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Reinterpreting Hatra: Tracing Nature-Based and Resilient Design Principles in Ancient Urban forms

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Keywords: Hatra, City development, Parthian Empire, Traditional Architecture, Nature-Based Solutions (NBS)

Parole chiave: Hatra, sviluppo urbano, Impero partico, Architettura tradizionale, Nature-Based Solutions (NBS)

Abstracts:
This paper analyzes and re-evaluates the archaeological and historical data related to the ancient city of Hatra, in northern Mesopotamia (2nd–3rd century CE), considering recent architectural studies and approaches focusing primarily on the concepts of nature-based solutions, resilience, and environmental adaptability. This comparative and dialogic approach, which can also be applied to other ancient sites, demonstrates how certain categories within the lexicon of urban layout and architectural design have deep historical roots, extending through traditional or vernacular architecture and converging with archaeology. At the same time, recent architectural and ethnoarchaeological studies, particularly those related to environmental adaptation and strategies for living in climatically challenging contexts, can provide valuable tools for a deeper understanding of these ancient sites. This work, to be considered as preliminary, aims to encourage further studies following this approach and to also promote the (re)use of ancient construction techniques and methods that remain effective today, for example, in the design and development of structures and buildings for archaeological parks.

In questo paper sono stati analizzati e rivalutati i dati archeologici e storici relativi alla città di Hatra, in Mesopotamia settentrionale (II-III sec. d.C.), alla luce dei recenti studi di architettura e degli approcci di questa disciplina che si concentrano principalmente sui concetti di resilienza, nature-based solutions e adattabilità ambientale. Questo approccio comparativo e dialogico, applicabile anche ad altri siti antichi, dimostra come alcune categorie appartenenti al lessico del progetto della città e delle sue architetture affondino le proprie radici in epoche lontane, attraversando l'architettura tradizionale fino a confluire nell'archeologia. Al contempo, modelli e studi recenti di architettura ed etnoarcheologia, in particolare quelli legati all'adattamento ambientale e alle strategie per abitare in contesti climaticamente difficili, possono offrire strumenti preziosi per una comprensione più approfondita degli stessi siti antichi. Questo lavoro, da considerarsi preliminare, intende stimolare nuovi studi secondo tale approccio e promuovere anche il (re)impiego di tecniche e modalità costruttive antiche, ma ancora oggi efficaci a quelli che sono gli impatti dei cambiamenti climatici, ad esempio per la progettazione e realizzazione di strutture ed edifici destinati ai parchi archeologici.

1. Adaptation, Resilience, and Nature-Based Solutions: A 'Contemporary' Lexicon Applicable to Archaeology?[1]

Climate resilience is an essential attribute for 21th century cities in confronting the current climate crisis. This necessity emerges unequivocally from recent analyses carried out by the Intergovernmental Panel on Climate Change[2] as well as from adaptation strategies promoted by the European Union, which are designed to strengthen urban systems' capacity to respond to ongoing climate changes (European Commission, 2022). Although the morphological configurations of most urban centres were not originally conceived to counteract the effects of climate change (such as episodes of extreme heat and exceptional rainfall events, since the frequency of such phenomena at the time of urban settlement was significantly lower than it is today, and urban expansion was not comparable to contemporary levels), urban and architectural forms, particularly in Europe, have gradually evolved toward an approach aimed at enhancing adaptability to

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[1] §1 was written exclusively by Maicol Negrello, §2-3 by Enrico Foietta, and § 4-8 were jointly elaborated by both authors.
[2] IPCC 2021.

extreme conditions, which have become increasingly frequent and intense due to global warming. From this perspective, extreme climatic phenomena – such as prolonged heat waves, drought, and flash floods – have exposed the vulnerability of urban contemporary infrastructures, which are often entirely unprepared to respond effectively to such events. Moreover, today, certain cities have demonstrated a limited capacity to manage global-scale health risks, as evidenced by the COVID-19 pandemic, which further underscored the need for a more resilient, flexible, and inclusive urban model[3]. In particular, adopting preventive strategies and implementing appropriate infrastructure have emerged as urgent imperatives in the context of a 'new normal' marked by constant increases in climatic variability and meteorological intensity.

A paradigmatic case, extensively studied and cited in the literature, is the city of Copenhagen. In 2011, an exceptionally intense storm–estimated to recur once every hundred years–struck the center, flooding critical infrastructure of the city's main hospital in just 30 minutes. The water rose to levels that nearly forced a complete evacuation, while total damages exceeded 1.6 billion euros, making it Europe's most economically burdensome natural disaster that year. This event underscored local authorities' need to plan and adapt infrastructure to withstand extreme weather phenomena systematically[4].

Following this experience, Copenhagen and other European cities (such as Paris and Barcelona) initiated urban transformation projects based on both technological and nature-based solutions[5] designed to improve their capacity to absorb and manage severe climatic events. Among the implemented measures, multifunctional parks stand out, serving as water containment basins during heavy rainfall, along with design solutions (such as green roofs and domestic water basins) and sustainable urban drainage systems (SUDS) inside the consolidated urban tissues, which slow down and absorb rainwater, thus reducing pressure on traditional sewer networks.

Simultaneously, the 'sponge city' concept, initially developed in Asian contexts, has increasingly been applied in Europe by adopting permeable surfaces and green areas that help mitigate flood risk. Such approaches represent a pivotal transition toward an integrated vision of blue, green, and grey infrastructures capable of providing coherent and adaptable responses to emerging climatic scenarios.

Beyond creating more efficient physical structures, urban resilience also requires forward-looking and participatory planning that actively involves local communities in decision-making processes, as in the case of Copenhagen and Barcelona[6]. Co-design, in particular, facilitates the development of solutions that genuinely address residents' needs while enhancing awareness of climate risks. An exemplary case in this regard is Rotterdam[7], where public education and participatory initiatives were launched to disseminate knowledge of climate adaptation practices. Financial and informational incentives have encouraged the creation of private gardens and green roofs, which help mitigate flooding and improve air quality, positively impacting residents' psychological and physical well-being.

However, one might question whether these adaptive strategies are genuinely novel. Indeed, during the Modern Movement, the control of climatic factors – ranging from water management to cooling, heating, and humidity regulation – became increasingly reliant on technological systems designed to ensure optimal comfort (as illustrated by Le Corbusier's concept of the *machine à habiter*). Rooted in a rationalist and mechanistic vision, this approach often prioritised technology's ability to shape built environments through standardised, industrialised solutions, reflecting the belief that architecture should function with the efficiency of a machine. While this method led to significant advancements in construction and urban design, it resulted in a reduced integration with natural elements and environmental dynamics.

Contemporary experience, however, reveals that technology alone cannot adequately solve today's escalating climatic and environmental challenges. Alongside artificial solutions, there has been a surge of interest in nature-based solutions, which include the rediscovery of traditional materials and the study of historically proven modes of habitation. These approaches aim to replicate or emulate biological and ecosystemic processes, promoting a more balanced relationship with the environment while simultaneously valuing local knowledge and construction techniques.
Upon closer inspection, interest in these strategies does not signify a complete break with the past. On the contrary what we now refer to as 'climatic devices' already existed, albeit in different forms, in design practices across diverse epochs and regions. Traditional and historical architectural forms often embodied intrinsic sustainability, achieved using durable materials, planning attuned to seasonal cycles and water-related risks, careful selection of solar and wind exposure, and the inclusion of green spaces and water resources directly integrated into settlements. Such an approach, described as 'architecture without architects'[8], was intimately connected to the specificity of place, effectively meeting climatic challenges through highly localised, site-specific strategies.

[3] Negrello, Ingaramo, 2021
[4] Negrello 2022
[5] Ingaramo, Negrello, Saradehi L.K., Saradehi A.K. 2023.
[6] Ramírez-Agudelo, Badia, Villares, Roca 2022. Assessing the benefits of nature-based solutions in the Barcelona metropolitan area based on citizen perceptions. *Nature-Based Solutions*, *2*, 100021.
[7] *Gemeente Rotterdam 2013. Rotterdam adaptation strategy. City of Rotterdam*.
[8] Rudofsky 1964.

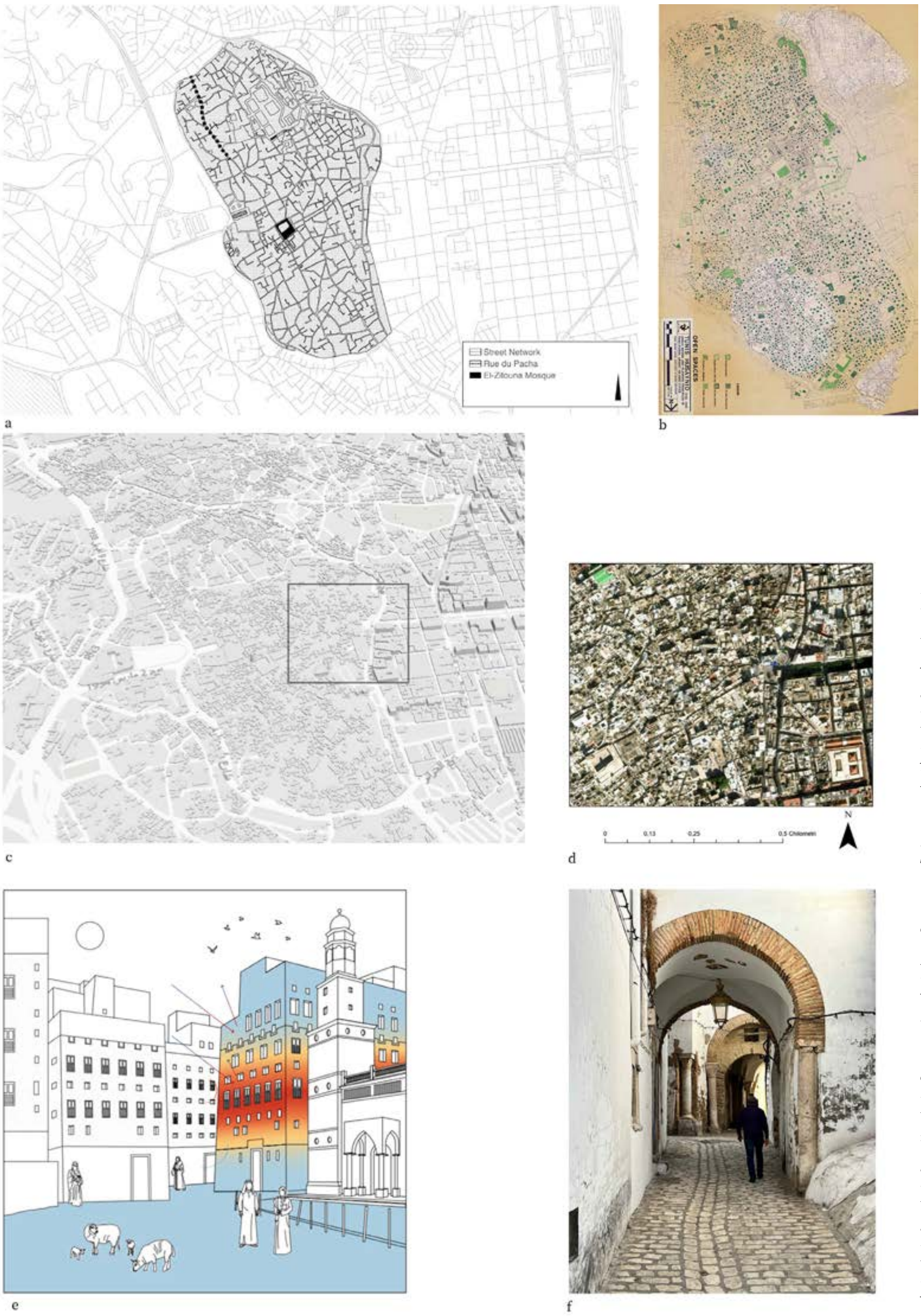


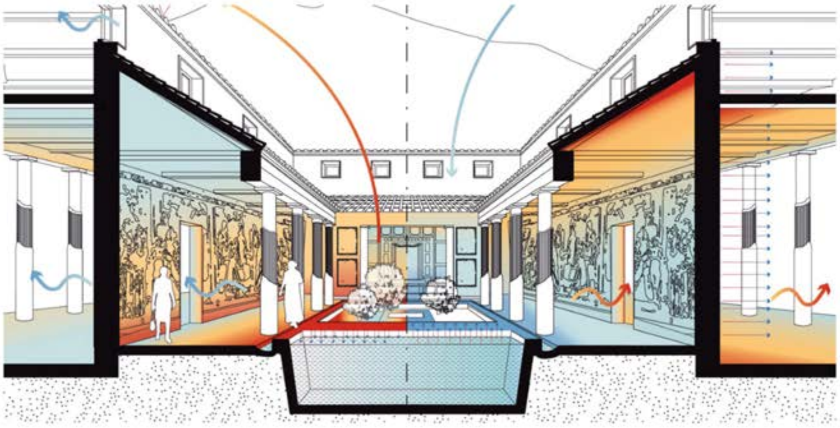
Fig. 1a-f. a) Tunis Medina, main street network (credit: Areti Kotsoni/Critical Landscapes Design Lab, 2023; Doherty, Kotsoni 2024, p. 88, fig. 3); b) Map of the historic centre of Tunis 1:1000 produced by B.S. Hakim; c) 3d map of the Tunis Medina (ArcGISPro – copyright Esri); d) detail of a district of the Tunis Medina showing the street layout; e) tower buildings, Shibam, Yemen, 16th cent. (elaborated during the Atelier of Architecture and Urban Design directed by Ingaramo and Negrello); f) A Medina street at Tunis (credit: Gareth Doherty/Critical Landscapes Design Lab, 2023; Doherty, Kotsoni 2024, p. 88, fig. 6).

