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ORIGINAL PAPER
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BLUE-GREEN INFRASTRUCTURE IN BAGHDAD'S RESIDENTIAL COMPLEXES

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ABSTRACT

Motivates: Studies have shown that many cities worldwide face environmental challenges imposed by climate change and rapid urban expansion, which reduces green spaces and transforms them into urban areas. Addressing these challenges requires the adoption of methodologies and strategies and methodologies that promote blue-green infrastructure, which integrate greening and water features to enhance thermal comfort, public health, and overall quality of life.
Aims: This study provides a context-specific evaluation of Blue-Green Infrastructure in the hot-arid climate of Baghdad, where extreme heat and low humidity create microclimatic conditions distinct from those of temperate regions commonly addressed in previous research. The research examines key microclimate indicators – Potential Air Temperature, Sky View Factor (SVF), Mean Radiant Temperature (MRT), Relative Humidity, and PMV – within a residential complex to assess the effectiveness of BGI in improving outdoor thermal comfort. The study addresses a knowledge gap regarding the role of BGI in mitigating heat stress in Baghdad and demonstrates that integrating vegetation and water elements can contribute to reducing temperatures and enhancing comfort levels in hot-dry environments.
Results: The research findings confirm the significant impact of blue-green infrastructure in improving the climatic conditions of residential complexes in Baghdad.

Keywords: Blue-green infrastructure, Urban Microclimate, Thermal Comfort, Mean Radiant Temperature (MRT), Sky View Factor (SVF), Predicted Mean Vote (PMV)

INTRODUCTION

Reports indicate that more than 400 cities worldwide have declared a "climate emergency" in response to the escalating challenge of climate change (Mumtaz, 2021). To address these consequences, cities have adopted various measures, often related to blue-green infrastructure. Accordingly, the implementation of adaptation and mitigation strategies has become essential to reducing the risks that climate change imposes on urban environments. Expanding blue-green infrastructure in cities is considering a critical pathway toward sustainable development and climate resilience (Mumtaz, 2021; Shaheen & Khalaf, 2009). Extreme environmental phenomena such as droughts and heat waves are recognized as integral components of human-ecological systems. However, their severity and unpredictability, and consequences for public

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health, well-being, infrastructure and settlements are intensifying under changing climate conditions. These impacts are further compounded by limited awareness and inadequate preparedness for climate variability in regardless countries' development levels. In this context, sustainable approaches such as Blue-Green Infrastructure (BGI) provide a resilient foundation for long-term urban development (Ghofrani et al., 2017; Salem, 2008).

Urban areas are expanding significantly globally. While one-third of the world's population lived in cities in the 1950s, this rate is expected to rise to two-thirds by 2050. Such growth has driven urban expansion at the expense of natural areas and wildlife habitats. Urbanization encroaches upon rural and natural areas, increasing demands for roads, energy, and infrastructure while simultaneously shrinking and fragmenting remaining ecosystems (AlTalebi & Al-Bazzaz, 2018; Yildirim et al., 2022). The resulting spread of impervious surfaces such as roads, rooftops and parking lots – has accelerated the loss of natural green and blue areas. Consequently, many cities worldwide have developed adaptation strategies not only to mitigate climate change impact but also to safeguard public health, enhance quality of life, and sustain economic activity (Al-Saffar & Al Siliq, 2014; O'Donnell, Gosling, et al., 2021). The reduction of natural land areas, combined with the extensive impervious surfaces, has intensified extreme urban phenomena including elevated air temperatures and urban droughts (Pochodyła et al., 2021; Tareq & Al-Kindy, 2025b).

The research problem was identified as the knowledge gap concerning the role of blue-green infrastructure in mitigating high temperatures and improving thermal comfort in Baghdad. Despite the global adoption of blue-green infrastructure (BGI) to mitigate urban heat and improve outdoor comfort, there is a lack of studies examining its effectiveness in hot-arid cities such as Baghdad. Previous research in Iraq has not fully addressed the role of vegetation and water features in residential complexes. This study, therefore, aims to evaluate the effectiveness of BGI in reducing high temperatures and enhancing outdoor thermal comfort in the Abraaj Baghdad residential complex. It is hypothesized areas with high-density vegetation and integrated water features show a greater reduction in air temperature and radiant temperature than areas with sparse vegetation or no BGI elements.

LITERATURE REVIEW

Blue-Green Infrastructure (BGI) is a comprehensive approach that builds upon the notion of "green infrastructure," a planning concept widely adopted since the early 2000s to design and enhance urban green spaces within integrated environmental framework. It encompasses artificial, natural, and semi-natural components of multifunctional ecosystems within, around, and between urban areas. The increasing global adoption of green infrastructure highlights its multiple benefits, as it can be defined as an interconnected network of waterways, wetlands, wildlife habitats, and other natural areas; greenways, parks, and other conservation lands; working farms, pastures, and forests; wilderness areas and other open spaces that support species, maintain ecological processes, conserve air and water resources, and enhance community health and quality of life (Ghofrani et al., 2017; Hassan & Al-Kindy, 2023). The BGI approach integrates both blue and green infrastructure elements that to enhance urban ecosystems through natural processes within built environments. Its key benefits include: (Improving water quality by absorbing and purifying runoff while reducing energy demands for treatment; mitigating climate change impacts by alleviating the urban heat island effect; Enriching urban aesthetics through accessible integration of green and water spaces; and Providing recreational areas that strength social interaction) (Afata et al., 2022; Ghofrani et al., 2017; Wouters et al., 2016).

