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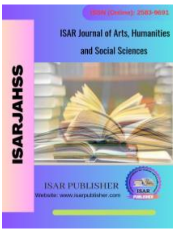

ISAR Journal of Arts, Humanities and Social Sciences
Abbriviate Tittle- ISAR J Arts Humanit Soc Sci
ISSN *(Online)*- 2583-9691
https://isarpublisher.com/journal/isarjahss

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Numerical simulation and optimization of outdoor thermal comfort in a public garden under hot and arid climate

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Article History
Received: 08.10.2023
Accepted: 15.10.2023
Published: 20.11.2023

Abstract: This article studies the phenomenon of partial exploitation of public gardens in the city of Biskra (Algeria), which is characterized by a hot and dry climate, where most of its inhabitants seek public places to sit, rest and relax to protect from heat especially in summer. The aim of the study is to investigate the problem of partial use of green spaces by users, and the effect of vegetated landscape choices. The study was based on a quantitative measurement of the effect of plant cover on thermal comfort in open spaces (public gardens) by carrying out a numerical simulation using the ENVI-met program "27 and 28 June" of the hottest months in Biskra, in Measurement of air temperature, relative humidity, wind speed, PMV, diffuse solar radiation and direct solar radiation; In addition to on-site experience during selected typical days in digital simulation; It measures the air temperature, the relative humidity and the wind speed were measured using an instrument (Testo 480), then the results were compared between the current situation of the garden and its proposed state of reforest its deserted areas, in order to create a favorable environment for full utilization. This research can give architects and landscapers a way to create public gardens, by controlling the percentage of their plant cover by choosing local trees, and plants that are resistant to climatic factors for their climate and by achieving thermal comfort.

Keywords: Thermal comfort; Public gardens; Arid regions; Numerical simulation; Vegetation.

1. INTRODUCTION

Public spaces have an effective role in improving the quality of life in cities, their use and frequency depend on the physical and climatic characteristics that guide, increase, modify or limit the degree of their exploitation (TEBBANI & BOUCHAHM, 2016). Public gardens in desert cities with a hot and arid climate are considered the lungs of the human body, as they have a positive impact on the environment and act as a thermal regulator of the citie's microclimate. The feeling of comfort and the quality of the place for the user are linked to the extent of the feeling of thermal comfort, Research has proven that climatic factors are among the most important factors contributing to achieving outdoor thermal comfort, and thus optimal use of space is achieved (NIKOLOPOULOU, BAKER, & STEEMERS, 2001). We chose among these places the public gardens of the desert city of Biskra (Algeria), by observation through our visit to all the public gardens of the city of Biskra (their number is five: according to the classification obtained by the management of conservation of the forests of Biskra city). When we visited the five gardens on different days and times, we noticed the phenomenon of certain areas being overcrowded with visitors, unlike other areas of the garden"November 1st" as it suffers from exploitation partial coverage of its spaces by its users, knowing that it suffers from a notable lack of plant cover.

The purpose of this study is to investigate whether the reason for the partial exploitation of the garden's public spaces by users in cities characterized by its hot and arid climate is: the absence and lack of vegetation cover in certain parts of the garden space. For this, we carried out a numerical simulation using the ENVI-met software to quantitatively measure the impact of the lack of vegetation on the external thermal comfort of a public garden to study the parameters to be simulated are the temperature of the air, relative humidity, wind speed, thermal comfort index PMV, diffuse solar radiation and direct solar radiation, simulation made of the data of the current state of the garden, and that of its proposed state, these two stages follow each other with a comparison between the two states and an in situ experiment to measure air temperature, relative humidity, and wind speedusing a measuring instrument called (testo 480). Finally will discuss the results and give specific recommendations.

1.1. The effect of revegetation on outdoor thermal comfort in public gardens in hot and arid climates:

The effect of greening on the outdoor comfort of public spaces has been addressed in many researches, studies have shown that trees represent a mask against the sun and the wind, as they control the temperature of the air and surrounding surfaces, the temperature difference varies with their density, shape, size and position (Boukhabla & Alkama , 2012),as green spaces and tree density