An examination of ancient urban morphology and buildings, modules and construction techniques clearly shows how these solutions were embedded in collective knowledge from a time when available resources, primarily local, were limited and difficult to transport, thereby requiring judicious use. Empirical methods and cumulative experiential know-how allowed for targeted, effective interventions, even in areas considered inhospitable by contemporary standards. Indeed, the capacity of these techniques to adapt to climatic and environmental conditions, absent advanced technology, enabled human settlement in marginal zones by integrated systems for natural ventilation, water collection, and temperature regulation.

Numerous historical examples confirm that traditional architecture was developed by skilfully harnessing construction materials' properties, the measured use of colour to reflect or absorb heat[9], passive ventilation, and rainwater harvesting. Consider, for instance, the covered, shaded alleys of Islamic medinas[10], designed to reduce the impact of the daytime sun and allow the flow of cooler air. Similarly, tower buildings (fig. 1), often featuring varied colour schemes,

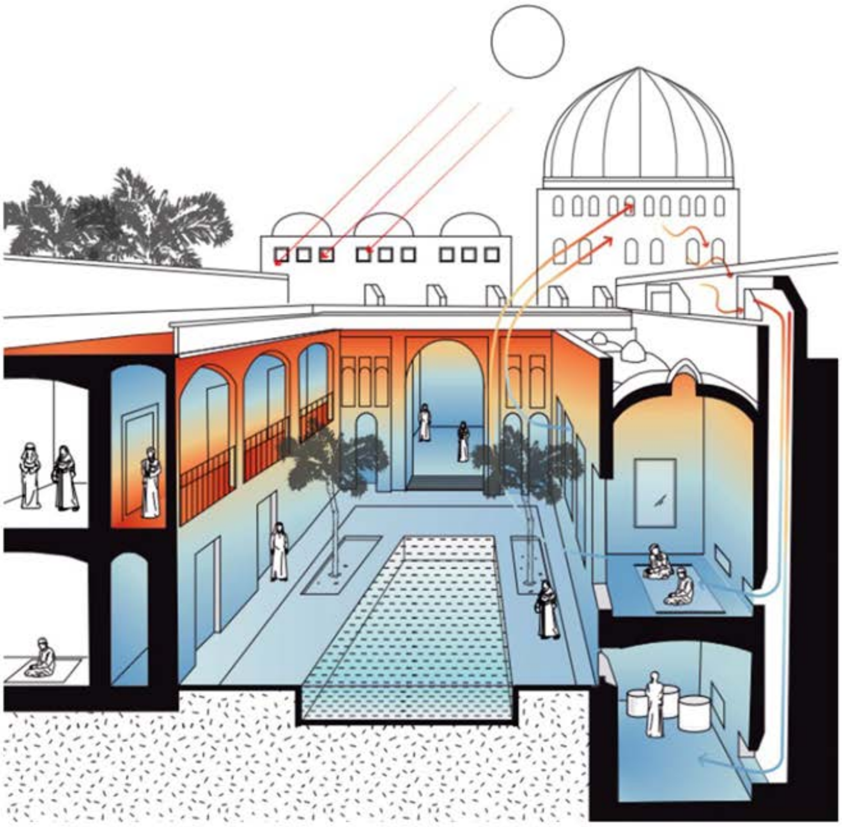
[9] Moretti, Bori 2005, pp. 104-119.

[10] For recent studies on Islamic medinas, mainly on Tunis medina: Achour 2016; Ben salem 2018; Doherty, Kotsoni 2024.



a

Fig. 2a-b. a) Coutyard house typology: Roman period (elaborated during the Atelier of Architecture and Urban Design directed by Ingaramo and Negrello); b) al-Qasr, Dkhla Oasis, Egypt, 16th cent. (elaborated during the Atelier of Architecture and Urban Design directed by Ingaramo and Negrello).



b

enhanced the urban microclimate by reducing perceived heat in outdoor spaces. Another noteworthy example is the courtyard house typology, found from North Africa in the Islamic period to ancient Rome – and earlier in Classical and Pre-Classical Greece, Mesopotamia – where central basins and reservoir for rainwater collection provided natural cooling for indoor spaces[11] (fig. 2). The Alhambra in Granada, like other Moorish architectural complexes, exemplifies the sophisticated use of water and fountains to regulate microclimates in both indoor and outdoor settings[12]. Additional ingenious solutions include hypogean dwellings in parts of Tunisia[13], taking advantage of the ground's thermal stability to maintain a consistently favourable indoor climate, as also other examples from the Islamic world from the 7th-8th centuries onward (figs. 3-4). Likewise, 16th-century Palermo villas (such as Villa Naselli Ambleri) (fig. 5) often featured underground corridors connected to complex water systems, thereby providing protection from extreme summer heat and ensuring stable hygrothermal conditions.

[11] Alhmoud, Alhmoud 2024.
[12] Moretti, Bori 2005, pp. 248-249
[13] Moretti, Bori 2005, pp. 73-75

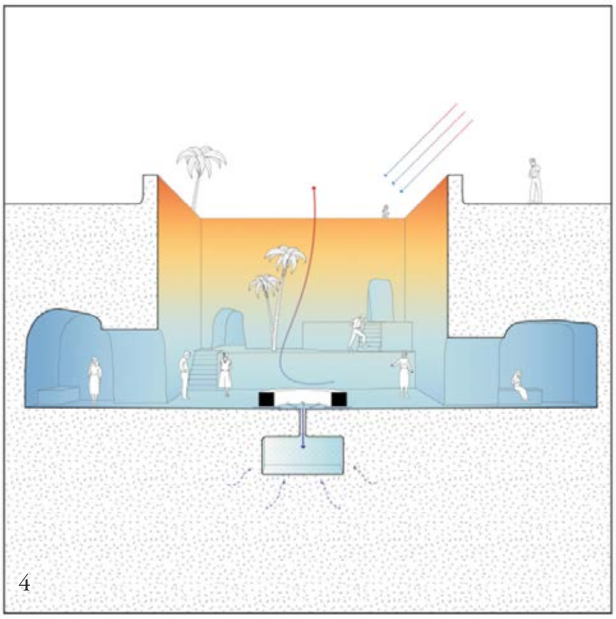
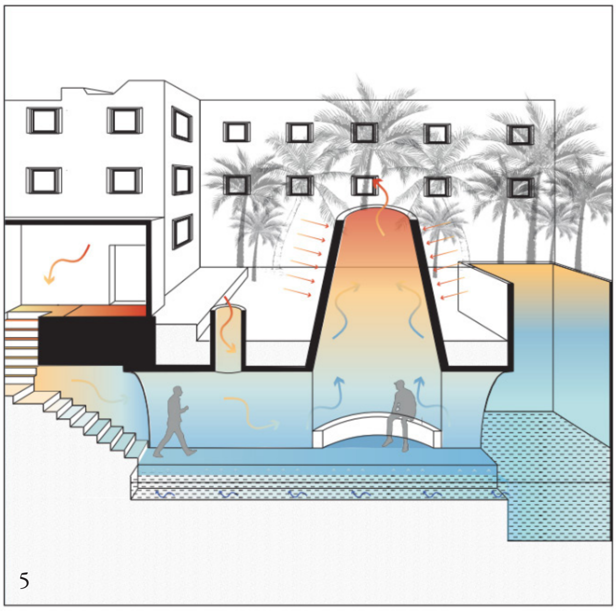


Fig. 3. Mishrabiya, Cairo, 5th cent. (elaborated during the Atelier of Architecture and Urban Design directed by Ingaramo and Negrello).

Fig. 4. Matmata, Tunis, 7th cent. (elaborated during the Atelier of Architecture and Urban Design directed by Ingaramo and Negrello).

Fig. 5. Villa Naselli Ambleri, Palermo, Italia, 1552 (elaborated during the Atelier of Architecture and Urban Design directed by Ingaramo and Negrello).



Widespread across different regions of the world, these construction methods rooted in local traditions demonstrate a deep knowledge of local materials and building techniques, highlighting an architectural dimension that is intrinsically – and perhaps even unconsciously – connected to ecological sustainability and environmental harmony, which often corresponds to greater effectiveness. The objective is to identify similar practices that have proven successful over the centuries and, by their achievement, have continued to be adopted and, in some cases, reinvented in contemporary contexts. Properly situated, these strategies offer a new interpretive key for archaeology and architectural history and compelling ideas for the planning and the design of future cities at multiple scales of intervention. Such an integration of past and present knowledge thus becomes an essential element in developing more sustainable design approaches capable of responding holistically to the challenges posed by the current climate crisis.

The approach proposed in this paper goes beyond the commonly employed ethnoarchaeological comparisons for archaeology[14], which are widely used and closely tied to the study of traditional architecture. Instead, it delves deeper into the causes and functions of urban spaces and buildings, engaging with contemporary design studies and its methodology. This approach fosters a productive dialogue between two disciplines – architecture design and archaeology – which have, until now, interacted only marginally. Moreover, this approach offers an innovative way to assess the

[14] For instance: Ochnenschlager 2002; Fiorina 1985, pp. 72-74.

Fig. 6. Location of Hatra in Iraq (elaborated by E. Foietta).

level of environmental adaptation in ancient archaeological contexts, which are inevitably marked by partial datasets, in contrast to contemporary urban centres[15].

Indeed, a comparative perspective can first and foremost enrich, in an informed manner, the terminology and content of the respective disciplines and, above all, offer a genuinely integrated method for studying ancient material remains and new, 'low-tech' design proposals, which are sustainable from both an environmental and economic perspective. Furthermore, this approach is efficient and applicable in arid or semiarid regions, which are expanding rapidly due to climate change.

The concept of resilience theory – which refers to the capacity of an adaptive system to undergo change and reorganization while still maintaining its core functions, processes, and structures (such as landscape, social hierarchy, and land-use strategies) – has recently been summarized by C.L. Redman and E. Rashidian in the context of archaeology. Their work forms a foundational basis for this study, particularly in evaluating how both individual archaeological contexts and broader territorial and social ancient systems respond to environmental, social, and other forms of stress. This approach is extensively applied throughout the present work, in a broader sense than the narrower notion of climate resilience commonly used in contemporary studies[16].

In summary, archaeology can suggest fresh insights for future planning and urban design by investigating, examining, and comprehending ancient contexts. In contrast, architecture and urban planning can provide valuable interpretive tools, also by proposing diachronic and functional comparisons, and not necessarily from the same geographical areas, for understanding the layout of ancient cities, buildings, and structures, enabling an evaluation of their broader impact.

2. Why study Hatra through an integrated and comparative approach?

This paper will focus on the case study of Hatra, an ancient city of northern Mesopotamia located approximately 80 km southwest of Mosul, which reached its apogee during the 2nd-3rd centuries CE (fig. 6). The choice of Hatra is not incidental, as this crucial Iraqi archaeological site–inscribed on the UNESCO World Heritage List

[15] Contemporary public administrations and master plans furnish and store a vast amount of information, which does not exist usually in archaeological contexts. An exception can be considered for instance the 'Forma Urbis' of Rome.

[16] Redman 2005; Rashidian 2021.

Fig. 7. Oblique view of the ruins of Hatra from the air (RAF – 30s).

since 1985[17]–despite having been excavated over less than 10% of its total area,[18] offers numerous points of interest for evaluating the environmental adaptation strategies. Above all, it provides valuable opportunities for comparison with contemporary and modern cases presenting similar building materials, analogous functional choices, methods of managing environmental resources, and spatial designs tailored to the region's semiarid climate.