BGI is increasingly recognized as a vital strategy for addressing urban challenges associated with climate variability and rapid urbanization, while enhancing resilience to future environmental changes. Its implementation emphasizes the need to mitigate urban heat and to increase the ecological and economic value of natural capital. BGI is defined as interconnected network of natural and designed component – including open green

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spaces and water bodies (ephemeral, intermittent, and permanent) – that provide multiple functions (O'Donnell, Netusil et al., 2021). As an alternative and complement to traditional gray infrastructure, BGI offers practical and sustainable solutions for urban areas. In landscape design, it connects vegetation systems with hydrological functions, delivering combined ecological, social and economic benefits greater than those of its individual components. Cities that successfully integrate natural systems into their infrastructure not only achieve environmental resilience but also overlapping benefits that contribute simultaneously to both "green" and "blue" objectives (Sunita et al., 2023) BGI also represents a key nature-based solution for sustainable storm water management in cities, while expanding the range of ecosystem services. Environmental quality, in this regards, is a crucial determinant for improving living conditions and addressing climate change in the planning and designing of dense urban areas (Pochodyła et al., 2021).

Blue-green infrastructure (BGI) is an emerging concept that has attracted growing attention in land development, landscape design, and environmental conservation. It is not only of interest to urban planners, landscape architects but also to decision-makers, environmental groups, and natural scientists (Nassani et al., 2023). BGI can be defined as a systematic and strategic approach to integrating natural elements, such as vegetation, open land, and water bodies, etc. Into urban environments. In cities BGI serves as practical solution to mitigate pollution, enhance ecosystem services environmental services and improves resilience to climate change (Mumtaz, 2021). Fig. 1 illustrate the Blue Green Infrastructure Concept.

Tareq & Al-Kindy (2025a) addressed the environmental challenges in the hot, dry climate of Baghdad by examining the urban heat island phenomenon in contemporary residential complexes. Using the ENVI-met environmental simulation program, the study provided a set of recommendations for the planning and design of residential complexes and their outdoor spaces in hot, dry climates. Alhadedy & Alomary (2024) focused on the relationship between the Urban Happiness Index and blue-green infrastructure. The study employed NDVI and NDWI indices to analyze green and water spaces in the cities of Mosul, Basra, and Najaf, and compared the results with Denmark and Amsterdam, which topped the 2023 Happiness Index. The findings revealed that Iraqi cities suffer from a significant lack of blue-green infrastructure compared to the two leading cities, contributing to their lower rankings.

Perrelet et al. (2024) demonstrated that blue-green infrastructure combines semi-natural and designed elements. The study called for integrating engineering and environmental objectives in BGI design to enhance both performance and biodiversity. It further emphasized the importance of interdisciplinary collaboration to achieve balance between engineering and ecological goals. Najah et al. (2023) examined the impact of urban expansion on green infrastructure in cities, showing that open green spaces were transformed into buildings and streets, which intensified the urban heat island phenomenon. The study analyzed a district in Baghdad using various simulation scenarios.

Abdulateef & Al-Alwan (2022) investigated the role of urban green infrastructure in reducing the heat island phenomenon in Baghdad. The research

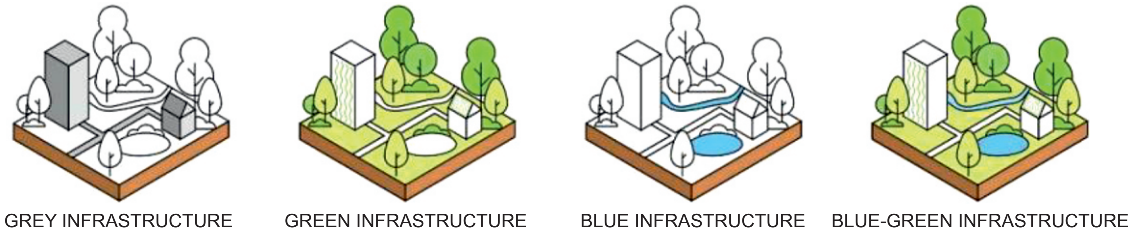

Fig. 1. Blue Green Infrastructure Concept
Source: Pochodyła et al., 2021.

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relied on computer simulations in the ENVI-met program and applied multiple green infrastructure scenarios. Dai et al. (2021) evaluated the potential of blue-green infrastructure in improving environmental conditions. The results showed that water parks were most effective in regulating climate and water, while natural parks provided higher cultural services. Green spaces were also found to support physical activity, depending on their size. The study called for improving the distribution of BGI to achieve environmental justice and sustainability.

Kopp et al. (2021) analyzed 27 studies and documents on BGI between 2006 and 2019. Six approaches were identified and reclassified into three basic conceptual categories. The study aimed to strengthen the integrative concept of BGI in support of sustainable urban planning. Almaaitah et al. (2021) reviewed the benefits of blue-green infrastructure in reducing urban heat islands and managing storm water. The study confirmed BGI's effectiveness in runoff reduction and urban cooling, but also highlighted that most studies focused on single aspects of BGI and relied heavily on computer modeling and sensors.

Lamond & Everett (2019) explored user behaviors in urban environments with BGI and their capacity to engage with, care for, and maintain such spaces. Using Social Practice Theory (SPT), the study analyzed the relationship between daily practices and user attitudes toward BGI, providing recommendations to guide community engagement strategies. O'Donnell et al. (2017) highlighted the need to adopt blue-green infrastructure approaches, identifying 17 barriers to implementation and suggesting strategies to overcome them. The study also stressed the importance of collaboration among decision-makers.

