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Evaluation the Climate Change Suitability for Al Hillah City Using THI and RH Indicators

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Abstract: High-resolution spatial data obtained through remote sensing technology is necessary to address climate change, which is a serious issue due to the ongoing dynamic changes in urbanization in cities. Data from the Ministry of Communications' Space Science Network of the Republic of Iraq was used to measure climate change in Al Hillah city between 1990 and 2022. This research was conducted to study the manifestations of climate change in Al-Hillah, the center of Babylon Governorate. Based on the Temperature-Humidity Index (THI) indicator, the hottest period in Al-Hillah is between June and July and the beginning of August, when the average monthly temperature reaches 33.4–35.3°C. Meanwhile, the average relative humidity (RH) decreases inversely with the average temperature, reaching 30.8% during the three summer months. The mild months are October and April, while the cold months are March and November. The results showed that January, February, and December are months of discomfort tending toward coldness. The mild months became clear during March and November. THI values in Al-Hillah for that class ranged between 18.1 and 21, according to the THI guide. The months of discomfort that recorded in Al-Hillah related to THI equation and guide, was due to exceeds the values of temperature and RH the appropriate range for human body comfort and their activity, which ranges from (18–28°C) in relation to temperature, as well as from (40–60%) in relation to RH. It also affected the dryness of the land. The results indicated Iraq has been affected by global climate change.

Keywords: Temperature-Humidity Index; Comfort; Discomfort; Iraq; Climate

1 Introduction

Applied climatology is one of the branches of climatic geography that studies the impact of climate on human activity. Examining the influence of climate on buildings is one of the fields within this branch. City planning and architecture are not limited to architects and city planners; climatologists also play a prominent and important role in incorporating climatic elements and their effects into the planning process, as it connects climate, place, and time through its interaction with the environmental and practical realities of modern life, ultimately leading to the development of guidelines for urban planning. This topic has garnered significant attention worldwide from architects and climate professionals since the 1930s. The UNESCO region also held a special symposium in 1963 to study climate in relation to indoor environments in both dry and humid areas, and another study on climate and its role in housing design, particularly for hot climates, was published in 1971 [1]. The urban climate is one of the axes of the study in the applied climate that has received attention great by scholars, planners and city dwellers themselves at the global and regional levels over the decades [2]. Although it is a topic studied in most geographical departments, the list of study locations is still sparse, and the number of specialists in this field is very few. Studies of the preferential climate (microclimate) for cities have revealed a large discrepancy between the ranges of individual cities in terms of their air components, temperatures, air movement, and flow through streets and roads, among other factors. Consequently, applied climate studies have focused on cities to investigate the reasons behind these discrepancies and differences. The dry climate of central Iraq features significant annual temperature variations. Summers are extremely hot, winters are mild, and the region remains dry throughout the year. From a human comfort perspective, summers can be oppressive. The wide range of average monthly temperatures is typical of a continental climate, with uncomfortably hot days followed by cool, comfortable nights [3]. Additionally, over half of the global population currently lives in urban areas, and this proportion is expected to increase to 70% by 2050, according to the United Nations' 2009 World Urbanization Prospects report. In 2009, the United Nations [4]. Many cities with less favorable climates represent an actual translation of human behavior and interactions among different natural, human, and architectural factors in the city. The city's climate is characterized as a local climate compared to the suburbs, which are characterized by the presence of various city facilities that influence its entire microclimate system. This is called the preferential climate, whose features depend on factors including the nature of the land, the width and presence of streets, and the different spaces within the city [5]. Therefore, there is a need to pay more attention to the effects of urban heat islands on future climate change in urban climates and to analyze the patterns of climate elements within them. The results unanimously agree that cities form their own climates. Cities create population and housing, their functional composition, and the variation in the degree of human activity within their ranges, which are determined by the density of residents, buildings, facilities, roads, and what is emitted from the stone blocks and reinforced concrete walls of those buildings, installations, and asphalt from heat, as well as what leaks from refrigeration equipment and is emitted from cars and fossil fuel engines in factories. All of this has thermal, chemical, and vital environmental repercussions [6]. The sun angles for each orientation are derived from the region's sun chart [7, 8]. This refers to the observed century-scale increase in the Earth's average climate temperature and its associated impacts [9]. It was effectively shown at the Conference of the Parties' (COP 22) 22nd session that the Paris Agreement is being implemented and that multilateral cooperation on combating climate change is still being conducted in a positive manner. Global warming has not been researched in Iraq [10, 11]. The climate of the city (the urban climate) is one of the main focuses of applied climate studies, which has received significant attention [12] from scholars, planners, and city dwellers at both global and regional levels over the decades. Although it remains a subject of study, the city's climate features very brief transitional seasons. The lengthy, hot summer season lasts from late April to early October, whereas the frigid winter season lasts from December to the end of February [13, 14]. Due to high temperatures and climate change in Iraq, desertification has occurred [15]. As the high temperatures and climate change in Iraq led to desertification [16–18]. Consequently, the climate greatly affects vegetation and vegetation cover, as well as the lack of rain during the summer in Iraq. In this context, people feel uncomfortable due to the high temperature and relative humidity (RH) in Al Hillah city [19].

