

# RA

restauro archeologico

Conoscenza, conservazione e valorizzazione  
del patrimonio architettonico  
Rivista del Dipartimento di Architettura  
dell'Università degli Studi di Firenze

Knowledge, preservation and enhancement  
of architectural heritage  
Journal of the Department of Architecture  
University of Florence

Poste Italiane spa - Tassa pagata - Piego di libro Aut. n. 072/DCB/FI/VF del 31.03.2005

1972/2022  
**World Heritage in transition**  
About management,  
protection and sustainability

2022  
special issue

2

FIRENZE  
UNIVERSITY  
PRESS





**Il Patrimonio Mondiale  
alla prova del tempo.**

**A proposito di gestione,  
salvaguardia e sostenibilità**

Firenze, 18-19 novembre 2022

**World Heritage in transition**  
**About management, protection and sustainability**  
International Conference (Florence, 18-19 november 2022)

**Le Patrimoine mondial à l'épreuve du temps**  
**Sur la gestion, la protection et la durabilité**  
Colloque international (Florence, 18-19 novembre 2022)



UNIVERSITÀ  
DEGLI STUDI  
FIRENZE

**DIDA**  
DIPARTIMENTO DI  
ARCHITETTURA

## RA | restauro archeologico

Conoscenza, conservazione e valorizzazione  
del patrimonio architettonico  
**Rivista del Dipartimento di Architettura  
dell'Università degli Studi di Firenze**

Knowledge, preservation and enhancement  
of architectural heritage  
**Journal of the Department of Architecture  
University of Florence**

Anno XXX special issue/2022  
Registrazione Tribunale di Firenze  
n. 5313 del 15.12.2003

ISSN 1724-9686 (print)  
ISSN 2465-2377 (online)

### Director

Giuseppe De Luca  
(Università degli Studi di Firenze)

### Editors in Chief

Susanna Caccia Gherardini,  
Maurizio De Vita  
(Università degli Studi di Firenze)

### Guest Editors

Susanna Caccia Gherardini  
*Università degli Studi di Firenze*

Maurizio De Vita  
*Università degli Studi di Firenze*

Carlo Francini  
*Comune di Firenze*

### INTERNATIONAL SCIENTIFIC BOARD

Hélène Dessales, Benjamin Mouton, Carlo Olmo,  
Zhang Peng, Andrea Pessina, Guido Vannini

### EDITORIAL BOARD

Andrea Arrighetti, Sara Di Resta, Junmei Du,  
Annamaria Ducci, Maria Grazia Ercolino, Rita Fabbri,  
Gioia Marino, Pietro Matracchi, Emanuele Morezzi,  
Federica Ottoni, Andrea Pane, Rosario Scaduto,  
Raffaella Simonelli, Andrea Ugolini, Maria Vitiello

### EDITORIAL STAFF

Francesca Giusti, Virginia Neri,  
Francesco Pisani, Margherita Vicario

### layout revision by

Giorgio Ghelfi, Adele Rossi, Marta Raggi, Margherita Vicario, Salvatore Zocco  
*Università degli Studi di Firenze*

The authors are at the disposal of those who, untraced, were legally entitled to  
payment of any publication rights, subject to the solely scientific character of  
this study and its nonprofit purpose.

### Copyright: © The Author(s) 2022

This is an open access journal distributed under the Creative Commons  
Attribution-ShareAlike 4.0 International License  
(CC BY-SA 4.0: <https://creativecommons.org/licenses/by-sa/4.0/legalcode>).

### cover photo

Firenze, Grotta del Buontalenti, Giardino di Boboli,  
(123RF)

### cover design

●●● didacommunicationlab  
**DIDA** Dipartimento di Architettura  
Università degli Studi di Firenze  
via della Mattonaia, 8  
50121 Firenze, Italy

### published by

**Firenze University Press**  
Università degli Studi di Firenze  
Firenze University Press  
Via Cittadella, 7 - 50144 Firenze, Italy  
[www.fupress.com](http://www.fupress.com)



Stampato su carta di pura cellulosa Fedrigoni

ELEMENTAL  
CHLORINE  
**FREE**  
GUARANTEED



**COMITATO PROMOTORE | Promoting  
Committee | Comité de Pilotage**

Susanna Caccia Gherardini  
*Università degli Studi di Firenze*  
Maurizio De Vita  
*Università degli Studi di Firenze*  
Carlo Francini  
*Comune di Firenze*

**COMITATO SCIENTIFICO  
INTERNAZIONALE | International  
Scientific Committee | Comité  
Scientifique International**

Patricia Alberth  
*Site manager Bamberg World Heritage  
/ President International Association of  
World Heritage Professionals (IAWHHP)*  
Gianluca Belli  
*University of Florence*  
Chris Blandford  
*President World Heritage UK*  
Wolfgang Börner  
*Municipality of Vienna / ICOMOS  
Austria / Founder of the International  
Conference "Cultural Heritage and New  
Technologies"*  
Susanna Caccia Gherardini  
*Co-director of the academic journal  
«Restauro Archeologico», University of  
Florence*  
Chloé Campo de Montauzon  
*General Delegate of the Association of  
French World Heritage properties*  
Lorenzo Cantoni  
*UNESCO Chair on ICT to Develop and  
Promote Sustainable Tourism at World  
Heritage Sites, Università della Svizzera  
Italiana, Lugano*

Nicola Casagli  
*UNESCO Chair on the Prevention and  
Sustainable Management of Geo-  
Hydrological Hazards, University of  
Florence*  
Adele Cesi  
*National Focal Point for the World  
Heritage Convention, UNESCO Office of  
the Ministry of Culture, Italy*