Ghofrani et al. (2017) examined the impacts of BGI on water resources and vegetation, analyzing applications across different countries. The study suggested prioritizing feasibility and impact assessments, particularly in regions with natural tourism resources. Al-Kindy (2012) discussed the effects of poor sustainability and weak spatial organization in contemporary Iraqi residential neighborhoods. The study highlighted inefficiencies in the design of residential spaces and the dominance of physical aspects over environmental and social ones, aiming to propose organizational mechanisms that could contribute to a more sustainable residential environment.

While several studies have examined BGI in Iraq, focusing on urban heat mitigation and green space distribution (Abdulateef & Al-Alwan, 2022; Alhadedy & Alomary, 2024; Najah et al., 2023; Tareq & Al-kindy, 2025a), examples from other cities worldwide illustrate its broader adoption and benefits. Cities such as Singapore, Copenhagen, and Melbourne have implemented integrated networks of vegetation and water features to enhance thermal comfort, manage stormwater, and improve public spaces. Despite this global experience, there is a notable lack of research on BGI in hot-arid contexts like Baghdad, highlighting the need for a context-specific study to evaluate its effectiveness in residential complexes.

METHODOLOGY

The research adopted an analytical field study approach to study the microclimatic performance of blue-green infrastructure within Abraaj Baghdad residential complex which encompasses built-up areas, vegetation cover, and water features in the hot and dry climate of Baghdad. The study combined field observation with office-based analysis utilizing computer climate simulations conducted through the ENVI-MET software. The primary objective was to evaluate the existing conditions without assuming or testing alternative scenarios.

Five Receptors were strategically selected within the project to represent diverse microclimatic conditions, including exposed areas, shaded zones, and locations near vegetation and water features. This distribution allows for a comprehensive assessment of the spatial impact of BGI on key thermal comfort indicators (Potential Air Temperature, MRT, Relative Humidity, and PMV). The sensors were placed at a height of 1.8 m to reflect adult outdoor comfort levels. The research methodology can be summarized in Fig. 2:

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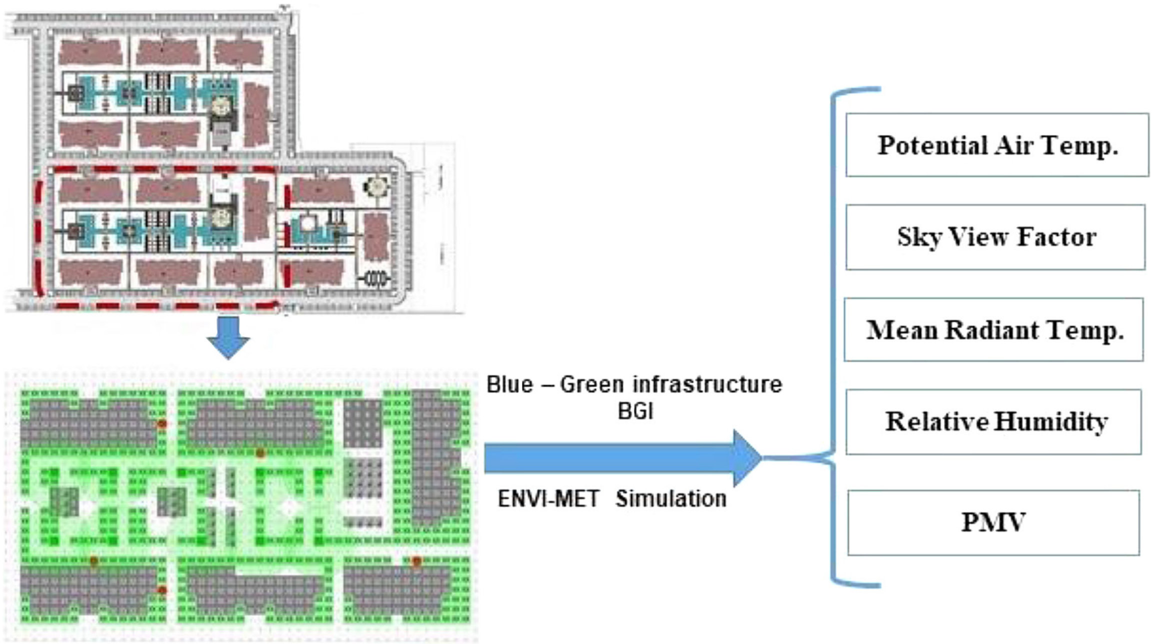

Fig. 2. Simulation stages of research methodology
Source: own elaboration.

ABRAAJ BAGHDAD RESIDENTIAL PROJECT:

PROJECT DESCRIPTION:

The project is situated on Baghdad International Airport Street, near Al-Mashreq Mosque, occupying a central location that ensures accessibility and strategic significance (Table 1). The complex primarily consists of residential buildings, commercial centers, and a school as shown in Figs. 3–5.

Table 1. Information on Abraaj Baghdad Residential Project

Abraaj Baghdad	Project Name
2021– present	Year
Approximately 90,000 m^2	Project Area
Multi-family	Housing Type
15	Number of Residential Buildings

Source: own elaboration.

Fig. 3. Location of the study area: Iraq, Baghdad, and Abraaj Baghdad residential complex
Source: own elaboration.

