Climate change related urban transformation and the role of cultural heritage

Matthias Ripp & Christer Gustafsson
(Eds.)

Foreword by Claire Cave

IL Sileno Edizioni

Geographies of the Anthropocene

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Editors

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Geographies of the Anthropocene

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is a collective volume of the Open Access and peer-reviewed series
"Geographies of the Anthropocene"
(Il Sileno Edizioni), ISSN 2611-3171

www.ilsileno.it/geographiesoftheanthropocene

Cover: "Public and private Transport at Potsdamer Platz, Berlin" (c) Matthias Ripp 2024

International Scientific Publisher, VAT 03716380781
Via Piave, 3/A, 87035 - Lago (CS), Italy, e-mail: ilsilenoedizioni@gmail.com

ISBN 979-12-80064-58-5

Vol. 6, No. 2 (December 2023)

ISSN 2611-3171

Geographies of the Anthropocene

Open Access and Peer-Reviewed series

Website: www.ilsileno.it/geographiesoftheanthropocene;

The book series “Geographies of the Anthropocene” edited by the Scientific International Publisher “Il Sileno” (Il Sileno Edizioni) will discuss the new processes of the Anthropocene epoch through the various worldviews of geoscientists and humanists, intersecting disciplines of Geosciences, Geography, Geoethics, Philosophy, Socio-Anthropology, Sociology of Environment and Territory, Psychology, Economics, Environmental Humanities and cognate disciplines.

Geoethics focuses on how scientists (natural and social), arts and humanities scholars working in tandem can become more aware of their ethical responsibilities to guide society on matters related to public safety in the face of natural hazards, sustainable use of resources, climate change and protection of the environment. Furthermore, the integrated and multiple perspectives of the Environmental Humanities, can help to more fully understand the cultures of, and the cultures which frame the Anthropocene. Indeed, the focus of Geoethics and Environmental Humanities research, that is, the analysis of the way humans think and act for the purpose of advising and suggesting appropriate behaviors where human activities interact with the geosphere, is dialectically linked to the complex concept of Anthropocene.

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The volume proposals can be presented in English, Italian, French or Spanish.

The choice of digital Open Access format is coherent with the flexible structure of the series, in order to facilitate the direct accessibility and usability by both authors and readers.

Contents

10. How does Cultural Heritage Foster Climate Action? Examples of Histo-Culture-based Urban Resilience from Around the World

Marika Fior[1], *Rosa Romano*[2], *Maria Paz Abad Gonzalez*[3], *Jui Ambani*[4]

Abstract

Climate variability and change have been ongoing. Urban areas with historical and cultural significance are vulnerable to the increasing effects of climate change, both physically (such as building materials durability) and socially (such as loss of inhabitants, internal displacement, tourism, and worsening economic conditions for disadvantaged populations). However, people and cities have proven to be resilient over time, even in the face of global challenges.

Combatting climate change impacts on heritage and people requires consideration of social, cultural, environmental, and economic factors. This chapter focuses on the unique challenges posed by the presence of Cultural Heritage in an urban setting and explores design actions that balance preservation with innovation. By examining the physical and structural features of historical cities, their public spaces, and sociocultural connotations, the chapter aims to highlight how communities on the frontlines of the climate crisis use them as an expression of intrinsic resilience.

Through case studies from different climatic zones, the chapter explores the rediscovery and re-evaluation of 'histo-cultural forms' of climate change adaptation. It outlines techniques and solutions -from traditional and Indigenous knowledge to tangible structural features- that are being used to cope with heat islands, storms, floods, etc. and are congenial to heritage sites, in sustaining local culture and knowledge and know-how while demonstrating renewal and adaptability.

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Keywords

Climate-proof planning, adaptation, communities, historic-based solutions

1. State of the Art

1.1 Cultural Heritage and Community are co-evolutionary elements for the adaptation

The scientific community recognises that integrated urban systems are a key-factor in the regeneration of cities, now chosen by the world population as their place of living (UN, 2019). At the same time, reports by the International Panel for Climate Change (IPCC) have systematically demonstrated that human activities are the primary cause of the intensifying in global warming, the melting of glaciers, rising sea level, and the increase in the frequency and intensity of extreme weather events exacerbating the exposure of cities and settled communities (Musco & Magni, 2014).

For the first time in 2013, Cultural Heritage was recognised as a key-factor in addressing global risks, placing culture at the heart of sustainable development policies (UNESCO, 2013). In 2015, the *Sendai Framework* emphasised that Cultural Heritage -as the most symbolic expression of a cultural system- must be considered in any disaster risk reduction programmes and thus strengthen the communities' resilience (UNDRR, 2015). Form another perspective, Cultural Heritage could support "the building of a community able to prevent, cope with and recover from disturbances" (Fabbricatti, Boissenin & Citoni, 2020, talk about "Heritage Community Resilience").

In this chapter, Cultural Heritage is understood as the set of material signs stratified on the territory over time (Corboz, 1983; Secchi, 2005). It is strictly linked to a community because it is the empirical evidence of the adaptive/transformative/evolutionary capacity of civilisations to face existential challenges. Different eras have marked the progress of civilisations; and the Cultural Heritage is the result of these transitions, not always peaceful, but expressive of the societies that created and preserved it. Therefore, Cultural Heritage is not static (reaching an ideal *status*) and immutable, but changes according to different social and environmental conditions. In other words, it is a "gene-culture-environment coevolution": the way through which a group of people figure out 'how we live here'. "It is in this way that cultural evolution generates insights about what is and is not adaptive; and such insights are directly applicable to issues of climate-change adaptation in the world today" (Brewer & Riede, 2018). The evolutionary capacity of Cultural Heritage, in adherence to the community, is the element that determines its conservation or abandonment, and above all, it shows the replicable Histo-Culture-based urban-building solutions. After all, none historic city could live without a community. Indeed, the article 1 of the *UNESCO Convention* (1972) emphasised that Cultural Heritage is created and animated by the society; while, the article 6 of the *Faro Convention* (2005) included the definition of "Heritage Community" and set off the inseparability between the two dimensions. Nevertheless, the process of adapting the historic city to the society's needs -that inherits the heritage- is crucial and it can only take place together with citizenship's evolution. The latter must re-actualises its environmental, social, economic and cultural values for developing of a more sustainable and inclusive city (Redaelli, 2019).

To make cities climate-proof, it is strategic to study the urban-building solutions that communities have employed over time to cope with negative micro-climatic conditions and reducing social costs (building and building back better). With this perspective, one must learn from the past to write the present and prepare for the future. Moreover, the fact that historical cities have survived until today represents the first real lesson in urban resilience, as it derives precisely from their ability to adapt and evolve (Holtorf, 2018). The climate change impacts on tangible heritage and has both direct effects on buildings, public spaces and infrastructures, as well as indirect effects on people and habitats, leading to climatic migrations (or displacement of cultural bearers) and abandonment of their place of living (Shirvani Dastgerdi *et al*., 2020).

