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A Study of the Vegetal Effect on the Thermal Comfort of Outdoor Area in Hot Regions

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Abstarct

The present research is a study of the thermal effect of vegetation cover on outdoor thermal comfort is residential areas in Biskra city during the hot period. Through numerical simulations using different scenarios of vegetation cover type where main PMVs have determined, besides a user satisfaction survey during typical hot period, the study concludes that vegetation density and types reduces air temperatures and have a substantial effect on user thermal comfort. The study concludes by arriving at the thermal effect of each scenario on the hourly values of PMV for the user, where it reaches their perceived comfort area as determined by interrogation. The results showed that the vegetal massif cover that depends on trees with dense crowns had an important effect in reducing the air temperature compared to the vegetated flat cover (using climbing plants), and it also had an effective impact in lowering the hourly values of PMV.

Key words: ATSV (Actual Thermal Sensation Vote), hot and arid region, PMV (Predicting Mean Vote), thermal comfort of users, vegetation cover.

INTRODUCTION

The relationship between the green cover and the space occupied by humans has been the focus of many studies since the late last century, as the works of Givoni [1],Bernatzky [2], Rowntree [3], Chiesura [4], Vailshery et al [5]. In these researches, many positive points are reached and the important roles of the green field in human life on several levels are revealed, such as the aesthetic, visual, symbolic, acoustic, social, climatic and other aspects. From a biophysical, social and cultural point of view, the green cover plays an important role in improving human life, where Stewart et al [6] summarizes it in six points: the effect on the human psyche, the effect on human health, the effect on the purity of the air, the creation of shadows and humidity Adding an aesthetic aspect to the site and biodiversity.

Furthermore, the effects of the green cover on human life are on several levels, mainly related to its size and location, from its effects on the architectural and urban levels through its impact on a part of the city or the entire city to the regional and global level such as tropical forests and Amazon forests, which are classified as the lungs of the world [7,8,9]. These benefits and effects have been the focus of many researchers, most of whom classify them in five points: changing surface temperatures, water control of the air, purifying air from pollutants, acoustic control, and carbon emission control [10,11,12,13].

The climatic functions of the green areas in urban space were the focus of serious studies that took part in most of the points, but differed in their expression, the first classification [14] talks about categorizing the climatic effects of green areas into tree climatic impact measures: microclimate, local climate and meso-climate, then the other classifications, each according to the climate impact scale.

According to Shahidan and John [15] there are four ways in which the green cover can affect the urban climate, namely changing the intensity, direction and quality of wind, relative humidity, solar radiation, terrestrial radiation. While Akbari et al [16], in a study conducted in the United States of America found that three trees in each dwelling reach a cooling rate between 17% to 57% at the city level, and with a direct shading rate between 10% to 35% [17].

Based on Andrade and Vieira [14] The effect of the green cover is divided according to the degree of influence as follows: (a) the effect on radiation, energy and water balance, (b) the effect on air temperature and velocity, (c) the effect on the human energy balance and then (d) the effect on the thermal comfort level. Thermal modification carried out by vegetation in the air allows to reduce the temperature, and increases the relative humidity in the air [18], the decrease in temperature allows compensating the upward movement of air at the level of the urban canopy [19].

The city of Biskra was known for its dense palm forests that play multiple roles in the social life of its residents; besides the perceived bioclimatic role of palm oases; which has a significant impact on the local climate. In addition, this effect can reach 6 °C to reduce the temperature and increase by 12% in relative humidity [20], and this leads us to the fact that there is a change in the characteristics of the microclimate of the city due to the decreasing vegetation cover in it; Its areas reached 1,400 hectares in 1962; Recently its area became 49 hectares; According to the statistics of the governorate of forests for the year 2017 [21].

The decrease in vegetation cover negatively affects the local climate [22], and this forces the population to spend most of the time indoors, especially in the hot period, which increases energy consumption in industrial indoor cooling [23]. This leads us to study the microclimate [9] at the level of the fabric of collective housing in the city, and to study the effect of the plant elements on it, and the extent of their impact on the expected average rating (PMV) of the users of these areas [24].

The current study's objectives are to determine the thermal comfort range for group dwelling green area users in June, July, September, and October for the selected sample and calculate their PMV while they are questioned about their thermal comfort, extracting the PMV values of data for a typical user in the proposed scenarios to determine the best plant type and composition that can be used in outdoor spaces while determining its area and size.

MATERIALS AND STUDY METHODOLOGY

This present study combined three of the most valuable approaches in the field of environmental studies (a) a measurement campaign, (b) a survey and (c) a simulation experiment on a future sample (Figure 3). A preliminary step was made by collecting all data of the studied site as urban fabric parameters and the detailed vegetated cover proprieties; counting the plant species, classifying them, extracting their dimensions, then extracting the location of the plant elements in the site, as well as extracting the sample components from the area and size of the plants in it and the area and size of residential buildings were the main steps of the collection data process.

Furthermore, a field of measurements was taken in the studied site using the measuring instrument (TESTO 480), which is intended for measuring several climatic parameters air temperature (°C), relative humidity (%), and wind velocity (m/s) (Table 1). The measurements were taken on June 17, July 13, September 17, and October 23, at five different times throughout the day: at 7 a.m., 10 a.m., 13 p.m., 16 p.m., and 19 p.m. (figure 1).

Table1. Characteristics of instrument measuring TESTO 480,[a]

Feature	Values	
Measurement parameters	▪ Temperature (C°, F°, difference – C°, difference-F°) ▪ Humidity (RH %, td F°, wet bulb C°, wet bulb F°, g/m^3, g/ft^3, g/kg, g/lb, kJ/kg, BTU/lb, ppm, vol%) ▪ Flow velocity (m/s, ft/m) ▪ Pressure (Pa, hPa, mbar, kPa, bar, psi, inH$_2$O, inHg, mmH$_2$O, Torr) ▪ Co$_2$ (ppm, vol %) ▪ Lux (Lux, footcandle)	
Measuring cycle	0.5 s	
Operating temperature	0 to +40 °C	
Storage temperature	-20 to +60 °C	
		
Hand instrument	Temperature and Humidity probe	Velocity wind probe

Figure 1. Determining the points for taking measurements in the sample

Second, as a second step of the research method, on June 17, July 13, September 17, and October 23, 2018, site users were questioned about the actual thermal sensation vote. The number of respondents was 94. The questions were about the instantaneous sensation of thermal comfort for the respondent, describing him in the following terms (slightly cold, comfort, warm, hot, very hot), then asking about age, height, weight, and the activity was practiced five minutes before the interrogation, and finally describing the type and color of respondents clothes, in conjunction with taking measurements of air temperature, relative humidity, and air velocity (Table 2).

Table 2. A typical table for taking measurements while interviewing sample field's users, Source: the author, 2018.

	Hour	Thermal sensation	Measurement of			Metabolic rate (W)	CLO
			T_{air} (c°)	RH (%)	V_{air} (m/s)		
S_1	....	....	....	....	....	....	....
S_2	....	....	....	....	....	....	....
S_3	....	....	....	....	....	....	....