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reduce heat stress and create thermal comfort in the open air (Abdallah, Hussein, & Nayel, 2020), and in a study conducted in the city of Essen in the Netherlands demonstrated that urban green infrastructure consisting of trees resulted in the improvement of thermal comfort and the regulation of the microclimate, moreover by comparing the results of the measurements in the shaded and unshaded areas, they found that the maximum daily temperature differed by 2.5°C between the two areas, and physical factors (temperature, humidity and solar radiation) have been shown to be significantly affected by the presence and absence of trees (Wang, et al., 2015), as we also found that many studies that trees contribute to achieving the thermal quality of outdoor spaces, which helps to improve the outdoor microclimate and thermal comfort for humans (Atwa, Ibrahim, & Murata, 2020), it has been proven by simulations in many studies that trees contribute to modifying the local climate in summer, the vegetation cover including trees plays an effective role, in obtaining thermal comfort in hot areas and increasing coldness, especially on summer nights (Sayad & Alkama, 2021) In a study that aimed to find better solutions to improve thermal comfort levels in outdoor spaces in hot summers, it concluded that the optimal level of thermal comfort in outdoor spaces is improved through two solutions: increasing vegetation cover and increasing water surfaces (Sayad B. , et al., 2021), and other studies have confirmed that the proportion of trees and arboriculture (the number and shape of the tree) are parameters that have an impact on the percentage of shade in outdoor spaces (Ridha, Ginestet, & Lorente, 2018), et and in a study conducted in Iran, it confirmed that the frequency and use of public gardens in desert cities depends on obtaining outdoor thermal comfort through vegetation, where trees have helped increase coolness in summer, and have proven that trunk height relative to the ground has an effect on the airflow and contributes to lower radiation values, as well as the use of very white materials in the sidewalks and the planting of broad-topped trees in public gardens contribute to achieving the thermal comfort required (Karimi, Sanaieian, Farhadi, & Maleki, 2020).

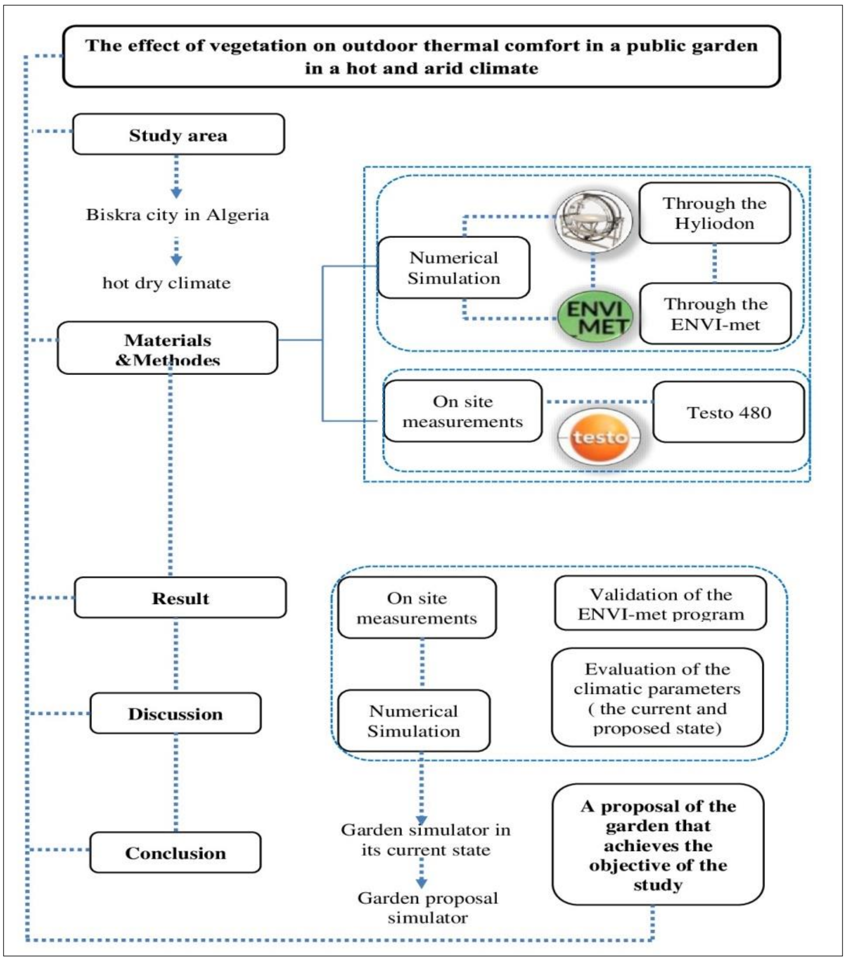


Fig.1. The study's conceptual framework

2. Materials & Methods

The study sample is a public garden among the largest gardens in the city of Biskra: a city characterized by its hot and arid climate located on its western shore; it was established in 1972, with an area of 29 691 m^2, it is a place of leisure and entertainment for families in this city, in the first years of its establishment, it underwent several transformations such as the introduction of forest plants, the establishment of a nursery but due to the neglect of its maintenance foradministrative reasons, it has lost much of its plant richness which has led to the degradation of its plant cover and the disappearance of existing infrastructure.