However, climate change is also an opportunity for 'transformative development', activating opportunities for cities to generate urban quality, security/healthy and innovation from Cultural Heritage. According to Wolfram (2016), transformative capacity focuses on understanding how urban systems can reshape themselves and transition to a more sustainable form and function that is better than the conditions they had before the shock/stress experienced. Such knowledge can be acquired through Traditional Ecological Knowledge, an evolving body of knowledge acquired by local populations over hundreds of years through direct links with nature (Nelson & Shilling, 2018). Observing Cultural Heritage as not only a fragility factor but also as a resource stimulates the principle of sustainable urban development, based on the deep link between culture and territory.

1.2 From architecture to vernacular urbanism increasing resilience

Heritage features are closely linked to climate: urban and rural landscapes are linked to the plant species that thrive in different climatic regimes. They are designed with the local climate in mind, taking on the vernacular dimension that Oliver (2006) calls "domestic". The history of cities offers several examples of how civilisations have dealt with climatic hazards by creating site-specific adaptation solutions, sometimes still practised by some Indigenous societies and preserved in the urban structure of places.

Today, these systems based on empirical actions related to everyday life, rooted in Indigenous societies -constituting vernacular production-, are considered key elements for the sustainable development of built environments. The term *vernaculum* was used by the Latins to distinguish everything that was produced on the side from what was acquired from commercial exchanges. In literature, "vernacular architecture"[5] refers to buildings built by non-academic and anonymous labour that incorporates traditional construction systems and responds sustainably to a geographical environment (Peralta González, 2017). There is a growing interest in this topic in discussions related to building history highlighting a relationship between building function, climate and traditional construction techniques with historical context (Moholy-Nagy, 1976). The definition of 'vernacular urban planning' is less obvious but can be traced back to what Françoise Choay (1996) calls the "city idea" or Alberto Magnaghi (2000) the "statute of places".

On the contrary, globalisation and the trend towards cultural homogenisation show little attention to Cultural Heritage and site-specific characteristics of places (Dipasquale & Mecca, 2016). In architecture, this translates into the use of standardised design solutions to the detriment of local craft creativity, which in many cases involves high consumption of natural and energy resources because it is based on the linear fossil principle.

Vernacular architecture, by its nature, is a practical knowledge of continuous evolution and contamination. A valid example of it is the evolution of the Spanish covered streets, from which street roof-protection became an architectural feature, defining porticoed areas that in turn evolved from building character to urban morphology -a structure capable of con-

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[5] The debate on what vernacular architecture is, has been raging since the creation in 1976 of the International Committee on Vernacular Architecture (CIAV) of International Council on Monuments and Sites (ICOMOS), whose central concern was to prevent the disappearance of this type of construction, which is vulnerable to the rapid growth and changes of modern life (Charter on the Built Vernacular Heritage ratified by the ICOMOS 12th General Assembly, in Mexico, October 1999).

figuring entire cities- as the *Portici* of Bologna (arcades) demonstrate (Rudofsky, 1970).

Therefore, tradition and innovation are allied for urban sustainable development, concretely implementing the idea of "transformative resilience" (Manca *et al.*, 2017) that underlies a process in which the society learns from the past for dealing with the future cities and facing new challenges.

2. Goals and Methodology

Throughout human history, vernacular architecture and urbanism have represented adaptive solutions to environmental, climatic, socio-economic, and societal constraints (Correia *et al.*, 2014). These traditional multi-scalar actions range from technological elements to architectural and urban solutions. They reflect a practical response to the local community's identity and know-how, in other words, its culture.

The chapter highlights how -along the human history- adaptive solutions to climate change can be found at various scales. From ancient times to the closest urban history, solutions -from the building detail to the definition of a new district- represent a set of local-based actions/techniques showing a community's identity and its know-how, in other words its culture.

The idea behind the article is that urban resilience to climate change should not be created from scratch through a top-down approach. Resilience must be found in the existing settlement fabrics and strengthened (Fabbro, 2020). In fact, it is peculiar to artefacts that have variety, multi-functionality and redundancy, i.e. the typical characteristics of resilient complex systems such as historic cities and, in general, the Cultural Heritage handed down from/to the generations.

To support this idea, this chapter presents four urban contexts from Ecuador, India, Spain, and Italy, each with different histories, cultures, traditions, geographies, and climates. Their diversity shows how local knowledge and culture have always allowed civilizations to adapt to environmental and climatic challenges. The chapter discusses concepts and techniques that can be replicated in our current situation.

The case study is a recent research methodology mainly used in the humanities to analyse unique or complex situations. Cities are "evolving complex systems" determined by their own (unpredictable) capacity for self-regulation, i.e. by the changes that occur over time in both physical and social structures (Bertuglia & Vaio, 2019). Hence, this contribution presents a non-systematic review of four cities from around the world (Azuay-Cañar provinces in Ecuador, Udaipur in India, Madrid in Spain, and Rome in Italy). The review aims to analyse these cities and identify their adaptive solutions to climatic and meteorological hazards from the past, handed down from the past as good solutions to meteorological and climatic hazards. The methodology used in this research is a QUALITATIVE literature review for each city, focusing on identifying traditional climate adaptation forms. This method is based on a second-level study through a hermeneutical review of the scientific literature. Unlike a systematic review, typically used in medical settings, the hermeneutical review focuses on qualitative reflection and interpretation of phenomena. The review aims to generate ideas and hypotheses rather than on the completeness of the literature selection. (Greenhalgh, 1997; Greenhalgh *et al.*, 2018).

The four case studies represent preliminary qualitative research on traditional forms of adaptation to the climate with the aim of collecting 'data' (observations and comments) to generate ideas and hypotheses through the so-called inductive approach whose strength is the proximity to the 'truth of the reality that happened'.

After a brief summary of the state of the art (ph. 1) on Cultural Heritage in relation to climate change and communities, and the illustration of the working methodology (ph. 2), a specific paragraph describes each city's historical, environmental, and social characteristics. This includes highlighting the architectural and urban planning solutions used to cope with urban heat islands and heavy rainfall[6].

The paragraph 3 collects the discussion of Azuay-Cañar provinces in Ecuador (ph. 3.1), Udaipur in India (ph. 3.2), Madrid in Spain (ph. 3.3), Rome in Italy (ph. 3.4). The first case study in the Azuay-Cañar provinces in Ecuador tries to understand low-impact mitigation practices, where the earth is the predominant material for vernacular architecture (a technique used by 30% of the global population for building their home). It also highlights the social practice of *minga,* which is used to organise private, semi-public, and public spaces, reducing realisation costs and ecological footprint. The second case study is about Udaipur, India, where traditional materials such as marble and lime are used to mitigate the impacts of severe heat, and the region's five lakes and underground systems (*Paar, Talabs, Bawri* and *Kundi*) are used to store rainwater. The third case study focuses on another low-impact and sustain-

6 As highlighted in the Sixth Assessment Report during the IPCC's 58th Session held in Switzerland (2023, March 13-19), urban heat islands and extreme rainfall are the most disruptive and transversal effects on all cities in the world. The increase in global temperature due to greenhouse gases determines the increase of heat waves and accelerates the water cycle, causing more floods and droughts (Hoegh-Guldberg et al., 2018).

able solution in Madrid, Spain, where the ancient groundwater capture and management system, the *qanat* technique, is used to sustain water resources. The fourth case study is about Rome, Italy, where the role of post-unification districts, "new Piedmontese," is highlighted based on the orthogonal grid of streets rotated towards the west (equisolar axis) are used to favour wind cooling.