The setting in which Hatra was established might appear quite inhospitable. Today, the area is much less populated than in antiquity (particularly during the Parthian period). To the southeast of the archaeological site, there is a settlement of only a few thousand inhabitants, built in the 1930s[19], and throughout the Iraqi Jazirah – where Hatra is situated – there are very few population centres and urban areas, mainly found along waterways[20]. The ancient climate during the Parthian and Sasanian periods, as evidenced by the palynological sequence from the lake Khattuniyeh, appears to have been relatively stable and comparable to the present climate, though perhaps slightly more humid.[21]

Hatra lies in a semiarid steppe environment with a limited number of plant and trees species, extremely hot summers, and relatively cold winters, during which most of the annual precipitation occurs[22]. It is located roughly 30 km south of the 200 mm isohyet line, necessitating infrastructural interventions to sustain local agriculture through the predominant use of a well-based capture system in a mainly karst environment[23]. Moreover, unlike most Mesopotamian centres, the settlement lies about 3 km from the main local stream, the Wadi Tarthar, whose aquifer south of Hatra is characterised by slightly high salt concentrations, preventing intensive agricultural exploitation[24].

The city in the 2nd-3rd centuries CE evolved into a significant urban settlement covering approximately 300 hectares and, according to some scholars such as S. Hauser and D. Tucker, possibly housing around 50.000 inhabitants[25] (fig. 7). Through a network of settlements, infrastructure, and a formidable military force, Hatra controlled in this period a regional kingdom stretching from the Euphrates and Khabur to the west, to the Tigris to the east, extending as far as the Sinjar mountain range in the north and likely the Tikrit area to the south[26]. This territory was notably more significant than the immediate hinterland, allowing for the exploitation of diverse resources within a society that,

[17] https://whc.unesco.org/en/list/277/. Last view: 04/01/2025.
[18] Foietta 2022, p. 209.
[19] Foietta 2018, p. 101.
[20] For the settlement pattern and its characteristics in the Kingdom of Hatra: Foietta 2020a; Foietta 2020b; Foietta 2024.
[21] al-Aswad 1991, pp. 196-197; Hauser 2000, 188, Kaizer 2013, pp. 70-71.
[22] See Hauser 2000; Foietta 2018, pp. 57-116.
[23] Foietta 2020a, p. 302.
[24] For the area's hydrology: Foietta 2018, pp. 60-62, pp. 78-81; Foietta 2020a, pp. 304-305. Several scholars have proposed a model of non-intensive agricultural production in the alluvial plain near the Tarthar River.
[25] Hauser, Tucker 2009.
[26] For the Kingdom of Hatra: Foietta 2020a; Foietta 2020b; Foietta 2024 and related bibliography.

based on specific archaeological, historical, and epigraphic data, can be described as 'dimorphic,' integrating nomadic and semi-nomadic groups and tribes into urban and settlement contexts[27].

Over the course of its history, Hatra experienced a number of changes clearly driven by contingent geopolitical situations, which in turn triggered significant environmental, social, and systemic stresses–both at the local site level and across the broader region. Notable examples include its emergence during the 'Post-Assyrian' period in a territory that appears to have been sparsely built-up, or at least lacking major urban centers, and the city's rapid expansion and population boom during the 2nd-3rd centuries CE. For these reasons, Hatra represents an excellent case study for testing resilience theory, particularly in relation to its period of relative stability situated between two major episodes of collapse or crisis: the fall of the Neo-Assyrian Empire and the city's destruction at the hands of the Sasanian Empire in 240/1 CE.

3. Historical and Archaeological Introduction

The deep soundings carried out by the Italian Archaeological Mission at Hatra within the Temenos have identified the earliest phase of occupation – likely corresponding to an initial village dating to the 4th century BCE – based on specific diagnostic finds discovered there[28] (fig. 8a). Before this phase, the site was probably occupied intermittently by nomadic or semi-nomadic groups, as suggested by extensive layers of ash and anthropic deposits containing charcoal and small amounts of pottery fragments found in the same area, investigated mainly by the Iraqi Archaeological Expeditions[29].

From this initial core, the settlement gradually expanded: between the 1st century BCE and the 1st century CE, it reached an extent of about 90 hectares[30] (fig. 8b-c). A large sacred precinct was established at its centre, initially built of mud bricks and later monumentalised in stone, beginning first with the main temples and subsequently the enclosing wall (Temenos)[31]. Although little is known about the settlement from this period, there is evidence that a quadrangular curtain wall was erected, likely in the 1st century CE, which undoubtedly protected Hatra's inhabitants during the siege by the Roman Emperor Trajan in 117 CE, during his Parthian campaign[32]. At the end of the 1st and the beginning of the 2nd century CE, construction began on the Great Iwans, Hatra's most important temple, dedicated to the local Divine Triad of Maren, Marten, and Bar Maren[33]. This indicates considerable public investment on the part of one of the centre's earliest known rulers, Worod (end of the 1st CE, first decades of the 2nd cent. CE) (fig. 9). This period also saw the erection of some funerary buildings, possibly already established within necropolises, as well as a few smaller shrines within the residential area (Shrine VIIIa and Shrine XIV)[34].

From the second half of the 2nd century CE, the city expanded significantly to cover some 300 hectares (fig. 8e-g)[35]. During this phase, Hatra's ruler, Nasru (128/129-137/138 CE), constructed the principal pseudo-circular curtain wall. In the 2nd-3rd centuries CE, the other small shrines were built, in some cases through the initiative of Hatra's Lords and Kings, and the necropoleis–consisting of stone family funerary buildings–were progressively constructed and incorporated within the city's walls. In 197-198 CE, the town was once again besieged by the Roman army under Septimius Severus, though it was not taken[36]. Around this time, towers and massive walls were likely added to strengthen the city's defences, initially against the Romans and subsequently against the emerging Sasanian threat. After an initial attack, probably by Ardashir I, the city was besieged by the Sasanian army led probably by his son, Shapur I, and eventually captured in 240/241 CE[37]. From that point onwards, Hatra was abandoned, save for a limited occupation mainly during the period of the Atabegs of Mosul, concentrated within the Temenos[38].

The city's development was extremely rapid compared to other ancient cities in Mesopotamia and is primarily concentrated during the 2nd-3rd centuries CE, a period to which many of the site's extensive visible

[27] Foietta 2020a, pp. 312-313.

[28] Foietta 2022, pp. 209-212. For the deep soundings of the Italian Archaeological Expedition: Peruzzetto, Valentini 2000; Peruzzetto, Venco Ricciardi 2013.

[29] F. Safar and M.A. Mustafa opened some small trenches in rooms 3, 6, 10 and 14 of the Great Iwans (Safar, Mustafa 1974, p. 331), while J. Ibrahim excavated some trial trenches north of the stair of the Allat Temple (sounding 1) and south of the Square Temple (sounding 2) (Ibrahim 1986, pl. 59).

[30] Foietta 2020a, pp. 212-213.

[31] For the development of the Temenos area: Foietta 2020a, pp. 213-215. For the description of the Temenos: Parapetti, Venco Ricciardi 2000; Parapetti, Venco Ricciardi 2013.

[32] For the Ancient Curtain wall excavated with trenches by the Polish Expedition: Gawklikowski 1994.

[33] Foietta 2018, 458; Foietta 2020a, p.215.

[34] Foietta 2020a, pp. 215-216. For the necropoleis and funerary buildings at Hatra: Dorna Metzger 1998; Dorna Metzger 2000b.

[35] Foietta 2020a, pp. 217-218.

[36] Roman sources as Herodian and Cassius Dio report the sieges: Cassius Dio 76, 10–12; Erodianus 3, 9, 1–7.

[37] The Mani Codex of Köln report the destruction of Hatra (Foietta 2020a, pp.300-301).

[38] For the occupation of the Atabegs of Mosul (Parapetti, Venco 2013).

Fig. 8. Development of Hatra from its foundation as a village (phase a) until the a city of 300 ha (phase f) (elaborated by E. Foietta).

ruins belong (fig. 7). This impressive development was undoubtedly supported by significant investments from the city authorities and extensive urban domestic and public constructions that extended to the pseudo-circular city walls, also reflecting a considerable increase in the city's population during the same centuries[39]. The reasons for this extensive development, according to some scholars, could lie in the increase in trade along the north-south axis that likely passed between the Roman Empire and the Parthian capitals. However, this proposal has generally been abandoned in favour of the idea that the city's growth was due to its emergence as a regional capital with strong religious significance and its strategic and military location between the Roman and Parthian Empires during a period of intense rivalry between the two powers[40]. This did not hinder the development of a thriving trade system among the main settlements, which likely relied on an integrated network for the management of food and agricultural products, foodstuffs, and other types of goods[41].

39 See for the city population: Hauser, Tucker 2009.

40 For a general overview of the 'sudden' development of Hatra: Kaizer 2013, pp. 57-72 and related bibliography.

41 Foietta 2024, pp.180-182

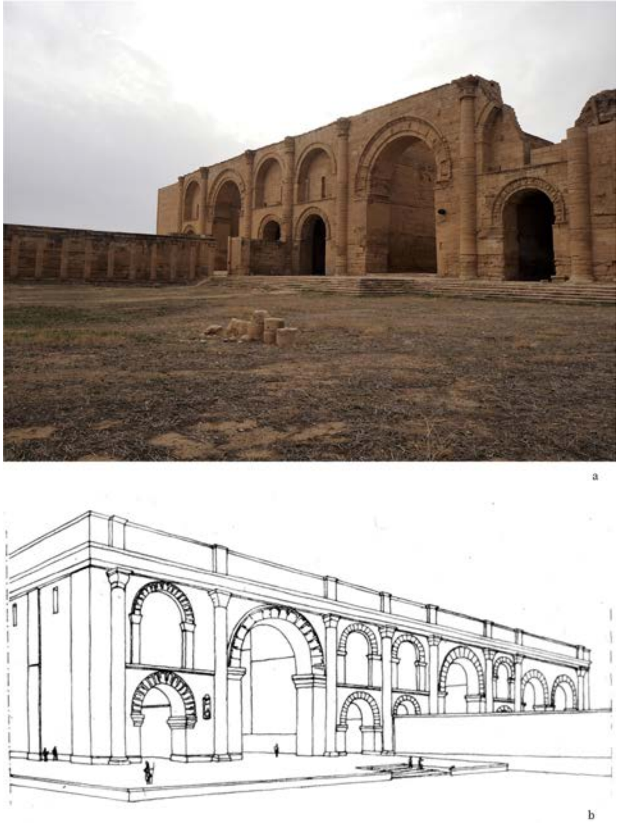


Fig. 9a-b. a) Great Iwans from north-east (2022); b) Reconstruction of the Great Iwans from south-east (Archive of the Italian Expedition - Torino).

Fig. 10. Building A from south (Archive of the Italian Expedition – Torino).

Hatra again became familiar to Western audiences through information conveyed by travelogues and archival records of various travellers and archaeologists who visited the ruins[42]. In some instances, such as arch. Fossey, they conducted limited excavations[43]. However, the most significant corpus of information was published by the German Archaeological Mission of Ashur, directed by W. Andrae, who conducted extensive surveys of the ruins. Their findings were presented in two foundational volumes published in 1908 and 1912, which remain primarily reliable today[44].

From the 1950s onwards, substantial Iraqi excavations occurred at the site, focusing primarily on the central Temenos area and its main temples, small shrines, several funerary buildings and houses, and parts of the fortifications, including the North Gate and the East Gate[45]. In 1990, a Polish archaeological expedition directed by M. Gawlikowski operated at the site for a year, investigating the city's defences – particularly the eastern section of the main curtain wall – and conducting small-scale test trenches on an earlier curtain wall likely dating to the Trajan period[46].

In 1986, an Italian archaeological mission from the University of Torino (UniTO), led by R. Ricciardi Venco, began working in Hatra, initially excavating a large house near the Temenos (Building A)[47] (fig. 10), and subsequently, from 2000 onwards, carrying out deep soundings in the Temenos area to clarify the earliest phases of settlement[48]. Following a difficult period during which the archaeological site was occupied and partly damaged by ISIS/Daesh, an Italian archaeological expedition – coordinated by ISMEO, the University of Padova (Director: Massimo Vidale), and the University of Siena, with support from the ALIPH Foundation – has been operating in Hatra since 2020[49]. Their objectives include restoring public access to the archaeological areas and assessing and repairing the damage inflicted during the site's occupation.

