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Functional Performance of Light and Shadow in Islamic Architecture

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Abstract

Light and shadow constitute fundamental environmental mechanisms in Islamic architecture, where they were employed as practical tools for climatic adaptation and functional optimization. Rather than serving decorative or symbolic purposes, the use of shading, controlled daylighting, and filtered openings enabled historic Islamic buildings to achieve thermal moderation, enhance natural ventilation, regulate visual comfort, and maintain privacy within hot and arid environments. This research examines the functional performance of light and shadow through four representative case studies: the Umayyad Mosque in Damascus, the Mustansiriya School in Baghdad, al-Azhar Mosque in Cairo, and the Süleymaniye Mosque in Istanbul. Using descriptive and analytical methods supported by ArcGIS thermal simulations, the study evaluates temperature variations between sunlit and shaded zones at different times of day to assess their impact on environmental comfort and spatial usability. The results confirm that courtyards, arcades, mashrabiyas, domes, and controlled openings formed an integrated passive system that reduced heat gain, stabilized interior microclimates, improved airflow, and decreased reliance on mechanical cooling. These findings validate the hypothesis that light and shadow in Islamic architecture functioned as deliberate climatic strategies, enabling buildings to respond effectively to their environments. The study concludes that the environmental logic embedded in traditional Islamic architecture offers valuable lessons for contemporary sustainable design, particularly in developing passive solutions that enhance thermal performance, energy efficiency, and climatic adaptability.

Keywords: *Islamic architecture; light and shadow; thermal simulation; ArcGIS; climatic adaptation*

Introduction

Light and shadow have long served as fundamental functional elements in the development of Islamic architecture, extending far beyond their traditional roles of illumination and visual clarity. In the hot and arid regions where Islamic civilization flourished, architects developed a profound understanding of how light and shadow could be harnessed to regulate the environment, mitigate heat, and enhance thermal comfort. Architectural features such as courtyards, arcades, domes, and mashrabiyas were not only aesthetic components but also sophisticated environmental devices designed to filter sunlight, generate protective shading, and reduce solar radiation. Through these elements, early Muslim architects achieved effective climate moderation while simultaneously shaping the sensory and spatial identity of architectural spaces. The functional performance of light and shadow thus became deeply intertwined with aesthetic and spiritual values, reflecting the Islamic principle that utility forms the foundation of beauty. This study explores the environmental and functional dimensions of light and shadow in Islamic architecture by examining their role in climatic adaptation, thermal comfort, and spatial regulation across different historical periods and architectural types.

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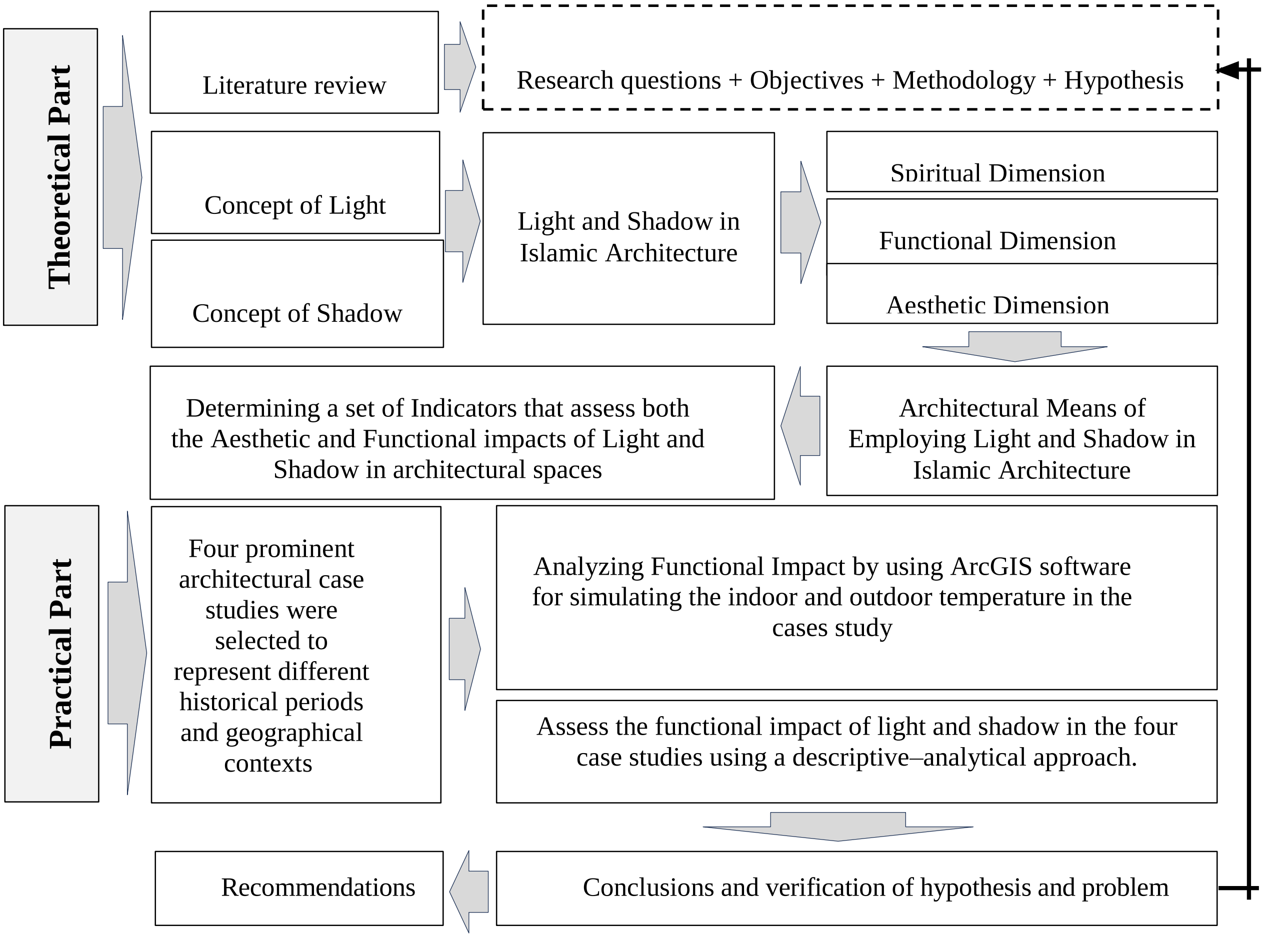


