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The Effect of Buildings Shading Elements on Outdoor Thermal Comfort

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***Abstract*—One of the biggest challenges facing urban designers in the face of climate change is making cities more walk able. Strategies for street design can reduce heat stress and improve the livability of pedestrian areas have the ability to improve summer conditions, although most previous studies conducted suggest adopting deep canyons instead. In order to produce an ideal street model for Ladybug Grasshopper program, but the study of shadings elements effect on outdoor thermal comfort was not conducted. This research aims to discover the effect of shading elements on outdoor thermal comfort in hot arid cities. The Ladybug Grasshopper program was used in testing the research hypothesis. The research concluded that using shading innovatively and effectively could reduce the rising temperatures in urban cities and improve the quality of life for its residents. Based on the results, innovative design strategies can be developed that effectively integrate shade use into urban infrastructure, contributing to improved thermal and environmental comfort of residents, and enhancing resilience and sustainability in the face of increasing climate challenges.**

Keywords—Shading elements, outdoor thermal comfort, urban design, hot arid climate, Ladybug Grasshopper program

I. INTRODUCTION

The problem of climate change has emerged globally in recent decades. One of its most prominent indicators is the increase in temperatures in all countries [1]. In Hot Aired climate cities, urban residents suffer from problems related to high temperatures during the summer, High temperatures involve many problems, such as increased energy consumption for cooling systems, and increased heat emissions. The façade of building play an important role in buildings energy consumption due to its daily confronted to environmental outdoor [2,3]. The traditional cities were more proper with the local climate than modern one [4]. Recent studies focused on this problem from much aspect. The study of [5] investigates the effect of urban architecture and urban shading on pedestrian thermal comfort in Ahvaz, Iran. Six urban valleys with different geometric characteristics were selected to evaluate outdoor thermal comfort. The study used Ray Man to calculate the physiological equivalent temperature (PET) using micrometeorological measurements and questionnaires. The results showed that the nearest direction of the valley is the north-south direction, and the lower air temperature (Ta) and the mean radiant temperature (MRT) increase with the decrease in the aspect ratio of the valley. Urban shading reduced the PET and MRT to 34 and 6.71 °C, respectively. However, shading did not significantly affect the air temperature. The decrease was more pronounced in the eastern and western canyons and the wider canyons. Observations showed no strong relationship between the relative T and the relative T of urban valleys. This is a comprehensive study exploring the effect of urban shading and valley architecture on air temperature in areas with cold and hot climates, with a focus on the city of Ahvaz, Iran. The main objective of the study is to understand how urban shading affects temperature in hot regions, as well as to determine the relationship between valley geometry and temperature in cold regions. The inductive method is used to investigate these relationships, in addition to numerical simulation using ENVI-met data. The study showed that urban shading and valley engineering reduce air temperature in hot and cold regions. The study noted that urban shading has a greater impact on pedestrian comfort temperature than air temperature. With the study's conclusions, the results can be applied to the design of cities and buildings to improve the comfort and health of residents in hot and cold climates. While the study [6] focused on particularly in light of the recent developments in the dimensions and constituents of the urban environment, there are numerous approaches to identify and improve architectural trends and techniques pertaining to the principle of planning and designing light and shading in urban areas. Through improving the functional, environmental, social, and aesthetic aspects, the research aims to gain a vision of the aspects and indicators through which light and shading play an active role in identifying valuable interactive urban spaces and improving the relationship between the user and the surrounding environment to achieve the opportunity to create visually pleasing and meaningful experiments. "Lack of knowledge regarding the role and effect of light and shading on creating interactive and effective urban spaces" is the research challenge. The functional, environmental, social, and aesthetic aspects of urban spaces, as well as their subsidiaries and parameters, are the main and essential terms of the theoretical background that the research concluded from a synthesis of literature review. Ultimately, by enhancing these aspects, light and shading can be effective in creating and finding interactive and active urban spaces. The study of [7] testing the mitigation methods in "Emir Abdelkader Boulevard," the primary structural roadway inside the city, throughout the course of this study, which was carried out in Biskra, southern Algeria. Three criteria were used to