The final paragraph (ph. 4) offers some concluding reflections on the lessons that the case studies offer. It highlights that Cultural Heritage is both an object of adaptation actions (site-specific) and a solution for adaptation actions (place-based). Architectural and urban planning techniques/solutions -that have spanned continents and history (from antiquity to modernity)- demonstrate how historic cities have always been resilient organisms providing adaptive solutions consistent with local culture. They are Cultural Heritage, on the one hand, to be preserved and, on the other hand, to be re-actualised in order to defend cities and people from climate hazard.

The collection of four case studies demonstrates that the adaptation of historic cities needs implementing useful actions and methods to face global challenges, starting from the re-signification of the Cultural Heritage. The latter already offers valuable solutions to the negative climate effects (heat waves and heavy rains especially). Local practices and traditions represent a fundamental *trade d'union* for the development in continuity of urban history, to simultaneously protect and adapt cities. This approach can only be implemented on a case-by-case basis. However, common elements among different contexts that can be taken as inspiration for new Histo-Culture-based solutions. In order to increase urban resilience, among climate change adaptation actions, it is strategic to recover traditional building techniques and urban planning solutions by integrating them with innovative technologies (Garcìa Hermida, 2019; Bonazza, De Nuntiis & Sardella, 2021).

3. Case Studies Discussion

3.1 Azuay-Cañar provinces, Ecuador

The provinces of Azuay and Cañar have an average multiannual temperature between 15-17° C. The historical zone of the city of Cuenca is located at approximately -2.8974° latitude, -79.0045° longitude, and at an altitude of around 2,543 meters above sea level.

To understand the vernacular architecture in the provinces of Azuay and Cañar, it is necessary to refer briefly to the Cañari and Inca people (the first settlers) and the influence of Spanish colonisation on this type of architecture. The mountainous landscape has greatly influenced the vernacular architecture of these provinces. Before the Spanish occupation, settlements were typically located in high settlements and even steep sites, as this allowed them to ensure a strategic position over their enemies, as well as good ventilation and sanitary conditions. According to González Suárez (2017), the shape of the houses in these provinces varied from almost round to quadrangular, with elliptical houses having two doors among the Cañaris. Their construction systems were strongly linked to ways of life that have since been lost. To fully understand the vernacular architecture of these provinces, it is necessary to establish a relationship between technological solutions, cultural values of the property and users' comfort requirements.

According to Houben and Guillaud (1994) and ASTM E2393/E2392M-10 (2016), earth has been a construction material for a long time, and adobe is one of the oldest systems, with records dating back to 8000 b.C. It is also the most widespread with examples in almost all the warm-dry and temperate climates of the world (Achig *et al.*, 2013). It is observed that about 30% of the total population lives in earthen constructions, not only adobe, with approximately 50% concentrated in developing countries in Latin America, Africa, India, Asia, the Middle East and Southern Europe, with a predominance in rural areas (Houben & Guillaud, 1994; Blondet, Villa García & Brzev, 2003; Fratini *et al.*, 2011). On the other hand, according to the inventory of World Heritage architecture on earth (CRAterre, 2012), 150 properties are constituted by this materiality, with a majority presence in the region defined as Asia-Pacific regions, followed by Latin America.

The main constant in this type of architecture is using earth as the predominant material (Eljuri, 2010). The structures are predominantly made of adobe or bahareque. In some cases, a combination of both materials (bahareque and rammed earth) is used, especially if the building has more than two stories (García *et al.*, 2017). Each location's variations in form and function result in unique characteristics that respond to the specific urban or rural context. The use of wood in ornamental elements and the play of planes create semi-public spaces that enhance the functionality of the building (Pesantes, 2011). Using local materials not only enhances the identity of the place, but also reduces transportation costs and pollution. Traditional materials such as hemp, lime or straw absorb CO_2 making them an eco-friendly option (Godwin, 2011).

Adobe has thermal inertia, which allows it to store heat and transmit it from the outside to the inside, depending on the wall thickness and orientation (Wrigth, 1981). Structures with this system have a low environmental impact since less energy is needed to produce them, and they are 100% recyclable and reusable. Only 1% of the energy needed to manufacture reinforced concrete is required to prepare, transport and work the mud on site (Minke, 1994). Research on buildings in the Netherlands shows that using wood in the construction of buildings could reduce CO_2 emissions by 50% compared to traditional materials (Pérez Gálvez *et al.*, 2012). Additionally, manufacturing processes with this material have the potential to reduce the production of about 100 tons of CO_2 emissions each year. Using this material in construction represents an important contribution to the eco-efficiency of the construction industry and, therefore, to a more sustainable development (Pacheco-Torgal & Jalali, 2012). Adobe mainly consists of mud, which also absorbs pollutants and regulates environmental humidity and indoor climate (Carangui, 2010).

The space in these structures is mainly semi-public, denoting a sense of community and trust. The social practice of community or voluntary collective work, called *minga*, is used for agriculture, canal and bridge construction, and other infrastructure works in the American Andes. The result entails the satisfaction of participation for the common good and retribution, expressed in the direct benefit of those who have helped. The *minga* is used to build and manage human, economic and natural resources, which are born from social organisations, cooperatives and communities, to achieve goals that contribute to the common good. The *minga* becomes efficient and modern, with roots in past cultural moments of regional and local communities. From the procurement of materials to the construction, the *minga* begins in the family nucleus, which the community joins. Everyone participates, including children, elders and women accompanied by ritual elements that guarantee the well-being of the occupants. Community work is the platform for transmitting knowledge to the next generations. (Vázquez *et al.*, 2018).

3.2 Udaipur, India

Rajasthan, a western desert state of India, is known for its harsh climatic conditions, including extreme heat, hailstorms, frost, cold waves, locust attacks, cyclones, cloudbursts, and sandstorms. The region is also grappling with the intensifying impact of global warming, leading to unprecedented heat waves (Hess *et al.*, 2018).

Rapid urbanization and infrastructure development further expose the state, including its Cultural Heritage and people, to the adverse effects of climate change. This case study focuses on Udaipur, often called the 'City of Lakes' and 'White City', to explore how traditional water systems are pivotal in mitigating climate change impacts.

Udaipur has a rich history of traditional and ancestral knowledge-bearing communities whose practices predate the modern infrastructure. The city's iconic architecture and urban fabric have earned it the White City. This is attributed to the use of white marble and lime wash in the construction of houses, which not only adds to the city's aesthetics but also helps mitigate the impacts of severe heat (capaCITIES, year n.a.).

Udaipur is also known as a 'City of Lakes' due to its sophisticated system of five man-made lakes: Fateh Sagar Lake, Lake Pichola, Swaroop Sagar Lake, Rangsagar and Doodh Talai Lake. Over 300 years ago, the Maharanas (rulers) of Mewar built this interconnected lake system in Udaipur which supports and sustains groundwater recharge, ensuring the availability of water for the purpose of consumption, industries, agriculture and tourism (MMHPTN, 2020).