4. Elements of Climate and Environmental Adaptation in the Urban design of Hatra

It has often been assumed that ancient Mesopotamian centres did not exhibit identifiable urban paradigms comparable to those of the classical world (Greek or Roman), with scholars at times naively imagining a

[42] For a general overview of the history of research at the site: Foietta 2018, pp. 7-40.
[43] On the French Expedition: Foietta 2021.
[44] See Andrae 1908 and Andrae 1912. The information provided in Andrae's publications is essential for all scholars who have dealt with Hatra and has been extensively used by the present author in the architectural and urban analysis, see, for instance, Foietta 2018, where the bibliographies of the German, Iraqi, Polish, and Italian investigations have been widely employed and processed.
[45] Foietta 2018, pp. 14-19.
[46] Gawlikowski 1994.
[47] Dorna Metzger 2000a, and 2016 and related bibliography
[48] Peruzzetto, Venco Ricciardi 2013 and related bibliography.
[49] https://www.ismeo.eu/portfolio_page/hatra/; last view: 04/01/2025.

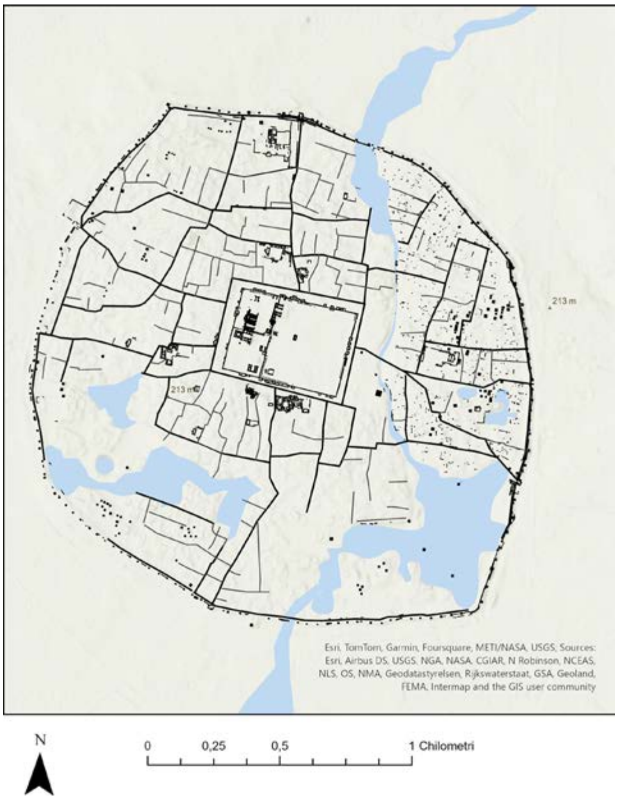


Fig. 11. General plan of Hatra with the excavated and surveyed structures and the street network (elaborated by E. Foietta).

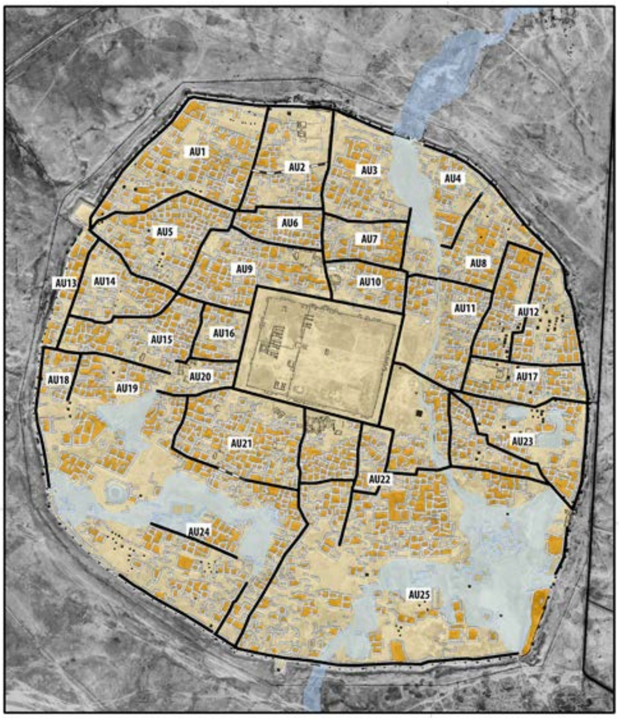


Fig. 12. General plan of Hatra with the street network and urban areas (elaborated by E. Foietta).

largely spontaneous process of urban growth in Near and Middle Eastern cities, except in some cases for the capitals and few major Neo-Assyrian cities.

In reality, numerous recent studies have demonstrated the existence of guiding principles in the urban planning of Mesopotamian centres and have shown that in the realm of public urban design–both in the ancient Mesopotamian world and the subsequent Parthian and Sasanian contexts–a clear set of strategies was indeed adopted for organising and managing space[50].

In the specific case of Hatra, the city's layout resulted from the deliberate programming and planning, first and foremost, of the vast central Temenos area, the boundary between the city and the outlying areas–marked by infrastructure such as the curtain walls (initially the so-called 'Trajanic' walls and then the pseudo-circular enclosure)–and the construction of the main roads that define the principal urban zones or 'districts'[51] (fig. 11). The street network in Hatra can be hierarchised on three levels (main roads, secondary roads, and alleyways). By analysing satellite images and archaeological evidence, it has been possible to reconstruct the primary urban road network[52]. Although this system does not follow paradigms similar to those of Western urban planning (with orthogonal axes or Hippodamian layouts), it nonetheless includes several routes connecting the four main city gates to the centre, as well as other 'transversal' arteries that effectively subdivide and interconnect the urban fabric. This arrangement is the predecessor of the well-known street systems of the Islamic-period Medina (described in contemporary treatises), while sharing constructive principles that had been used in ancient Mesopotamian cities since the 4th millennium BCE (fig. 1)[53]. The main roads are wider than the secondary roads and alleys. However, all of them feature somewhat winding paths that, on the one hand, provide ample shade and protection from intense summer sunlight and, on the other, shield inhabitants from strong winds and dust storms, which are frequent in spring and autumn.

As previously noted, analogous principles are evident in the structure of medinas in prominent Arab-origin cities for instance such as Marrakech, where urban configurations respond to functional, climatic, and social needs[54], as well as in historic Mediterranean urban contexts – particularly along the Greek and Spanish coastlines – whose spatial

[50] See for instance: van de Mieroop 1997; Margueron 2013.
[51] For the street network and the division in districts: Foietta 2018, pp.199-348; Foietta 2022, pp. 208-209.
[52] The street network was primarly studied by W. Andrae and partially reported in his volumes and in its city maps: Andrae 1912, Taf. II; Foietta 2018, pp. 200-211.
[53] Foietta 2018, pp. 214-216.
[54] al-Sayyad 1991.

Fig. 13. Hatra. North Street from south (Archive of the Italian Expedition - Torino).

arrangements and building orientations embody established environmental conditions and cultural traditions; nevertheless, Hatra's streetscape diverges distinctly from these classical Greek and Roman urban models, especially regarding the relationship between public and private spaces. In part, the street space itself may have been 'encroached upon' by private space, especially along secondary roads and alleys. In extreme cases–known for instance in medieval Islamic contexts–this encroachment could lead to the privatisation of the street[55].

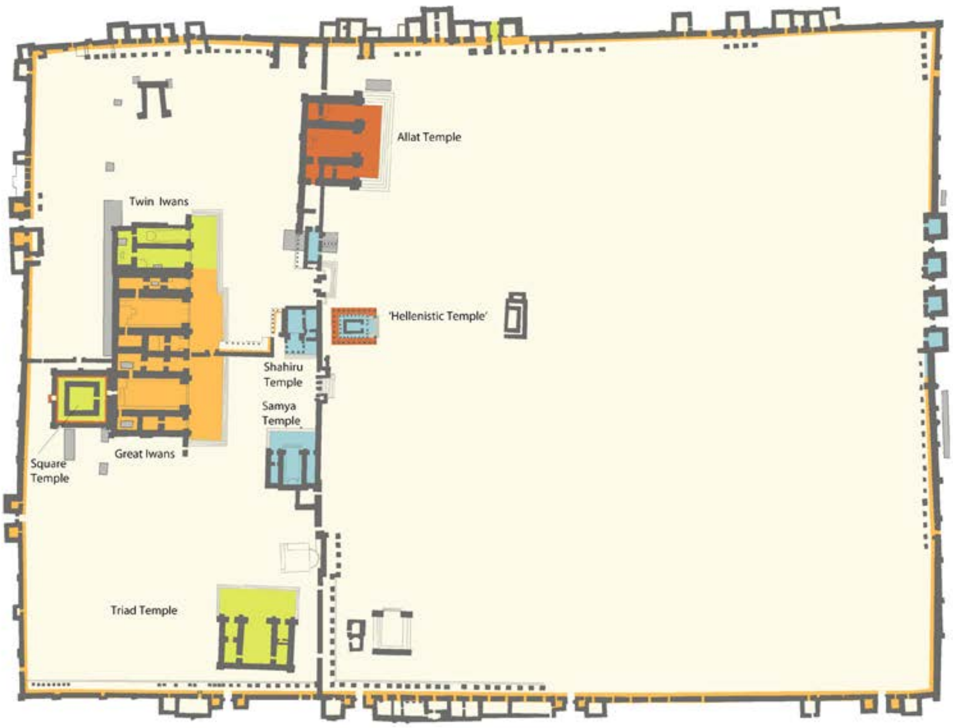
The road network of Hatra defines districts or urban areas consisting of irregular blocks in which artisanal, commercial, religious, and public spaces appear to be closely integrated (fig. 12). Although less than 10% of the city surface have been archaeologically investigated, one might provocatively suggest that ancient Hatra could be fully considered a sort of '15-minute city'[56] just as contemporary cities like Paris aspire to become today. It is impossible to have comprehensive information on all the 'services' the city might have provided or their distances from residential areas, nor can we confirm that this effect resulted from top-down planning by Hatra's governors and their architects. Instead, it is likely simply the consequence of a highly dense and compact urban fabric characterised by the coexistence of diverse functions and building types. Along the so-called North Road (fig. 13), one of the best-archaeologically investigated residential areas[57], one finds domestic buildings, including elite houses such as Building A, shops of various kinds fronting the street, small shrines, necropoleis (LN), palaces (Qasr-e Shimali), and zones that could currently be defined as 'waste disposal areas' (UA10)[58].

Although such waste areas have been little studied archaeologically, they do provide some general information about waste management in the city (fig. 14). One such area was investigated close to the North Road in the 1980s by J. Ibrahim, revealing extensive layers of earth-rich in organic material and pottery fragments[59]. Possible ancient waste *loci* were also identified by the early Iraqi expeditions in the western area of the city, as well as during W. Andrae's survey[60]. It may be assumed that the creation of these defined zones–currently recognisable by the presence of exceptionally high and green mounds in spring, owing to the significant organic content deposited there in antiquity–was at least partially planned, both in terms of their location within the city layout and to prevent risky sanitary conditions. There is no record of a 'city prefect' in the inscriptions of Hatra–someone analogous to the official responsible for such matters in the Roman world–but such a position did likely exist considering the hierarchical society and the extension of the city[61].

55 Foietta 2018, p. 215.
56 Morenos 2024.
57 For Building A: Dorna Metzger 2000a; Dorna Metzger 2016.
58 Foietta 2018, p. 207; Dorna Metzger 2016. The urban area (UA) where the excavated waste disposal area is placed is UA10 (Foietta 2018, pp. 286-288); see also Ibrahim 1997-1998.
59 Ibrahim 1997-1998.
60 See Foietta 2018, p. 209 and related bibliography, See the general plan of W. Andrae (Andrae 1912, Taf. I).
61 For the inscriptions of Hatra: Beyer 1998; Beyer 2013; Moriggi, Bucci, pp. 156-193.

Fig. 14. Waste areas (marked in dark with a white triangles) (elaborated from Andrae 1912, Hatra general plan).

Fig. 15. Satellite Image (WV2) of the Temenos area (elaborated by E. Foietta).



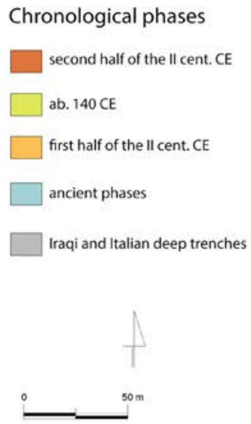


Fig. 16. Plan of the Temenos area (Archive of the Italian Expedition).