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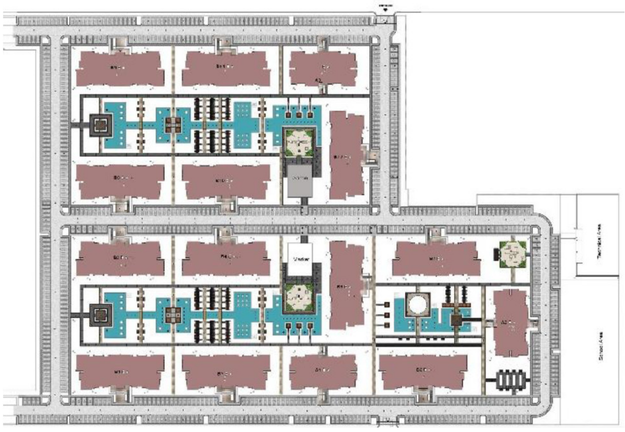

Fig. 4. Site plan of Abraaj Baghdad residential project
Source: own elaboration.

Fig. 5. Illustrative shots of Abraaj Baghdad residential project
Source: own elaboration.

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BASIC SIMULATION SETTINGS

The simulation day was selected based on hourly environmental data obtained from the General Authority of Meteorology and Seismic Monitoring, representing one of the hottest days of 2023. It should be noted that the maximum air temperature allowable as input in the ENVI-met software is 50°C. The simulation inputs data used in the ENVI-met software are summarized in Table 2:

The selected sample of the project can be illustrated by simulation in Fig. 6:

Table 2. Simulation inputs in the ENVI-met program for selected projects

Baghdad (lat. 33°34′N, long. 44°40′E)	Location
August 13, 2023	Simulation date
00:00 AM	Simulation start time
24 hours	Total simulation time:
Minimum temperature: 30°C at 6:00 AM. Maximum temperature: 50°C at 6:00 PM	Temperature
Minimum relative humidity: 6% at 2:00 AM. Maximum relative humidity: 26% at 12:00 PM	Relative humidity
24 hours	Total simulation time
3.9	Wind speed
315 (0 = North, 180 = South)	Wind angle:
X-Grids = 49, Y-Grids = 28, Z-Grids = 40 Grids: dx = 2, dy = 2, dz = 2 Model rotation angle: 52	Model boundaries

Source: own elaboration.

RESULTS

To assess the microclimatic performance of the Abraaj Baghdad Residential Project, various environmental indicators were analyzed at 12 noon, corresponding to peak thermal stress conditions. The study focused on key parameters including Potential Air Temperature, Sky View Factor (SVF), Mean Radiant Temperature (MRT), Relative Humidity, and Predicted Mean Vote (PMV) to evaluate the impact of blue-green infrastructure (BGI), shading, and water features on outdoor thermal comfort. The following section presents the results obtained from the simulation for selected locations within the project site, highlighting both maximum and minimum values to demonstrate the variability across shaded and exposed areas.

The results for the actual situation of Abraaj Baghdad project shown in at 12 noon and at a height of 1.8 m. Presented in Fig. 7. Summary of these results is provided in Table 3:

The comparison results for the selected research samples at 12 noon show the following:

1. Potential Air Temp.: Although the maximum outdoor temperature input for the simulation inputs was 50°C, the simulated temperature within the project were significantly lower. This reduction can be attributed to the presence of blue-green infrastructure, shading elements, and the absence of reflective surfaces.
2. Sky View Factor (SVF): The analysis indicates that approximately 60% of the selected sample recorded SVF values less than 0.5, suggesting that most areas benefit from considerable shading provided by trees

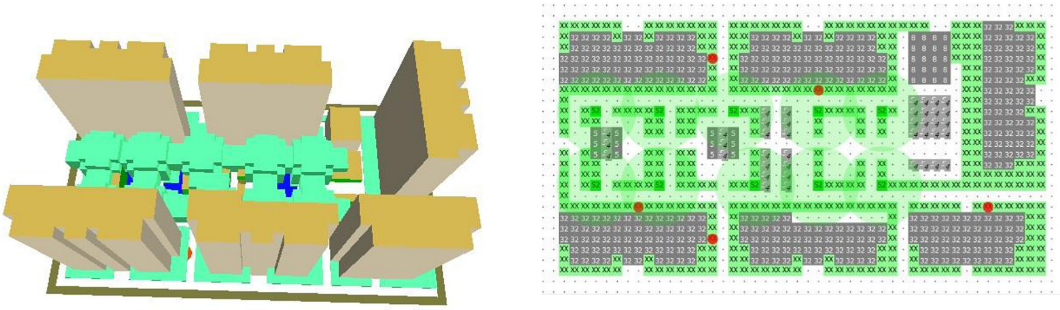

Fig. 6. The selected sample of Abraaj Baghdad residential project
Source: own elaboration.