The traditional water systems -*Paar* (Table Water), *Talabs* (Lakes), *Bawri* (Stepwells), and *Kundi*- are still used and relied upon by the city to store rainwater through its network of catchments in man-made lakes, ponds, and step wells, as well as porous agriculture techniques. Apart from being the most efficient way for water harvesting and management, these systems also serve religious, cultural, traditional, and sociological purposes (CSE, 2020).
Paar system is a common water harvesting practice in Udaipur, where rainwater flows from catchment areas and percolates into the sandy soil. To control water wastage and create a *Paar* system, 6-10 deep holes, known as *Kuis* or *Beris*, are constructed near water-leaking tanks.

Udaipur boasts a variety of stepwells with different typologies. *Kua* is usually a well owned by an individual, while *Bawri* or stepwells are deep trenches lined with stone blocks. These stepwells serve as venues for social and religious gatherings. They help maintain water levels with rainfall, keep the water cool even in summer, and act as natural water purifiers.

Tankas, also known as small tanks, can be found in the courtyards of traditional homes. They are constructed with lime plaster and thatched bushes to divert surface water runoff. This concept can also be applied on a large scale, serving clean water to an entire neighbourhood.

Talabs are lakes or large reservoirs constructed in natural depressions or valleys. These are community-based constructions with lime masonry walls and soil filling. Smaller reservoirs are called *Talai*, medium-sized lakes are *Bandhi* or *Talab*, and larger ones are sagar or samand. These lakes are crucial in sustaining water availability for consumption, industries, agriculture, and tourism (Murugesan & Amirthalingam, 2014). When the water in these reservoirs dries up just a few days after the monsoon, the pond beds are cultivated with rice (CSE, 2020).

Udaipur faces water-related challenges due to its need for perennial rivers. The region relies on deep wells and rainwater harvesting systems. However, rapid urbanization, increased demand for agricultural land, and deforestation have led to impermeable concrete surfaces, making natural water storage difficult. The escalating heat waves have intensified droughts and further reduced water availability. Groundwater levels have plummeted significantly (Udaipur Urja, 2022).

At the same time, Udaipur's traditional water systems offer valuable lessons in climate resilience. These systems not only serve as efficient water harvesting and management methods but also safeguard Cultural Heritage and provide a sustainable solution to the water scarcity exacerbated by climate change. As other regions grapple with similar challenges, the experience of Udaipur serves as a beacon of hope and a model for incorporating traditional knowledge into modern climate adaptation strategies.

Water Conservation: traditional water systems have been instrumental in conserving and storing water. Stepwells, *Tankas*, and *Talabs* help capture rainwater and replenish groundwater, providing a sustainable water source for various needs.

Cultural and Social Significance: these traditional systems serve not only as water reservoirs but also hold immense cultural, religious, and sociological value. They are gathering places for the community and contribute to preserving heritage.

Resilience to Climate Change: the interconnected lake system in Udaipur has proven to be resilient against the challenges of climate change. It supports groundwater recharge, ensuring a consistent water supply, even during periods of drought (MMHPTN, 2020).

3.3 Madrid, Spain

Madrid was established by the Muslims (around 860 a.D.) as a fortress to control the Manzanares River valley. The Moors, skilled 'hydraulic engineers', introduced irrigation systems and water management techniques, such as the *qanat*. This is an ancient system for capturing and managing groundwater, which involves long underground tunnels known by different names including *karez*, *aflaji*, *ingruttati*, *khottara* and *foggara*. These tunnels transport water to the surface using the gravity, providing a low-impact and sustainable exploitation system even by today's standards.[7]

The foundation of Madrid itself is closely linked to its hydraulic infrastructures, which naturally developed due to the morphology of the land. Some scholars suggest that the name Madrid is derived from the Arabic word *mayra*, which means 'water conduit', combined with the Ibero-Roman suffix -*it*, which means 'place of'. The outcome is *Mayrit*, the word from which Madrid is derived (Martınez-Santos & Martınez-Alfaro, 2012).

The *qanats* of Madrid are often called the '*viajes de agua*' (water trips), derived from the Latin phrase *Via Aquae*. Other local traditions still connect Madrid to groundwater. For example, Madrid's oldest coat of arms bears the inscription: "*Fui sobre agua edificada mis muros de fuego son esta es mi insignia y blasón*" (I have been on the water and built my walls of fire, this is my badge and my coat of arms). Legends about Saint Isidro the Worker, a native of the region and Patron Saint of the city, depict him as a renowned water seeker, i.e. diviner. In total, 124 km of *qanats* run beneath the Spanish capital; 70 km of which are used to catch water and 54 km to transport it to the city, supplying water to 750 water sources, which over time became fountains.

The *qanats* vary in size and shape; some are unlined, while others are brick-lined with arched ceilings to improve stability and prevent contamination; most are high enough for a person to walk inside and about 60-80 cm wide (Martınez-Santos & Martınez-Alfaro, 2012).

Madrid became the capital of Spain in 1561, and as the population grew, so did the demand for water. Historical documents indicate that several new tunnels were opened during this period, with the last branch being inaugurated in 1855. The *qanats*, the capital's only water source until then, were replaced by water from the Lozoya River, channelled through the Canal de Isabel II in 1858. (Gerrard & Gutiérrez, 2018). This change marked a cultural transition that led first to the decommissioning and then to the disappearance of these systems. The disposal of *qanats* implies the loss of history, tradition, memory and local identity, inextricably linked to the contamination of civil-

[7] The construction technique of the *qanats* involves digging a mother well in order to assess the depth of the water table. Based on the depth, the lower outlet point of the tunnel is calculated, which is then excavated to join the two points. Vertical shafts are excavated along the tunnel route to facilitate access and removal of excavated material, as well as to ensure ventilation and evaporation. When the tunnel intersects the water table, the groundwater infiltrates and is transported by gravity towards the outlet: the water is then conveyed into the city in distribution reservoirs or irrigation fields.

isations that in the past, as today, represents the main vector of innovation and socio-cultural evolution. The *qanat* technique, along with vernacular architecture in general, underlies that connection between the artificial and the natural systems, between technological and ecological principles, favouring those ecosystem services essential for planetary equilibrium based on a system of mutual exchange between human activity and the cycle of nature.

The *qanat* technique originated in the Middle East and spread to Europe and America over time. The ancient *qanat* system still supports agricultural and permanent settlements in Iran's arid regions, and the traditional community management system allows for fair and sustainable water sharing and distribution (De Cesaris, 2023). In 2016, Iran's *qanats* were declared a World Heritage Site. Similarly, in 2002, UNESCO recommended the protection of Madrid's *qanats* as a World Heritage Site to preserve an important part of the city's heritage. However, well-preserved *qanats* are rare, and only a few of them have survived today. Occasionally, a tunnel is discovered during excavation, as is the case with the *Viaje de Agua de Amaniel* built between 1614 and 1616. Also known as the Palace waterway, because it was created during the reign of Felipe III to supply the Alcázar. Today, it can be seen in the galleries near Juan XXIII Street facing the Amaniel Aqueduct. In the same way, some of its *capirotes* (well caps) have stood the test of time and survived as elements of the urban landscape (Madrid, 2009).

The valorisation, management and utilisation of this Cultural Heritage -compatible with its original function as the city's water supply- represents an unmissable opportunity to address the phenomena of heavy rains and heat islands in Madrid (and perhaps also in other parts of the world). Starting from these ancient underground infrastructures, an integral regenerative process can be triggered in line with the recent *Nature Restoration Law* (approved by European Parliament in 2023, July 12).