Public spaces in Hatra also display clear elements of planning and design. The best-known example in terms of both importance and the extent of archaeological investigations is the Temenos, covering an area of 13.90 hectares, or three times the size of the Temple of Bel in Palmyra[62] (figs. 15-16). Hatra's rulers (*marya* and *malka*) deliberately structured this vast central zone to accommodate large numbers of pilgrims, who would have travelled from outside

[62] Foietta 2018, p. 349. For the Temenos area: Parapetti Venco 2000; Parapetti, Venco 2013.

Fig. 17. Façade of the Great and Twin Iwans (2022).

Fig. 18. Inner openings inside the Square Temple (2022).

the city to participate in ceremonies[63]. Indeed, as evidenced by the numerous dedicatory inscriptions, the centrality of religious buildings, and references in the city's coinage[64], Hatra fulfilled a primarily religious function. The Temenos area itself and the immediate surroundings likely offered various services applicable to the many pilgrims (e.g., water supply, food provision, commerce).

Many of the more prominent temples, built entirely of stone between the 2nd-3rd centuries CE and characterised by marked monumentality for representative and religious purposes, were often furnished with iwans–open-fronted chambers capable of hosting large numbers of worshipers[65] (fig. 17). The considerable height of these spaces (i.e. Great Iwans, Twin Iwans, Temple of Allat, etc.) promoted natural ventilation, creating cooler and more comfortable interior environments, even during the hottest summers.[66] In this sense, these spaces, built for the veneration of the principal gods of the local pantheon, can be interpreted as veritable 'climate shelters,' anticipating the role played by specific contemporary infrastructures designed to provide refuge from increasingly intense extreme heat dome. This issue is particularly relevant today, as the intensification of urban heat islands and the exacerbation of global warming prompt populations to seek thermally moderated spaces[67]. Even now, these vaulted spaces–often more than 20 meters high–are characterised by notable temperature differentials in summer. Others, such as the Square Temple, likely had more restricted accessibility and admitted little light due to the presence of narrow, splayed openings (fig. 18)[68].

The nearly continuous presence of colonnades or porticoes around the Temenos may have served as resting areas for pilgrims or for those performing rites, providing shaded zones where they could also purchase goods, as suggested by the presence of numerous shops[69] (fig. 19). Porticoes were also common in the ancient Mediterranean, exemplified by Greek *stoai,* the porticoes of the Hellenistic civil and religious buildings, and the Roman *fora,* open yet covered

[63] For the use of the Temenos and also the religious spaces in the city: Downey 1988, pp. 159-162; Dirven 2006.
[64] Foietta 2018, p. 485; Foietta 2022, p. 219. For the coins at Hatra: Gaslain 2009.
[65] For the religious architecture with iwans: Downey 1988, pp. 148-162. The religious buildings with iwans in the Temenos are: the Great Iwans, the Twin Iwans, the Triad Temple, the Samya temple, and the Temple of Allat.
[66] For a general analysis of these temples: Parapetti, Venco 2000; Jakubiak 2014.
[67] Middel, Chhetri 2019; Emmanuel *et al.*, 2020.
[68] Downey 1988, 161; Jakubiak 2014, 56-64.
[69] For the use of porticoes: Parapetti, Venco 2014.

Fig. 19. South side of the Temenos with rooms and porticoes view from the East court (Archive of the Italian Expedition – Torino).

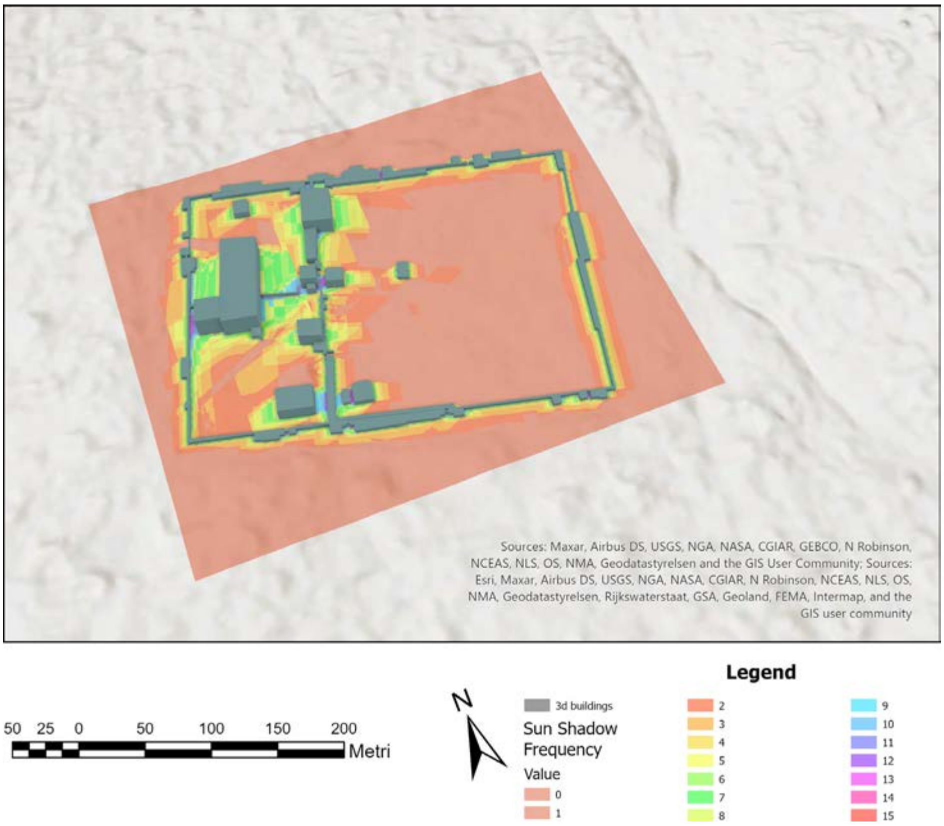


Fig. 20. Temenos area. Shadow Frequency Index (ArcGISPro – copyright Esri, elaborated by E. Foietta).

areas that facilitated pedestrian circulation, social interaction, and commercial exchanges, while mitigating climatic effects[70]. In ancient Near Eastern cities, the presence of porticoes and similar structures–sometimes in combination with architectural elements such as iwans–responded to climatic, cultural, and religious imperatives. In Hatra specifically, the porticoes, testified by the columns and pilasters surrounding the large sacred areas and monumental temples (such as the Great Iwans), not only sheltered worshipers from sun and rain but also fostered social interaction, allowing people to gather and converse in the urban space[71]. In a region characterised by sharp temperature fluctuations and intensely hot seasons, these structures played a primary role in microclimatic regulation and in shaping spaces for communal life. Similar solutions can be observed in other Near and Middle Eastern cities, such as Palmyra and Dura-

[70] Coulton, 1976; Ward-Perkins, 1981.

Fig. 21. Circular basin ('lake') (1986 - Archive of the Italian Expedition, and taken in 2022).

Europos, where porticoes acted as transitional elements between interior and exterior, creating covered, gently shaded spatial sequences and operating as a filter between public areas and those that were sacred or residential[72].

Although construction techniques, proportions, and motivations varied across time and space, the recurring use of porticoes and covered galleries remains a constant feature, cutting across many urban cultures–from the ancient Mediterranean world to the major cities of the pre-Islamic and Roman-Oriental Middle East. In all these contexts, porticoes served as functional devices for climate control, contributed to the aesthetic enhancement of urban space, reinforced urban identity, and encouraged public life.

Moreover, the varied height of the buildings – some of which originally exceeded 20-25 meters (such as the Great Iwans, the Twin Iwans, Square Temple, and the Temple of Allat), while others ranged between 10 and 20 meters (including the Temples of the Triad, Samya, Shahiru, and Maran) – would have created significant shading. While their primary function was undoubtedly monumental and religious, the presence of such imposing structures provided extensive shaded areas (fig. 20) in much of the western courtyard. This is clearly demonstrated by the shadow frequency index generated for the Temenos using ArcGIS software over a one-year period, taking into account the building heights as indicated above and consistent with the most recent architectural studies and reconstructions of these structures, primarily those conducted by R. Parapetti, R. Ricciardi Venco and W. al-Salihi[73]. The most shaded areas are shown in green, light blue, and blue, while the sunniest–and therefore warmest–areas are indicated in red and orange.

5. Water as a Fundamental Resource and the Careful Use of the Site's Water Resources

Given the area's environmental conditions, water was undoubtedly a fundamental resource in Hatra[74]. This importance likely influenced the initial choice of location for the first settlement in the 'Post-Assyrian' period[75].

A minor, seasonally flowing seasonal stream cuts through the site from south to north and subsequently joins the Wadi Tarthar northeast of the city[76] (fig. 11). The stream currently carries abundant water only during the winter-spring period, coinciding with the seasonal rainfall. Numerous photographs in the Archive of the Italian Expedition show substantial water presence in both the stream and the city's eastern areas; due to bank overflow in that sector, surface water accumulates in low-lying zones. Paleoenvironmental data from Lake Khatuniye in the macro-region suggest that the ancient climate was not drastically different from the modern one[77], implying that the stream would have been dry or carried only limited water flow for most of the year. Nonetheless, specific stretches along the stream featured built embankments, identified by the Italian Archaeological Expedition survey and W. Andrae's research[78]. These constructions likely served to prevent flooding during periods of high-water flow. Within the site is a roughly circular basin (60-67 m in diameter and 78 m deep), described by some authors as a 'lake.'[79]

[71] Sommer 2003.
[72] Gawlikowski 1990; Schlumberger 1952.
[73] Parapetti, Venco Ricciardi 2000; Parapetti, Venco Ricciardi 2013; al-Salihi 2023.
[74] For a synthesis about this topic: Foietta 2023.
[75] Peruzzetto, Valentini 2000, pp. 159-161.
[76] Foietta 2023, pp. 19-23. The entrance and exit of the wadi into the city likely had 'water gates' which have not been excavated by archaeological expeditions, but can be inferred based on surface remains (Foietta 2023, p. 21).
[77] Hauser 2000, p. 188.
[78] Andrae 1912, Taf. II. For the so-called *Außlass*, see Andrae 1912, p. 28.
[79] Ibrahim 1986, p. 29; al-Aswad 1991, pp. 210-211.

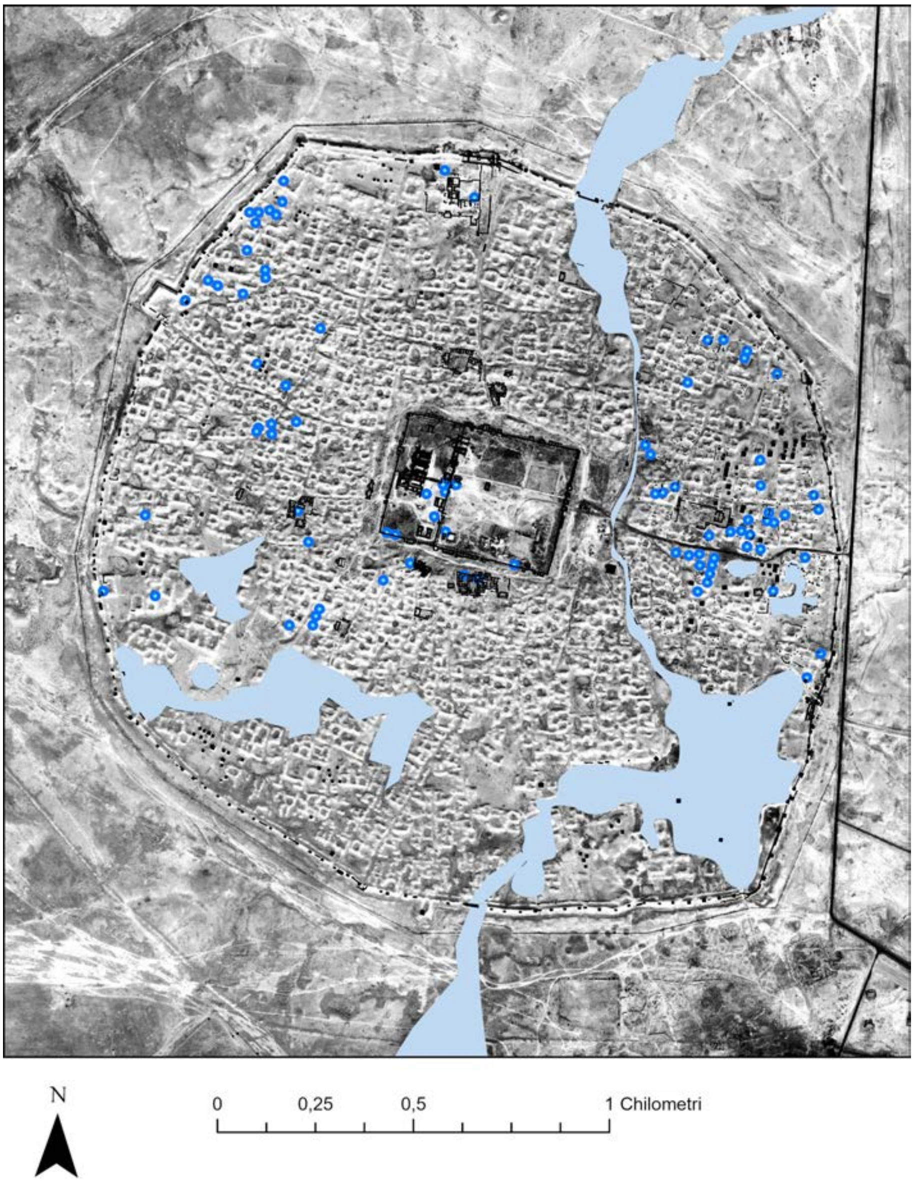


Fig. 22. Hydrology at Hatra with location of the surveyed wells (blue circles) (elaborated by E. Foietta).

