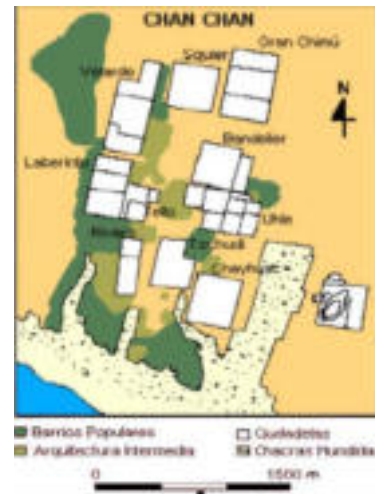


Figure 1. – Chan chan. The lay-out of the archaeological area

The principal economic activities were the agriculture, the fishing, the breeding. The arid earth of the coastal desert was made fertile thanks to a sophisticated irrigation system collecting the waters coming from the Andean rivers. The raw-earth brique, the so-called adobe, is made of dried mud. To the degrade of the site, contributed the widening of the cultivated grounds and, subsequently, the expansion of the area of Trujillo city.

## 2. THE SURVEY

The object of the survey was first limited to one of the ten so-called “palacios”, buildings, the Palacio Rivero (figure 1). They receive the name from the archaeologist who studied them. The survey has been carried out with integrated surveying techniques: first traditional means and procedures like tachometry, then Differential GPS, low-altitude photogrammetry, and finally high resolution satellite imagery. The first part of the tachometric survey was carried out in 2002 by the surveyor Mario Magellani, the last part the following year by the A. In figure 2 are visible the traverse stations and the result of this survey.



Figure2 - The control network and the thachometric survey

The control network for the photogrammetry has been assessed using a reflectorless theodolite GTP1002 Topcon and making use of signalized visible targets stuck on the ground.

## 3. THE DGPS SURVEY

The differential GPS technique was used to survey the shape of the ground and to transfer the survey from a local reference system to the national datum. A DGPS has been adopted for the contour lines survey. The master station was placed in a control vertex, while the rover carried on the shoulders of the operator according to the Stop&go and the kinematic methods. The baseline computation and adjustment have been executed by means of the Pinnacle software by Topcon and the NETGPS by Mattia Crespi (1).



Figure 3 - The paths tracked by the moving GPS receiver

The coordinate transformation of the whole complex from GPS datum WGS84 geocentric coordinates (X,Y,Z) to the local UTM reference system with the ellipsoid SAN-I South America 1969, Perú, has been executed by means of the software **GEOTRANS V2.2.3**.

The ellipsoidal heights have been corrected to the gravimetric elevations by subtracting the constant value

$$\delta Z = 10.147 \text{ m}$$

## 4. THE PHOTOGRAMMETRIC SURVEY

The aerial photogrammetric survey has been carried out from a small Cessna 172 airplane, with a precalibrated digital camera Canon Eos D1s, 50 mm focal length at a relative altitude of about 200m, getting a photo scale 1/4000. The strip is formed by nine images. The reason for such a narrow field of view is to be able to see as deep as possible inside the holes of the pyramid. The attention has been concentrated in the most important part of the whole complex, the so-called “Plataforma de Entierro”, the burial platform. It was a terrace pyramid, where the king was buried with all his belongings. The platform has been ravaged by the thieves and by the storms during the centuries. In figures 4 and 15 aerial images of the strip taken north-south direction is visible with a resolution of 4064 x 2704 pixel. The plotting has been performed in a digital stereoplotter RFD (Restitutore Fotogrammetrico Digitale) by Geopro, Ancona. In figure 5 the plotting with the contour lines is visible. The contour interval set at 25 cm. From the digital models a DTM has been derived, figures 6, and 8, and finally the true-orthophoto produced, figure 7.



Figure 4: An aerial photogrammetric image of the “plataforma de entierro” taken with Canon camera.

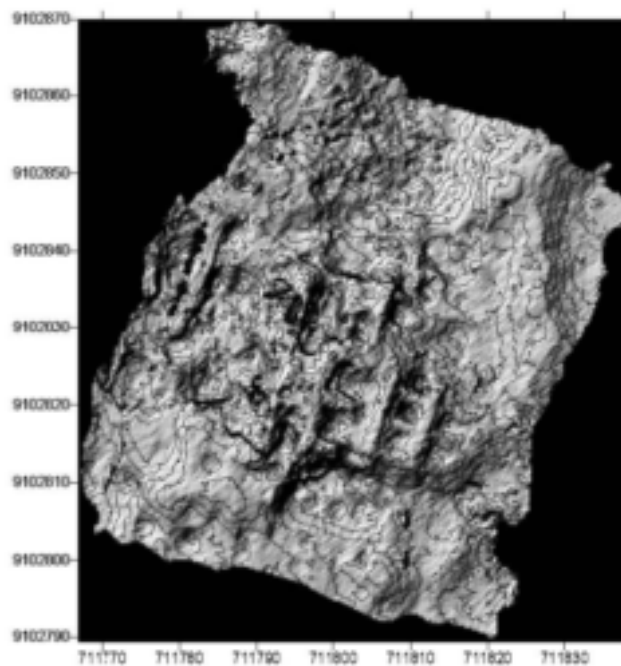


Figure 6 – The DTM of the plataforma de entierro



Figure 5 – The contour line plotting of the “plataforma de entierro”