3.4 Rome, Italy

Rome *Caput Mundi*. The city's history is rich and spans millennia of civilisation. This discussion will focus on modern Rome, specifically the city development between the 19th and 20th centuries, aiming to assess the resilience of its settlement's fabrics to climate change. During this period, the concept of vernacular/traditional architecture and the focus on the environmental comfort of settlement fabrics gave way to the real estate market, which became increasingly independent of the hydro-geo-morphology of the territory and the historical landscape (Funiciello & Testa, 2008). Is this really the case?

Historically, Rome was built on seven hills (no higher than 40-50 m), which guaranteed defence from enemies and healthiness from the plain of the River Tiber. The land was anthropised through drainage networks with the burial of watercourses and works such as the *Cloaca Maxima* (Pica & Del Monte, 2018). The progressive anthropisation of the soils and the continuous levelling of the minimum altitude differences have certainly influenced the climatic comfort of the city. The reduction of the steepness and the inefficiency of the underground drainage systems cause evident problems throughout the urban area (Funiciello & Cologgi, 2008), and the impacts of the floods of the Tiber extend especially in the historic centre (Lanzini *et al.*, 2008). Furthermore, the ancient Romans had devised solutions for the thermal comfort of both private spaces -through the use of white and porous lime mortar (which allowed air permeability and the reduction of humidity inside buildings)- and public spaces -through the creation of the *Viae Tectae*, i.e. the covered streets to protect passers-by from solar radiation- addressing the issue of urban heat islands *ante litteram*.

Over the centuries, the city has undergone a slow and fluid stratification process, adopting settlement rules linked to the knowledge and canons of the time and favoured by a mild climate. It was during the establishment of the great European capitals after the Second Industrial Revolution that Rome began to redesign its urban spaces (Cassetti, 2005). On an experimental basis, we believe that these solutions have supported the process of continuous adaptation of the city to environmental, meteorological and climatic factors by creating climate-proof settlement fabrics. The objective, through the study of the post-unification districts of Rome, is to recognize not the features of vernacular architecture, but of a 'vernacular/traditional urban planning' which has been deposited in Rome, in other European capitals as well, a model of a resilient city and today recognized for its quality and historical value.

Briefly reviewing the modern history of Rome, the city started to draw its first city plan after the unification of Italy (1870). The Viviani's Plan, was not definitively approved, and instead, the city followed a model of expandion similar to what was happening in Paris by Baron Haussmann and in Barcelona by Ildefonso Cerdà[8]. The far-sighted experience of Barcelona proves the

[8] The Spanish case is emblematic for briefly summarizing the inspiring principles of a new, modern settlement model which aimed to combine efficiency and aesthetic quality. The Cerdà's Plan (*Proyecto de Reforma y Ensanche de Barcelona*, 1859) is well-known for having used the cuadrícula, the orthogonal grid of streets, to facilitate mobility and create urban blocks that satisfy conditions of density, ventilation and sunlight. Another interesting aspect is the attention that Cerdà retained, to a collector avenue to protect the Eixample from torrential rains in 1855 (Magrinyá & Marzà 2009).

extreme confidence on technological innovation based on a hard engineering approach. Seems that the approach progressively interrupted the traditional relationship between humans and nature.

Rome waited until 1887 the official plan, again by Viviani engineer. Nevertheless, in those ten years, the urban area grew through the development of the "new Piedmontese districts". They were so called because they housed the new ministerial management class that arrived from Turin (in Piedmont region), but also because they repurposed, with the necessary adjustments, the Turin settlement model. It consisted of straight streets, with four/five-storey rental houses (already present in Baroque Rome) plastered with yellow ocher, the cheapest colour, and built around the public squares. "Here and there, timidly, the 'Piedmontese' tried to transplant the *portico* (arcades): but on the one hand the weather of Rome did not require them and tradition did not know them, on the other hand, they stole area from speculation" (Insolera, 2011). The *portico* was an architectural element that would not have brought great climatic benefits to Rome at that time, given the constant relationship with the surrounding countryside – the *Agro romano* Which transferred the fundamental 'ecosystem services' for free and vegetated soil to the urban districts (ventilation, cooling, rainwater absorption).

In these circumstances, the expansion of the popular peripheries in the capital gave rise through the development of two important neighbourhoods: San Lorenzo and Santa Croce. San Lorenzo in particular, was build as a quarter for the rail workers, covering almost 40 hectares and featuring an orthogonal grid of streets, with five-storey ochre-plastered houses flush with the street and a closed inner courtyard for ventilation and lighting.

The orientation of the grid is rotated towards the west by 30-40 DEGREES, allowing the winds to enter, especially in the summer, when they come from the east and west, channelling themselves into the neighbourhood's road network. The orientation follows the equisolar axis defined by Gaetano Vinaccia in 1940, a pioneer in solar engineering (Chiri & Giovagnorio, 2015). This axis ensure the correct thermal exposure on four sides of the buildings instead of just two, making it better than the heliothermic one (Vinaccia, 1952). The road network is not particularly wide (about 12-14 metres), but manuals from the beginning of the century stated that unlike cold countries, in warm ones, narrow streets defend inhabitants from the sun and dust, reconciling shading and ventilation.

4. Final Remarks

What is the lesson offered by the FOUR WORLDWIDE case studies? Heritage is not just historical elements and practices. It is the urban, the new, the old, the ignored, the forgotten, and the valued. It serves as a story-telling machine and a cascading research tool, providing insights to mitigate modern-day challenges such as climate change through its lived experiences.

In the case of Ecuador, vernacular architecture has economic value because it uses resources efficiently, both spatial and material. The vernacular architecture uses what is necessary -no less, no more- making it highly energy efficient. Heritage buildings highlight aspects such as the walls thickness, which helps in gaining heat during the day and expelling it during the night to the building's interior. Using recyclable materials is a relatively new concept that aims to reduce energy expenditure and maintain a long-term energy balance in the building (Pérez Gálvez *et al.*, 2012). This approach maximises and prioritises the use of materials from the immediate environment, favouring *in-situ* construction, which reduces the ecological footprint and optimises transportation costs and facilitates its constant maintenance. The *minga* has also been used as a tool for heritage conservation that implies cost reduction, greater feasibility of execution, and optimisation of human resources. This type of non-wage labour significantly reduces the cost of labour and entrepreneurship (Vázquez *et al.*, 2018).

Culture, is the full range of human experiences: from the ones living through knowledge and practices of indigenous and local communities to tangible remains of earlier societies, who also faced environmental shocks along with historical trajectories that have created the places and climatic situations within which we live now (ICCROM-FAR, 2022).

The study conducted on Udaipur sheds light on the importance of cultural knowledge in supplementing scientific data for effective climate change management. Traditional methods of rainwater and natural water harvesting can serve as examples of water conservation in India to combat the impending water crisis. The research emphasizes that city-wide measures, involving citizens in enhancing preparedness and utilizing traditional knowledge, have a sustainable and long-lasting impact. Culture and heritage play a crucial role in developing fair and inclusive pathways for climate action and decarbonizing. Combining indigenous and local knowledge, ecosystem-based and community-based adaptations can generate transformative sustainable changes. Governance measures that transparently incorporate scientific and indigenous knowledge can act as enablers of such co-production (ICCROM-FAR, 2022).