Fig. 23a-c. a) Well located west of the Temple of Shahiru (Temenos area); b) well located South of the Allat Temple (Temenos area); c) well discovered in the city area (Archive of the Italian Expedition).

Fig. 24 The 'Ablution Temple' from the north (Archive of the Italian Expedition).

The remains of various ancient structures linked to this basin are still visible (fig. 21). The basin, which may be partly natural and comparable to a doline in a karst landscape like Hatra's, tapped directly into the water table about 8 to 10 meters below the surface[80]. The same aquifer was also accessed by numerous wells excavated in residential areas and in public or semi-public spaces–including squares, streets, and the central Temenos[81] (fig. 22). These wells typically feature a circular or quadrangular stone parapet, often with a trapezoidal cross-section and partially lined with masonry (fig. 23a-c). According to W. Andrae, every dwelling in antiquity likely had its well. Combining data from the German, Italian, and Iraqi surveys, 117 wells have been documented; however, the estimate of nearly 300 wells across the city appears plausible. The aquifer is extremely rich and experiences only minor water levels drop during summer. Its salinity remains low enough for potable use and other urban needs, including livestock watering and street cleaning[82]. In the Temenos, where the main temples were located and, during certain periods of the year, large numbers of pilgrims from the entire region gathered, access to water was ensured by numerous wells and cisterns. Ten of these water-capturing structures were studied in detail by al-Aswad in the 1990s. These structures not only guaranteed access to drinking water for human use but also served ritual purposes and, in particular, some specific religious structures associated with water, such as the so-called 'Ablution Temple' in the eastern court of the Temenos and the so-called 'Bouleuterion' in the western court. The Ablution Temple was a raised platform accessible from the north. An adjacent well was located to the west, originally covered, and a room with a stone basin was likely connected to it[83]. J. Ibrahim suggests that the platform was an open-air structure[84] (fig. 24).

The so-called 'Bouleuterion' is a very poorly preserved building, identified by a depression located in the southeastern corner of the western courtyard of the Temenos (fig. 25a-b). At the time of its discovery, it showed clear evidence of having been partially dismantled in antiquity, possibly as part of restoration efforts. The building (16.40 x 15 m)[85] has been interpreted by some scholars as an assembly hall or theatrical space, aligning with the identification in Hatra's inscriptions of an assembly of elders. H.S.I. Baqqain reconstructs ten rows of seating, although at the time of the 1969 excavation, only three were preserved along the north, east, and west sides[86] (fig. 25c-d), According to the Iraqi reconstruction there were also staircases, 90 cm wide, along the sides, leading to the lower area (8 x 3.20 m). R. Parapetti and R. Ricciardi Venco suggest that the building was originally an open-air structure. By the 1980s, the remains of two stairways were still identifiable, descending at a right angle below the external paved floor, forming a quadrangular space. At the upper level, a semicircular balustrade, resembling a kind of tribune, is preserved, with its

[80] Foietta 2023, p. 22. The direct connection with the aquifer is now interrupted, so during periods of drought the basin is almost empty.

[81] Foietta 2023, p. 24.

[82] Data for the aquifer and its salinity are diffusely reported in Ma'ala 2009; Salih, Kadim, Qadir 2012. Foietta 2023, pp. 27-28.

[83] Safar, Mustafa 1974, p. 348; Parapetti, Venco Ricciardi 2000, p. 115.

[84] Ibrahim 1986, p. 127.

[85] Baqqain 1988, p. 154.

[86] Baqqain 1988, p. 154.

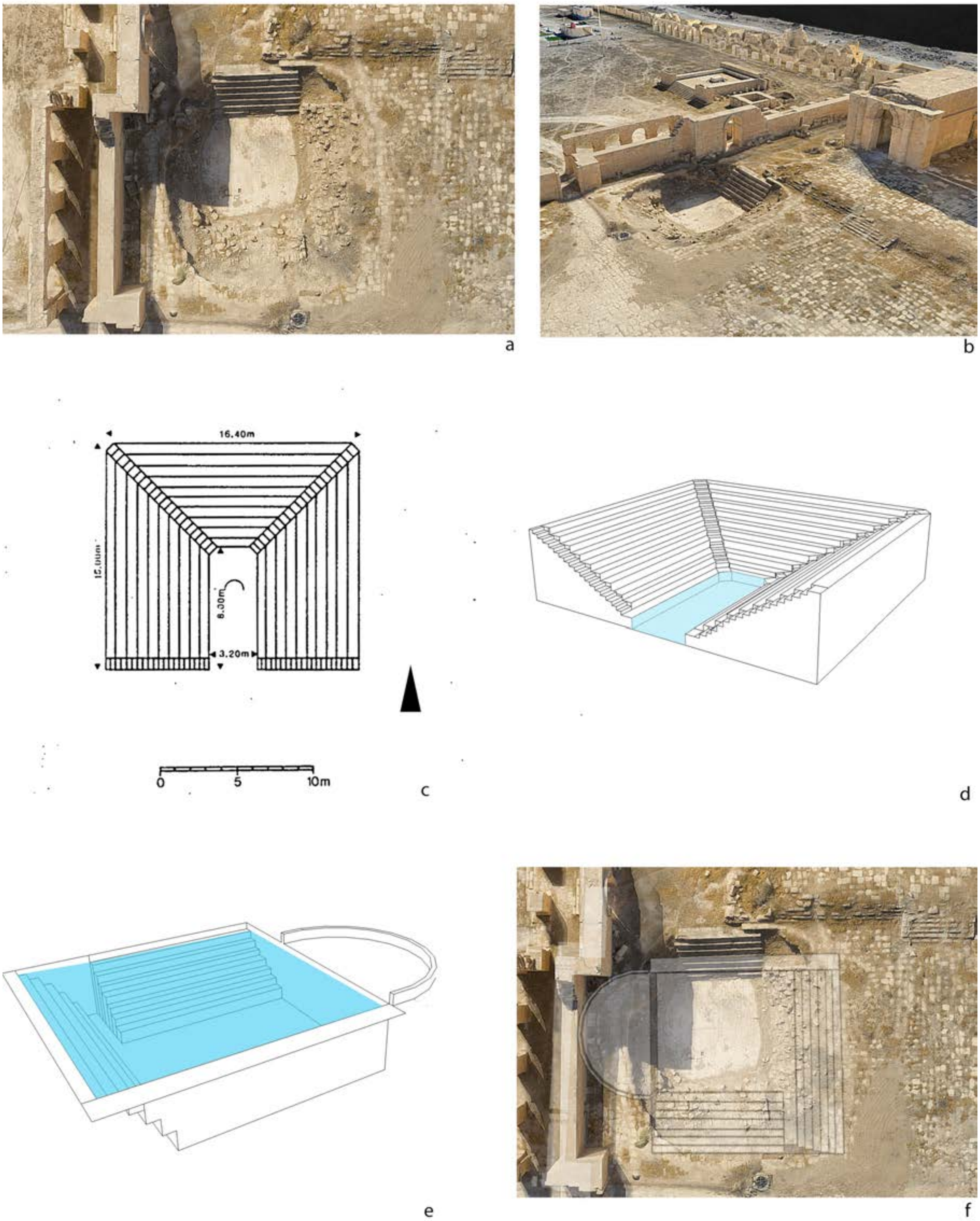


Fig. 25a-f. The so-called 'Bouleuterion', possibly a fountain or a pool; a-b) 3d model made by photogrammetry of the structure (Sketchfab online model - www.savinghatra.org; last view 15/01/2025); c) Iraqi plan of the Bouleuterion (Baqqain 1988, fig. 7);d) 3d reconstruction according to Baqqain's data (elaborated by E. Foietta); e) 3d reconstruction according to Italian Expedition data (Archive of the Italian Expedition elaborated by E. Foietta); f) 3d model made by photogrammetry of the structure with the plan of the Italian Expedition (elaborated by E. Foietta).

concavity facing westward[87] (fig. 25e-f). A doorway in the dividing wall between this structure and the Temple of Samya provided access to the area from the large eastern courtyard. A deeper portico, projecting beyond the alignment of the portico defining the southwestern corner, likely marked the presence of, according to the interpretation of R. Parapetti and R. Ricciardi Venco, either a pool for ritual ablutions or the monumentalization of a spring (fig. 25e). Close to the structure is located in fact a well and several drainage channels marked also in Andrae's plan of the Temenos.

[87] Parapetti, Venco Ricciardi 2000, p. 124.

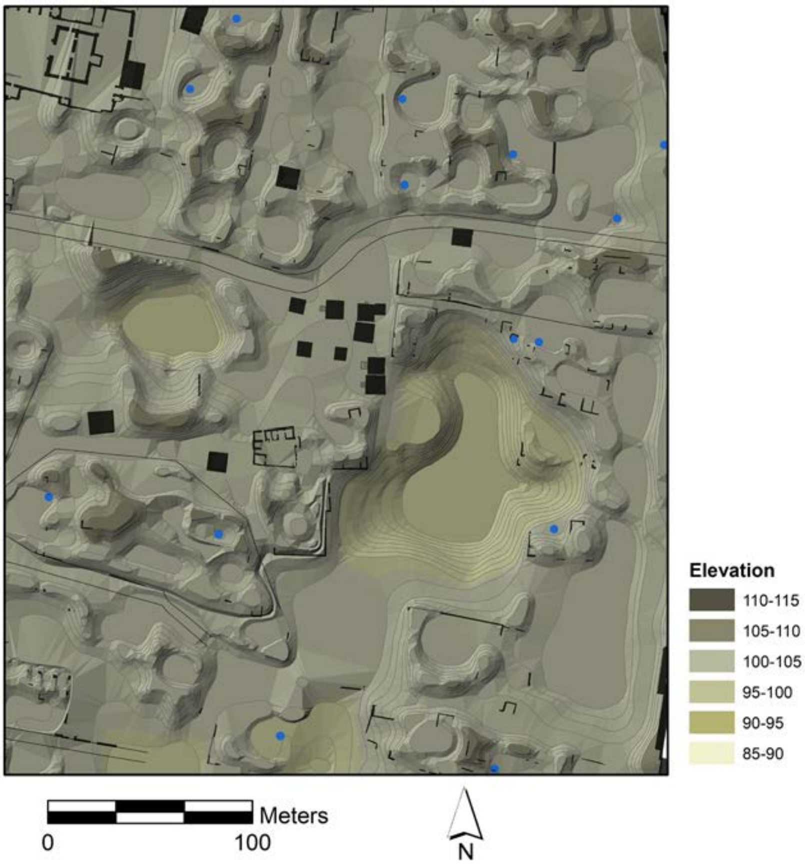


Fig. 26. Water basins in the east part of the city (elaborated by E. Foietta from the topography of the Italian Expedition at Hatra).

If this hypothesis is correct, the southern area of the western Temenos area near the dividing wall between the eastern and western courtyards would have contained sacred spaces with widespread use of water allowing also better thermal conditioning in the area, considering also the shadowing of the porticoes and the 'fresh' areas of the inner spaces of the temples (figs. 25d, 21). These spaces likely included basins or pools that not only supplied water for purification rituals but also cooled the environment and provided relief from the heat for pilgrims.