Fig.1 Research plan and methodology, (researchers)

Literature Review

Several studies have examined light and shadow in Islamic architecture, highlighting their environmental and functional contributions in addition to their visual roles. Ibrahim et al. (2011) emphasized the importance of light and shadow as active spatial elements, noting their functional capacity in regulating illumination and influencing environmental comfort within architectural spaces. Al-Suwaikha (2019) identified mashrabiyas as architectural devices that not only provide privacy but also serve practical functions by filtering sunlight and generating protective shading suited to hot climates. Alzahrani (2021) discussed the balance between form and function in Islamic architecture, indicating that environmental performance—especially in controlling light—was a fundamental consideration in traditional design. Moreover, Salama (2019) highlighted light as a key factor influencing contemporary environmentally responsive architecture, demonstrating how traditional methods of daylight control can inspire modern climatic solutions. Goda and Elkalshy (2021), through their analysis of architectural elements such as courtyards and arches, illustrated how these components inherently structure light and shadow in ways that influence spatial and environmental conditions. Collectively, these studies affirm that light and shadow in Islamic architecture operate as essential functional tools for climatic adaptation, supporting the central aim of this research.

Research problem: This study addresses the limited understanding of light and shadow as functional environmental tools in Islamic architecture, despite their essential role in reducing heat, controlling sunlight, and improving climatic comfort in historical buildings.

Research questions: The study asks how light and shadow were functionally used to reduce solar radiation, moderate temperature, and create comfortable environments, and how elements such as courtyards, arcades, domes, and mashrabiyas operated as systems of shading and natural light regulation.

Research objectives: The study aims to explore the environmental role of light and shadow in Islamic architecture, and to analyze how shading devices, filtered light, and controlled natural illumination contributed to climatic adaptation and thermal comfort.

Research hypothesis: The study assumes that the functional use of light and shadow—especially in reducing heat gain, filtering sunlight, and providing effective shading—was central to achieving climatic moderation and improving thermal comfort in Islamic buildings.

Research methodology: This study uses a descriptive–analytical comparative approach to assess the functional role of light and shadow in Islamic architecture. Four case studies—the Umayyad Mosque (Damascus), the Mustansiriya Madrasa (Baghdad), Al-Azhar Mosque (Cairo), and the Süleymaniye Mosque (Istanbul)—were selected to represent major Islamic periods and diverse climatic contexts, enabling a broad comparative understanding of environmental adaptation strategies.

Research limitations: The study relies mainly on descriptive–analytical assessment supported by ArcGIS simulations, without on-site thermal measurements to validate seasonal variations. The analysis focused on selected architectural elements (courtyards, arcades, domes, mashrabiyas), while other environmental components were not examined in depth. The limited number of case studies may affect generalizability, and simulations at only two times of day do not capture full daily thermal dynamics. Nonetheless, the findings provide valuable insights into the functional performance of light and shadow in Islamic architecture.

The Functional Understanding of light and shadow

Light and shadow played a foundational role in shaping the environmental performance of Islamic architecture, where their regulation was essential for achieving climatic adaptation and thermal comfort. Light functioned as a primary environmental variable that required intentional control to reduce glare, prevent excessive heat gain, and provide balanced natural illumination, as noted by Ching (2014, p. 123). Islamic architects developed sophisticated daylight-management strategies—such as mashrabiyas, arcades, clerestory openings, and domes—to modulate light intensity and filter direct solar exposure in accordance with climatic needs. The scientific insights of Ibn al-Haytham (1983, p. 77) regarding vision and light reflection formed an early theoretical basis for understanding how surfaces interact with light and how illumination can be controlled for environmental benefit.