Age:…………years

Sex:

( ) Female

( ) Male

Weight:……..kg

Height:………m

Dress

( ) T-shirt ( ) shirt ( ) trousers

( ) pants short ( ) hat ( ) men summer prayer dress

( ) shoes ( ) sports shoes ( ) sandal

( ) summer dress ( ) women hijab

Emplacement:

( ) under trees ( ) under canopy ( ) under sun ( )

1. Activity you were performing 5 minutes ago?

……………………………………………………………………………………

2. How do you feel right now?

( ) a little cold -1

( ) comfort 0

( ) warm +1

( ) hot +2

( ) very hot +3

Figure 2. the questioner adapted, source: the author, 2018.

Finally, to simulate the studied site in the proposed scenarios, meteorological information for Biskra city was extracted from the EPW weather file format (Energy Plus Weather data) for the year (table 3). Among several modeling tools (Envi-met V4) have been chosen to perform the simulation process. A validation step basing on the RMSE and the MAE error metrics was made validate the Envi-met model before the simulation process.

Table 3. Model data and Input parameters used for setting the ENVI-met model Items [b]

Model data			
Situation	Biskra, Algeria	**Geographic coordinates**	Latitude:34.84 / Longitude: 5.75
Simulation model size	110x110x30 (meter)		
Input data			
Simulation day	13 July		
Simulation time	06:00 - 23:00		
Initial temperature	31,61 °C	Hourly input was forced by data from the meteorological station	
Relative humidity at 2m above ground (%)	20,0 °C	Hourly input was forced by data from the meteorological station	
Wind speed at 10 m	6,39 m/s		
Wind direction	107,30°		
Specific humidity in 2500 m	8,05 g/Kg		

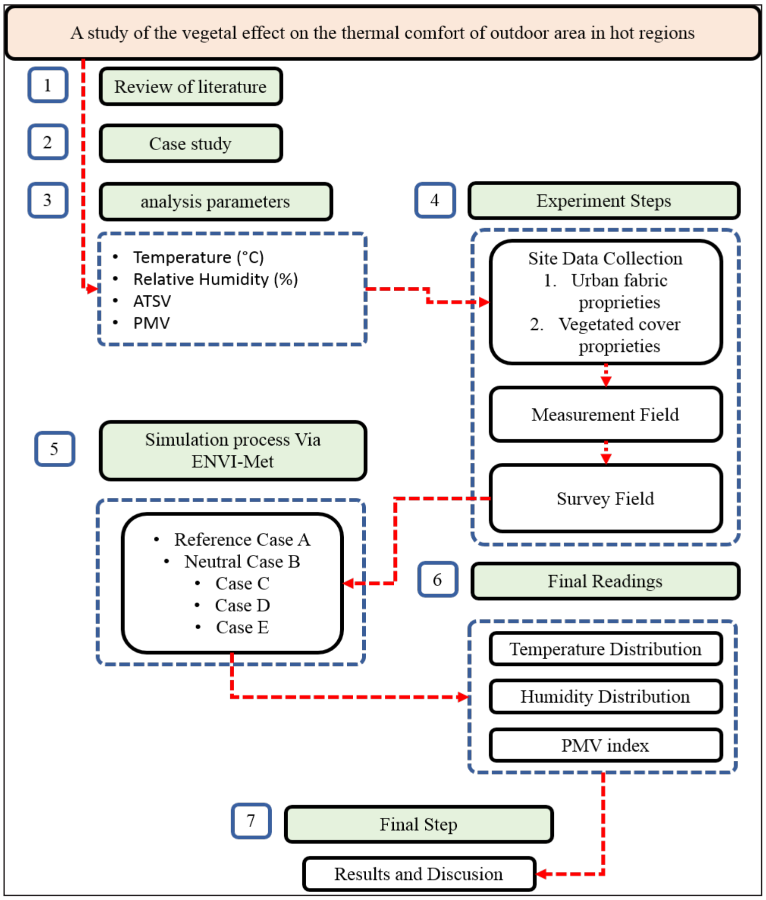


Figure 3. The frame work of study

Case Study

Environmental analysis

Biskra has a desert climate all year round; the rain is almost non-existent. According to the Köppen-Geiger classification from 1951 to 2000 [27], Biskra has a BWh climate type, i.e., a desert climate; hot and dry. The annual temperature is 21.8 °C, and the annual precipitation is 141 mm.

The hot season lasts 3.1 months, from June 8 to September 10, with daily high temperatures averaging more than 35°C. July is the hottest month in Biskra, with average highs of 40°C and lows of 28°C.

From November 17 to March 9, the cool season lasts 3.7 months, with an average daily high temperature of less than 21°C. January is the coldest month in Biskra, with an average low of 8°C and a high of 17°C (see Figure 4).

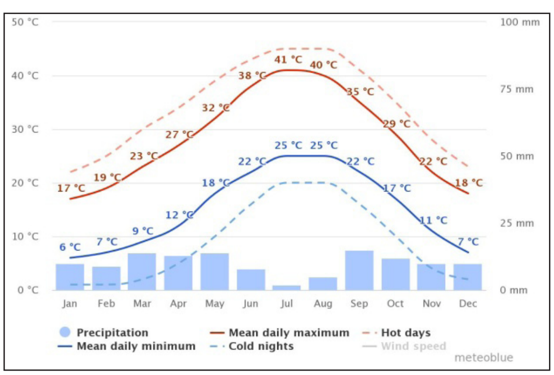


Figure 4. a) Average minimum and maximum temperature, with mean temperature of hot days and cold days, over a 30-year period for Biskra city [c]

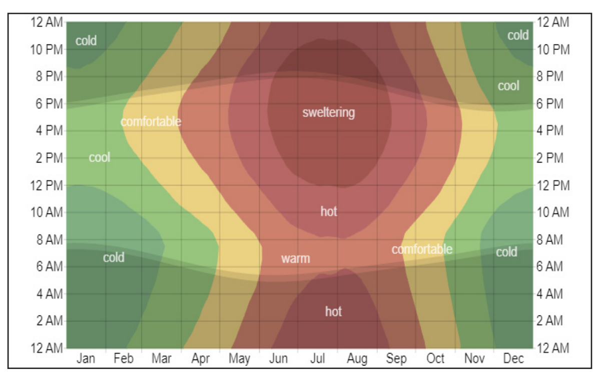


Figure 4. b) Average Hourly Temperature at Biskra Airport [d]

Case Study Proprieties

In the present research, the case study has been chosen from the main residential typologies existing in Biskra city. The neighborhood of 216 dwellings is located on the western side of the city of Biskra within the framework of the new western residential urban areas planning project, which was established in the eighties. The neighborhood consists of collective dwellings with a maximum height of 15 m. It is assembled in the form of a rectangle, resulting in a median area. Around the boundaries of each residential building, you'll find a cover vegetal specific to the residents, which are trees, shrubs, and dense climbers that cover the windows on the ground floor. The sample floor is dirt, interspersed with asphalt roads and concrete corridors. A part of the neighborhood was selected (see Figure 5), which occupies an area of 9975 m2, where the building percentage is 29.9% and the vegetal cover is 21%, of which 13% is in the median area of the sample and 8% surrounding it.