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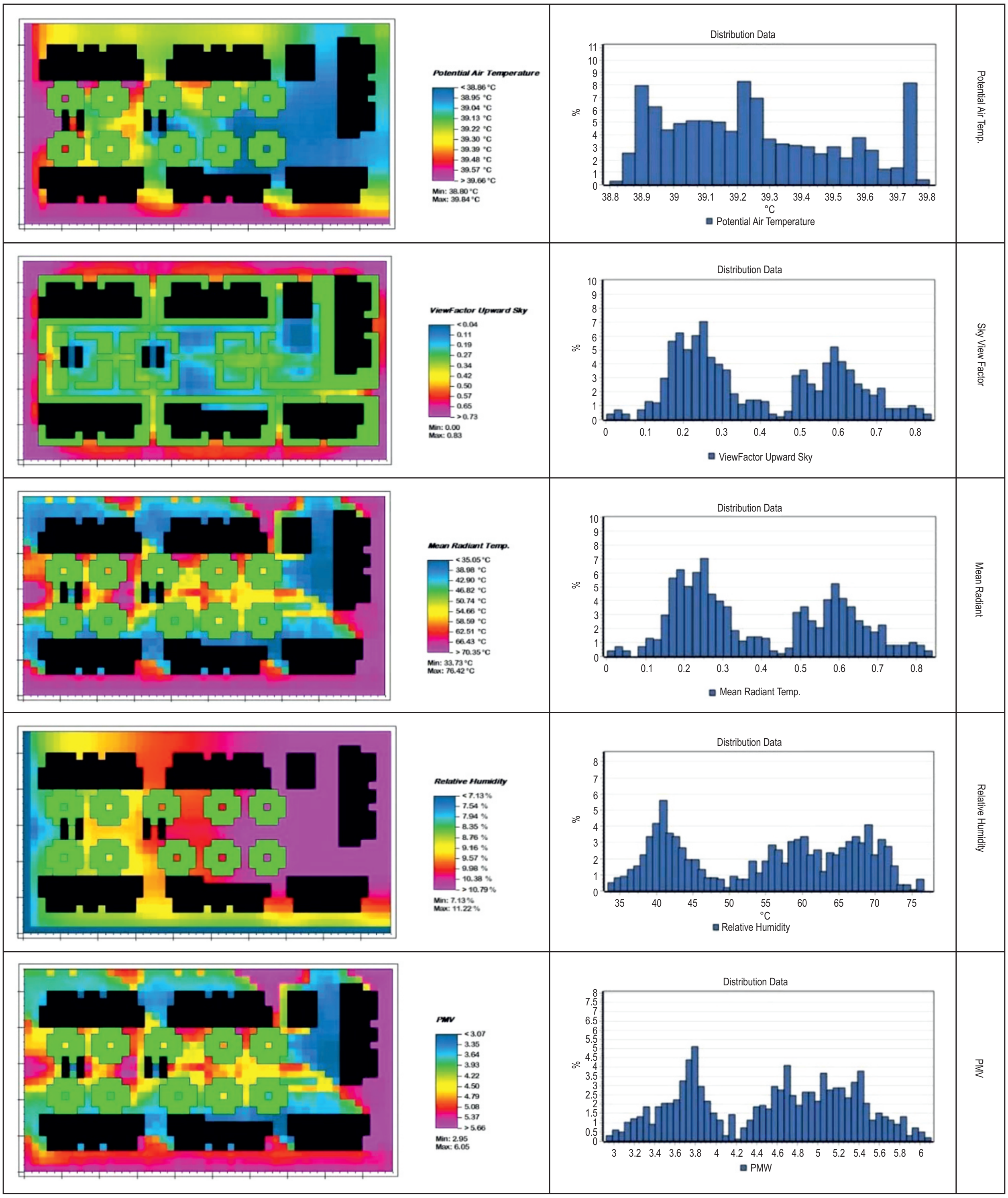

Fig. 7. Comparison between the selected research tools in terms of (Potential Air Temp., Sky View Factor, Mean Radiant Temp., Relative Humidity, PMV) at 12 noon

Source: own elaboration.

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Table 3. Results of the selected sample in terms of (Potential Air Temp., Sky View Factor, Mean Radiant Temp. Relative Humidity, PMV) maximum and minimum at 12 noon

Potential Air Temp.		Sky View Factor		Mean Radiant Temp.		Relative Humidity		PMV	
MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN
39.84	38.80	0	0.83	76.42	33.73	11.22%	7.13%	2.95	6.05

Source: own elaboration.

or surrounding buildings. The highest SVF values approaching 0.8, correspond to open, unshaded areas exposed to direct solar radiation.

3. Mean Radiant Temp. (MRT): The difference between maximum and minimum MRT exceeded 42°C between the exposed and shaded areas. Simulation results indicate that MRT values are significantly higher in unshaded areas, imposing substantial thermal stress on occupants. Shaded areas and zones adjacent to water bodies exhibited lower MRT values.
4. Relative Humidity: Although the relative humidity input was 26% at 12 noon, the simulated values in most area were approximately half of this, indicating that arid conditions dominate the project site. Water bodies contributed to localized increases in relative humidity, but their overall effect was limited.
5. PMV: approximately 66% of the studied areas recorded PMV values below 5, indicating a considerable improvement in thermal comfort. This enhancement can be attributed natural shading provided by trees, vegetation, and water features.

RECEPTORS RESULTS

To assess the spatial impact of the blue and green structure on climate indicators, five (Receptors) were identified within the selected sample, as shown in Fig. 8. Data on probable atmospheric temperature, relative humidity, and mean radiant temperature were collected throughout the day to illustrate spatial and temporal variations within the project.

Potential Air Temp. shown in Fig. 9 the following:

- All receptors (R1–R5) follow the same temporal pattern, with the lowest temperature occurring early in the morning at 7:00 AM, followed by a gradual increase that peaked between 4:00 PM and 6:00 PM, before declining in the evening.
- Temperate variation among the receptors (R1–R5) were minimal, reflecting the moderating influence of blue-green infrastructure, particularly in reducing morning temperature.
- The close similarity in values across (R1–R5) suggests a relatively homogeneous distribution and coverage of blue-green infrastructure elements within the study area.
- Overall, blue-green infrastructure contributed to minimizing temperature disparities among receptors (R1–R5) and lowering temperatures during both daytime and nighttime, demonstrating indicating its positive impact on the local climate in the selected sample.