Shadow complemented this functional role by acting as an essential environmental moderator. Defined by Aristotle (1931, p. 195a) as the result of obstructed light, shadow provided natural cooling by reducing solar radiation and stabilizing indoor and outdoor temperatures. As highlighted by Ibrahim et al. (2011, p. 610), shaded zones significantly improve thermal comfort in hot climates, while layered shadow patterns produced by arcades and mashrabiyas further enhanced microclimatic cooling (Omer & Bakr, 2020, p. 77). Understanding the environmental behavior of light and shadow, as emphasized by Ching (2014, p. 126) and Rasmussen (1962, p. 41), is therefore fundamental to explaining how traditional Islamic buildings achieved climatically responsive and thermally efficient architectural environments.

Theoretical Foundations for Understanding Light and Shadow in Architecture

Early natural philosophies established the physical principles governing light and shadow. Aristotle defined shadow as the natural consequence of obstructed light (Aristotle, 1931, p. 219b), while Vitruvius emphasized solar orientation as a basis for achieving controlled exposure and balanced environmental conditions (Vitruvius, 1960, p. 72). Islamic scientific contributions, particularly Ibn al-Haytham's explanation of vision through reflected light (Ibn al-Haytham, 1983, p. 77), provided a precise understanding of light behavior that informed architectural strategies for reducing glare, regulating daylight, and limiting heat gain. Modern architectural thought reinforces these functional principles: Le Corbusier highlighted the role of light in defining spatial quality (Le Corbusier, 1986, p. 102), whereas Kahn emphasized the environmental importance of shadow as a byproduct of mass (Kahn, 2003, p. 57). Contemporary approaches, including those identified in Ando's work (Ando, 1990, p. 33), demonstrate how controlled light and calculated shading contribute to climatic responsiveness. Together, these theoretical foundations establish light and shadow as functional tools essential for environmental regulation and thermal comfort in architecture.

Light and Shadow in Islamic Architecture

In Islamic architecture, light and shadow have historically encompassed spiritual, functional, and aesthetic roles that shaped both architectural intention and environmental performance. Spiritually, light was associated with divine guidance—as reflected in the Qur'anic verse "Allah is the Light of the heavens and the earth" [al-Nūr: 35]—while shadow evoked comfort and tranquility, as indicated in "Have you not considered your Lord—how He extends the shadow" [al-Furqān: 45]. These meanings influenced architectural practice, where light was directed toward focal elements such as the mihrab or central dome, and shadow was used to create calm, contemplative zones (Bakr, 2022, p. 44). Functionally, light and shadow played a crucial role in adapting buildings to hot and arid climates; courtyards generated shaded areas that reduced heat intensity, while arcades and mashrabiyas filtered sunlight and limited direct solar gain, contributing significantly to thermal moderation and environmental comfort (Ibrahim et al., 2011, p. 610). Aesthetically, the interplay of light and shadow enhanced spatial perception by emphasizing form, depth, and contrast, while the movement of the Sun produced dynamic shadow patterns that reinforced rhythm and visual clarity within architectural compositions. Although these dimensions collectively demonstrate the multifaceted significance of light and shadow in Islamic architecture, the present research focuses exclusively on their functional performance, particularly their role in climatic adaptation, thermal comfort, and environmental regulation.

Architectural Means of employing light and Shadow in Islamic Architecture

In Islamic architecture, a set of refined environmental strategies was developed to regulate light and shadow in response to climatic conditions, thereby enhancing the functional performance of buildings. Central courtyards played a significant role in reducing heat intensity and promoting air movement within architectural spaces, as noted by Creswell (1989, p. 115), while Fathy emphasized their capacity to generate cooler microclimates and improve thermal comfort (Fathy, 1986, p. 46). Mashrabiyas and ornamental windows filtered incoming sunlight, reduced glare, and limited excessive solar heat gain, contributing to stable indoor thermal conditions, as highlighted by Al-Suwaikha (2019, p. 40). Arcades and iwans enhanced climatic responsiveness by casting deep protective shade, a function documented by Creswell (1989, p. 118), and by shielding façades from intense solar radiation during peak hours, as demonstrated by Ibrahim et al. (2011, p. 610). Domes and arches provided indirect natural lighting through upper openings, thereby minimizing direct heat gain, a phenomenon discussed by Creswell (1989, p. 135), while Frishman and Khan noted that the mass of domes generated consistent shading that contributed to regulating interior temperatures (Frishman & Khan, 2002, p. 98). Moreover, material selection and surface texture influenced the interaction between light and shadow; rough materials created micro-shadows that reduced reflectivity and moderated heat absorption, as explained by Rasmussen (1962, p. 145).

Collectively, these strategies demonstrate that the use of light and shadow in Islamic architecture was rooted in deliberate functional objectives aimed at climatic adaptation, reducing heat gain, and achieving thermal comfort through environmentally responsive design.