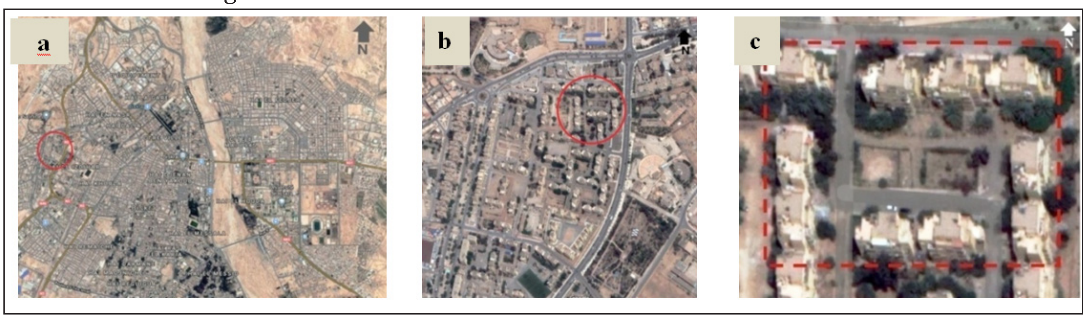


Figure 5. Maps showing the location of the study site: a) Biskra city; b) District of 216 lodgments, c) limits of study sample [e]

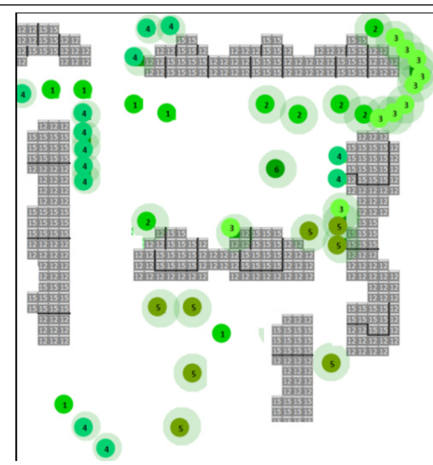
Vegetation Typology and Characteristics

The vegetation existing in the case study is a group of plant types such as trees, shrubs, and palms, both perennial and deciduous, distributed circumferentially around residential buildings that do not exceed a height of 15 m. It has different crowns, from cylindrical to conical and palm-shaped, occupying 21% of the sample area, and Table 5 shows the plant species found with their heights, numbers, and crown sizes.

Table 4. showing the type of trees in the study sample.

N°	sample of trees	Height (m)	Crown's volume (m3)	N^{ub} of trees
1	Palm, dense, Small	5	18	7
2	Palm, dense, medium	15	243	6
3	Cylindrical, dense, small	5	27	10
4	Cylindrical, dense, medium	15	810	13
5	Conic, dense, medium	15	441	9
6	Spherical, dense, medium	15	855	1

Map showing the location of the sample trees

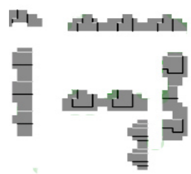
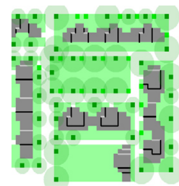
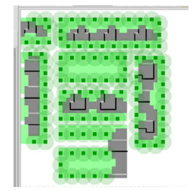
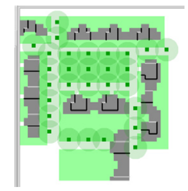
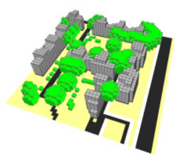
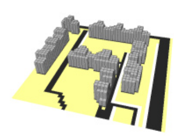
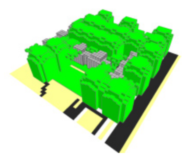
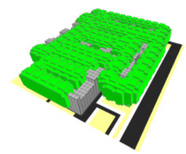
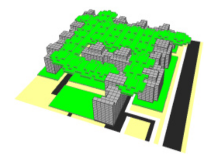


Creation of the Analysis Model

Finally, simulating the site under various scenarios by playing on the types of proposed plants, their number, and dimensions are determined in each case (height, crown width, crown height, crown volume). The PMV was also calculated using Biomet (an attached application to Envi-met 4) with the inputs of a typical person from the respondents (height, weight, age, gender, and the CLO value) derived from the questionnaire (see table 2).

The creation of the analysis model depends on two strategies in creating a micro-climate and this is at (Lin, Jiawei, & Robert Brown) [9, 31], where the first is the shading ratio of vegetation represented by the flat vegetation composition (climbing plants) in scenario E, and the second strategy is moisture through evaporation-transpiration of vegetation; Which is represented by the plant mass structures in the following scenarios (C, D), as for scenario (A) it is the original case, and scenario B is represented by the case of the sample without vegetation cover. These strategies appear in the plant formulations for each proposed scenario. Scenario (C) is based on a multi-layered combination of vegetation cover, alternating between trees with a height of 15 m and a crown width of 9 m; And trees with a height of 25 m and a crown width of 13 m. For scenario (D), it depends on a single tree structure with a height of 15 m and a crown width of 9 m, and scenario (E) depends on climbing plants in the form of a trellis with a height of 15 m. In Table 5, we make it possible to identify the proposed cases for simulation by (Envi-met 4) program, including the case of the original sample; in each scenario, we review the type and height of vegetation, the total volume of vegetation.

Table 5. Show all modeling scenarios with the volume of the vegetation cover performed by Envi-met V4

The cases					
	Case A	**Case B**	**Case C**	**Case D**	**Case E**
modeling of cases					
3D					
crown's volume of all trees (m³)	**21258**	**0**	**28 107**	**82620**	**5122**
Cover vegetal type	**Look table 4**	**-**	**Canopy trees h≥15m**	**Canopy trees h=15m**	**Climbing vegetal h=15m, thickness =1m**

RESULTS AND DISCUSSION

ATSV Statistical Analysis

On June 17, July 13, September 17, and October 23 of 2018, the users of the external field of the sample were questioned about their actual thermal sensation vote (ATSV). The results were that the average percentage of the respondents who feel comfortable and express it moderately is 45.94% in June; 16.66% in September; 31,81% in October, except for July, which is considered the hottest month in this period (see Figure 6). The range of measured temperature in this category ranges between 21.1 and 33 °C, relative humidity is between 25 and 47.5%, and the air velocity is between 0.5 and 4 m/s, and in Table 4; we show the thermal comfort limits for each month (table 6).