The case of Madrid offered a clear example of the evolutionary capacity of vernacular architecture through the use of Islamic hydraulic technology. The architecture adapts to the changing temporal needs of society, while maintaining a harmonious link with natural and urban context. Horizontal wells, as opposed to drilled wells, respect natural balances and hydrogeological balances, utilizing free water tables and following only seasonal recharge rhythms. These durable and sustainable systems transport of water to the surface without the use of mechanical energy, relying on gravity dependent on orographic altitude. The aquifer's potential as a complementary water source offers an alternative resource to running water to cope with droughts and water shortages linked to climate change. However, Madrid's *qanats* have mostly disappeared, tombed or closed for security reasons, and to avoid indiscriminate use as landfills. Most of the isolated segments that have survived are integrated into the wastewater network. Identifying still existing tunnels may represent a unique opportunity for the recovery of rainwater in ongoing growth. The restoration and adaptation of tunnels and connected cisterns offer a high potential for adaptation to extreme climatic phenomena in a historical context difficult to modify and transform using modern technologies. Instead, the successive stratification of such systems has shaped and consolidated the context.

In the case of Rome, the reported chronicle of urban development at the end of the 19th century emphasises how the town planning of the time was not indifferent to climatic issues; indeed, in line with European town planning of the period, it started from considerations closely linked to the geography and hygiene of places. The review of the San Lorenzo district in Rome shows that it is a real piece of the 'historical city' as defined by Rome's land use plan (PRG 2008). The local plan clearly indicates that regeneration actions for these fabrics must consolidate the characteristics of the layout, enhancing the process of street hierarchisation and rethinking the morphological characters of the streets, i.e. downgrading some road axes in order to favour pedestrian use.

The general idea that derives from these considerations is that exploiting the 'co-evolutionary capacity' of Cultural Heritage (expressive of local know-how and its techniques) determines its proactive role in the planning of the city's future, thus abandoning its role as a constrained asset to be safeguarded (Della Torre, 2010). The aim is first of all to leverage the vernacular character of heritage, its ability to resist change and to update itself with respect to the needs of the times, maintaining a character of compatibility with the environment in which it interacts because it does not alter it but incorporates its specific features.

Today, talking about regeneration implies implementing development actions restoring meaning to the material and immaterial culture of places. Renewed tradition can be the basis for setting up the construction of the sustainable city because it supports urban development in continuity and with respect for its history. The specificity of local history translates into local forms of adaptation, i.e. ‘established forms of climate resilience’. By recovering traces, re-signifying and innovating them in terms of sustainability will contribute to transforming and enhancing urban resilience. The physical and structural components of Cultural Heritage, if re-enacted, can contribute to adaptation. They are transformed from fragility to opportunity. Furthermore, Cultural Heritage is a resource for the identity value and the sense of belonging it generates.

Acknowledgements

The authors would like thank Professor Chiara Ravagnan for connecting the authors and drawing out common knowledge that made this paper happen. We also thank ICCROM’s First Aid and Resilience for Cultural Heritage in Times of Crisis Programme, whose ongoing project, Net Zero: Heritage for Climate Action, funded by the Swedish Postcode Foundation, was the main source of inspiration behind this research. We are also grateful to the Sapienza University of Rome for providing the time and in-kind contribution to the paper.

Authorship

The authors decided and discussed the article’s topic and contents. Marika Fior defined the structure and wrote paragraphs 1.1, 2, and 3.4; Jui Ambani wrote paragraph 3.2; Maria Paz Abad Gonzalez wrote paragraph 3.1; Rosa Romano wrote paragraphs 1.2 and 3.3. The authors wrote the final remarks together.

Funding sources

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

Achig, M.C., Zuñiga, M., Van Balen, K., Abad, L., 2013, "Sistema de registro de daños para determinar el estado constructivo en muros de adobe", *MASKANA*, 4, 2, 71-84.

ASTM E2393/E2392M-10, 2016, *Standard guide for design of earthen wall building systems. Building Systems*, ASTM International, West Conshohocken, PA, UAS.

Bertuglia, C.S., Vaio, F., 2019, *Il fenomeno urbano e la complessità*, Bollati Boringhieri, Torino.

Binani, G.D., Rama Rao, T.V., 1954, *India at a Glance: A Comprehensive Reference Book on India*, Orient Longmans, India.

Blondet, M., Villa Garcia, G., Brzev, S., 2003, *Construcciones de adobe resistentes a los terremotos*, Earthquake Engineering Research Institute, California, USA.

Brewer, J., Riede, F., 2018, "Cultural heritage and climate adaptation: a cultural evolutionary perspective for the Anthropocene", *World Archaeology*, 50, 4, 554-569, https://doi.org/10.1080/00438243.2018.1527246.

Bonazza, A., De Nuntiis, P., Sardella, A., 2021, *Impatto dei cambiamenti climatici sui beni culturali e sul paesaggio. Affare assegnato n. 808 (impatto dei cambiamenti climatici sui beni culturali e sul paesaggio). Invio Contributo in risposta alla Nota Prot. n. 489/7a*, Istituto di Scienze dell'Atmosfera e del Clima, Consiglio Nazionale delle Ricerche, Bologna.

capaCITIES, year n.a., *Climate Resilient City Action Plan – Udaipur*, retrieved from: <https://www.capacitiesindia.org/about/) accessed on May 02 2023>.

Cassetti, R., 2005, *Roma e Lazio 1870-1945. La costruzione della capitale e della sua regione*, Gangemi Editore, Roma.

Carangui, S., 2010, *Estudio de los sistemas constructivos tradicionales en madera*, Facultad de Arquitectura, Universidad de Cuenca, Cuenca.

Chiri, G., Giovagnorio, I., 2015, "Gaetano Vinaccia's (1881–1971) Theoretical Work on the Relationship between Microclimate and Urban Design", *Sustainability*, 7, 4, 4448-4473, https://doi.org/10.3390/su7044448.

Choay, F., 1996, *La città. Utopie e realtà*, Einaudi, Torino.

Clayton, L.A., 1978, *Los astilleros de Guayaquil colonial* (Archivo Histórico de Guayas), 11, Ser. Col. Monográfica, Archivo Histórico del Guayas.

Corboz, A., 1983, "Il Territorio come palinsesto", *Casabella*, 516, 22-27.

Correia, M., Dipasquale, L., Mecca, S., 2014, *VERSUS: Heritage for tomorrow, vernacular knowledge for sustainable architecture*, Firenze University Press, Firenze.

CRAterre, 2012, *World heritage inventory of earthen architecture*, retrieved from: <http://unesdoc.unesco.org/images/0021/002170/217020e.pdf>.

De Cesaris, A., 2023, "Tehran: la storia urbana e le contraddizioni di una capitale", *Urbanistica* 167, Inu Edizioni, Roma, 48-59.

Della Torre, S., 2010, Preventiva, integrata, programmata: le logiche coevolutive della conservazione. In: Biscontin, G., Driussi, G. (Eds.), *Pensare la prevenzione. Manufatti, usi, ambienti: atti del XXVI convegno Scienza e Beni culturali*, Bressanone 13-16 luglio 2010, Venezia, Arcadia Ricerche, Venezia, 67-76.