The Functional Impact of Light and Shadow in Islamic Architecture

Light and shadow in Islamic architecture served essential functional purposes that enabled buildings to adapt to environmental conditions and meet human needs.

a. Climatic Moderation and Thermal Comfort: Shade acted as a primary means of reducing heat in hot and arid climates. Courtyards and arcades created shaded areas that decreased ambient temperature and improved thermal comfort (Fathy, 1986, p. 34).

b. Ventilation and Natural Lighting: Shaded courtyards and windcatchers enhanced natural ventilation by directing cooler air indoors and reducing reliance on mechanical systems (Fathy, 1986, p. 72). Controlled daylighting improved visibility while limiting heat gain.

c. Privacy and Social Comfort: Mashrabiyas and latticed windows regulated sunlight while preserving privacy, reflecting social and cultural norms (Al-Suwaikha, 2019, p. 40).

d. Energy and Material Efficiency: Through shade and natural illumination, buildings minimized heat gain and reduced the need for artificial lighting or additional protective materials, promoting early forms of environmental efficiency.

e. Spatial Organization and Circulation: Shadow influenced the arrangement and use of spaces. Shaded areas were favored for sitting and resting, while brighter areas accommodated circulation and short-term activities (Frishman & Khan, 2002, p. 98).

f. Functional Beauty: In Islamic architecture, the aesthetic value of light and shadow arose directly from their functional role. Fathy explains that shadow is considered beautiful because it reduces heat and contributes to comfort (Fathy, 1986, p. 101). Al-Suwaikha notes that elements such as mashrabiyas derive their visual appeal from their ability to provide privacy and regulate light (Al-Suwaikha, 2019, p. 40). Al-Ghazali states that utility forms the basis of beauty, affirming that what benefits human life is inherently beautiful (Al-Ghazali, 2004, p. 41). Thus, functional success—thermal moderation, visual clarity, and spatial organization—became the foundation of architectural beauty.

Practical Study: Functional Evaluation of Light and Shadow

The practical component of this research focuses solely on assessing the functional performance of light and shadow in selected examples of Islamic architecture. An environmental analytical approach was adopted to examine how shading and sunlight exposure influence thermal comfort, ventilation efficiency, and overall climatic adaptation. To achieve this, ArcGIS software was used to simulate temperature variations across different spatial zones—both shaded and sunlit—at two key times of the day (10:00 AM and 5:00 PM). The simulations revealed clear thermal differences, with courtyards, arcades, and other shaded areas consistently recording lower temperatures compared to sun-exposed zones. These results confirm the essential role of shade in moderating heat, improving thermal comfort, and enhancing natural environmental performance. The findings were subsequently interpreted in relation to the functional indicators identified in this study, including climate moderation, enhanced natural ventilation and lighting, privacy regulation, and reduced energy dependence.

The Umayyad Mosque (Damascus)

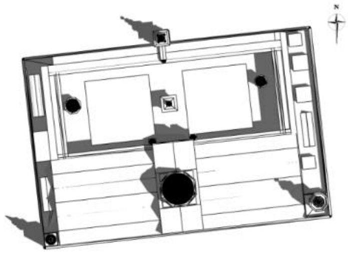
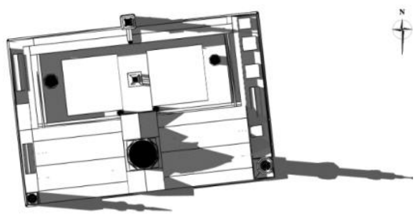
Completed in 715 CE, the Umayyad Mosque is one of the earliest and most important congregational mosques. Built over earlier Roman and Byzantine structures, it is characterized by its vast courtyard, arcaded porticos, marble columns, and clerestory windows. These features admit soft natural light while producing extensive shadows that generate rhythmic visual patterns and enhance the mosque's spiritual atmosphere (Creswell, 1989, p. 210).

Thermal Simulation Results of the Umayyad Mosque

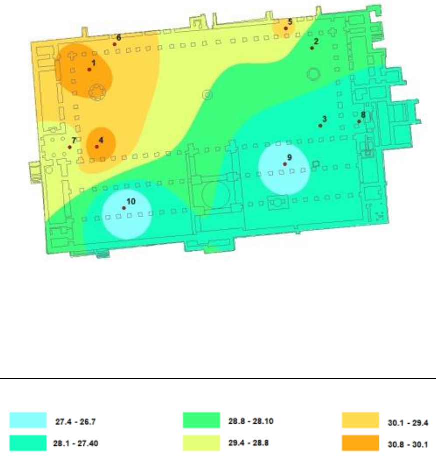
ArcGIS data from the Umayyad Mosque showed a clear thermal gap between exposed and shaded areas. At 10:00 AM, courtyard temperatures reached around 31°C, while shaded porticos recorded approximately 27.5°C—a difference of 3.5°C. A similar difference remained at 5:00 PM. These measurements confirm that shading operates as an intentional functional strategy that supports climate control and improves spatial performance. The functional impact of light and shadow in the Umayyad Mosque can be elucidated through the following axes:

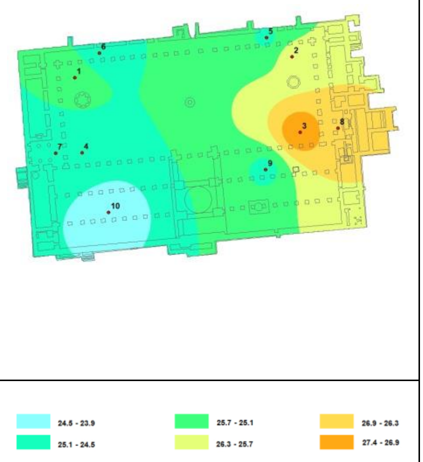
1. **Climate Moderation:** Shaded areas reduced thermal load and improved comfort during peak sunlight hours.
2. **Ventilation & Lighting:** Clerestory windows offered balanced daylight and enhanced air circulation.
3. **Privacy:** High surrounding walls ensured separation from the urban environment, supporting communal and religious activities.
4. **Energy Efficiency:** Use of natural shade and daylight reduced the need for artificial cooling and lighting.
5. **Movement Regulation:** Shadow distribution helped organize movement, with shaded zones used for sitting and worship, while brighter areas supported circulation.

Fig.2: Simulation of indoor and outdoor temperatures of the mosque using ArcGIS software.

The Umayyad Mosque	Top View-/-10:00 a.m.	Top View-/-5:00 p.m.
		

Simulation of Indoor and Outdoor Temperatures of the Mosque Using (ArcGIS)		
Date of Temperature Observation (20/08/2024)		
5:00 p.m.	**10:00 a.m.**	**Observation Points**
25.5	30.9	1
25.9	28.2	2
27.5	27.9	3
25	30.8	4
25	29.7	5
24.8	29.5	6
24.6	29	7
26.7	27.5	8
24.9	27	9
23.9	26.7	10



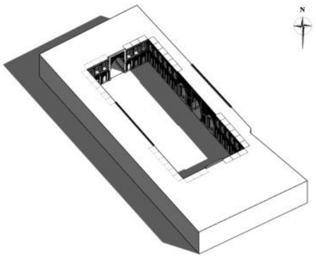
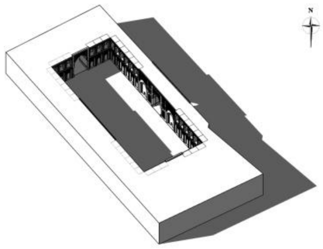
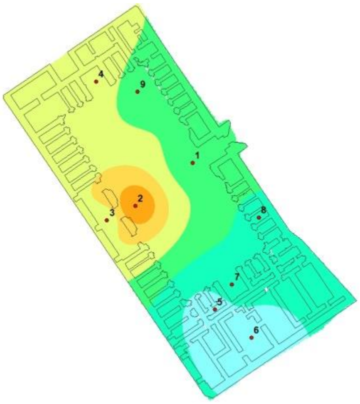
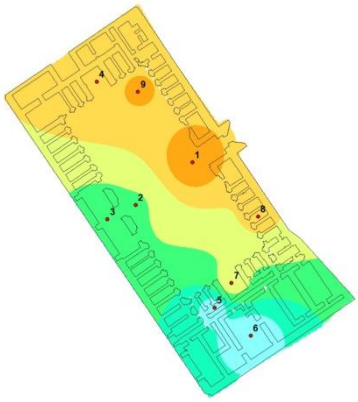


The Mustansiriya School (Baghdad): The Mustansiriya School, founded in 1233 CE in Baghdad, was organized around a central courtyard surrounded by arcades and functional rooms. This design illustrates how light and shadow were adapted to Baghdad's hot, arid climate. The courtyard provided daylight and ventilation, while the surrounding arcades created shaded zones that supported comfortable movement, teaching, and gathering.

Thermal Simulation Results of the al-Mustansiriyya School: ArcGIS thermal simulations revealed substantial temperature differences between shaded and sunlit areas. At 10:00 AM, courtyard temperatures reached 45.6°C, compared to 39.8°C in the shaded iwan. At 5:00 PM, sunny zones recorded 44.2°C, while shaded areas remained around 39°C. These results show that the iwan and porticos functioned as essential climatic devices rather than decorative elements**. The functional impact can be summarized in the following axes:**

1. **Climate Moderation:** Shading reduced temperatures by 5–6°C, significantly improving comfort in the harsh climate.
2. **Ventilation & Lighting:** The courtyard enhanced air circulation and allowed balanced natural illumination, while porticos minimized direct solar exposure.
3. **Privacy:** The courtyard's enclosure created a controlled educational and social environment aligned with Islamic cultural values.
4. **Energy Efficiency:** Dependence on natural ventilation and daylight reduced the need for additional energy.
5. **Movement Regulation:** Shadows helped define study and seating zones, while illuminated areas facilitated circulation around the courtyard.