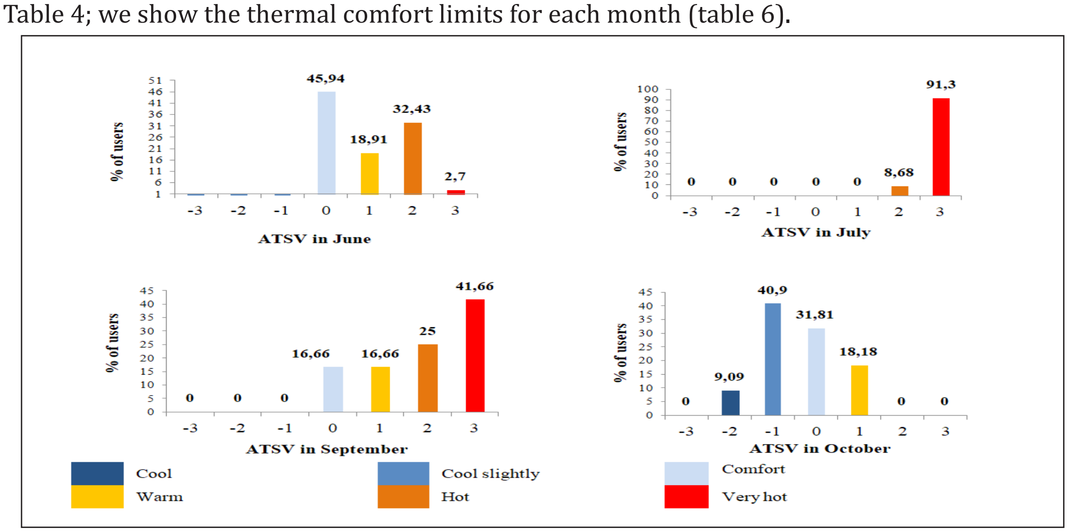


Figure 6. The percentages of the respondents regarding their feel of thermal comfort in the sample field

Table 6. The thermal comfort limits by respondents, for each measured month.

thermal comfort limits by each months	June		September		October	
	Min	Max	Min	Max	Min	Max
Air Temperature (c°)	28.6	33	28.5	29.5	21.1	27.6
Relative humidity (%)	25	35.5	44	47.5	28.4	32
Wind speed (m/s)	0.5	4	0.5	0.5	0.5	0.8

Behavioral Analysis

It was also noted that the category of respondents who were satisfied with the thermal condition was located under the building shades or tree shades (see Figure 7). Shades have a significant effect on thermal comfort. But it is not the only one. There are several factors, including wind velocity, that an impact the sense of thermal comfort for the user of the sample; and the cooling air effect [32]; the thermal insulation coefficient (CLO), which has a significant impact on the user and is related to the type of clothing and the percentage of coverage of the body [33], as well as its weight, age, height, and gender, influences determining the thermal comfort field [34].

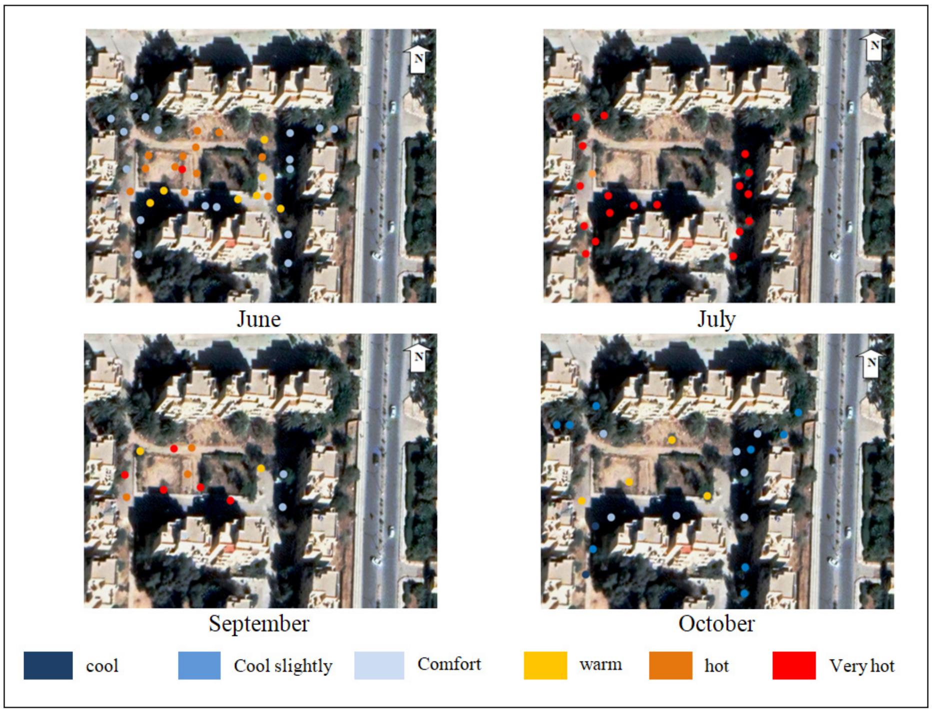


Figure 7. Behavioral maps for the location of the respondents in each month of the hot period

There is a very important element that interferes in the feeling of thermal comfort for the user of the outer field, which is the climatic adaptation and the user's ability to coexist with the thermal state [35], which falls under the adaptation through behavior, and it may be represented in the actions taken by the user of the field to change his thermal environment such as reducing clothing, drinking Refreshments, moving in shady places. As for the second method of adaptation, it is the physiology of the human body, which is a complex system; It gradually adapts to the change in its thermal surroundings, which may reach a maximum of 42 °C [36], for example, a change in the metabolic processes responsible for energy production, a decrease in the heart rate, or even the sweating of the skin of the body; It is called thermal endurance, which is the ability of the body and its cellular structures to withstand heat stress that exceeds the temperature range that is optimal for human performance [37].

In Figure 8, the interrogation results with the users in June, July, September, and October are represented in performing behaviors to reduce the thermal stress. Which appears strongly in July, such as going to shade places, standing or walking under the shade of trees, using a hat or wearing lightweight clothes, drinking water, going out in the early morning or at the end of the evening, all at a variable percentage from 4 to 19%, where the behavior of Going out at a higher rate only in July, while in June and September, the behavior of going to shaded places and walking under the shade of trees is the most prevalent, with a percentage of 30.8%, followed by the behavior of reducing clothing by 15.4% in October. The behavior that distinguishes it from the rest of the months is the increased clothing by 50%, especially in the morning period, where the CLO value increases from 0.34 in July to 1.05 in October, which indicates that a feeling of moderation and slightly cool is prevalent.

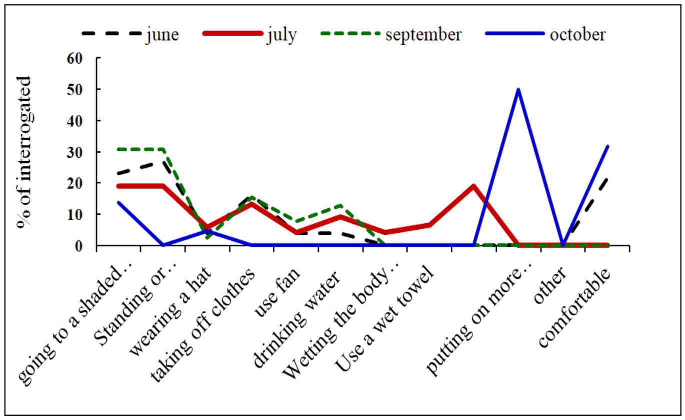


Figure 8. behavior changes in June, July, September and October

Simulation Experimental Analysis

Validation of ENVI-Met Model

A statistical reading was made between the measured temperature values and the simulated temperature at specific points in the sample (illustrated in Figure 10) and the simulation values using the (Envi-met) program, where the measurements were taken in the following hours: 7 h, 10 h, 13 h, 16 h and 19 h from Date of June 17, 2018. We noticed that there is a convergence between the measured values and the simulation values, but the simulation values in the morning are close to the measured values; The degree of congruence, then decreasing from it until the difference reaches the largest value estimated at 4 °C, and this is what we show in the curves of Figure 10 for some points of measurement.