2 Study Area

The study area is situated in the Al Hillah district at coordinates 32° 28' 46" North and 44° 25' 58" East. The full original name is Al-Hillah, covering a total area of 270 km^2. The terrain slopes southward, rising to 35 meters above sea level. The climate is predominantly desert, with low rainfall and very high summer temperatures reaching up to 50°C, while winters are generally warm. The district has an estimated population of approximately 317,835 people [20], as shown in Figure 1.

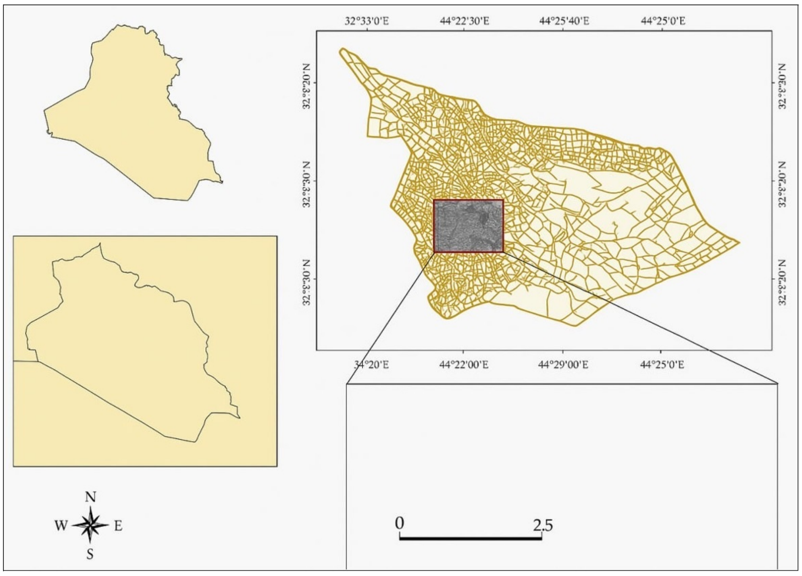

Figure 1. Location of the study area

3 Methodology

The study methodology included the following steps:

1. The case study focused on Al-Hillah city, located in central Iraq. The climatic conditions, including temperature ranges, seasonal variations, and humidity patterns, were described to provide context for the analysis.

2. Primary data on daily maximum and minimum temperatures and RH for Al-Hillah city were obtained for the period 1990–2022 [21]. The data were sourced from the Ministry of Transport and Communication, General Meteorological Organization, Baghdad, Iraq (2017).

3. The collected data were examined for completeness, consistency, and reliability. Missing or anomalous observations were identified and handled according to standard statistical procedures.