Dipasquale, L., Mecca, I., 2016, "L'architettura vernacolare come modello codificato per il progetto contemporaneo sostenibile", *TECHNE*, 12, 190-198.

Eljuri, G., 2010, "Arquitectura tradicional en Azuay y Cañar. Técnicas, creencias, prácticas y saberes", *Serie Estudios Instituto Nacional de Patrimonio Cultural*, INPC, Ecuador.

Fabbricatti, K., Boissenin, L., Citoni, M., 2020, "Heritage Community Resilience: towards new approaches for urban resilience and sustainability", *City, Territory and Architecture. An interdisciplinary debate on project perspectives*, 7, 17, https://doi.org/10.1186/s40410-020-00126-7.

Fabbro, S., 2020, "Ecopolis: un approccio integrato alla resilienza dei sistemi territoriali non metropolitani", *Urbanistica Informazioni*, 289, Special Issue no. 15, 1-6.

Fratini, F., Pecchioni, E., Rovero, L., Tonietti, U., 2011, "The earth in the architecture of the historical centre of LameziaTerme (Italy): Characterization for restoration", *Appl. Clay Sci.*, 53, 519-516.

Funiciello, R., Cologgi, P., 2008, I fattori di pericolosità e lo sviluppo urbano. In: Funiciello, R., Testa, O. (Eds.), *Periodici Tecnici – La Geologia di Roma – Dal centro storico alla periferia*, *Memorie descrittive della Carta Geologica d'Italia*, Ispra, Firenze, 80, 7-12.

Funiciello, R., Testa, O., 2008, Cambiamenti morfologici e sviluppo urbano nella città di Roma: il versante destro del Tevere. In: Funiciello, R., Testa, O. (Eds.), *Periodici Tecnici – La Geologia di Roma – Dal centro storico alla periferia*, *Memorie descrittive della Carta Geologica d'Italia*, Ispra, Firenze, 80, 261-274.

Garcìa Hermida, A., 2019, "New Vernacular Architecture. Acts of International seminar", *New Vernacular Architecure*, Escuela Técnica Superior de Arquitectura de Madrid (ETSAM), 17-18 October 2019, 55-64.

García, G., Tamayo, J., Malo, G., 2017, "Seminario iberoamericano de arquitectura y construcción con tierra", *Valoración de la arquitectura vernácula de Azuay y Cañar, Ecuador* (17th ed., ser. siacot), PROTERRA, La Paz.

Gerrard, C., Gutiérrez, A., 2018, "The Qanat in Spain: Archaeology and Environment", retrieved from: <edition-topoi.org/articles/details/1435>.

Gerundo, C., 2016, *Città e clima: forma urbana e adattamento ai cambiamenti climatici*, Tesi di Dottorato in Ingegneria dei Sistemi Idraulici, di Trasporto e Territoriali (XXVIII Ciclo), Università Federico II di Napoli, Supervisor Prof. Marialuce Stanganelli.

González Suárez, F., 2017, *Historia General de la República del Ecuador*, Biblioteca Cervantes Virtual.

Godwin, P. J., 2011, "Building conservation and sustainability in the United Kingdom", *Procedia Engineering*, 20, 12-21, doi: http://doi.org/10.1016/j.proeng.2011.11.135.

Greenhalgh, T., 1997, "How to read a paper: Papers that go beyond numbers (qualitative research)", BMJ, 315, 740, doi: https://doi.org/10.1136/bmj.315.7110.740.

Greenhalgh, T., Thorne, S., Malterud, K., 2018, "Time to challenge the spurious hierarchy of systematic over narrative reviews?", *Eur J Clin Invest*. 2018 June 48, 6, e12931, doi: 10.1111/eci.12931.

Guerrero, B., 2016, January 8, "Arquitectura vernácula Paja Toquilla y otros materiales de la selva", *Clave!*, retrived from: <https://www.clave.com.ec/arquitectura-vernacula-paja-toquilla-y-otros-materiales-de-la-selva/>.

Hess, J.J., Lm, S., Knowlton, K., Saha, S., Dutta, P., Ganguly, P., Mavalankar, D., 2018, "Building Resilience to Climate Change: Pilot evaluation of the impact of India's first heat action plan on all-cause mortality", *Journal of \ Environmental Public Health*, 7973519, doi: 10.1155/2018/7973519.

Hoegh-Guldberg, O., Jacob, D., Taylor, M., Bindi, M., Brown, S., Camilloni, I., Diedhiou, A., Djalante, R., Ebi, K.L., Engelbrecht, F., Guiot, J., Hijioka, Y., Mehrotra, S., Payne, A., Seneviratne, S.I., Thomas, A., Warren, R., Zhou, G., 2018, Impacts of 1.5ºC Global Warming on Natural and Human Systems. In: Masson-Delmotte, V., *et al*. (Eds.), *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*, Cambridge University Press, Cambridge, NY, USA, 175-312, https://doi.org/10.1017/9781009157940.005.

Holtorf, C., 2018, "Embracing change: how cultural resilience is increased through cultural heritage", *World Archaeology*, 50, 4, 639-650, doi: 10.1080/00438243.2018.1510340.

Houben, H., Guillaud H., 1994, "Earth construction: A comprehensive guide", *CRATerre-EAG*, Intermediate Technology Publications, Marseille.

ICCROM-FAR, 2022, First Aid and Resilience for Cultural Heritage in Times of Crisis Programme. In: Tandon, A. (Ed.), *Net Zero: Heritage for Climate Action*, retrieved from: <https://www.iccrom.org/projects/net-zero-heritage-climate-action>.

ICOMOS, 1999, *ICOMOS. CIAV. International Comitee of Vernacular Architecture*, retrieved from: <http://www.international.icomos.org/charters/vernacular_sp.pdf>.

Insolera, I., 2011, *Roma moderna. Da Napoleone I al XXI secolo*, Einaudi, Torino.

IPCC, 2022, *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (Eds.)], Cambridge University Press, Cambridge, NY, USA, doi:10.1017/9781009325844.

Lanzini, M., Mazza, R., Capelli, G., 2008, Le antiche alluvioni del Tevere ed i dissesti storici (Prati-Balduina XVII Municipio). In: Funiciello, R., Testa, O. (Eds.), *Periodici Tecnici – La Geologia di Roma – Dal centro storico alla periferia*, *Memorie descrittive della Carta Geologica d'Italia*, Ispra, Firenze, 80, 185-194.

Madrid, 2009, Ciudadanía y Patrimonio, *madridciudadaniaypatrimonio,* retrived from: <https://madridciudadaniaypatrimonio.org/contenido/coordinadora-salvemos-la-dehesa-de-la-villa>.

Magnaghi, A., 2000, *Il progetto locale*, Bollati Boringhieri, Torino.

Magrinyá, F., Marzá, F., 2009, *Cerdà, 150 años de modernidad*, ACTAR Publishers, New York.

MMHPTN - Maharana Mewar Historical Publication Trust & Nayyar, 2020, *About LAKES of Udaipur, Water Conservation ahead of its time*, *Esamskriti.com*, retrieved from: <https://www.esamskriti.com/e/Culture/Indian-Culture/About-LAKES-of-Udaipur,-Water-Conservation-ahead-of-its-time-1.aspx>.