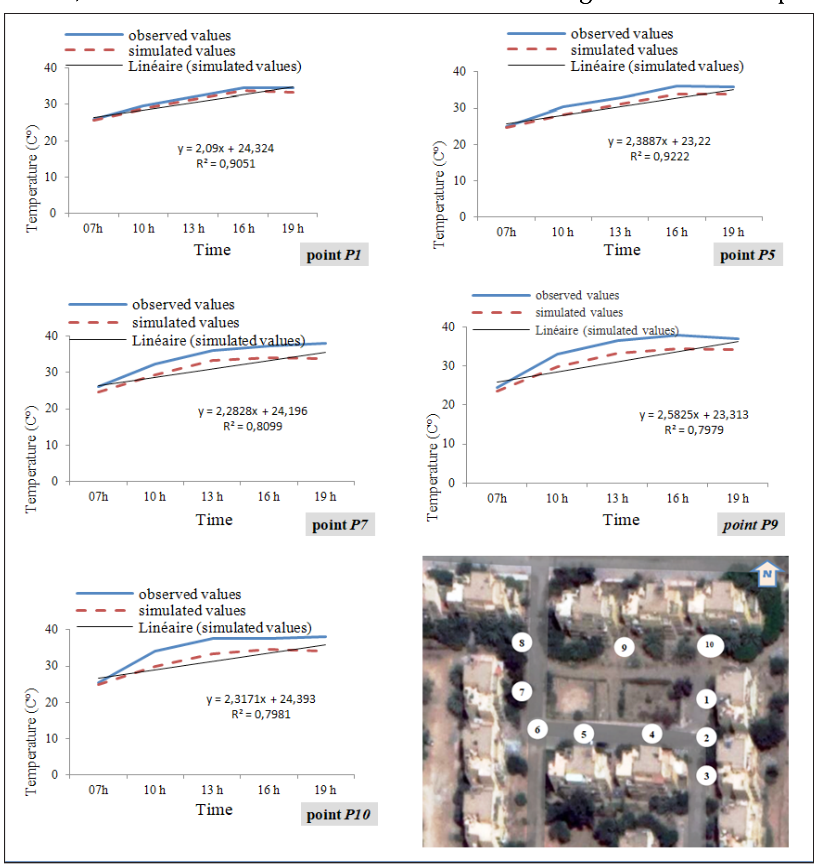


Figure 9. comparison between observed and simulated values in points of taking measurements in the sample

The accuracy of the simulated results was evaluated using the RMSE index and the MAE index, to evaluate the performance of the model [38] (See table 7). The mean absolute error (MAPE) ranged between 2.04 and 19.49%. As for the root mean squared error (RMSE) index, the values range between 0.72 and 2.65, with an error rate of 2.83 to 7.80%. It is noticeable that the indicators (MAE) and (RMSE) show that the error rate between the measured and simulated values is greater at 10:00 h and starts decreasing until it is 16:00 h to 19:00 h. Generally, the simulated air temperature values converge well with the hourly values and do not exceed 30%. The maximum percentage in RMSPE is 7.8% and the maximum for MAPE is 19.49% [39].

Table 7. Difference between ENVI-met model simulated temperatures and the observed data

Hours	h= 1,5m					Equation of Indices	
	7h	10h	13h	16h	19h		
RMSE	0,72	2,44	2,35	2,26	2,65	$RMSE = \sqrt{\sum_{i=1}^{n} \frac{(Pi - Oi)^2}{n}}$	n: number of samples Pi: predicted values Oi: observed values
RMSPE % of error	2,83	7,80	6,79	6,28	7,36	$RMSPE = \frac{\left(\left(\sqrt{\sum_{i=1}^{n} \frac{(Pi - Oi)^2}{n}}\right) \times 100\right)}{\mathbf{MAX}\ (Oi: Pi)}$	
MAE	0,52	5,95	5,51	5,11	7,01	$MAE = \frac{\sum_{i=1}^{n} \lvert Pi - Oi \rvert}{n}$	
MAPE %	2,04	19,04	16.90	14,19	19.49	$MAPE = \frac{100}{n} \sum_{i=1}^{n} \left\lvert \frac{Oi - Pi}{Oi} \right\rvert$	

Statistical Reading Between PMV and ATSV

The thermal comfort field is not determined by expressing the user's feeling of satisfaction, but rather it can be determined mathematically, and from it, the PMV of the respondents in the sample can be calculated. This is a quantitative mixture of activity, clothing, air temperature, mean radiant temperature, wind velocity, and relative humidity [40]. and comparing the calculated PMV values with the perceived values. Figure 9 shows a comparison between the percentages of the respondents regarding their actual thermal sensation vote (ATSV) and the PMV percentages calculated in the locations of their interrogation; After collecting information about the respondents such as age, weight, height, type of dress, gender, and the body position of the interrogator while standing, sitting, walking,... the results were as follows: In moderation or comfort, the difference between the ratios was significant, as the (PMV) ratio calculated in June It is absent as it is in September, and compared to (ATSV), it has rates of 45.94% and 16.66%, respectively. In October, the values of (ATSV) exceeded those of (PMV) by 9%. It can be said that the (ATSV) values differ in large proportions from the (PMV) values in June and September, concerning the sense of thermal comfort in the external fields, and this is due to the influence of the climatic adaptation factor on the users as well as the effect of behavioral change towards the thermal environment, which we define as a wider thermal comfort range for the studied sample [41].

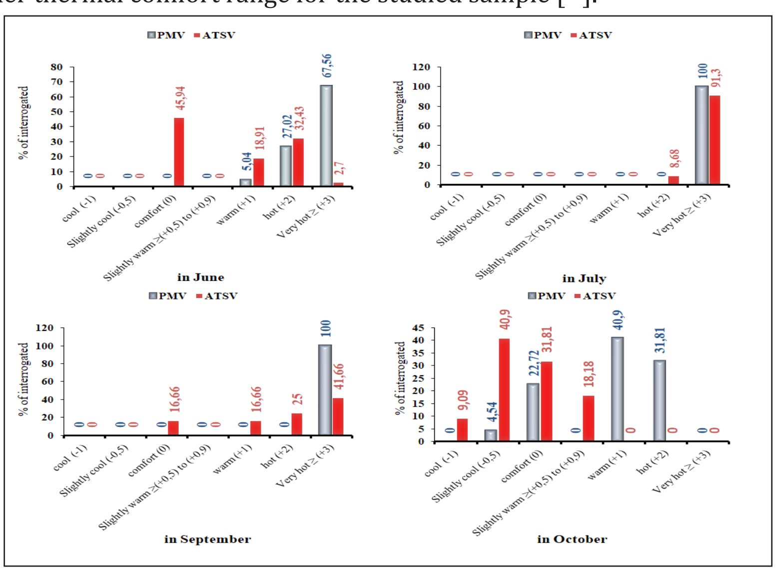


Figure 10. Comparison between PMV and ATSV in each month of measurement.