4. Recommendations to avoid indoor air pollution were provided.

5. Use Temperature-Humidity Index (THI) equation:

$$\mathrm{THI} = \mathrm{T} - 0.55 * (1 - 0.01 * \mathrm{RH}) * (\mathrm{T} - 14.5) \tag{1}$$

4 Results

4.1 THI in Al-Hillah

In this study, the months of comfort and discomfort were identified using the THI at the Al-Hillah station. The influence of temperature and RH on the THI values was analyzed by examining the relationship between these variables through the calculation of the correlation coefficient. Figure 2 and Figure 3 show the monthly averages of temperature and RH, respectively, at the Al-Hillah station for a period of 33 years from 1990 to 2022. The highest average temperature was recorded in July and August, at about 35.3°C, while the lowest temperature was recorded in January at 11.2°C. On the other hand, RH recorded its highest value in December at about 70.9%, while the lowest percentage was recorded in June and July at 30.8%.

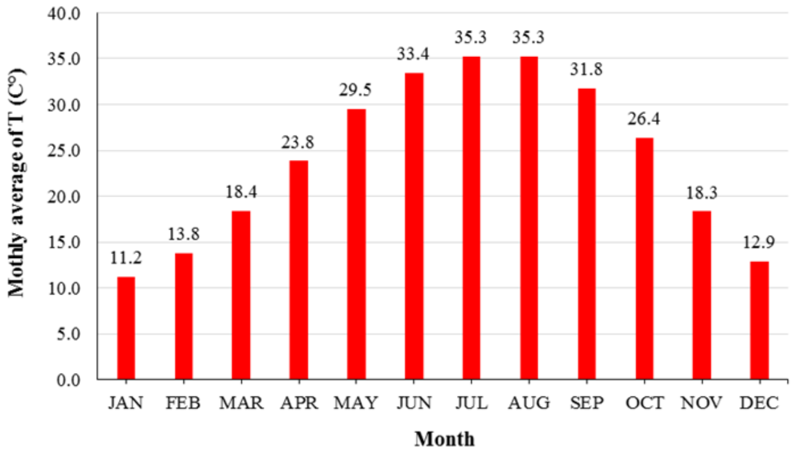

Figure 2. Monthly average of temperature in Al-Hillah station from 1990–2022

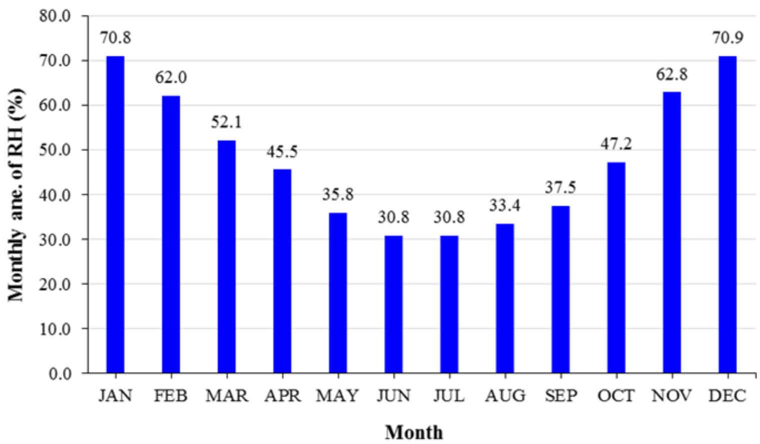

Figure 3. Monthly average of RH in Al-Hillah station from 1990–2022

Table 1 and Figure 4 showed the values of the THI values at the Hilla station from 1990–2022.

Table 1. THI values at Al-Hillah station from 1990–2022

Month	THI	Symbol	Climate Sense
JAN	11.75	C	Cold discomfort
FEB	13.92	C	Cold discomfort
MAR	17.39	P-	Cool comfort
APR	21.03	P+	Thermal comfort
MAY	24.21	H	Feverish discomfort
JUN	26.22	H	Feverish discomfort
JUL	27.36	H+	Severe heat discomfort
AUG	27.66	H+	Severe heat discomfort
SEP	25.83	H	Feverish discomfort
OCT	22.92	P+	Thermal comfort
NOV	17.54	P-	Cool comfort
DEC	13.16	C	Cold discomfort