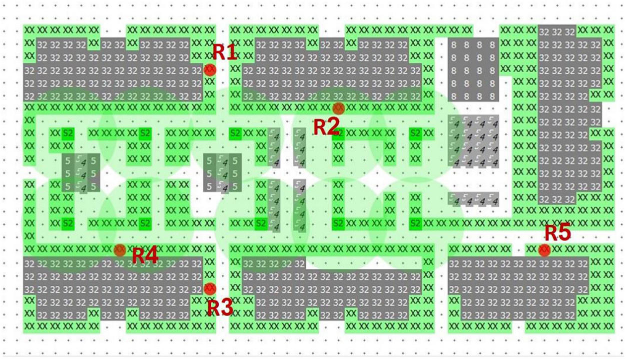

Fig. 8. Location of the Receptors for the selected sample of the of Abraaj Baghdad Residential Project

Source: own elaboration.

Relative humidity results shows in Fig. 10 the following:

- All receptors (R1–R5) exhibited a consistent temporal pattern, characterized by higher relative humidity levels in the evening and lower relative humidity values in the morning. The elevated relative

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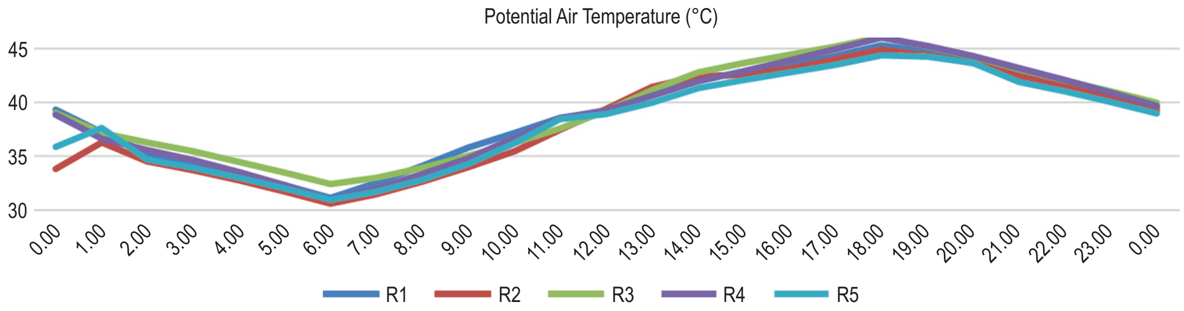

Fig. 9. Receptor results of Potential Air Temperature
Source: own elaboration.

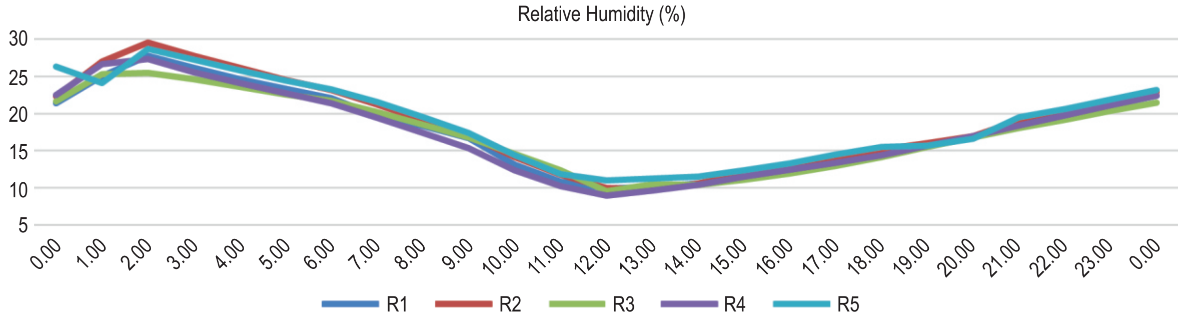

Fig. 10. Receptor results of relative humidity
Source: own elaboration.

humidity values, compared to the initial climate input, can be attributed to the presence of blue-green infrastructure, which enhance evaporation processes and contributes to local climate moderation. This effect plays a significant role in mitigating drought conditions and creating a more comfortable microclimate environment for residents with the selected sample.

MRT results shown in Fig. 11 the following:

- Receptors R1 and R5 recorded elevated values exceeding 65°C during the morning period (8:00–12:00), reflecting exposure to direct solar radiation and the absence of sufficient vegetation shading.
- Receptor R3 registered the highest peak value, super passing 70°C, although only for a short duration. In contrast Receptors R2 and R4 maintained lower

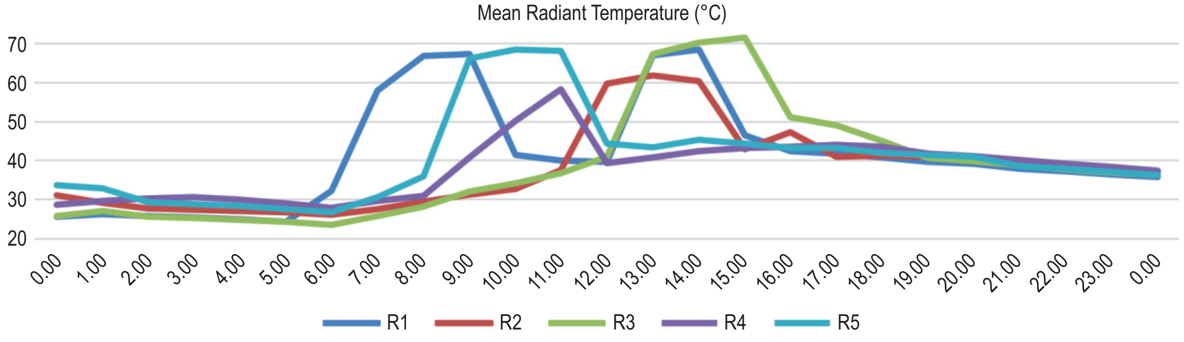

Fig. 11. Receptor results of MRT – the researchers
Source: own elaboration.