Critical reading between air temperature (T), relative humidity (RH), and PMV in the sample's various scenarios

Figure 10, in July, shows the simulated air temperature at an altitude of 1.5 m for the different cases. July is the hottest month in the summer period in Biskra, so it was chosen to show the simulation results of the study scenarios. Case B had the highest air temperature, reaching 49.15 °C at 14h, followed by Case A at 44.71 °C at 16h, Case C at 44.29 °C at 17h, and Case E at 42.81 °C at 16h, with the largest difference between it and Case B being 7.12 °C. Case D is considered being the lowest of all cases, with a peak temperature of 41 °C at 14 h.

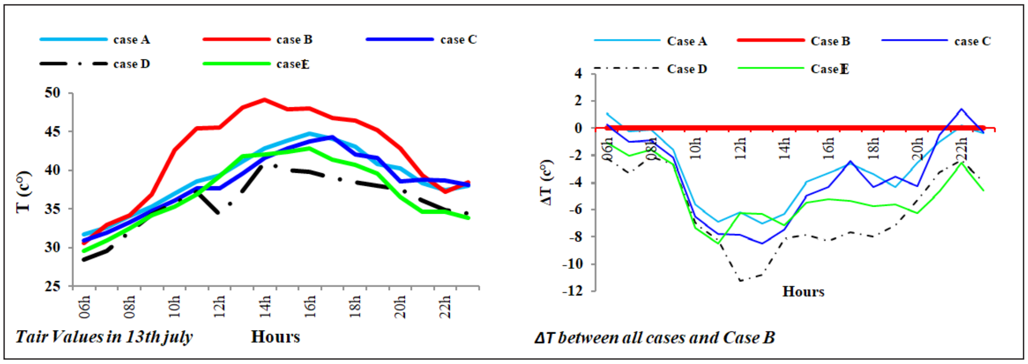


Figure 11. Comparison of air temperature by different cases, in July.

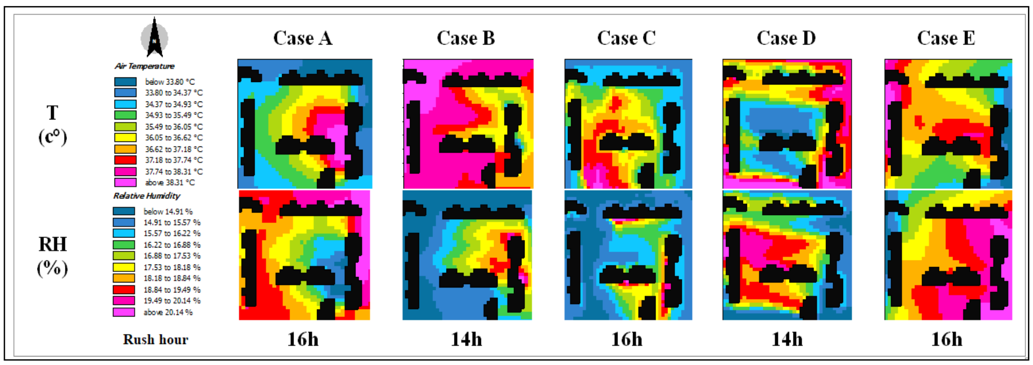


Figure 12. spatial distribution of T and RH in all scenarios

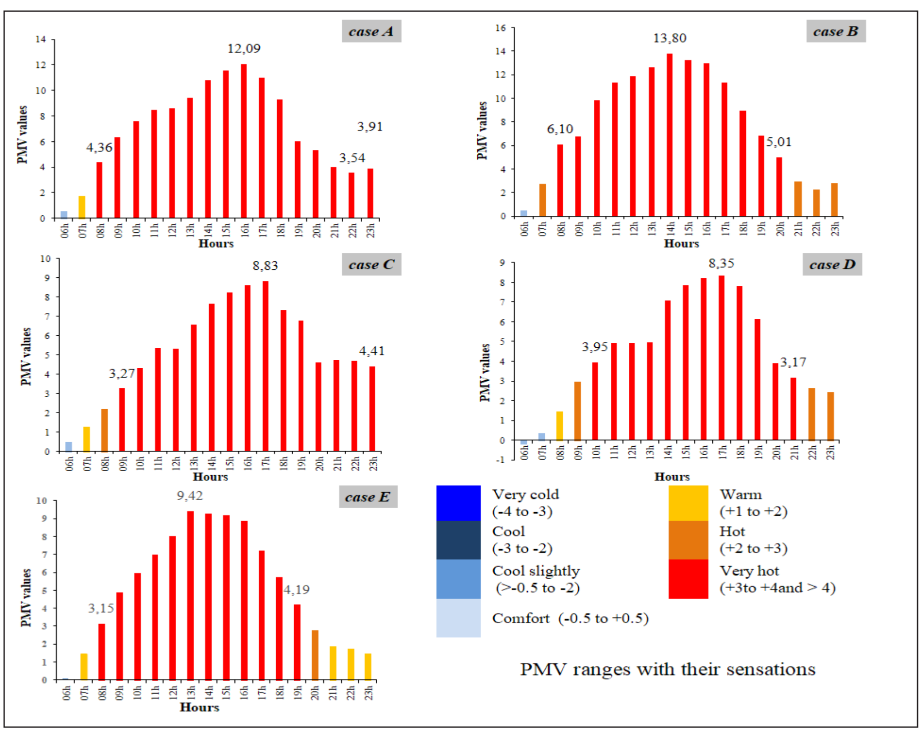


Figure 13. Average values of PMV in the different cases (A, B, C, D, E) in July.

Figure 11 shows the spatial distributions of (T) and (RH) at peak hours, obtained from ENVI-met at an altitude of 1.5 m. Lower air temperatures in cases where vegetation is Massively, that is, the use of trees with a dense crown, and this is in the middle part of the sample. On the contrary, the relative humidity showed a different direction to the air temperature, where higher values of RH were found in the middle part of the sample. In the flat vegetal cover (scenario E), despite the large coverage rate of the space, its effect on reducing the air temperature is small, as it decreases by 2.45 to 2.95 °C at the peak hour.

Figure 12 shows the mean values of PMV from 6 h to 23 h. Case B was entirely under extreme heat stress from 8 h to 20 h hours, with PMV values reaching 13.8 at their peak at 14 h and the lowest value at 5. Case A is under extreme heat pressure from 8 h to 23 h with a peak of 12.09 and a minimum of 3.9. For case C, extreme heat pressure starts from 9 h to 23 h with a peak of 8.83 and a minimum value of 3.27. The heat pressure extends in the case of E from 8 h to 19 h with a maximum value of 9.42 at 13 h and a minimum value of 3.15. In the case of D, the temperature pressure starts from 10 h to 21 h with a peak of 8.35 and a minimum value of 3.17.