Sarah Court  
*Instead Heritage  
ICCROM / Herculaneum Conservation  
Project*

Maurizio De Vita  
*Co-director of the academic journal  
«Restauro Archeologico», University of  
Florence*

Paolo Faccio  
*Iuav University, Venice*

Emanuela Ferretti  
*University of Florence*

Donatella Fiorani  
*Sapienza University of Rome*

Nicole Franceschini  
*International Consultant on World  
Heritage / World Heritage Leadership  
programme, ICCROM*

Carlo Francini  
*Site manager Historic Centre of Florence,  
Municipality of Florence / Scientific  
Coordinator Association of Italian World  
Heritage sites*

Maria Cristina Giambruno  
*Polytechnic University of Milan*

Francesca Giliberto  
*University of Leeds*

Fergus MacLaren  
*President, ICOMOS International  
Cultural Tourism Committee*

Pietro Matracchi  
*University of Florence*

Alessandro Merlo  
*University of Florence*

Giovanni Minutoli  
*University of Florence*

Anne-Laure Moniot  
*Bordeaux Metropole*

Stefano Musso  
*Università di Genova*

Mara Nemela  
*Director, "Dolomiti-Dolomiten-  
Dolomites-Dolomitis UNESCO"  
Foundation*

Emanuele Pellegrini  
*IMT School for Advanced Studies Lucca*

Renata Picone  
*University of Naples Federico II*

Marco Pretelli  
*University of Bologna*

Alessio Re  
*Fondazione Santagata  
Università degli Studi di Torino*

Emanuele Romeo  
*Polytechnic University of Turin*

Paolo Salonia  
*National Research Council / ICOMOS  
Italia*

Christina Sinclair  
*Director of Edinburgh World Heritage*

Jane Thompson  
*Instead Heritage / ICCROM /  
Herculaneum Conservation Project /  
SDA Bocconi*

Michael Turner  
*Bezalel Academy of Arts and Design,  
UNESCO Chair in Urban Design and  
Conservation Studies*

**COMITATO ORGANIZZATIVO |  
Organising Committee | Comité  
d'Organisation**

*Università degli Studi di Firenze*  
Paola Bordoni  
Maddalena Branchi  
Marta Conte  
Elisa Fallani  
Giorgio Ghelfi  
Francesca Giusti  
Gaia Lavoratti  
Giulia Lazzari  
Alessia Montacchini  
Francesco Pisani  
Carlo Ricci  
Loredana Rita Scuto  
Gaia Vannucci  
Margherita Vicario

**CON IL PATROCINIO DI | sponsored by | avec le soutien de**

Ministero degli Affari Esteri e della Cooperazione Internazionale, Ministero della Transizione Ecologica, Ministero della Cultura, Commissione Nazionale Italiana per l'UNESCO, Regione Toscana, International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM), ICOMOS Italia Consiglio Internazionale dei Monumenti e dei Siti - Comitato Nazionale Italiano, Associazione Beni Italiani Patrimonio Mondiale, Accademia delle Arti del Disegno.



# Indice | Summary | Index

vol. 2

<b>Uomo, natura e clima: i siti Patrimonio Mondiale a rischio</b>   Man, nature and climate: World Heritage properties at risk   Homme, nature et climat : les sites du Patrimoine mondial en danger	<b>10</b>
<b>Analisi multi-rischio del centro storico di Firenze per la salvaguardia e valorizzazione</b> <i>Chiara Arrighi, Vieri Cardinali, Maria Teresa Cristofaro, Antonino Maria Marra, Fabio Castelli, Mario De Stefano</i>	<b>12</b>
<b>The Management of the World Heritage Site “Venice and its Lagoon”: state of the art and new challenges</b> <i>Katia Basili, Francesco Trovò</i>	<b>18</b>
<b>Multidisciplinary analysis and HBIM methodology for the risk management of harmful events: the large raw earth complex of Chan Chan (Trujillo, Peru)</b> <i>Francesca Colosi, Francisco James León Trujillo, Eva S. Malinverni, Sandra Kobata Alva, Roberto Orazi</i>	<b>24</b>
<b>Il Centro Storico di Firenze tra conservazione e metamorfosi urbana: appunti per un modello strategico di Valutazione di Impatto sul Patrimonio</b> <i>Marta Conte, Alessia Montacchini</i>	<b>32</b>
<b>Analisi dei fattori di rischio microclimatico in casi studio operativi nel centro storico di Napoli</b> <i>Maria Antonietta De Vivo</i>	<b>38</b>
<b>Documentation of Syrian lost heritage: 3D modelling to support an open information system and Mixed Reality</b> <i>Francesco Di Stefano, Roberto Pierdicca, Zaid Zaim</i>	<b>44</b>
<b>Identification du cadre d’efficacité de l’évaluation d’impact sur le patrimoine</b> <i>Souaad Fanit, Nadia Chabi</i>	<b>50</b>
<b>Management and protection strategies to preserve World Heritage properties endangered of armed conflicts</b> <i>Lidia Klupsz, Krzysztof Salaciński</i>	<b>56</b>
<b>Una (im)possibile universalità del patrimonio? Il ruolo di UNESCO nei processi di conservazione e ricostruzione nei Balcani</b> <i>Emanuele Morezzi</i>	<b>62</b>
<b>La gestione dei siti Patrimonio Mondiale</b>   The management of World Heritage properties   La gestion des sites du Patrimoine mondial	<b>68</b>
<b>Community empowerment for cultural heritage management: from principles to practice</b> <i>Giulia Avanza, Erica Meneghin</i>	<b>70</b>
<b>Piani di Gestione dei centri storici UNESCO: aggiornamenti indispensabili</b> <i>Aldo Aveta</i>	<b>76</b>
<b>Servizi Ecosistemici e paesaggio: una gestione patrimoniale</b> <i>Elisa Butelli</i>	<b>82</b>
<b>Olivetti come valore universale. Una proposta di ampliamento del WHS “Ivrea, città industriale del ‘900”</b> <i>Francesca Castanò, Anna Gallo</i>	<b>88</b>
<b>Il sito seriale “Ville e Giardini medicei in Toscana”. Revisione del modello di governance e ipotesi di funzionamento per il miglioramento dell’accessibilità</b> <i>Elisa Fallani, Carlo Ricci</i>	<b>94</b>