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and more stable values, indicating the presence of partial shading.

- Overall, the values across all receptors (R1–R5) generally decreased after 4:00 PM, stabilizing at approximately 35–37°C, highlighting the cooling influnce of shading and reduced solar exposure in the evening.

CONCLUSIONS

Simulation results of Abraaj Baghdad project and receptors data on a typical hot summer day (August 13, 2023), in the hot, dry climate of Baghdad, demonstrated the blue-green infrastructure significantly improved key environmental indicators. The study focused on the following indicators: Sky View Factor, Mean Radiant Temp, Relative Humidity (PMV), and Potential Air Temp. The main findings can be summarized as follows:

- Potential Air Temp: values decreased noticeable, highlighting the cooling effect of vegetation, landscaping, and water features on local cooling.
- Sky View Factor: value declined considerably, reaching minimum values of zero in certain locations, reflecting dense shading from trees and surrounding buildings that reduced direct solar exposure.
- Mean Radiant Temp: vegetation and Shading effectively lowered MRT values, mitigating thermal stress on occupants.
- Relative humidity: The simulation results indicate that the relative humidity of the sample area were approximately half the value of the 26% input value, confirming that dryness remained dominate. However, the receptor data showed that blue-green infrastructure elements contributed to localized increases in evaporation and microclimate moderate, though its impact the effect was spatially limited due to uneven distribution.
- PMV (Predicted Mean vote): Aapproximately 66% of the study area recorded PMV values below than 0.5, confirming the effectiveness of natural shading, water bodies, and vegetation in improving thermal comfort levels.
- Spatial variation: The observed difference in environmental indicators values revealed a heterogeneous distribution of vegetation cover and water bodies, which created microclimate variations across the site.
- Overall Impact: Blue-green infrastructure played a vital role in enhancing the local climate by reducing heat stress and improving thermal comfort. Nevertheless, a more balanced and integrated distribution of blue and green elements is necessary their overall effectiveness.

LIMITATION AND RECOMMENDATION

Although this study provided valuable insights into the effects of blue-green infrastructure (BGI) on improving the hot and dry climatic conditions of a residential complex in Baghdad, it is subject to certain limitations. These include the reliance on a computer-based simulation program and the analysis of only a single summer day. In light of these limitations, the study suggests broadening the scope of future research to cover different climatic seasons, thereby developing a more comprehensive understanding of the annual climatic performance of BGI. Furthermore, practical recommendations for the design and planning of BGI in Baghdad and similar hot-arid urban contexts are provided: Prioritize a balanced distribution of green and blue elements across residential complexes to enhance overall microclimatic performance and minimize spatial disparities in thermal comfort. Strategically integrate vegetation to provide shading in exposed areas and maximize localized cooling effects. Combine water features with green areas to improve humidity and moderate the microclimate effectively. Incorporate BGI planning as a key component of sustainable urban design policies to improve outdoor thermal comfort for residents. These recommendations aim to ensure that BGI implementation not only mitigates heat stress but also enhances the overall quality of life in dense, hot-arid urban environments, while linking the findings with relevant previous studies for broader applicability.

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REFERENCES

Abdulateef, M. F., & Al-Alwan, H. A. S. (2022). The effectiveness of urban green infrastructure in reducing surface urban heat island. *Ain Shams Engineering Journal*, *13*(1), 101526. https://doi.org/10.1016/j.asej.2021.06.012

Afata, T. N., Derib, S., & Nemo, R. (2022). Review of blue--green infrastructure in some selected countries. *Am. J. Environ. Sci*, *18*(4), 81–88. https://doi.org/10.3844/ajessp.2022.81.88

Al-Kindy, S. K. (2012). The Effect of Spatial Organization on the Sustainability of the Neighborhood Unit in the Residential Environment. *Journal of Engineering*, *18*(2), 19–38. https://doi.org/10.31026/j.eng.2012.02.10

Al-Saffar, M. H. M., & Al_Siliq, G. M. R. (2014). The sustainable urban development in Al_Kharkh historic center. *Journal of Engineering*, *20*(11), 1–28. https://doi.org/10.31026/j.eng.2014.11.10

Alhadedy, S. G., & Alomary, A. Y. (2024). The Impact of Green-Blue Infrastructure on Enhancing Cities Happiness Indicators-A Comparative Study. *International Journal of Sustainable Development* & *Planning*, *19*(5). https://doi.org/10.18280/ijsdp.190503

Almaaitah, T., Appleby, M., Rosenblat, H., Drake, J., & Joksimovic, D. (2021). The potential of Blue-Green infrastructure as a climate change adaptation strategy: a systematic literature review. *Blue-Green Systems*, *3*(1), 223–248. https://doi.org/10.2166/bgs.2021.016

AlTalebi, R. A., & Al-Bazzaz, I. (2018). Similarity and Difference between Sustainable and Green Architecture (a Comparative Study). *Journal of Engineering*, *24*(12), 21–42. https://doi.org/10.31026/j.eng.2018.12.10