Figure 7 – The true orthophotomap of the “Plataforma de Entierro”

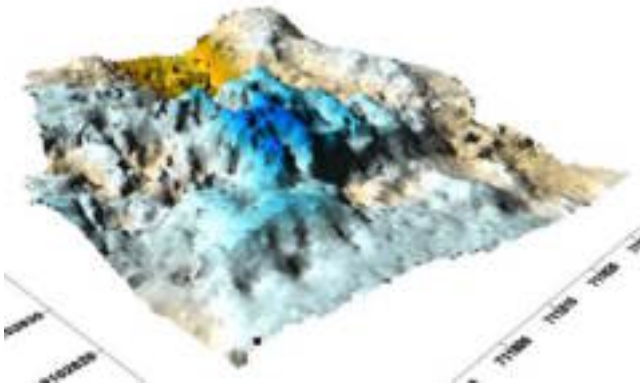


Figure 8 – The 3d model of the Plataforma de Entierro generated in WinSurf by Kriging interpolation

## 5. THE SATELLITE IMAGERY

The QUICKBIRD satellite is operative since 2002. It is able to acquire both in multi-spectral mode both in panchromatic mode, with geometric resolutions about 0.6m and about 3 m in the XS mode (four bands with the followings intervals: from 450 to 520 nm; from 520 to 600 nm; from 630 to 690 nm; from 760 to 890 nm). QUICKBIRD imagery have the highest resolution of the available commercial satellites today. The image used for the present study (Figures 9,14) has been acquired in the XS mode in 10-05-2003 as Standard level (corrections of the system, radiometric corrections, geometric corrections, organization in a specific cartographic system of reference: Datum WGS84, UTM projection, 17 Fuse, South Hemisphere). Quickbird data “bundle”, panchromatic and multi-spectral (0,6m pan , 2,4 m from blu to near infrared) and with radiometri resolution 11 bit (2048 grey level), supplied by Eurimage, Rome, has been georeferencied with Erdas Ortho-Engine 8.5 and elaborated and classificated with Envi 3.2. The satellite imagery is immediately available, the quality is so high that it constitutes a tool extremely useful.

### 5.1 Analysis of the image

The visual analysis of the syntheses RGB 3-2-1 (true colours) and 4-3-2 (false colours), facilitated by the elevated geometric resolution of the image, allowed to find some zones with diversified features: a) the principal archaeological site of Chan Chan (the center); b) a band of intensive cultivations characterized by bills of elevated extension (South - East); c) a band of mixed cultivations characterized by bills of redoubt dimension (North); d) a coastal band of vegetation characterized by a less evident parcels (South); e) parcels without vegetation and modified by antropic phenomena (West and North); f) areas densely urbanized (West and Northwest), (figures 10, 11).

The classification clearly separates the central archaeological site from the areas intensively cultivated to south-east and from those less intensive to North. And besides the evidence of the coastal band, characterized by a reduced parceling and by the presence of damp zones (underlined from the small zones of water), the so-called "humedales" where according to a millennial practice countrymen cultivate the “totoral” can, spontaneous and perennial grassy formation from which foods and small objects were obtained by the craftsmen. Moreover, the classification highlighted several particular emergencies.

### 5.2. The Central Archaeological Site

The central zone of the image (letter "a", figure 11) is characterized by open grounds (clear cyan and dark cyan, figure 10) that have correctly been classified by the unsupervised algorithm.



Figure 9 - A portion of the high resolution image by Quick bird. Starting from left are visible Palacio Rivero, Palacio Tchudi and Palacio Chayhuat

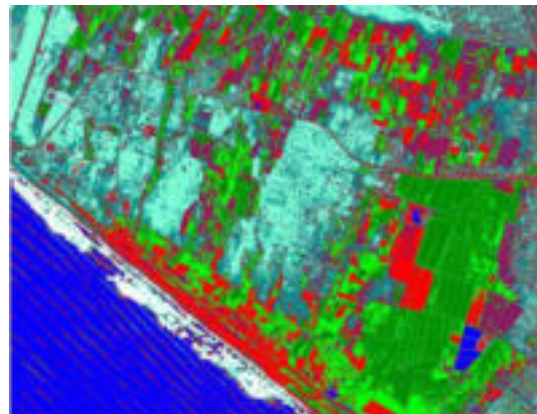


Figure 10 - The unsupervised classification

The classification highlights the perimeter of the buildings (where a difficult vegetation is present, encoded in red) and some stains of the more developed vegetation (in green) invading the archaeological area. A small pond is present (in blue) signalling the presence of one of the typical cisterns annexed to the courts of the buildings, inside which an abundant aquatic vegetation (in green) develops, useful to purify the water.