Fig.3: Simulation of indoor and outdoor temperatures of the school using ArcGIS software

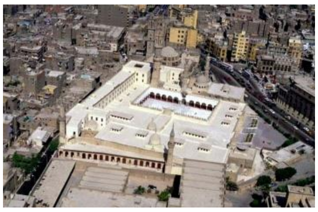
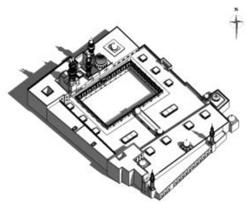
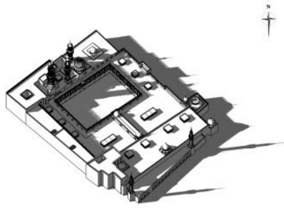
<table>
<tr><th colspan="3">Mustansiriya School</th><th>Top View-/-10:00 a.m.</th><th>Top View-/-5:00 p.m.</th></tr>
<tr><td colspan="3"></td><td></td><td></td></tr>
<tr><td colspan="3">Simulation of Indoor and Outdoor Temperatures of the School Using (ArcGIS)</td><td rowspan="10"></td><td rowspan="10"></td></tr>
<tr><td colspan="3">Date of Temperature Observation (25/08/2024)</td></tr>
<tr><td>5:00 p.m.</td><td>10:00 a.m.</td><td>Observation Points</td></tr>
<tr><td>44.2</td><td>40.5</td><td>1</td></tr>
<tr><td>40</td><td>45.6</td><td>2</td></tr>
<tr><td>39</td><td>42.3</td><td>3</td></tr>
<tr><td>42.5</td><td>42.4</td><td>4</td></tr>
<tr><td>36.7</td><td>37.2</td><td>5</td></tr>
<tr><td>36</td><td>37</td><td>6</td></tr>
<tr><td>41</td><td>39.8</td><td>7</td></tr>
<tr><td>41.8</td><td>39.8</td><td>8</td><td rowspan="2">38.4 - 37.0; 39.8 - 38.4; 41.2 - 39.8; 42.7 - 41.2; 44.1 - 42.7; 45.5 - 44.1</td><td rowspan="2">37.3 - 36.0; 38.7 - 37.3; 40.0 - 38.7; 41.4 - 40.0; 42.8 - 41.4; 44.1 -42.8</td></tr>
<tr><td>43</td><td>40.5</td><td>9</td></tr>
</table>

Al-Azhar Mosque (Cairo): Founded in 970 CE as both a congregational mosque and an educational institution, Al-Azhar has undergone numerous expansions that created a layered architectural complex. Its central courtyard, arcades, prayer hall, domes, and minarets illustrate how light and shadow evolved across different historical periods in Cairo (Behrens-Abouseif, 1992, p. 87).

Thermal Simulation Results of the al-Azhar Mosque: ArcGIS simulations showed noticeable thermal differences between sunny and shaded areas. At 10:00 AM, temperatures reached about 35.5°C in exposed areas and 31.6°C in shaded porticos. At 5:00 PM, sunny zones recorded 38.2°C versus 34.2°C in shaded areas—a difference of almost 4°C. This confirms that porticos and stucco windows functioned as effective environmental devices rather than decorative additions. This can be elucidated through the following axes:

1. **Climate Moderation:** Shaded zones reduced temperatures by around 4°C, improving comfort for worshippers and students.
2. **Ventilation & Lighting:** Stucco windows filtered light and facilitated airflow, creating balanced illumination.
3. **Privacy:** High enclosure walls enhanced separation from the urban environment while controlling internal brightness.
4. **Energy Efficiency:** Natural lighting and shading reduced dependence on artificial environmental systems.
5. **Movement Regulation:** Variations between bright and shaded areas helped distinguish circulation paths from teaching and worship zones.

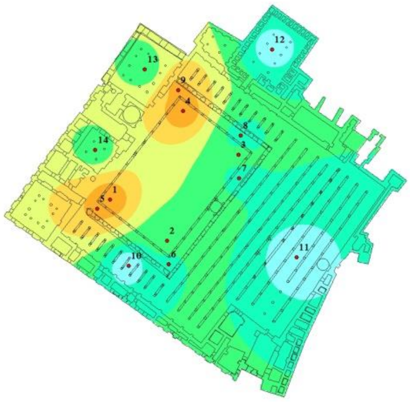
Fig.4: Simulation of indoor and outdoor temperatures of the mosque using ArcGIS software

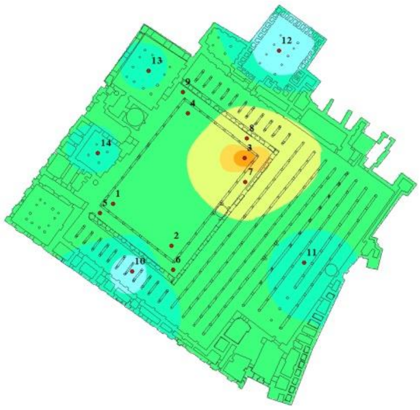
Al-Azhar Mosque	Top View-/-10:00 a.m.	Top View-/-5:00 p.m.
		