<b>Quando l'architettura racconta di rovine. Nuovi modelli museali per l'archeologia</b>	100
<i>Angela Fiorelli</i>	
<b>Heritage Place Approach: Linking People, Nature and Culture in the Management of World Heritage</b>	106
<i>Nicole Franceschini, Sarah Court, Maya Ishizawa, Eugene Jo</i>	
<b>Il parco agricolo come strumento di prossimità per la gestione attiva di un territorio dal valore patrimoniale: il caso del Parc des Jalles a Bordeaux (FR)</b>	110
<i>Maria Rita Gisotti, Sophie Lebreton, Maddalena Rossi</i>	
<b>Un percorso museale per un turismo sostenibile nell'area UNESCO di Pisa</b>	116
<i>Francesca Giusti</i>	
<b>Riconoscere, conservare e gestire il Patrimonio Mondiale dell'Umanità attraverso il coinvolgimento delle comunità locali</b>	122
<i>Manuela Mattone</i>	
<b>Italian archaeological World Heritage Sites: disaster risk reduction in the management plans</b>	128
<i>Eleonora Melandri, Andrea Ugolini</i>	
<b>Il Management Plan del sito UNESCO di Bologna. Sinergie a più livelli tra tutela e pianificazione urbana</b>	134
<i>Valentina Orioli, Chiara Mariotti</i>	
<b>Il centro storico di Napoli tra piano di gestione e scenari di restauro e valorizzazione</b>	140
<i>Andrea Pane, Maria Pia Testa</i>	
<b>Il patrimonio UNESCO in Piemonte e il coinvolgimento delle comunità locali</b>	146
<i>Alessandra Panicco</i>	
<b>“Esquilino chiama Roma” Strumenti per affrontare complessità irrisolte nel centro storico della Capitale</b>	152
<i>Pietro Petrarola, Simona Salvo</i>	
<b>Nuovi processi di patrimonializzazione per i territori post-minerari. Il caso della regione del Bassin Minier Nord-Pas-de-Calais in Francia</b>	158
<i>Daniela Poli</i>	
<b>Urban agriculture and rural landscapes in the buffer zone of the UNESCO site Firenze Historic Center</b>	164
<i>Maria Chiara Pozzana</i>	
<b>Per una nuova centralità delle <i>buffer-zones</i> UNESCO: due casi studio nel Mediterraneo</b>	170
<i>Renata Prescia, Aldo R. D. Accardi</i>	
<b>Notes on the contemporary challenges of the management of World Heritage properties; Reflection on Rani-Ki-Vav (The Queen's Stepwell) at Gujarat, India</b>	178
<i>Mehmaz Rajabi</i>	
<b>Monitorare il Piano di Gestione di un bene Patrimonio Mondiale. Il caso del Centro Storico di Firenze</b>	184
<i>Loredana Rita Scuto, Valentina Ippolito</i>	
<b>Filling the Gaps. Il modello valoriale della rotta culturale ATRIUM per le future sfide di UNESCO</b>	190
<i>Leila Signorelli</i>	
<b>La costruzione del modello di governance per siti UNESCO complessi. Riflessioni e casi studio</b>	196
<i>Silvia Soldano, Silvia Summa, Patrizia Borlizzi, Marco Valle</i>	
<b>Safeguarding of the World Heritage properties through minds transformation</b>	200
<i>Tatyana Trudolyubova</i>	
<b>Ruderi antichi, spazi vissuti. Alcune osservazioni sui fenomeni di frequentazione e partecipazione in corso nella necropoli etrusca della Banditaccia di Cerveteri</b>	206
<i>Tommaso Vagnarelli</i>	
<b>'Chi proteggerà l'Egitto libero?'. Il Cairo tra conservazione e città informale</b>	212
<i>Mariarosaria Villani</i>	