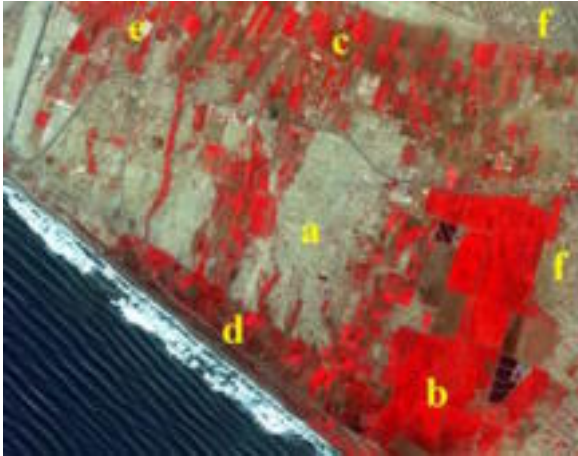


Figure 11 – The classification of Chan Chan

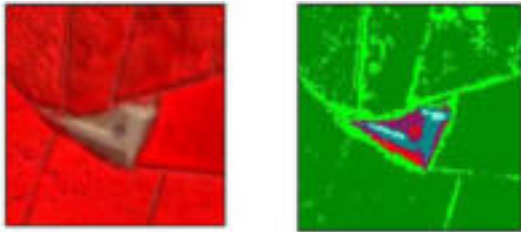


Figure 12 – Probable remaining of a pyramid inside a cultivated area

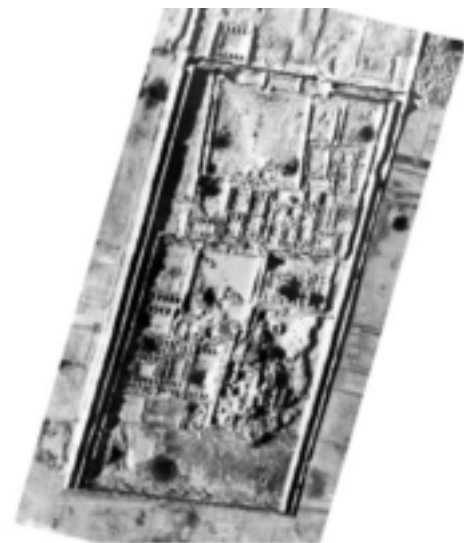
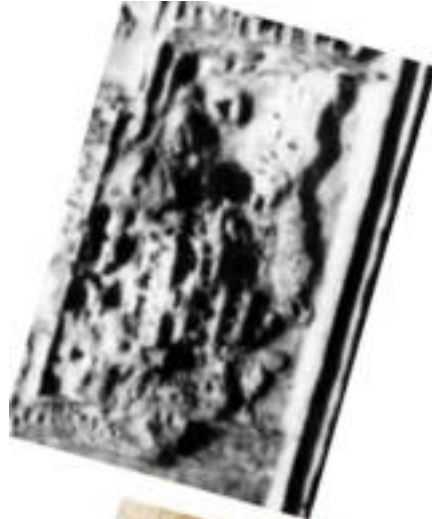
As a proof that the spreading of the agriculture is responsible for the destruction of the archaeological area, we can observe in the Southeast, inside an intensive cultivation, the probable rests of one of the typical terraces pyramids, very frequent in the area of Chan Chan, (figure 12).

### 5.3 The comparison with Harvard University aerial image.

We obtained an arial photographic image of the Chan Chan (figure 13) of the Harvard University, taken in 1970 (M. Moseley, 1975). The quantitative analysis is not possible, because the image is only a tourist one and therefore it doesn't have any known parameter. Only qualitative comparison is feasible. Also the position of the sun and the pattern of the shadows should be taken into consideration. The Harvard image seems to have the sun low in the horizon to enhance the shadow. Nevertheless the comparison with the actual satellite image and the low-altitude image put in evidence the strong difference in the sense of decay of the area (figures 13,14,15,16).

Figures 13,14 – The aerial photograph of the Harvard University (1970) and the satellite quickbird image of the Palacio Rivero (2003)

Figures 15, 16 – Comparison between the aerial image taken in 1970 by the Harvard University and the one taken in 2003 of the "Plataforma de entierro"





## 6. CONCLUSIONS

The satellite imagery is proven to be extremely useful for the study of the area. With this one, we could carry out a first classification of the area, we obtained the extraction of the most meaningful features. We verify also the quick deterioration of the remaining of the archaeological constructions. The realization of the archaeological echo-park of Chan Chan will not only allow to protect a monumental patrimony that the time, the carelessness and above all the thefts and the dispossessions strongly have already threatened, but it should also contribute to prevent that one of the richest place in culture and biodiversity of Peru is definitely devastated by the urbanisation and agricultural abusiveness, by the pollution, by harmful economic and productive activity for the environment, for the realization of great necessary public works. For such a purpose it is necessary not only to mobilize the international scientific community, to favour new searches and the use of advanced technologies able to improve the knowledge on the site, but also to involve the population to really build up a project of shared sustainable local development. In the same time we are collecting all the data in a dedicated GIS to allow a generation of different thematic maps. The potentiality of GIS improves the archaeological studies, not only because it makes possible to organize different kind of data in an unique database but also because it plays an important role in the a posteriori analysis.

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Figure 17 - The macro-areas proposed for the park: the "palacios" and the emergencies circled by rings.

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