DISCUSSION

This study was presented at the level of the sample field users who were interrogated while taking measurements in the sample, on June 17, July 13, September 17, and October 23 of 2018, in order to determine the extent of their thermal comfort; The results were as follows, 27.66% of the respondents felt thermal comfort (ATSV = 0) at all measurement times; This is in the measured temperature range between 21°C and 33 °C; a relative humidity between 25% and 47.5% and an air velocity of 4 m/s; and compared to the zero value of the index (PMV) for this category; And extracted from the simulation of the sample, we find that the percentage is estimated at 22.7%, which is a value that does not converge with the results of the interrogation, and this is somewhat consistent with the findings of Zhaosong Fang [42] who conducted his study in the period extending from the month June to September in Guangzhou, southern China, where he found that the predicted PMV values correspond to the expected mean thermal sensation (MTSV); This is when the temperature reaches the value 34 °C, and if it exceeds 34 °C, the MTSV values are relatively stable between the 2.5 and 3 scale degrees, while the PMV values overestimate the thermal sensation until it reaches the 9th scale, and This is due to the fact that users' bodies adapt to the climate and have the ability to coexist with the thermal state.

At the level of the plant components of the sample, there were different plant scenarios - including the scenario of the original sample to study the effects of the composition of vegetation cover on the micro-climate and thermal comfort of this type of outdoor residential areas, and the proposal of these plant compositions came on the basis of two strategies; The first is the shading caused by vegetation; The second humidifies the air by evaporation-transpiration of vegetation (Table 6).

The average air temperature (T) was compared between the different cases; Case D showed the lowest temperature over an 18-hour period, followed by cases C, E, and A, in that order. This means that the dense mass vegetation compared to the flat vegetation represented by case E; it is most effective for reducing extreme heat stress. But what negatively affects the case (D), which is the maximum case of the density of vegetation cover; the use of the sample field is limited to the displacement corridors only, so it cannot be used for playing, sitting or any other activity. Also, the mean values of PMV in case D are considered the lowest, as the heat stress in it extends from 8h to 19h with values reaching a peak of 9.42, but it is classified as extreme heat stress; Because it is far from the thermal comfort range of PMV values, which starts from -0.5 to +0.5 [43].

CONCLUSION

Five different scenarios of vegetation cover were examined. What we conclude from these scenarios is that the lower air temperatures are better in the cases of mass vegetation cover (use of trees with a dense crown), as these plant combinations were able to reduce the temperature by 6 to 7 °C compared to scenario B (no vegetation cover). These vegetation compositions cover a percentage range from 17.67 to 54.19% of the sample area. As for the flat vegetation scenario, its ability to reduce the temperature is small, ranging from 2.45 to 2.95 °C, compared to case B, where the flat plant compositions take up a percentage ranging from 45 to 51.3% of the sample area.

Although plant mass compositions play an important bioclimatic role in outdoor spaces, especially in hot climates that create a micro-climate due to evaporation, transpiration, and shading effects, they hinder the user from practicing their activities in them. Therefore, it is possible to work on prior studies for the urban development of the proposed residential areas where studied areas are allocated to plant mass compositions that allow the creation of microclimates that perform their bioclimatic function.

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Competing of Interests

The author(s) declare that they have no competing interests.

Endnotes

a. "Testo 480 · Climate Measuring Instrument-Instruction Manual." 2016.

b. http://climate.onebuilding.org/WMO_Region_1_Africa/DZA_Algeria/index.html#IDBS_Biskra-

c. https://www.meteoblue.com/en/weather/historyclimate/climatemodelled/biskra_algeria_2503826 (Consulted on April 26th, 2022).

d. https://weatherspark.com/y/148004/Average-Weather-at-Biskra-Airport-Algeria-Year-Round

e. https://www.google.com/maps/place/Biskra/@34.8554 517,5.7110171,153m

REFERENCES

1. Givoni, B. "Impact of Planted Areas on Urban Environmental Quality: A Review." *Atmospheric Environment. Part B, Urban Atmosphere* 25, no. 3 (1991): 289–99. https://doi.org/10.1016/0957-1272(91)90001-U.
2. Bernatzky, A. "Tree Ecology and Preservation." Amsterdam: Elsevier Science, 2014. http://qut.eblib.com.au/patron/FullRecord.aspx?p=1179996.
3. Rowntree, Rowan A. "Ecology of the Urban Forest-Introduction to Part II." *Urban Ecology* 9, no. 3–4 (1986): 229–43. https://doi.org/10.1016/0304-4009(86)90002-1.
4. Rowntree, Rowan A. "Ecology of the Urban Forest-Introduction to Part II." *Urban Ecology* 9, no. 3–4 (1986): 229–43. https://doi.org/10.1016/0304-4009(86)90002-1.
5. Vailshery, L. S., Jaganmohan, M. and Nagendra, H. "Ecology of the Urban Forest-Introduction to Part II." *Urban Ecology* 9, no. 3–4 (1986): 229–43. https://doi.org/10.1016/0304-4009(86)90002-1.
6. STEWART, H., OWEN, S., DONOVAN, R., MACKENZIE, R., FOWLER, S. & FOWLER,D. "Trees &sustainable Urban Air Quality." *The Forests Handbook,…*, 2008. http://onlinelibrary.wiley.com/doi/10.1002/9780470757062.ch13/summary.
7. Lin, Bau Show, and Yann Jou Lin. "Cooling Effect of Shade Trees with Different Characteristics in a Subtropical Urban Park." *HortScience* 45, no. 1 (2010): 83–86. https://doi.org/10.21273/hortsci.45.1.83.
8. Akbari, H., S. Davis, S. Dorsano, J. Huang, and S. Winnett. "A Guidebook On Tree Planting And Light - ColoredSurfacing," 1992, 264.
9. Brown, Robert & D, Robert. *Design with Microclimate (The Secret to Comfortable Outdoor Space)*. ISLAND PRE. NW, Washington: ISLAND PRESS, 2010. https://www.researchgate.net/publication/236026459_Design_with_Microclimate_The_Secret_to_Comfortable_Outdoor_Space.
10. Shashua-Bar, Limor, David Pearlmutter, and Evyatar Erell. "The Cooling Efficiency of Urban Landscape Strategies in a Hot Dry Climate." *Landscape and Urban Planning* 92, no. 3–4 (2009): 179–86. https://doi.org/10.1016/j.landurbplan.2009.04.005.
11. Lehmann, Iris, Juliane Mathey, Stefanie Rößler, Anne Bräuer, and Valeri Goldberg. "Urban Vegetation Structure Types as a Methodological Approach for Identifying Ecosystem Services - Application to the Analysis of Micro-Climatic Effects." *Ecological Indicators* 42 (2014): 58–72. https://doi.org/10.1016/j.ecolind.2014.02.036.
12. Abreu-Harbich, Loyde Vieira de, Lucila Chebel Labaki, and Andreas Matzarakis. "Effect of Tree Planting Design and Tree Species on Human Thermal Comfort in the Tropics." *Landscape and Urban Planning* 138 (2015): 99–109. https://doi.org/10.1016/j.landurbplan.2015.02.008.
13. Mills, G. *A Climate-Friendly Built Environment*. University college dublin. (2006).