In the city's eastern part inside the districts, two shallow water-collection basins–likely not connected to the aquifer–were constructed. These basins were presumably filled during the rainy season and connected to the wetter, lower-lying areas of the eastern zone and the moat around the city walls (fig. 26). When filled to their maximum capacity, these two basins could contain approximately 6.000 m^3 and 8.500 m^3 of water, respectively[88]. Although this water was probably not potable, it could be used for street cleaning, livestock, or firefighting during the hotter months. Moreover, the city was, at least in part, designed according to what is now termed a 'sponge city': a contemporary concept applied to urban environments that, by incorporating mainly green spaces–such as parks or vegetated areas–can retain and absorb water, thereby mitigating flooding risks. At Hatra, the 'sponge city' concept primarily focuses on the ability to store water in various basins by directing the wadi's flow through river embankments towards internal drainage areas, and eventually into the moat surrounding the curtain wall.

This approach placed water–a primary resource–at the heart of urban design, employing configurations that simultaneously reduced flood risk and captured or temporarily stored water resources. In contemporary terminology, this would be considered a 'nature-based solution,' originating from traditional wisdom, which accommodates the seasonal variations of the place and potential adversities rather than opposing them: a design strategy grounded in practical necessity and common sense, in which urban design accounted for seasonal variations and flexible space management to accommodate periodic water influx. Today, elements such as rain gardens and water-holding basins remain crucial for stormwater management in many European cities. Having already been tested and refined in various urban settings, these measures are progressively being integrated into urban planning to help counter the impacts of climate change[89].

[88] Foietta 2023, p. 23.

[89] An emblematic example is offered by the city of Copenhagen (Negrello 2022), which has implemented a comprehensive array of measures – including bioswales, raingardens, retention basins, and "watersquares" – aimed at enhancing the resilience of its urban fabric in the face of increasingly severe extreme weather events (European Environment Agency 2016; Sekulova, Anguelovski 2017).

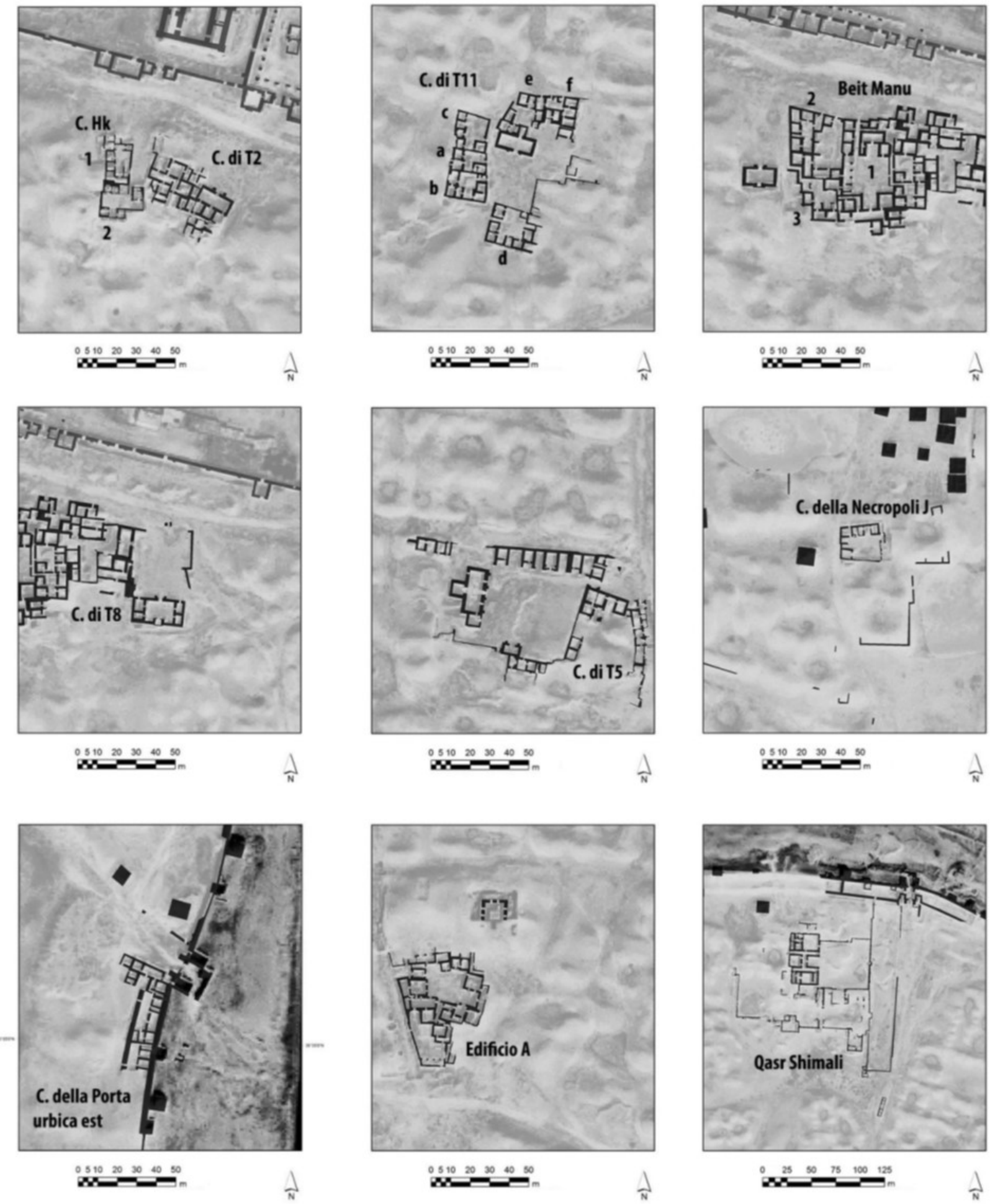


Fig. 27. Plans of the excavated houses and a palaces at Hatra.

6. Climate Adaptation Features in Private Buildings (Houses and Palaces)

Within Hatra's districts and urban areas, residential and domestic buildings would have predominated in their number and space, surpassing all other public or semi-public edifices[90]. Research into private architecture at Hatra began in the 1950s with the Iraqi Archaeological Missions, whose findings have been partially published[91]. At the same time, a wealth of additional data derives from excavations of Building A conducted by the Italian Expedition at Hatra (University of Torino)[92]. The houses of Hatra are distinguished by a central courtyard, with rooms constructed on two, three, or four sides of this courtyard (fig. 27). These courtyard houses feature certain rooms, corridors, or open transitional spaces between the access street and the courtyard.

[90] Foietta 2018, pp. 421-442. For the domestic buildings at Hatra see: Cabiale 2006.
[91] Foietta 2018, p. 421.
[92] Venco Ricciardi 1988; Venco Ricciardi 1990; Venco Ricciardi 1992; Venco Ricciardi 1996; Venco Ricciardi 2000; Dorna Metzger 2000a; Dorna Metzger 2016.

Fig. 28. Main iwan in the courtyard of Building A (Archive of the Italian Expedition).

Fig. 29. Iwan of Beit Manu (Archive of the Italian Expedition 1993).

Generally, numerous entrances and, above all, one or more iwans open onto the courtyard. Iwans are vaulted spaces typical of the Parthian period, fully open on the courtyard side and with an arched façade. Often, the iwan, used as a multifunctional space, including for welcoming guests, was positioned along the northern side of the courtyard, likely to ensure greater coolness during hot periods[93] (fig. 28). Moreover, their height, typically more significant than that of the other rooms, could have enhanced convective air movements, thereby facilitating ventilation and the cooling of the space by exploiting the stack effect mechanism[94]. The iwan is a typical innovation of the Parthian period (1st century BCE - 3rd century CE) and is widely attested in Hatra, both in domestic and religious architecture with 43 occurences in the different excavations of the city. Certainly, compared to previous periods, this type of space reflects not only a different intent of monumentalization of buildings, façades and courts, but also clear signs of functional improvement and adaptation to the environment and climate of the Near and Middle East. Indeed, due to its architectural and functional qualities, this shape was preserved and spread throughout the Sasanian and Islamic periods in monumental and domestic buildings[95].

The building technique in Hatra generally comprises walls of differing thicknesses, depending on whether they are perimeter or internal walls, with a stone or rubble foundation and a mudbrick superstructure[96]. The decision to use mudbrick was undoubtedly influenced by its low cost and the availability of clay in Mesopotamia, but also by its outstanding thermal insulation properties, which, in many cases, surpass those of stone (readily available in northern Mesopotamia and the Hatra region; mudbrick with a density of 1400 kg/m^3: $\lambda \approx 0.46$W/m·K; Semi-hard limestone with a density of 2100 kg/m^3: $\lambda \approx 1.4$ W/m·K (typical of the Hatra region) (fig. 29). Both walls and flat roofs were usually coated in gypsum plaster, which protected the mudbrick from the elements and offered a high degree of light reflection (albedo), reducing the overheating of surfaces and, consequently, helping to cool indoor spaces (fig. 30).

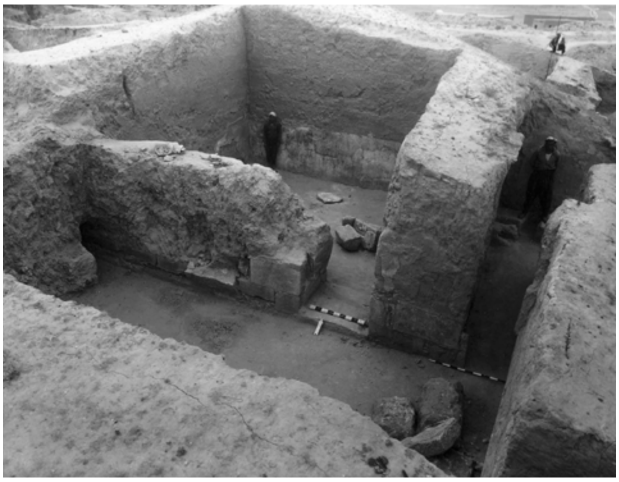
This building technique was well attested over millennia at many Mesopotamian archaeological sites and continued to be used in subsequent Sasanian and Islamic periods due to its apparent effectiveness[97]. In Parthian times, however, the use of gypsum plaster rather than mere clay plaster seems to have become more widespread than in earlier periods, as indicated by stucco decorations (for instance, in the Parthian Palace at Ashur)[98] and moulded decorations, such as those on the door jambs and corniches at Dura-Europos[99]. Moreover, this plaster coating was not limited to the courtyard or interior spaces; evidence shows it was also extensively applied to façades, as indicated by findings along the North Road. In some cases, the white plaster was even decorated with later-added graffiti and large painted surfaces[100] (fig. 31).

The courtyard served multiple functions, providing space for various domestic tasks and allowing residents to linger there at different times of the day or welcome visitors from outside[101]. Certain times of day and year allowed

[93] Dorna Metzger 2000a.
[94] Ascione, Bellia & Minichiello 2017.
[95] On this topic see Keall 1974. Recently Foietta and Bruno have proposed a new interpretation about the emergence and development of the Parthian Iwan (Foietta, Bruno forthcoming).
[96] Foietta 2018, p. 422.
[97] Margueron 2013, pp. 9, 25-40.
[98] Andrae, Lenzen 1933, pp. 25-54. The original construction of the palace dates to the Early Parthian period, approximately between the 2nd century BCE and the 2nd century CE. The stucco decorations are attributed more specifically to between the 1st century BCE and the 2nd century CE (Andrae, Lenzen 1933, p. 2)
[99] For the architectural corniche in plaster: Allag 2012, pp. 132-141 and related bibliography.
[100] Dorna Metzger 2016, pp. 308-309. For the graffiti at Hatra: Moriggi, Bucci 2019.
[101] For the different purposes of the courtyard in relation also with the preparation of food: Foietta 2021b.

a

b



c

Fig. 30a-c. Gypsum plaster: a) Beit Manu; b) the East Gate; c) rooms of the House of the Shrine VIII (Archive of the Italian Expedition – Torino).

Fig. 31a-b. Graffiti on plaster: a) from the East Gate; b) from Building A (Archive of the Italian Expedition).

a

b

for the pursuit of cool shade, particularly in the evening and early morning, and for basking in warm sunlight during the colder winter hours. The rooms adjacent to the courtyard typically consisted of a single storey. However, a second storey might occasionally have existed–although none has survived, it can be hypothesised based on stairways, wall thicknesses, construction features, and collapse layers. Courtyards often contained tannurs (bread ovens), fire points for food preparation, and stone basins for holding water or liquids used in diverse activities, from washing food and utensils to watering animals[102] (figs. 32-33).

[102] See Foietta 2021b.

Fig. 32. General plan of the late phase of Building A (Foietta 2021, p. 192, fig. 1).

Fig. 33. Stone basin in House C, 20 (Houses of Beit Manu complex) (Archive of the Italian Expedition).