<b>Paesaggi letterari e immaginario collettivo.</b> <b>“I paesaggi vitivinicoli del Piemonte: Langhe-Roero e Monferrato” tra valore estetico e memoria culturale</b> <i>Maurizio Villata</i>	218
<b>Threatening Venice and its Lagoon: the effect of international policies on management sustainability and heritage preservation</b> <i>Luca Zan, Roberta Ferrarini</i>	224
<b>Da monumento a Paesaggio Urbano Storico   From the concept of monument to the Historic Urban Landscape approach   Du monument au paysage urbain historique</b>	<b>228</b>
<b>Heritage and development – a classification of recent changes in the City of Bamberg (Germany) against the backdrop of the UNESCO Recommendation on the Historic Urban Landscape</b> <i>Patricia Alberth</i>	230
<b>Tutela attiva del patrimonio edilizio di base e disciplina urbanistica. Il caso di Firenze</b> <i>Francesco Alberti</i>	236
<b>Historic Ludic Landscapes. Il gioco nell’area UNESCO di Firenze tra storia e attualità</b> <i>Jacopo Ammendola, Francesco Caneschi, Benedetta Masiani</i>	242
<b>«Un museo a cielo aperto»: i casi emblematici del Mausoleo di Gallieno e della Villa dei Quintili</b> <i>Lavinia Antonelli, Federica Belli</i>	248
<b>Dal “Piano Cervellati” ai portici patrimonio UNESCO: il “Modello Bologna” nella conservazione della città storica</b> <i>Micaela Antonucci, Francesco Lipparini</i>	254
<b>Dal patrimonio urbano al patrimonio territoriale: strategie integrate per la riqualificazione sostenibile della Città Metropolitana di Roma Capitale</b> <i>Monica Bolognesi, Eni Nurihana</i>	260
<b>Architetture nuragiche e paesaggio protourbano. Relazioni antiche ed estese dimensioni attuali</b> <i>Marco Cadinu</i>	266
<b>La Festa dei Gigli di Nola come strumento di tutela. Il caso del borgo urbano di Cimitile</b> <i>Saverio Carillo</i>	272
<b>Itinerari museali urbani a carattere devozionale e siti museali diffusi. Storia, restauro e valorizzazione</b> <i>Alessia Comodini, Chiara Laudonio</i>	278
<b>Servizi igienico-sanitari: strategia di welfare urbano per la città storica</b> <i>Maria De Santis, Ludovica Gregori</i>	284
<b>Asmara e il Moderno d’Oltremare: una città Patrimonio Mondiale tra conoscenza e valorizzazione</b> <i>Sara Iaccarino</i>	290
<b>Towards an Integrated Assessment of Heritage Significance for Historic Urban Areas</b> <i>Niyati Jigyasu</i>	296
<b>A Paradox of Reusing Cultural Heritage: A Case Study of the Historic Centre of Macau</b> <i>Teng Wai Lao</i>	302
<b>Hidden Diversity: the Water Heritage in Upper Pearl River Basin in Southwest China</b> <i>Tiansheng Li</i>	308
<b>La valenza simbolico-culturale dei Colli Euganei come “paesaggio storico rur-bano”</b> <i>Andreina Milan</i>	314
<b>The Franciscan monastery in Bač: From the Research of the Single Monument to the Changed Perspective of the Cultural Landscape of Bač and its Surroundings</b> <i>Branislav Milićević</i>	320
<b>I giardini di don Luigi di Toledo: Firenze e Napoli due realtà a confronto</b> <i>Giovanni Minutoli</i>	326

<b>Il restauro dell'Orto del San Domenico a San Gimignano. Un progetto di paesaggio retro-innovativo per la trasmissione di valori e saperi alle future generazioni</b> <i>Lorenzo Nofroni</i>	332
<b>1972 – 2022. World Heritage in transition. About management, protection and sustainability</b> <i>Matthias Ripp, Julia Heinzl</i>	338
<b>Monumenti e frammenti archeologici nei contesti urbani Patrimonio Mondiale. Prospettive e strategie culturali di salvaguardia, conservazione e valorizzazione</b> <i>Emanuele Romeo</i>	344
<b>Il sistema difensivo di Verona: le mura, i forti e le campagne. Proposte per la tutela e valorizzazione di un sistema di paesaggio</b> <i>Carlo Schiesaro</i>	350
<b>Analysis of Visitors' Sentiment Tendency in Heritage Tourism Sites Based on Multi-Source Data: A Case Study of Grand Tang Mall, Xi'an</b> <i>Yanqing Wang, Weile Jiang, Yiqing Zhao</i>	356
<b>Conoscenza e formazione   Knowledge and capacity building   Connaissance et formation</b>	362
<b>La casa si vive da dentro e si tutela nella sua interezza</b> <i>Adriana Arena, Federica Ciarcià, Emilia Garda, Raffaella Lione</i>	364
<b>Accessibilità, partecipazione e inclusione per la trasmissione dei valori del Patrimonio Mondiale</b> <i>Michela Benente, Gianluca D'Agostino</i>	370
<b>Microprogetti per Tor Marancia per sensibilizzare alla valorizzazione del patrimonio delle torri medievali</b> <i>Angela Bruni</i>	376
<b>Piranesi Prix de Rome. Aufklärung e Paideia</b> <i>Pier Federico Caliarì, Francesco Novelli</i>	382
<b>A mountain theatre through art and faith: how to improve fruition of Sacro Monte in Varese?</b> <i>Giuliana Cardani</i>	388
<b>Consapevolezza e trasmissione dei valori nella Cattedra UNESCO Mediterranean Landscape in Context of Emergency</b> <i>Natalina Carrà, Paola Raffa</i>	394
<b>World Heritage Sites vs Ecomusei: prospettive comuni e strategie condivise</b> <i>Maria Grazia Ercolino</i>	400
<b>Firenze Forma Continua: raccontare l'evoluzione della città e del territorio</b> <i>Carlo Francini, Gaia Vannucci</i>	406
<b>Il museo Dar Ben Abd-Allah nella medina di Tunisi</b> <i>Lamia Hadda</i>	412
<b>Architettura, cinema e memoria: un secolo di narrazioni su Matera</b> <i>Alessandra Lancellotti</i>	418
<b>National surplus of World Heritage – Northern examples</b> <i>Marianne Lehtimäki</i>	422
<b>The culture of restoration: a new point of view for an international framework</b> <i>Rossana Mancini, Francesca Lembo Fazio</i>	428
<b>Le 'memorie interne' dei musei storici. Nuovi paradigmi per la conservazione e la comunicazione del patrimonio</b> <i>Bianca Gioia Marino</i>	434
<b>Vernacular and World Heritage sites: criticality and challenging for the conservation, awareness, and transmission of heritage values</b> <i>Lucia Montoni, Letizia Dipasquale, Mariana Correia, Saverio Mecca</i>	440
<b>Riconoscere e conservare il patrimonio: dal valore universale allo spirito del luogo</b> <i>Lucina Napoleone</i>	446