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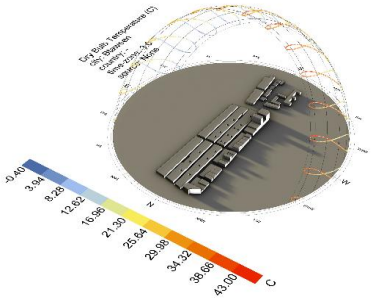
construct five different situations. Based on the physiological equivalent temperature (PET), the RayMan model and ENVI-met software version 5.1.1 were utilized to assess the local climate conditions and outdoor thermal comfort levels. PET values were lowered in all scenarios across the street; in Sc1, Sc2, Sc3, Sc4, and Sc5, the best reductions were −2.0 ◦C, −3.1 ◦C, −1.3 ◦C, −1.7 ◦C, and −1.2 ◦C, respectively. With regard to pedestrian zones, the best results were seen during peak hours on the southwest side beneath the arcade sidewalks: Sc2, Sc3, Sc4, Sc5 (2.2 ◦C–3 H, 2.3 ◦C–3 H, 2.4 ◦C–3 H, 2.5 ◦C–2 H). On the northeast side, during the day, Sc1 operated at its finest. The use of these findings can greatly assist landscape architects and urban planners in designing climate-responsive streets that improve the quality of life for inhabitants.

From a review of the previous literature in addition to studies that addressed the impact of Iraqi cities on the local climate environment [8,9,10]. This research aims to discover the effect of shading elements on outdoor thermal comfort in hot arid cities. The research assumes that adding shadings effective elements such as balconies and structures contribute improve outdoor thermal comfort in hot arid cities.

II. METHODOLOGY

This study was conducted in Baghdad, Al-Bataween area, through the Grassober Lady Bag program in 2024. The research were conducted to analysis the movement of the sun affects the formation and distribution of shadow in the surrounding environment, as shown in Fig.1, to determine the best strategies to reduce exposure to excessive shadows or maximize the use of existing shadows. The distribution of shadows and the direction of the sun significantly influence the surrounding environment. Changes in shade geometry and orientation can affect solar radiation levels and temperature in shaded areas. These factors are crucial when designing outdoor spaces like balconies, where directing the sun and providing adequate shade can create a comfortable.



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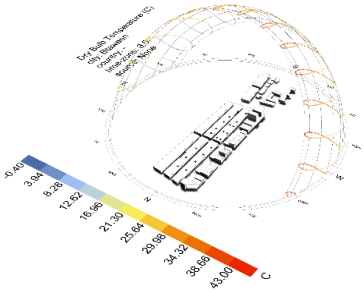

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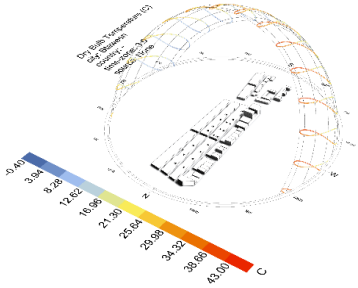

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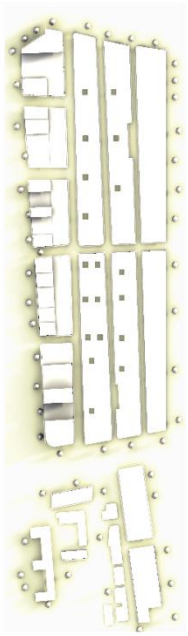

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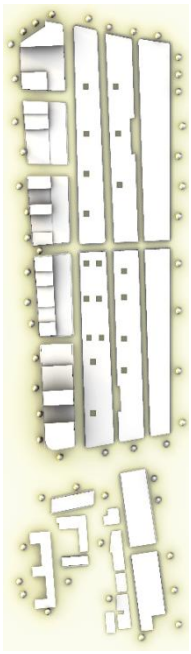

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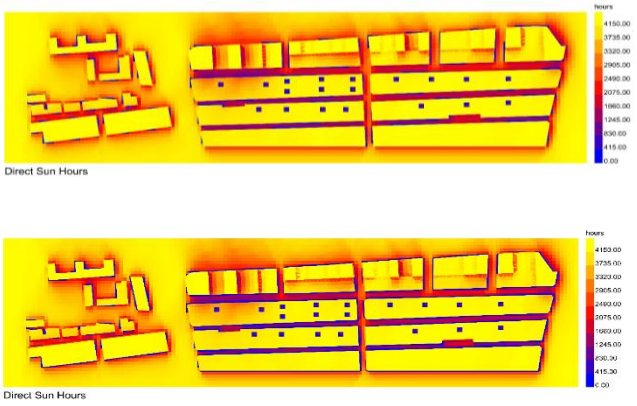
Fig.1 Al-Bataween area sun pattern analysis at different times

Fig.2. The selected area in the Al-Bataween sun pattern analysis in different times