Simulation of Indoor and Outdoor Temperatures of the Mosque Using (ArcGIS)

Date of Temperature Observation (12/08/2024)

5:00 p.m.	10:00 a.m.	Observation Points
34.2	35.5	1
34.3	32.1	2
38.2	32	3
34.5	35.5	4
33.5	34.8	5
33.5	31.7	6
34.7	31.6	7
34.8	31.4	8
33.4	34.8	9
31.2	30.1	10
32.5	30	11
31	30.5	12
33.1	32.1	13
33	32.2	14





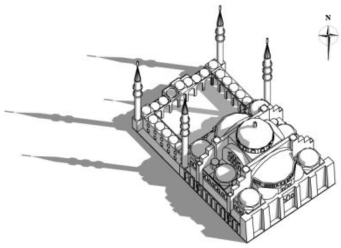
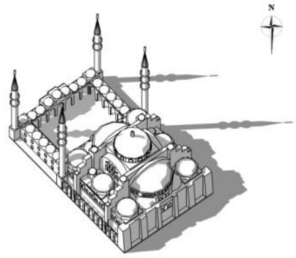
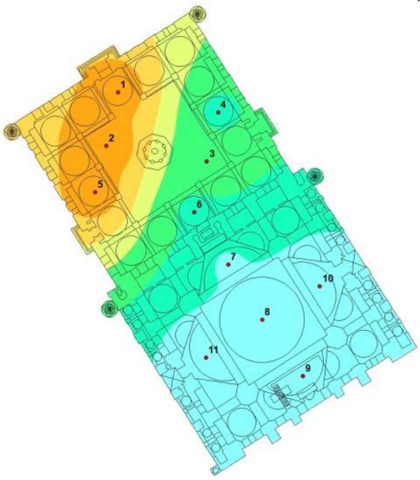
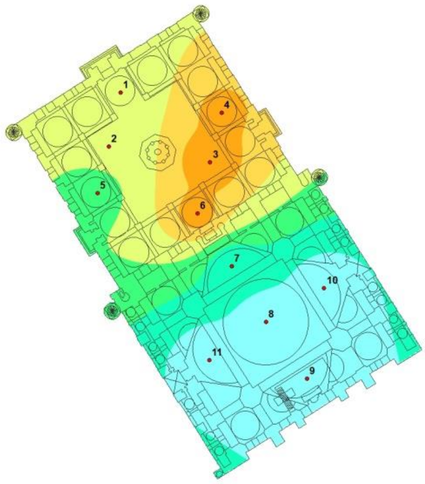
The Süleymaniye Mosque (Istanbul): Built between 1550–1557 CE under Sultan Süleyman, the Süleymaniye Mosque—designed by Sinan—stands as one of the masterpieces of classical Ottoman architecture. Its design is centered around a vast prayer hall with a monumental dome rising 53 meters and pierced by clerestory windows that admit natural light. The mosque's courtyard and arcades further support Sinan's deliberate orchestration of illumination and shadow, which enhances the spiritual prominence of the dome and creates a continuously renewed interior experience (Necipoğlu, 2005, p. 212).

Thermal Simulation Results of the Süleymaniye Mosque: Thermal simulation using ArcGIS revealed noticeable temperature differences between sunlit and shaded areas despite Istanbul's moderate climate. At 10:00 AM, temperatures were around 25.7°C in sunny areas and 21.5°C in shaded porticos. At 5:00 PM, the difference persisted—24.5°C versus 21°C—showing that Ottoman design considered functional environmental performance alongside spiritual symbolism. This can be elucidated through the following axes:

1. **Climate Moderation:** Shaded porticos reduced temperatures by 3–4°C, enhancing comfort even in a temperate climate.
2. **Ventilation & Lighting:** Stepped upper windows in the dome and walls improved air circulation and introduced balanced natural light.

3. **Privacy:** High exterior walls strengthened separation from the dense urban fabric and ensured a protected internal environment.
4. **Energy Efficiency:** Dependence on daylight through clerestory openings reduced reliance on artificial lighting.
5. **Movement Regulation:** Extended shadows defined circulation paths and waiting areas, while the central hall remained the primary worship space.

Fig.5: Simulation of indoor and outdoor temperatures of the mosque using ArcGIS software.