<b>Un Museo di Storia Pubblica per Crespi d'Adda</b> <i>Giorgio Ravasio</i>	452
<b>Resistenza.</b> <b>La questione della proto-sostenibilità del patrimonio preistorico sardo</b> <i>Andrea Scalas</i>	456
<b>Dal <i>tangibile</i> all'<i>intangibile</i> e ritorno? Per ripensare il significato della materia</b> <i>Angela Squassina</i>	462
<b>New Materialism of Boat: Museum and Cultural Heritage practice in Contemporary Quanzhou</b> <i>Jing Sun, Han Lin, Minghong Chen</i>	468
<b>Rigenerare e valorizzare i centri minori: strategie adattive per il borgo di Tocco da Casauria</b> <i>Alessandra Tosone, Virginia Lusi, Renato Morganti</i>	474
<b>Convention Concerning the Protection of the World Cultural and Natural Heritage and SDGs. Research and interviews about the role of museums as cultural hubs for the sustainable management, accessibility, and climate change in the context of urban regeneration processes</b> <i>Gaia Turchetti</i>	480
<b>How archaeological heritage is "locked and lost" in museums</b> <i>Kamil Zeidler, Paula Chmielowska</i>	486



# Multidisciplinary analysis and HBIM methodology for the risk management of harmful events: the large raw earth complex of Chan Chan (Trujillo, Peru)

**Francesca Colosi** | [francesca.colosi@gmail.com](mailto:francesca.colosi@gmail.com)

CNR, Istituto di Scienze del Patrimonio Culturale

**Francisco James León Trujillo** | [f.leon@ulima.edu.pe](mailto:f.leon@ulima.edu.pe)

Universidad de Lima

**Eva S. Malinverni** | [e.s.malinverni@staff.univpm.it](mailto:e.s.malinverni@staff.univpm.it)

Università Politecnica delle Marche

**Sandra Kobata Alva** | [sandra.kobata71@yahoo.es](mailto:sandra.kobata71@yahoo.es)

Universidad Privada Antenor Orrego

**Roberto Orazi** | [roberto.orazi@gmail.com](mailto:roberto.orazi@gmail.com)

CNR, Istituto di Scienze del Patrimonio Culturale

## Abstract

Chan Chan, the largest raw earth settlement in Latin America, has been on the UNESCO WHL since 1986 and on the World Heritage List in Danger since 1990. The archaeological complex is affected by a series of negative natural and anthropic events that threaten the preservation of the structures and maintenance of the original historical landscape. Within the framework of the bilateral agreement CNR-CONCYTEC (Consejo Nacional de Ciencia, Tecnología y Innovación Tecnológica), the Institute of Heritage Science (ISPC) launched a collaboration with the Università Politecnica delle Marche, Universidad de Lima (ULima) and Universidad Privada Antenor Orrego (UPAO), in order to provide tools (GIS, GIS3D, HBIM) for risk analysis, site vulnerability assessment and submission of proposals to reduce its effects. The desirable results of the project are to provide methodological support not only to the administrators of Chan Chan, but also to scholars and institutions dealing with raw earth heritage in various parts of the world.

## Keywords

Archaeological landscape, Earthen architecture, Risk management, GIS, HBIM.

## Introduction

Chan Chan, the capital of the Chimor empire (IX-XV cen. AD), is the largest pre-Columbian city built in raw earth. It is located about 600 km from Lima (Fig. 1), near Trujillo, and extends over 14 Km<sup>2</sup> with articulated structures surrounded by imposing walls, named palaces or *ciudadelas*, remnants of popular houses, and *huacas*, stepped pyramids with a sacred function<sup>1</sup>. The monumental complex has been on the UNESCO WHL since 1986 and on the WHL in Danger since 1990. As required by UNESCO, the Peruvian Institute of Culture drew up the *Plan Maestro de conservación y manejo del Complejo Arqueológico Chan Chan (Plan Maestro)*, approved by the Peruvian Government in 2000 and recently updated for the years 2021-2031<sup>2</sup>. The *Plan Maestro* foresees a series of projects regarding research, conservation and enhancement that are mainly related to conserving the earthen structures and protecting them from the Niño phenomenon.