Manca, A.R., Benczur, P., Giovannini, E., 2017, *Building a Scientific Narrative Towards a More Resilient EU Society*, JRC, Publications Office of the European Union, Luxembourg.

Martinez-Santos, P., Martınez-Alfaro, P., 2012, "A Brief Historical Account of Madrid's Qanats", *GROUND WATER*, 50, 645-653.

Minke, G., 1994, *Manual de construcción en tierra*, Kassel, Editorial Nordan Comunidad, Alemania.

Moholy-Nagy, S., 1976, *Native genius in anonymous architecture*, Schocken Books.

Musco, F., Magni, F., 2014, Mitigazione e adattamento: le sfide poste alla pianificazione del territorio. In: Musco, F., Fregolent, L. (Eds.), *Pianificazione urbanistica e clima urbano. Manuale per la riduzione dei fenomeni di isola di calore urbano*, Il Poligrafo, Padova, 17-28.

CSE - Centre for Science and Environment, 2020, *Traditional water harvesting systems*, retrieved from: <https://www.cseindia.org/traditional-water-harvesting-systems-683>.

Nelson, M.K., Shilling, D. (Eds.), 2018, *Traditional Ecological Knowledge: Learning from Indigenous Practices for Environmental Sustainability (New Directions in Sustainability and Society)*, Cambridge University Press, https://doi.org/10.1017/9781108552998.

Oliver, P., 2006, *Built to meet needs: cultural issues in vernacular architecture*, Elsevier, Oxford.

OMCG - Open Method of Coordination Group, 2022, *Rafforzare la resilienza del patrimonio culturale ai cambiamenti climatici Dove il Green Deal europeo incontra il patrimonio culturale*, Publications Office of the European Union, Luxembourg.

Pacheco-Torgal, F., Jalali, S, 2012, "Earth construction: Lessons from the past for future eco-efficient construction", *Construction and Building Materials*, 29, 512-519.

Peralta González, C., 2017, *La arquitectura tradicional en madera en las viviendas de la Cuenca del Río Guayas durante el segundo auge cacaotero (1880 – 1920) (thesis)*, Secretaría de Ciencia y Tecnología, FAPyD-UNR, Guayaquil.

Pérez Gálvez, F., Rubio de Hita, P., Ordóñez, M., Morales, C., Rodríguez, L., 2012, "Sustainable restoration of traditional building systems in the historical centre of Sevilla (Spain)", *Energy and Buildings*, 62, 648-659, http://doi.org/10.1016/j.enbuild.2012.05.009.

Pesantes, M., 2011, "La arquitectura popular y vernácula en las provincias de Azuay y Cañar", *Arquitectura tradicional en Azuay y Cañar. Técnicas, creencias, práticas y saberes. Serie estudios*, Instituto Nacional de Patriomonio Cultural, Cuenca.

Pica, A., Del Monte, M., 2021, "La Geomorfologia di Roma: il contributo delle carte storiche", *Memorie descrittive della Carta Geologica d'Italia*, 108, 143-154.

Redaelli, G., 2019, "PAX-Patios de la Axerquía Urban Regeneration and Social Innovation in a Heritage Context", *Built Heritage*, 1, 91-104.

Rudofsky, B., 1970, *Architecture without Architects: A Short Introduction to Non-Pedigreed Architecture*, Art Education, 23, 71, doi: 10.2307/3191516.

Secchi, B., 2005, *La città del ventesimo secolo*, Laterza, Bari.

Shirvani Dastgerdi, A., Sargolini, M., Broussard Allred, S., Chatrchyan, A., De Luca, G., 2020, "Climate Change and Sustaining Heritage Resources: A Framework for Boosting Cultural and Natural Heritage Conservation in Central Italy", *Climate,* 8, 26, doi:10.3390/cli8020026.

Todaro, P., 2007, "Lotta alla desertificazione - il progetto foggaras per il recupero dei sistemi idrici tradizionali nel Sahara algerino, wilaya d'Adrar", *Proceeding. XIII Congresso Consiglio Nazionale dei geologi d'Italia*, Matera 10-11-12 Maggio 2007, Matera.

Udaipur Urja, 2022, July 4, *Scorching Heat & Dry Wells. The Adverse Impact of Climate Change on Farming Households*, retrieved from: <https://www.udaipururja.in/helping-hands/scorching-heat-dry-wells-the-adverse-impact-of-climate-change-on-farming-households/>.

UNDRR – United Nations Disaster Risk Reduction, 2015, *Sendai Framework for Disaster Risk Reduction. 2015-2030*, United Nations, Geneva.

UNESCO, 2013, *The Hangzhou Declaration: Placing Culture at the Heart of Sustainable Development Policies*, retrieved from: <https://unesdoc.unesco.org/ark:/48223/pf0000221238>.

UNESCO, 2016, *UNESCO. World Heritage Convention*, retrieved from: <https://whc.unesco.org/en/list/1506/>.

UN - United Nations, 2019, *World Urbanization Prospects. The 2018 Revision* (ST/ESA/SER.A/420), New York, United Nations, retrived from: <https://population.un.org/wup/Publications/>.

Vázquez, L., Achig-Balarezo, M.C., Cardoso, F., 2018, "Minga: el patrimonio intangible en la campaña de mantenimiento de San Roque, Cuenca – Ecuador", *Arte y Sociedad. Revista de Investigación*, retrived from: <http://asri.eumed.net/14/minga-ecuador.html>.

Vázquez, L., Cardoso, F., Pogo, M., Tenén, T., Barsallo, G., Achig-Balarezo, C., 2018, "La minga: modelo participativo ancestral aplicado en las edificaciones de tierra del sur del Ecuador", *Siacot 2018 Tierra, Cultura, Hábitat Resiliente y Desarrollo Sostenible*, 18, retrived from: <http://dspace.ucuenca.edu.ec/bitstream/123456789/38475/1/documento.pdf>.

Vinaccia, G., 1952, *Per la città di domani*, vol. 1, Fratelli Palombi Editore, Roma.

Wolfram, M., 2016, "Conceptualizing Urban Transformative Capacity: A Framework for Research and Policy", *Cities*, 51, 121-130.

Wrigth, D., 1981, *Arquitecturas de adobe*, Editorial Gustavo Gili, Barcelona.

Starting with a systemic understanding of cultural heritage, climate-change related urban transformation processes are analyzed through a multi-disciplinary lens and methods that blend the arts, humanities, and sciences. Governance-specific topics range from relevant cultural markers and local policies to stimulate resilience, to a typology of heritage-related governance and the vulnerability of historic urban landscapes. A variety of contributions from the Americas, Asia, and Europe describe and analyze challenges and potential solutions for climate-change related urban transformation and the role of cultural heritage. Contributions focusing on innovation, adaptation, and reuse introduce the concept of urban acupuncture, adaptive reuse of industrial heritage, and how a historical spatial-functional network system can be related to a smart city approach. The potential role of cultural traditions for resilience is analyzed, as is the integration of sustainable energy production tools in a historic urban landscape. Examples of heritage-based urban resilience from around the world are introduced, as well as the path of medium-technology to address climate adaptation and prevention in historic buildings. The contributions emphasize the need for an updated narrative that cultural heritage can also contribute to climate adaptation and mitigation.

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