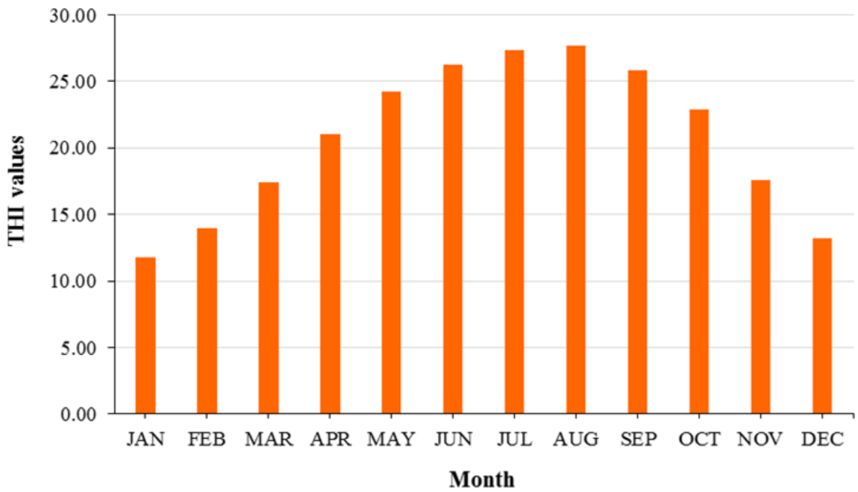

Figure 4. THI values in the Al-Hillah station from 1990–2022

The results of the THI values in the table showed that the number of months with cold discomfort was three, including January, February, and December, while the number of months with cold comfort was two (March and November). April and October were recorded as thermal comfort months, while May, June, and September showed feverish discomfort. Severe heat discomfort was recorded in two months (July and August). The highest THI value was recorded in August at 27.66, while the lowest THI value was 11.75 in January. The results indicate that there is no month with absolute comfort according to the THI values for Al-Hillah, as the values ranged between 18.1 and 21 according to the THI guide. Related to this result, Al-Hillah did not record any month of comfort during 1990–2022, based on the monthly averages of RH and temperature at the Al-Hillah station. The months of discomfort recorded in Al-Hillah, according to the THI equation and guide, were due to temperature and RH values exceeding the appropriate range for human body comfort and activity, which ranges from 18–28°C for temperature and 40–60% for RH. On the other hand, the months of comfort shown in Al-Hillah based on the THI equation and guide were due to the appropriate values of temperature and RH within the specific range for human body comfort and activity: between 18–28°C for temperature and between 40–60% for RH.

4.2 Correlation Relationships Between Temperature and THI Value

Figure 5 shows the correlation between the monthly averages of temperature and THI values from 1990 to 2022. The results illustrate a strong positive correlation, with a correlation coefficient of approximately $r = 0.99$. In contrast, Figure 6 shows a strong negative correlation between RH and THI values, with a correlation coefficient of about $r = 0.97$. These results confirm the existence of a direct correlation between temperature and THI values, and an inverse correlation between RH and THI values.

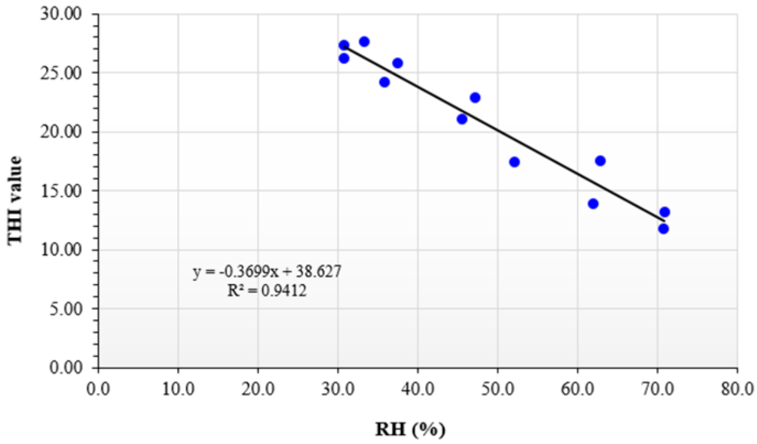

Figure 5. The correlation relationship between the monthly averages of temperature with THI values for Al-Hillah during 1990–2022