<table>
<tr><th colspan="3">Süleymaniye Mosque</th><th>Top View-/-10:00 a.m.</th><th>Top View-/-5:00 p.m.</th></tr>
<tr><td colspan="3"></td><td></td><td></td></tr>
<tr><td colspan="3">Simulation of Indoor and Outdoor Temperatures of the Mosque Using (ArcGIS)</td><td rowspan="14"></td><td rowspan="14"></td></tr>
<tr><td colspan="3">Date of Temperature Observation (04/07/2024)</td></tr>
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<tr><td>24.5</td><td>21.5</td><td>3</td></tr>
<tr><td>24</td><td>21</td><td>4</td></tr>
<tr><td>22</td><td>25.3</td><td>5</td></tr>
<tr><td>24.2</td><td>22</td><td>6</td></tr>
<tr><td>21</td><td>20</td><td>7</td></tr>
<tr><td>20.3</td><td>19.3</td><td>8</td></tr>
<tr><td>20.1</td><td>19</td><td>9</td></tr>
<tr><td>20.3</td><td>19.3</td><td>10</td></tr>
<tr><td>20.3</td><td>19.3</td><td>11</td></tr>
</table>

General Results of the Thermal Simulation of Light and Shadow in the Four Case Studies: The thermal simulations conducted using ArcGIS in the four case studies (al-Mustansiriyya School and the Umayyad, al-Azhar, and Süleymaniye Mosques) demonstrated that light and shadow had a direct functional impact in enhancing the environmental performance of Islamic architecture. The clear thermal variations—ranging between 3.5°C and 5.8°C between sunlit and shaded areas—indicated that shading constituted a fundamental strategy for climatic moderation and reducing heat stress, particularly in hot and arid environments such as Baghdad and Cairo. Moreover, the contrast between light and shadow contributed to improving natural ventilation and regulating light intensity, thereby creating more balanced indoor conditions.

From a practical perspective, shade guided the functional use of spaces: shaded areas were allocated for sitting, teaching, or worship, while sunlit zones were utilized for circulation and short-term activities. Collectively, these results confirm that the use of light and shadow in Islamic architecture was not ornamental or incidental but a deliberate environmental strategy aimed at achieving thermal and functional comfort, reflecting a profound architectural awareness of both environmental and human needs. Consequently, this functional performance of light and shadow, proven effective in improving environmental and thermal conditions, provides a complementary foundation for understanding their aesthetic and symbolic dimensions in Islamic architecture.

Comparative Summary: The comparative analysis of the four case studies—the Umayyad Mosque in Damascus, the Mustansiriya Madrasa in Baghdad, al-Azhar Mosque in Cairo, and the Süleymaniye Mosque in Istanbul—demonstrates that light and shadow served essential functional roles across different climatic and historical contexts. Although each building employed distinct architectural strategies, all relied on shaded courtyards, arcades, controlled openings, and structural massing to reduce heat gain, improve ventilation, regulate illumination, and ensure user comfort.

In the Umayyad Mosque, shading generated by the expansive courtyard and surrounding arcades moderated thermal conditions in the hot climate of Damascus. The Mustansiriya Madrasa used deep arcades and a central courtyard to create a cooler microclimate suited to educational activities. Al-Azhar Mosque employed a combination of courtyards, porticos, and screened windows that balanced daylight with thermal protection. The Süleymaniye Mosque integrated upper lighting and substantial structural mass to manage sunlight and stabilize interior temperature within a temperate environment.

Despite variations in form and context, the four buildings reveal a consistent environmental logic: light and shadow were fundamental functional tools used to create comfortable, climatically responsive spaces. These findings support the research hypothesis that the role of light and shadow in Islamic architecture was primarily functional—regulating heat, airflow, illumination, and privacy—while also contributing incidentally to visual clarity and spatial organization.

General Conclusion

The findings of this research demonstrate that light and shadow in Islamic architecture operated as essential functional systems that enabled buildings to adapt effectively to climatic conditions. ArcGIS thermal simulations across the four selected case studies—the Umayyad Mosque in Damascus, the Mustansiriya Madrasa in Baghdad, al-Azhar Mosque in Cairo, and the Süleymaniye Mosque in Istanbul—showed consistent temperature reductions in shaded zones compared to sun-exposed areas. Courtyards, arcades, mashrabiyas, and domes functioned as integrated environmental mechanisms that improved thermal comfort, enhanced natural ventilation, reduced heat gain, and supported energy-efficient performance.

The comparative analysis confirms that the use of light and shadow was neither decorative nor secondary, but rather a deliberate climatic strategy grounded in environmental logic. Across all cases, shading devices and controlled daylighting contributed to stable thermal conditions and comfortable internal microclimates. These results validate the research hypothesis that light and shadow in Islamic architecture are fundamentally functional elements that regulate heat, airflow, illumination, and spatial usability.

By highlighting the efficiency of traditional Islamic methods in managing solar exposure and climatic adaptation, this study provides a framework for understanding how historical architectural strategies can inform contemporary sustainable design. The functional integration of light and shadow—achieved without mechanical systems—demonstrates the potential of passive environmental design principles to address modern challenges related to energy use, thermal regulation, and ecological responsibility.

Recommendations

This study recommends integrating traditional light-and-shadow strategies into contemporary sustainable design by:

1. Using shading and controlled daylight as passive tools for thermal comfort.
2. Learning from historical Islamic models to enhance ventilation and reduce heat gain.
3. Reintroducing courtyards, arcades, and screened openings to improve environmental performance.
4. Promoting daylight-based energy efficiency.

Strengthening architectural education in passive climatic design

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