III. RESULTS

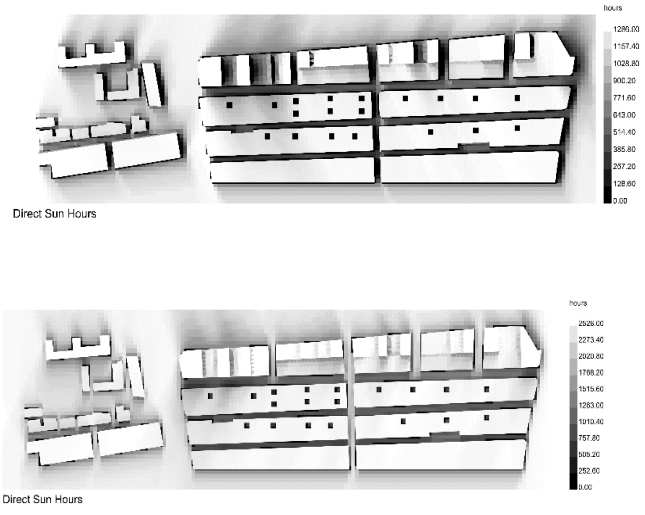
A. The effect of studying the direction of the sun hours to simulate shadow results

The LB Direct Sun Hours method uses sun vectors from the "LB SunPath" component to calculate the number of hours of direct sunlight received by a given geometry. This process includes calculating the sun's vector, intersecting the rays, and calculating the hourly sunlight. Sun vectors represent the direction of sunlight at different times of the day, while ray intersections determine which parts receive direct sunlight and which parts are in shade. Calculating sunlight per hour calculates the total number of hours during which each part of the geometric shape is exposed to direct sunlight. The calculating the efficiency for balconies. The results of the LB Direct Sun Hours study show that sites subject to shade from elements such as balconies and trees typically have more thermal comfort conditions compared to those subject to direct sun shown in Fig.3. This means that the presence of shade reduces extreme heat reached about 45% and provides a comfortable environment inside urban buildings. In addition, shade elements can contribute to improving the quality of life in cities by reducing the effect of excess heat and providing a comfortable environment for pedestrians and users of public spaces. This enhances environmental sustainability and contributes to creating healthy and sustainable urban communities.



Without shadow elements

Fig.3. The direct sun hours in the selected area in Al-Bataween with and without shadow elements



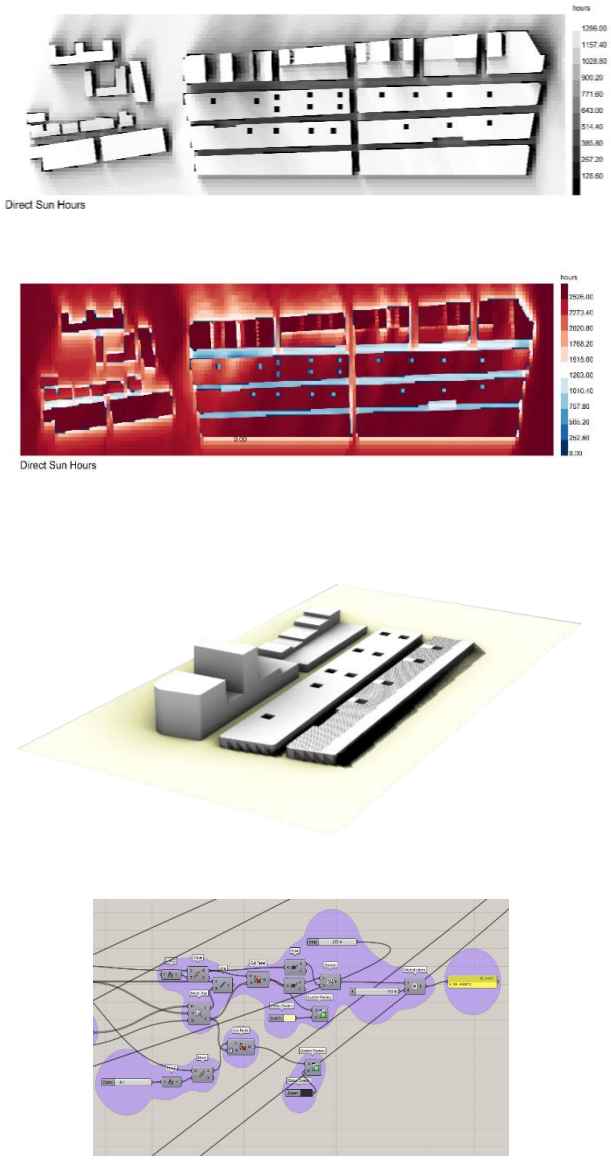


Fig.4. The direct sun hours in the selected area in Al-Bataween with and without shadow elements, and 3D simulation with Rihno calculation