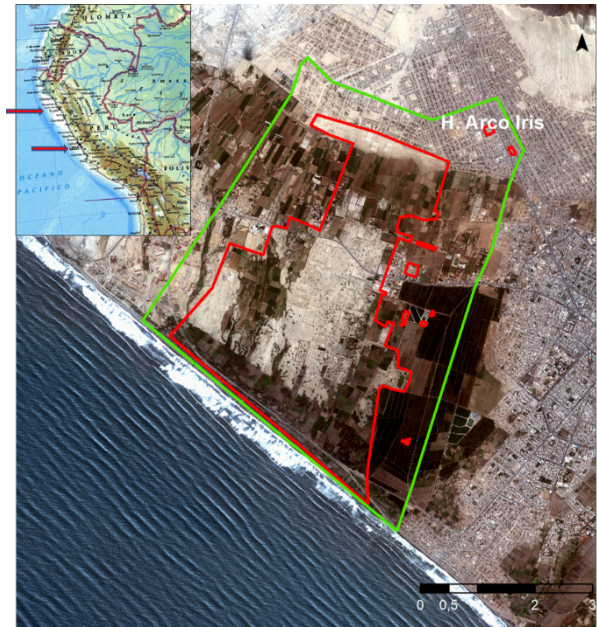


Fig. 1 Chan Chan archaeological site. In the small map the red arrows indicate Lima and Trujillo. On the satellite image, the core zone (in red) and the buffer zone (in green) are drawn. Elaboration by Francesca Colosi

The project “Risk Management Plan of Chan Chan (Trujillo, Perú): multidisciplinary analysis and HBIM methodology” , conducted in the frame of the bilateral agreement CNR-CONCYTEC and with the financial contribution of the Italian Ministry for Foreign Affairs and International Cooperation, wishes to support the Plan Maestro through a risk prevention plan using the GIS 3D and HBIM methodologies in an integrated way.

Among the many threats affecting Chan Chan there are major events, such as earthquakes or tsunamis, against which it is only possible to conceive of an adequate alarm system for the population or rapid civil protection interventions. However, there are natural or anthropogenic phenomena for which one can set up methods of control and defense to be achieved in a short time. The most dangerous for the preservation of the archaeological site are those that, on an architectural scale, erode the building material and those that, on a territorial scale, damage the integrity of the historical landscape.

#### **Architectonic survey: Huaca Arco Iris**

Chan Chan is affected by many phenomena of degradation resulting mainly from atmospheric agents and, in part, from the proximity of the sea. These particularly include erosion of the surfaces due to the wind, rising water with transport of salts, effects of breaking or collapse due to the abundant rainfall during the Niño. It is therefore important to set up monitoring, study and conservation programs and to identify appropriate technologies to achieve the objectives. With regard to the architectural aspects of construction in adobe, we have exper-

imented with the use of HBIM (Heritage Building Information Modelling), suitably modelled for the construction technique in raw earth. The investigation was conducted on the Huaca Arco Iris, one of the cult monuments of Chan Chan, which had previously been surveyed and of which a 3D photogrammetric model was obtained<sup>3</sup>. The main difficulty consisted in identifying the ontological characteristics specific to the construction, whether they are material or formal. Another issue was adapting these characteristics to a design system developed on the current building system, mostly accustomed to square shapes and the use of pre-established building libraries.

The main obstacles, deriving from the extreme formal heterogeneity of the earthen architecture, have been overcome by making forced squaring of curved or rounded parts and creating a first organization of ontological characteristics in classes and subclasses. An analysis was then made of the various parts of the building and the individual structural elements with a specific test on the south wall of the outer masonry. On this, a precious bas-relief was covered by a brick wall to protect it from the imminent rains of the Niño (Fig. 2).

The research on the 3d modelling, useful to define the structural and functional parts in HBIM, has demonstrated the growing need to involve scholars of different specializations in the complex activity of conservation and enhancement of cultural heritage<sup>4</sup>.

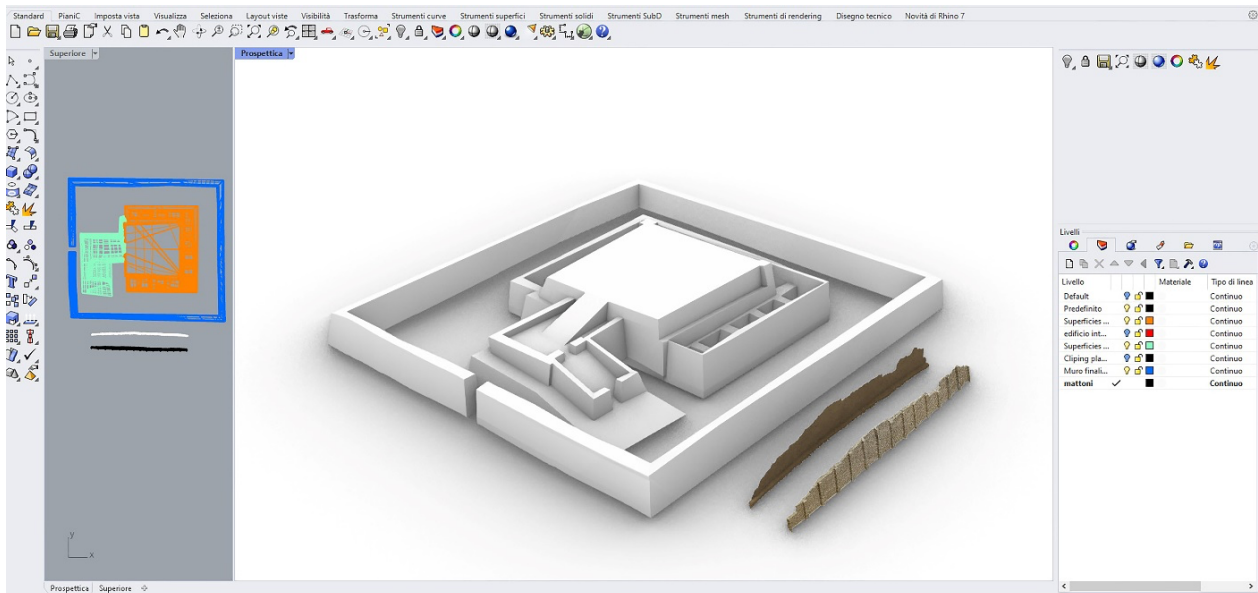


Fig. 2 Exploded axonometric view of the huaca with the bas-relief of the external wall of the themenos and the conservative cover.