14. Andrade, Henrique, and Rute Vieira. "A Climatic Study of an Urban Green Space: The Gulbenkian Park in Lisbon (Portugal)." *Finisterra* 42, no. 84 (2007). https://doi.org/10.18055/finis1420.

15. Mohd Fairuz Shahidan, Philip Jones. "Plant Canopy Planting Design in Modifying Urban Thermal Environment: Theory and Guidelines." In *25th Conference on Passive and Low Energy Architecture*, edited by PLEA, 10. Dublin: PLEA, 2008. https://www.researchgate.net/publication/220042607_Plant_Canopy_Planting_Design_in_Modifying_Urban_Thermal_Environment_Theory_and_Guidelines.

16. Akbari, Hashem, Dan M. Kurn, Sarah E. Bretz, and James W. Hanford. "Peak Power and Cooling Energy Savings of Shade Trees." *Energy and Buildings* 25, no. 2 (1997): 139–48. https://doi.org/10.1016/s0378-7788(96)01003-1.

17. Panagopoulos, T. "Using Microclimatic Lanscdape Design to Create Thermal Comfort and Energy Efficiency." *Actas Da 1ª Conferência Sobre Edifícios Eficientes,Universidade Do Algarve, 25 de Janeiro* 1s, no. June (2008): 1–4.

18. Boukhabla, Moufida, and Djamel Alkama. "Impact of Vegetation on Thermal Conditions Outside, Thermal Modeling of Urban Microclimate, Case Study: The Street of the Republic, Biskra." *Energy Procedia* 18 (2012): 73–84. https://doi.org/10.1016/j.egypro.2012.05.019.

19. Winbourne, Joy B., Taylor S. Jones, Sarah M. Garvey, Jamie L. Harrison, Liang Wang, Dan Li, Pamela H. Templer, and L. R. Hutyra. "Tree Transpiration and Urban Temperatures: Current Understanding, Implications, and Future Research Directions." *BioScience* 70, no. 7 (2020): 576–88. https://doi.org/10.1093/biosci/biaa055.

20. Ahriz, A, S Fezzai, and M A A Mady. "Predicting the Limits of the Oasis Effect as a Cooling Phenomenon in Hot Deserts." *Desert* 2 (2019): 255–66.

21. Direction des parcs et de la protection de la faune -Biskra-. (2017), " rapport de recensement des espaces verts."

22. Khisro, Wisam. "The Effect of Climate Change on the Vegetation Cover of the Mujib Nature Reserve – Dead Sea," 2013.

23. Yao, Jiawei, Feng Yang, Zhi Zhuang, Yuhan Shao, and Philip F. Yuan. "The Effect of Personal and Microclimatic Variables on Outdoor Thermal Comfort: A Field Study in a Cold Season in Lujiazui CBD, Shanghai." *Sustainable Cities and Society* 39, no. February (2018): 181–88. https://doi.org/10.1016/j.scs.2018.02.025.

24. Aljawabra, Faisal, and Marialena Nikolopoulou. "Influence of Hot Arid Climate on the Use of Outdoor Urban Spaces and Thermal Comfort: Do Cultural and Social Backgrounds Matter?" *Intelligent Buildings International* 2, no. 3 (2010): 198–217. https://doi.org/10.3763/inbi.2010.0046.

25. Kottek, Markus, Jürgen Grieser, Christoph Beck, Bruno Rudolf, and Franz Rubel. "World Map of the Köppen-Geiger Climate Classification Updated." *Meteorologische Zeitschrift* 15, no. 3 (2006): 259–63. https://doi.org/10.1127/0941-2948/2006/0130.

26. Lin, Jiawei, and Robert Brown. "Integrating Microclimate into Landscape Architecture for Outdoor Thermal Comfort: A Systematic Review." *Land* 10, no. 2 (2021): 196. https://doi.org/10.3390/land10020196.

27. Ahriz, Atef. *Outdoor Thermal Comfort: Concepts and Theories*. London: e-Kutub Ltd, 2018.

28. Baek, Yoon Jeong, Soo Kyung Hwang, Hyo Hyun Lee, Joonhee Park, Do Hee Kim, and Joo Young Lee. "Quantification of Thermal Insulation by Clothing Items and Analysis of Influencing Factors." *Journal of the Korean Society of Clothing and Textiles* 42, no. 1 (2018): 172–82. https://doi.org/10.5850/JKSCT.2018.42.1.172.

29. Baek, Yoon Jeong, Soo Kyung Hwang, Hyo Hyun Lee, Joonhee Park, Do Hee Kim, and Joo Young Lee. "Quantification of Thermal Insulation by Clothing Items and Analysis of Influencing Factors." *Journal of the Korean Society of Clothing and Textiles* 42, no. 1 (2018): 172–82. https://doi.org/10.5850/JKSCT.2018.42.1.172.

30. Enescu, Diana. "Models and Indicators to Assess Thermal Sensation under Steady-State and Transient Conditions." *Energies* 12, no. 5 (2019). https://doi.org/10.3390/en12050841.

31. Lim, C. L. (2020) 'Fundamental concepts of human thermoregulation and adaptation to heat: A review in the context of global warming', *International Journal of Environmental Research and Public Health*, 17(21), pp. 1–33. doi: 10.3390/ijerph17217795.

32. Hanna, Elizabeth G., and Peter W. Tait. "Limitations to Thermoregulation and Acclimatization Challenge Human Adaptation to Global Warming." *International Journal of Environmental Research and Public Health* 12, no. 7 (2015): 8034–74. https://doi.org/10.3390/ijerph120708034.

33. Chai, T., and R. R. Draxler. "Root Mean Square Error (RMSE) or Mean Absolute Error (MAE)? -Arguments against Avoiding RMSE in the Literature." *Geoscientific Model Development* 7, no. 3 (2014): 1247–50. https://doi.org/10.5194/gmd-7-1247-2014.

34. ASHRAE Technical Committee. *ASHRAE Handbook: Heating, Ventilating and Air-Conditioning Applications Inch-Pound Edition*, 2015.

35. Ekici, Can. "A Review of Thermal Comfort and Method of Using Fanger's PMV Equation." *5th International Symposium on Measurement, Analysis and Modelling of Human Functions, ISHF 2013*, no. January 2013 (2013): 61–64.

36. Dhaka, Shivraj, Jyotirmay Mathur, Gail Brager, and Anoop Honnekeri. "Assessment of Thermal Environmental Conditions and Quantification of Thermal Adaptation in Naturally Ventilated Buildings in Composite Climate of India." *Building and Environment* 86 (2015): 17–28. https://doi.org/10.1016/j.buildenv.2014.11.024.

37. Fang, Zhaosong, Xiwen Feng, and Zhang Lin. "Investigation of PMV Model for Evaluation of the Outdoor Thermal Comfort." *Procedia Engineering* 205, no. December (2017): 2457–62. https://doi.org/10.1016/j.proeng.2017.09.973.

38. Fanger, P. 0. "Assessment of Thermal Comfort." *British Journal of Industrial Medicine,* 84, no. 1 (1973): 1–6.

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