B. Thermal comfort with shade in buildings in a hot climate

UTCI (Universal Thermal Climate Index) is an evaluative tool for estimating the thermocline level in different environments. UTCI is determined to accept thermal acceptability with multiple parameters, including temperature, humidity, wind speed and solar radiation. The study was conducted using simulation techniques in computer programs, and the results were compared with actual air temperature data. The UTCI index was used to evaluate the level of thermal comfort in the study area, and a shading device was equipped for comparison and understanding the effect of shading on the environment. The results show that areas surrounded by shade elements have lower temperatures and greater thermal comfort conditions than areas without shade. In some cases, the results may show differences between direct and shade temperatures, reflecting the effect of shade on the temperature distribution at the site.

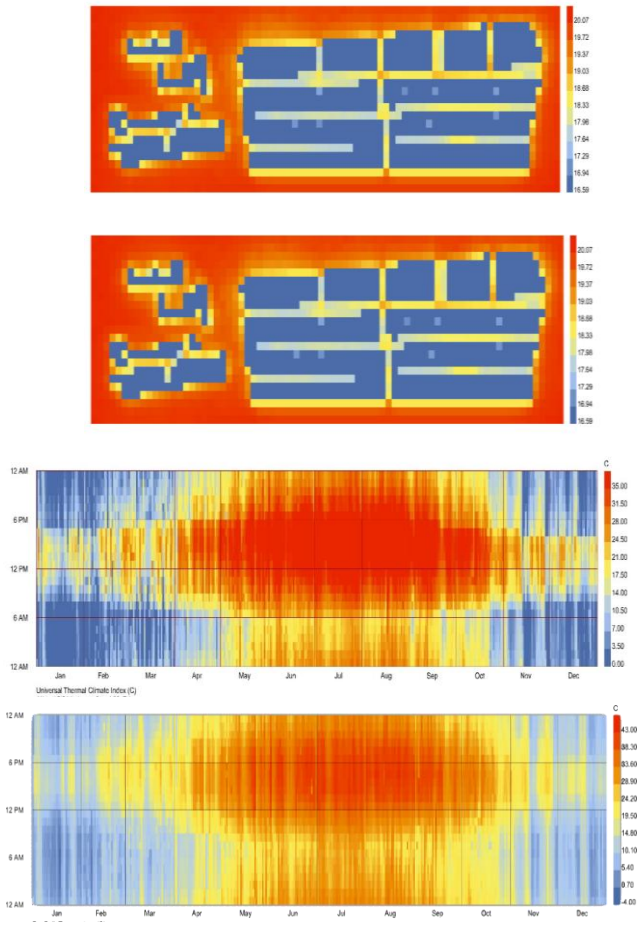


Fig.3. The UTC calculation in the selected area in Al-Bataween with and without shadow elements

IV. CONCLUSIONS

1. The importance of shade in improving the thermal environment: The study shows that shade elements such as balconies and trees play a crucial role in improving thermal comfort in urban areas and reducing extreme temperatures.
2. The impact of changes in shade engineering on shaded areas: The study showed that changes in the distribution and direction of shade significantly affect solar radiation levels and temperature in shaded areas.
3. Positive impact on quality of life and environmental sustainability: The analysis confirms that the use of shade elements can contribute to improving the quality of life in cities by reducing the impact of excess heat and providing a comfortable environment for pedestrians and users of public places, which contributes to environmental sustainability.
4. The importance of including shade elements in urban design: The research demonstrates the need to

include shade elements such as balconies and trees in urban design, especially in areas with extreme heat, to improve the quality of life and comfort of residents.

Based on these conclusions, the following recommendations can be made:

1. Include shade elements in urban design: It is recommended to include shade elements such as balconies and trees in the design of buildings and outdoor spaces to improve thermal comfort and provide a comfortable environment for residents.
2. Raising awareness of the importance of shade: The health and environmental benefits of using shade elements should be promoted and communities should be encouraged to implement projects aimed at providing more shade in cities. 3. Stimulating innovation in shade design: Encouraging the development of new technologies and systems to provide effective and sustainable shade, which contributes to enhancing environmental sustainability and improving the quality of life in cities?

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