Dai, X., Wang, L., Tao, M., Huang, C., Sun, J., & Wang, S. (2021). Assessing the ecological balance between supply and demand of blue-green infrastructure. *Journal of Environmental Management*, *288*, 112454. https://doi.org/10.1016/j.jenvman.2021.112454

Ghofrani, Z., Sposito, V., & Faggian, R. (2017). A comprehensive review of blue-green infrastructure concepts. *International Journal of Environment and Sustainability*, *6*(1), 15–36. https://doi.org/10.24102/ijes.v6i1.728

Hassan, M. F., & Al-Kindy, S. K. (2023). Success Criteria of Major Architectural Projects in Iraq. *International Journal of Sustainable Development & Planning*, *18*(3). https://doi.org/10.18280/ijsdp.180321

Kopp, J., Frajer, J., Lehnert, M., Kohout, M., & Ježek, J. (2021). Integrating concepts of blue-green infrastructure to support multidisciplinary planning of sustainable cities. *Problemy Ekorozwoju*, *16*(2), 137–146. https://doi.org/10.35784/pe.2021.2.14

Lamond, J., & Everett, G. (2019). Sustainable Blue-Green Infrastructure: A social practice approach to understanding community preferences and stewardship. *Landscape and Urban Planning*, *191*, 103639. https://doi.org/10.1016/j.landurbplan.2019.103639

Mumtaz, M. (2021). Role of civil society organizations for promoting green and blue infrastructure to adapting climate change: Evidence from Islamabad city, Pakistan. *Journal of Cleaner Production*, *309*, 127296. https://doi.org/10.1016/j.jclepro.2021.127296

Najah, F. T., Abdullah, S. F. K., & Abdulkareem, T. A. (2023). Urban land use changes: Effect of green urban spaces transformation on urban heat islands in Baghdad. *Alexandria Engineering Journal*, *66*, 555–571. https://doi.org/10.1016/j.aej.2022.11.005

Nassani, A. A., Yousaf, Z., Radulescu, M., Balsalobre--Lorente, D., Hussain, H., & Haffar, M. (2023). Green innovation through green and blue infrastructure development: Investigation of pollution reduction and green technology in emerging economy. *Energies*, *16*(4), 1944. https://doi.org/10.3390/en16041944

O’Donnell, E. C., Gosling, S. N., Netusil, N. R., Chan, F. K. S., & Dolman, N. J. (2021). Perceptions of blue-green and grey infrastructure as climate change adaptation strategies for urban water resilience. *Journal of the British Academy*, *9*(s9), 143–182. https://doi.org/10.5871/jba/009s9.143

O’Donnell, E. C., Lamond, J. E., & Thorne, C. R. (2017). Recognising barriers to implementation of Blue--Green Infrastructure: a Newcastle case study. *Urban Water Journal*, *14*(9), 964–971. https://doi.org/10.1080/1573062x.2017.1279190

O’Donnell, E. C., Netusil, N. R., Chan, F. K. S., Dolman, N. J., & Gosling, S. N. (2021). International Perceptions of Urban Blue-Green Infrastructure: A Comparison across Four Cities. *Water, 13*, 544. https://doi.org/10.3390/w13040544

Perrelet, K., Moretti, M., Dietzel, A., Altermatt, F., & Cook, L. M. (2024). Engineering blue-green infrastructure for and with biodiversity in cities. *Npj Urban Sustainability*, *4*(1), 27. https://doi.org/10.1038/s42949-024-00163-y

Pochodyła, E., Glińska-Lewczuk, K., & Jaszczak, A. (2021). Blue-green infrastructure as a new trend and an effective tool for water management in urban areas. *Landscape Online*, 92. https://doi.org/10.3097/lo.202192

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Salem, A. (2008). Sustainable architecture levels. *Journal of Engineering*, *14*(04), 560–583. https://doi.org/10.31026/j.eng.2008.04.04

Shaheen, B. R., & Khalaf, S. F. (2009). The traditional solutions in the sustainable climatic adaptation and its employment in the contemporary housing. *Journal of Engineering*, *15*(1), 584–604. https://doi.org/10.31026/j.eng.2009.01.01

Sunita, Kumar, D., Shahnawaz, & Shekhar, S. (2023). Evaluating urban green and blue spaces with space-based multi-sensor datasets for sustainable development. *Computational Urban Science*, *3*(1), 12. https://doi.org/10.1007/s43762-023-00091-0

Tareq, D. N., & Al-kindy, S. K. (2025a). Analysis thermal comfort in residential environments of hot-arid climates: a case study of Baghdad. *Acta Scientiarum Polonorum Administratio Locorum*, *24*(2), 299–310. https://doi.org/10.31648/aspal.11080

Tareq, D. N., & Al-Kindy, S. K. (2025b). Analytical comparison of rating systems in sustainable architecture. *AIP Conference Proceedings*, *3318*(1), 50022. https://doi.org/10.1063/5.0286074

Wouters, P., Dreiseitl, H., Wanschura, B., Wörlen, M., Moldaschl, M., Wescoat, J., & Noiva, K. (2016). *Blue-green infrastructures as tools for the management of urban development and the effects of climate change.* Ramboll Environ. https://doi.org/10.36535/0869-1010-2020-01-4

Yildirim, Y., Dilman, M., Muftuoglu, V., & Demir, S. (2022). Soundscape assessment of green and blue infrastructures. *Urban Science*, *6*(1), 22. https://doi.org/10.3390/urbansci6010022

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