### Territorial survey: the buffer zone

An equally serious problem is the danger of losing the historical landscape of the capital of the Chimu empire: large structures like the Mall, a chicken feed factory and many high buildings are visible from the archaeological site (Figs. 3, 4). This risk is increasingly evident and it is caused by various concomitant factors. The first is due to the proximity of the city of Trujillo, in full urban development with a population that exceeds 800.000 people

and an airport that is the most important hub for the north of the country. The connection between the city and the airport consists of a road that crosses the monumental complex, dividing it into two parts and expanding daily with new commercial facilities.

The Italian Mission in Peru, in accordance with the the Ministerio de Cultura-Dirección de Sitios del Patrimonio Mundial, defined the perimeter of the archaeological area (core zone) and then designed a special protection area<sup>5</sup>. This buffer zone or *area de amortiguamiento* should somehow regulate the transition from the absolute prohibition of building in the core zone to the urban development forecasts of Trujillo.

Unfortunately, there has been a dangerous lack of coordination between the competent authorities. The buffer zone involves four neighboring districts: Trujillo, La Esperanza, Huanchaco and Víctor Larco Herrera (Fig. 5)<sup>6</sup>.



Fig. 3 Chan Chan landscape. The structures of “Chimu agropecuaria” factory are visible from the archaeological site. Photo by Roberto Orazi.



Fig. 4 Chan Chan landscape. Some skyscrapers are visible from the archaeological site. Photo by Roberto Orazi.

It should have its own specific urban planning that considers its protective quality towards the core zone, but is actually simply inserted in the Trujillo urban development plan.

The lack of a specific plan for the buffer zone allows each district to provide building licenses in accordance with Peru’s national building regulations. This is supported by a varied and contradictory legal framework that privileges the occupation of the territory and the construction of new buildings without regard to conserving the historical landscape of the monument or granting public recreational spaces, with an impact on urban sustainability indicators.

The interest of the real estate sector in the buffer zone is growing, especially in multi-family buildings and condominiums, where the owners have exclusive units and are co-owners of common spaces (parks, swimming pools, etc.), obviously maintaining restricted and controlled access, creating urban islands.

Moreover, the absence of specific regulations has caused a gradual increase in vandalism through invasions of borders or the construction of buildings of various floors.

The phenomenon is constantly developing, but it can and must be contained. Within our bilateral project an





Fig. 5 Plan de Desarrollo Metropolitano de Trujillo 2020-2040, Ubicación del ámbito de intervención. The buffer zone is divided in the following districts: Trujillo, La Esperanza, Huanchaco and Víctor Larco Herrera.

extensive monitoring process has been developing based on the close collaboration between ISPC, ULima and UPAO researchers. A preliminary comparison between two VHR satellite images (2003 and 2019) has enabled highlighting areas of the buffer zone where important building processes are developing (Fig. 6). These areas, identified in the GIS with specific spatial coordinates, have been communicated to the Peruvian colleagues who, in the meantime, have prepared analysis sheets to record the constructive and dimensional characteristics of the building interventions. With the help of CENEPRED (Centro Nacional de Estimación, Prevención y Reducción del Riesgo de Desastres)<sup>7</sup>, groups of students, belonging to UPAO or to the National University of Trujillo, carried out a territorial survey, producing a detailed photographic documentation. The methodology consists of verifying the existence of blocks - lots, assigning them a coding, which allows knowing the changes in the territory (subdivisions, qualifications, etc.) with respect to the official plans of the city. The photographic record of the building enables understanding the current uses in the buildings, the degree of consolidation of the sector, the building heights etc. (Figs. 7, 8).

The first surveyed area, Villa del Mar district, shows that there is a predominance of residential buildings up to 2 levels. Although there is no high densification, there is a tendency to subdivide lots, predisposing the urban sector to overcrowding and shantytowns, without the a priori control of the pertinent authorities. The population does not identify with the Chan methodology archaeological complex. It is common to find accumulations of garbage and construction waste that require constant cleanup campaigns. The lack of street lighting in the intangible zone, adjacent to the buffer zone, creates public insecurity and neglect.