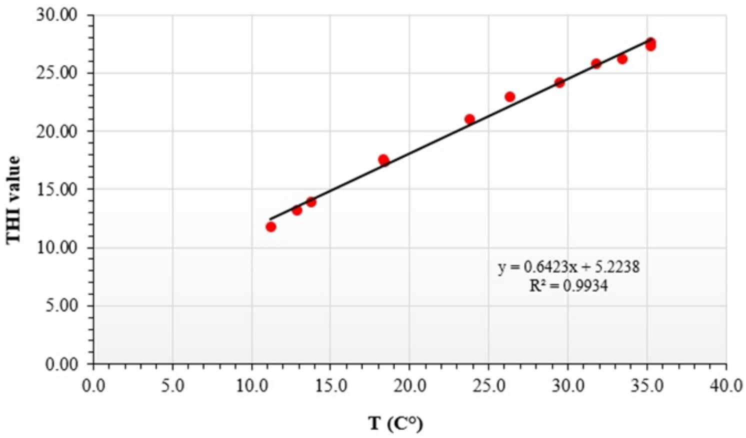

Figure 6. The correlation relationship between the monthly averages of RH with THI values for Al-Hillah during 1990–2022

Table 2 shows the correlation coefficients and the equation of simple linear regression between the monthly averages of temperature and RH with THI values for Al-Hillah during 1990–2022.

Table 2. Values of correlation coefficients for the monthly averages of temperature with THI values for Al-Hillah during 1990–2022

Parameter	r Value	Correlation Nature	Eq. of Simple Linear Regression
Temperature	0.99	Strong positive	THI = 0.6423 T + 5.2238
RH	0.97	Strong negative	THI = -0.3699 T + 38.627

5 Discussion

The analysis of THI and RH in Al-Hillah shows that the period from late June to early August represents the hottest and most stressful conditions, with THI reaching 27.66 in August and the lowest value of 11.75 in January. Seasonal variation was clear, with cold discomfort in the winter months, moderate comfort in spring and autumn, and severe heat stress in mid-summer. Statistical analysis confirmed a strong positive correlation between temperature and THI (r = 0.99) and a strong negative correlation with RH (r = -0.97).

These findings highlight significant public health risks, particularly dehydration, cardiovascular stress, and heat-related illnesses among vulnerable groups. From an urban resilience perspective, the lack of vegetation and shading intensifies heat exposure. Expanding green cover, creating shaded spaces, and using reflective materials are essential strategies. In terms of climate adaptation, measures such as cooling centers, improved water management, and awareness campaigns can mitigate the impacts of extreme heat on the local population.

6 Recommendations

Based on the THI and RH analysis for Al-Hillah, the following strategies are recommended to improve thermal comfort and public health:

• Vegetation Cover: Increase urban greenery, parks, and street trees to provide natural cooling.

• Shading: Introduce shaded corridors, pergolas, and canopies in pedestrian areas.

• Cooling Centers: Establish air-conditioned community centers for vulnerable populations during heatwaves.

• Water Management: Develop efficient irrigation and water features to support urban vegetation and reduce surface heat.

• Urban Design Guidelines: Promote reflective building materials, lighter pavements, and building orientations that reduce heat accumulation.

• Public Awareness: Implement educational campaigns on heat stress prevention and hydration practices.

Author Contributions

Conceptualization, R.D.M.A. and I.H.A.; methodology, R.D.M.A.; software, N.A.; validation, R.D.M.A., I.H.A., and A. S.H.A.; formal analysis, N.A.; investigation, R.D.M.A.; resources, A.S.H.A.; data curation, N.A.; writing—original draft preparation, R.D.M.A.; writing—review and editing, R.D.M.A., I.H.A., A. S.H.A., and N.A.; visualization, N.A.; supervision, A.S.H.A.; project administration, R.D.M.A.; funding acquisition, I.H.A. All authors have read and agreed to the published version of the manuscript.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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