Many houses possessed direct access to water via a well, generally located in the courtyard and tapping the water table at a shallow depth of around 10 metres[103]. In the case of Building A, no well has yet been identified, but it may have been situated in one of the two smaller, not fully excavated courtyards[104]. Clearly, in a semi-arid environment such as Hatra, water access in both public and private contexts was critically important to ensure potable water and for functional purposes such as cleaning and cooling.

The architectural morphology featuring internal courtyards with natural elements, including water features and vegetation, appears in different historical periods and cultural contexts. Indeed, traditional houses in hot, arid regions often incorporate a private open area known as a courtyard, serving as a central organising space for the dwelling, providing visual and acoustic insulation from the outside world, and affording residents a higher degree of privacy[105]. Besides being the social hub of the house, the courtyard also contributed to regulating internal temperatures. Doors and openings usually faced the courtyard, making it a connection point among the various parts of the home[106].

The thermal properties of a courtyard could be enhanced by increasing shaded areas and humidity levels. Adding water features and vegetation was an effective strategy to cool the space and improve comfort[107], an approach that today would be described as a nature-based solution. A key aspect of natural cooling in courtyards lies in the 'chimney effect', which facilitates natural ventilation and air recirculation. This passive process fosters air currents and increases air movement, improving thermal comfort[108]. In the courtyard houses of ancient Egypt[109], for example, climatic mitigation strategies are evidenced by archaeological reconstructions and remains. In the Roman era, domus frequently included central pools or basins to alleviate overheating within the interior (fig. 2). Besides enhancing thermal comfort, this solution demonstrates continuity with other architectural traditions. A particularly illustrative example can be found in Moorish architecture in Spain, where fountains and water features were integral to cooling and ensuring the liveability of interior spaces.

Fig. 34. Stairway in one of the houses of the Beit Manu complex (1986) (Archive of the Italian Expedition).

Fig. 35. Stairway located on the excavated area of the North Street (Archive of the Italian Expedition).

In contemporary contexts, these traditional solutions have been reinterpreted within the framework of Nature-Based Solutions (NBS), an approach that employs natural elements to address urban challenges. The use of cooling water features in courtyards or public spaces represents an innovative application of such principles[110].

[103] Foietta 2023, pp. 24-27.
[104] Foietta 2021b, p. 202.
[105] Rapoport 2007.
[106] Maleki, 2011.
[107] Alabsi, 2016.
[108] Sthapak, Bandyopadhyay 2014.
[109] Karem 2016; Mohamed 2010.
[110] A noteworthy example is the Jean-Max Llorca water square, designed by architect Pierre Gangnet and urban planner Michael Corajoud. Covering an area of 3,450 m² and with a depth of just 2 cm in Bordeaux's main square, this water feature was conceived to improve the microclimate and enhance users' well-being.

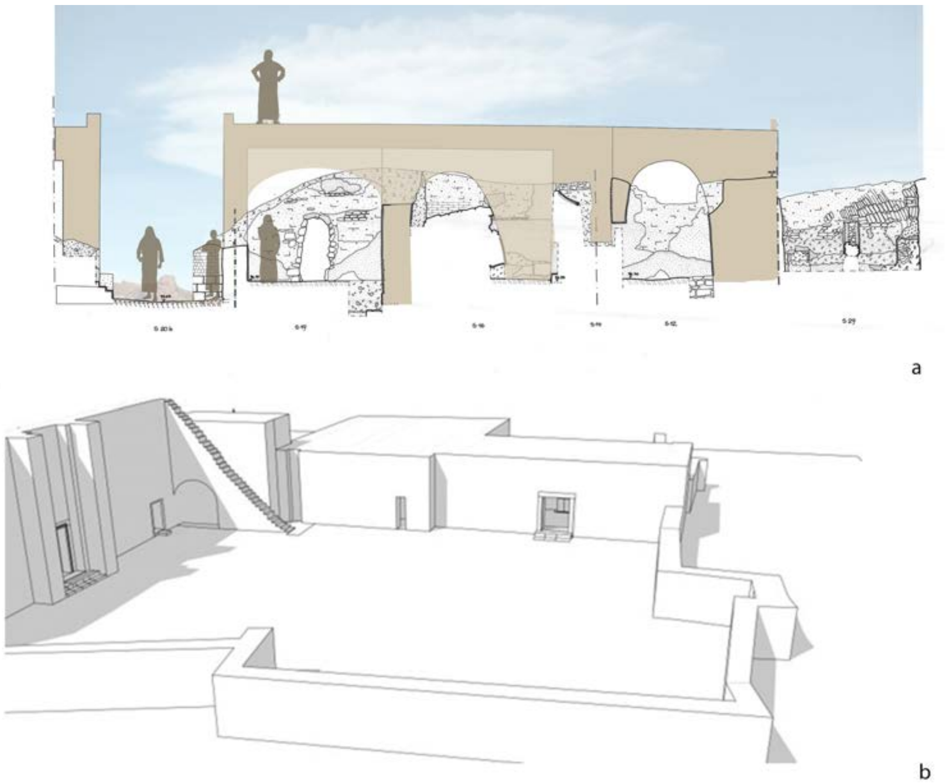


Fig. 36. Flat Rooftop of the House close to Shrine VIII (elaborated by E. Foietta and M. Negrello).

Analyses of Hatra's residential buildings and their collapse strata suggest that the flat roof would have been accessible using external staircases constructed within the courtyard on ramps or arches; the steps typically consisted of whitish slabs of local alabaster-like limestone (*marmar*) (figs. 34-35). This approach aligns with numerous contemporary designs where so-called 'cool materials' mitigate local warming and the urban heat island effect.

The flat roof probably served as a practical space for inhabitants throughout the day and was suitable for a variety of tasks. It is conceivable that temporary seating arrangements could have been installed, or that the roof might even have functioned as a sleeping area during exceptionally hot summer nights, reflecting practices documented until approximately fifty years ago in traditional Iraqi mudbrick villages (fig. 36). Additionally, one could envisage the installation of awnings or canopies on these rooftops to mitigate solar radiation. Furthermore, and quite evidently, access to the roof would have been essential for maintenance procedures and the periodic repair of the clay roofing surface.

7. Urban Greenery in Hatra: Desert City or a Paradigm in Need of Revision?

Since the 19th century, numerous scholars have classified Hatra – similarly to other settlements in the Near East – as a 'desert city,' occasionally going so far as to call it the 'Venice of the desert'[111]. This label is rooted in the assumption that Hatra's primary function, much like Palmyra, was commercial. Beyond its likely principal role as a religious and cultural centre – an aspect well attested by archaeological, epigraphic, and historical data[112]– the notion of a 'desert city' may derive from Roman sources, which emphasise the harsh, arid, and inhospitable environment, replete with venomous insects, scorpions, and snakes. Such depictions often served to rationalise the failed sieges of Trajan and Septimius Severus[113]. Western travellers' accounts further reinforced these perceptions. In reality, both presently and likely during the second to third centuries CE, fields surrounding Hatra and along the Wadi Tarthar may have supplied the city with food[114].

Given the extensive karstic network of subterranean channels and the availability of an aquifer accessible through numerous wells, Hatra may also have supported limited vegetation. Even today, in certain un-

[111] For instance: Hauser 2000; Gregoratti 2013, pp. 47-50. See Foietta 2018, p. 101; Foietta 2020a, p. 302.
[112] Kaizer 2013; Foietta 2018, pp. 485-487.
[113] Cassius Dio 67, 10 and 76.10-12; Herodian, 3, 9, 1-7.
[114] Foietta 2020a, pp. 302-305.

built areas of the city, large tracts of grass emerge during the spring, potentially serving as grazing land for local livestock and possibly for flocks from outside the city, at least during times of siege. Although no tall trees are known to have been indigenous to the area – timber was likely imported for construction, as evidenced by beam sockets found in certain towers along the city walls – wood was undoubtedly used for structural elements such as vault centring and other components in the monumental buildings of the Temenos[115].
Vegetation in the region of Hatra aligns with typical steppe flora, comprising shrubs, low-lying plants, and herbaceous species that inhabitants would have utilized for diverse purposes[116]. In the northern regions of the Kingdom of Hatra, tree species may have been more common, especially near the 200 mm isohyet, including parts of the Sinjar region endowed with springs and wadis. Consequently, while Hatra and its hinterland likely did not resemble other Mesopotamian settlements blessed with riverine environments and arboreal species, such as palm trees in central Mesopotamia, its landscapes were probably greener in winter and spring than historical accounts suggest. Although no evidence currently confirms the existence of formal gardens within the city, palynological studies of sediment layers in the circular basin located in the western part of Hatra could yield valuable insights into the plant species once cultivated and utilised by its ancient inhabitants.

8. Conclusion

In conclusion, the comparative analysis of the solutions adopted in antiquity and more recent resilient urban design strategies demonstrates that 'common sense' construction practices and attention to local environmental conditions were already integral aspects of past architectural and infrastructural interventions. Features such as the integration of water-collection basins, the arrangement of openings and walls for thermal regulation, the use of reflective surfaces, and the presence of natural filtration systems like bioswales and rain gardens attest to the sophistication of building concepts that, despite the absence of advanced technologies, aimed to mitigate climatic impacts and optimise the use of available water resources. These achievements were made possible at Hatra by a profound environmental knowledge developed over millennia of experiences in Mesopotamia and by the skillful use of locally available materials.

The approach founded on these 'nature-based' and low-tech solutions, evidence of which is observable in the cases examined, is not merely a cultural legacy that can help archaeologists interpret and become more aware of ancient construction and planning choices. Instead, it offers interpretive frameworks and practical insights for the present and the future. In a global context where the effects of climate change are increasingly evident, such strategies are relevant not only for high-density urban environments but also, perhaps significantly, for geographic areas characterised by limited water resources, modest economic means, and constrained technical expertise. In these scenarios, rethinking and adapting ancient approaches to current circumstances can help reduce climate vulnerability while promoting resilient, economically sustainable, culturally rooted solutions harmonising with the environment. A reappraisal of these traditional practices, including through archaeological study, thus represents a viable and concrete pathway toward architecture and adaptive urban design oriented to sustainability, resilience, and equity in resource use.

Moreover, the potential to employ compatible solutions, mediated by traditional architecture, for constructing new, innovative, sustainable areas and archaeological parks should not be overlooked. Such initiatives can genuinely interact with a changing territory, where conditions of aridity and heat (especially in the Middle East) are intensifying. By reactivating in archaeological sites the same practices used thousands of years ago in these very locations, we can render these heritage spaces operational and welcoming once again for future visitors, thereby re-contextualizing the past and its strategies profoundly and beneficially.

From the perspective of resilience and environmental adaptation, the archaeological evidence, most abundant for the period between the 1st and 3rd centuries CE, suggests that the adaptive strategies at Hatra did not undergo radical changes during this time. The urban fabrics of the pseudo-circular city in the 2nd-3rd centuries CE closely resemble that of the 1st century CE, defined by the so-called Trajanic wall. Likewise, domestic construction techniques appear to have remained largely unchanged[117], and the water management system likely continued to function along similar lines. This latter system was certainly enhanced from the second half of the 2nd century CE onward, probably through the adaptation of the local karst system and improved use of both natural and artificial basins within the city walls.

[115] Foietta 2018, p. 76.
[116] Guest 1966, pp. 78-82.
[117] One possible exception to this general continuity is the widespread appearance of the iwan in both domestic and religious architecture, likely beginning in the 1st century CE. As previously noted, the iwan not only contributed to the monumentalization of certain spaces but also offered notable environmental advantages, such as improved ventilation and thermal regulation.

A process of monumentalization of public spaces, particularly the Temenos, becomes evident starting with the reign of Nasru (128/129-137/138 CE). This reflects not only the staging of civil and religious public ceremonies but also attempts to adapt to the environment by creating large and partially shaded public areas. Environmental and social pressures must also have affected the military sector, especially considering repeated Roman military campaigns. Clear evidence of strategic responses can be seen, for example, in the construction of several massive towers along the city wall at the end of the 2nd century CE, the enhancement of city gates with bent-axis (baïonnette) entrances, and the restoration of existing defensive structures[118].

Future assessments of Hatrene resilience, as well as of moments of crisis and transition, will be necessary–not only at the level of the city itself but also in a broader territorial framework. Such studies could help shed light on the transition from the 'Post-Assyrian period', which is subject of numerous studies by various scholars in Northern Mesopotamia to the rise of the Kingdom of Hatra, and from its eventual fall to the emergence of the Sasanian Empire.

[118] For the fortifications at Hatra: Foietta 2016.

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