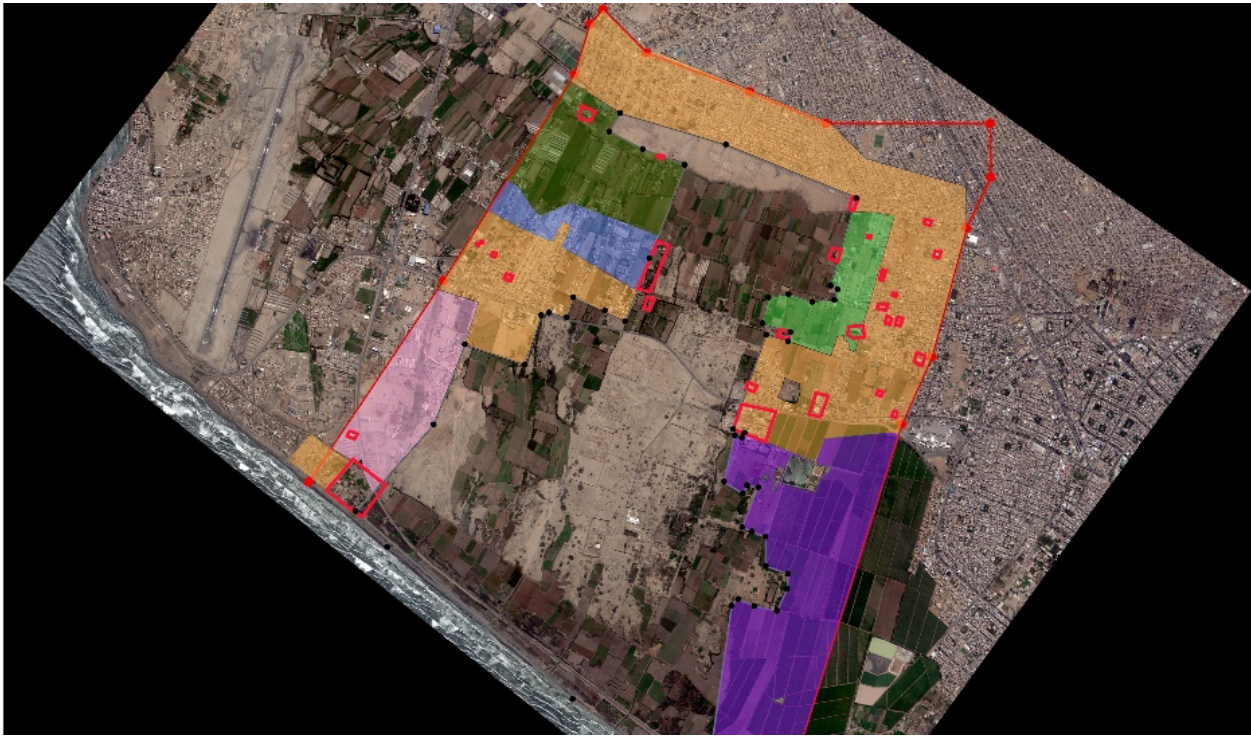


Fig. 6 Satellite image WV3, 2019. The different colors show the zoning of the buffer zone. The red squares indicate the areas subject to major urbanization risk. Elaboration ArcGis by Cinzia Bacigalupo and Anna de Meo.

## Conclusions

The bilateral project has been able to produce an experimentation on the use of HBIM in the documentation and recovery of monuments in raw earth and, on a territorial scale, a complex form of land control through the application of modern geomatic technologies.

The HBIM platform could be used not only in Chan Chan but on all the various raw earth monuments throughout the world and possibly provide elements of support to the UNESCO program for this specific construction technique (WHEAP)<sup>8</sup>.

Monitoring the buffer zone will continue in the coming months with the involvement of university students and local administrators. Of course, to counteract the uncontrolled expansion of the city of Trujillo, a specific legislative intervention will be necessary with the imposition, for the buffer zone, of specific height constraints and building density. Pending such intervention and in order to promote its implementation, the aim of the research is to establish a database that can possibly contain 3D territorial models, to promote a broad cultural movement aimed at safeguarding the integrity of Chan Chan and preserving its historical landscape. In this regard, it would



<sup>1</sup> Cfr. *Chan Chan, Andean Desert City*, edited by M. Moseley and K. C. Day, Albuquerque, University of New Mexico Press 1982; CRISTOBAL CAMPANA DELGADO, *Estudio de la ciudad de adobe mas grande de America latina*, Lima, Editorial Orus 2006; C. CAMPANA DELGADO, *Arquitectura y ceremonia en Chan Chan*, Trujillo, Universidad Privada Antenor Orrego 2012; Jesús Briceño Rosario, *Chan Chan, la capital del Chimor: 534 años después*, in *Aportes para la historia de Chan Chan* edited by L. Valle, Trujillo, Ediciones SIAN, pp. 13-28.

<sup>2</sup> *Plan Maestro para la Conservación y Manejo del Complejo Arqueológico Chan Chan 2021-2031*, Trujillo, Perú, Ministerio de Cultura, Proyecto Especial Complejo Arqueológico Chan Chan, 2021. <https://patrimoniomundial.cultura.pe> .

<sup>3</sup> Cfr. ROBERTO PIERDICCA et alii, *Virtual reconstruction of archaeological heritage using a combination of photogrammetric techniques: Huaca Arco Iris, Chan Chan, Peru*, «Digital Applications in Archaeology and Cultural Heritage » 3(3), 2016, pp. 80-90.

<sup>4</sup> Cfr. FRANCESCA COLOSI et alii, *Exploiting HBIM for Historical Mud Architecture: The Huaca Arco Iris in Chan Chan (Peru)*, «Heritage», 5, 3, 2022, pp. 2062-2082.

<sup>5</sup> Cfr. F. COLOSI et alii, *Discovering Chan Chan: modern Technologies for urban and architectural analysis*, «Archeologia e Calcolatori», 24, 2013, pp. 187-207.

<sup>6</sup> *Plan de desarrollo Metropolitano de Trujillo 2012-2022*, PLANDET, Municipalidad Provincial de Trujillo, 2022.

<sup>7</sup> We are very grateful to Eduardo Portuguez Barrientos, from CENEPRED, that have supported the first surveys on the ground with a specific training course.

<sup>8</sup> *World Heritage Earthen Architecture Programme (WHEAP)*. <http://whc.unesco.org/en/earthen-architecture>.



Finito di stampare da  
Rubbettino | Soveria Mannelli (CZ)  
**Università degli Studi di Firenze**





UNIVERSITÀ  
DEGLI STUDI  
FIRENZE