Fig. 2. (a) Geographical location of Biskra city, Algeria,
(Source : http://www.cder.dz › IMG › pdf › Atlas_solaire). (b) : administrative division, of Biskra city, Source: https://commons.wikimedia.org/wiki/File:DZ-07_Biskra.svg?uselang=fr. (c) Aerial view of the garden,. (Source: Google earth 2022)

2.1. Climate analysis of the public garden:

According to the meteorological data of the city of Biskra during the summer period, it appears that the month of July is the hottest and the driest, characterized by average daily temperatures equal to 34.7°C and peaks exceeding 40°C, and a large daily thermal amplitude of around 18°C, as well as an average relative humidity of 25%, with low wind speeds that are sometimes calm, as well as a very long period of sunshine compared to others months (Boukhabla M. , 2015).Faced with this situation of discomfort, the need for sun protection is essential with the use of shaded surfaces, and cooling by humidification of the air.

2.2. Choice of garden:

2.2.1. Current state of the garden:

Fig. 3. The location of the garden in the city of Biskra(Algeria)

Fig. 4.The entrance to the garden is directly exposed to the sun

Fig.5.Children's play area

Fig. 6.existing vegetation cover(40%)and the water body (8%).	Fig. 7. the vegetation cover (the absence of shaded areas)

3. Results

3.1. Numerical simulation

3.1.1. Simulation through the Hyliodon

In the first part of the simulation and to arrive at a proposal for a garden layout providing thermal comfort to its users, we proposed and sized climatic pergolas of wood and palm trees at the heights studied (Table1), by calculating the length and height of pergolas using a Hyliodon device (Fig.9)which is used to simulate the location and intensity of the sun during the year to determine the length of the shade of the designed pergolas(Fig. 8).

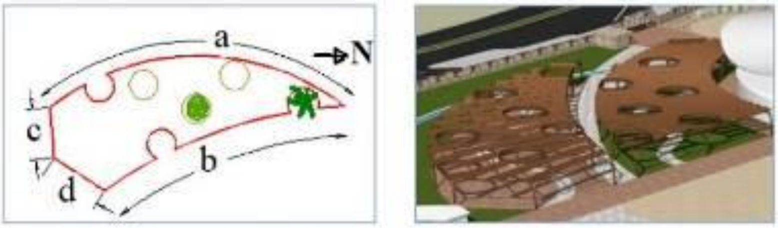


Fig. 8. 2D design for pergola

Fig. 9. The device used: Hyliodon

Hyliodon is used to calculate the shadow length projected by the pergolas in relation to the different heights proposed, the orientation of the sun's rays is chosen according to a specific location, in Biskra (latitude 34.50°), we chose the period of the first simulation done with envi-met which is the month of June, we used hours: On (27,28/06/2022) at (8:00, 14:00, 16:00, 18:00, 20:00, 22:00, 00:00, 4:00 , 8:00), the continuity of the work is based on the construction of the 03 proposed study models of the pergolas, we observed the path of the light that presents the shadows (take pictures on different shaded places) (Table1).

Table 1 : Simulation using Hyliodon

Hours	Pergola height	Shadow length	Application
8:00	6 m	14 m	
12:00	6 m	6 m	

14:00	6 m	12 m	
16:00	6 m	20 m	
18:00	6 m	62	

3.1.2 Simulation through ENVI-met

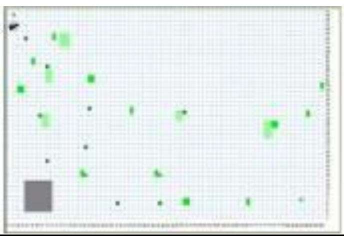
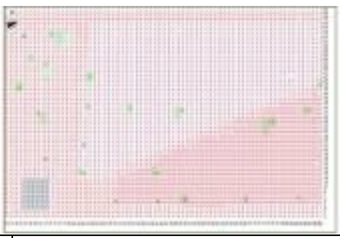
ENVI-met was used to simulate the thermal comfort strategies, we performed a numerical simulation to quantify the effect of the lack of plant cover on the outdoor thermal comfort of the public garden to be studied, where the simulation was made by doing data on the current state of the garden and the proposed state, then comparing the two cases.

Table 2: Software input parameters

Location of the city of Biskra Longitude: 5.6 EST. Latitude: 34.5 NORD. Altitude: 120 m….	
Type of Climate ……………………..……….	Hot and aride in summer
Simulation day (typical summer day)……….	On 27/06/2022 and 28/06/2022
Duration of the Simulation…………………..…	Start of the day: 8:00 a.m (27/06/2022). To 8:00 a.m (28/06/2022)
The area to be simulated…………..……………	See Figure 9.
Air speed……………………………….……….	2.1 m/s at 10 m above ground
Prevailing wind direction……………..….…..	South-East in summer and North-West in winter
Indoor temperature[K]………………………..…	293 (20°C)
Thermal conductance of walls………………..…	0.379 [W/m²K]
Thermal conductance of roofs…………………..	1.94 [W/m²K]
Albedo of the walls……………………….………..	0.2
roof albedo………………………………..…..	0.3

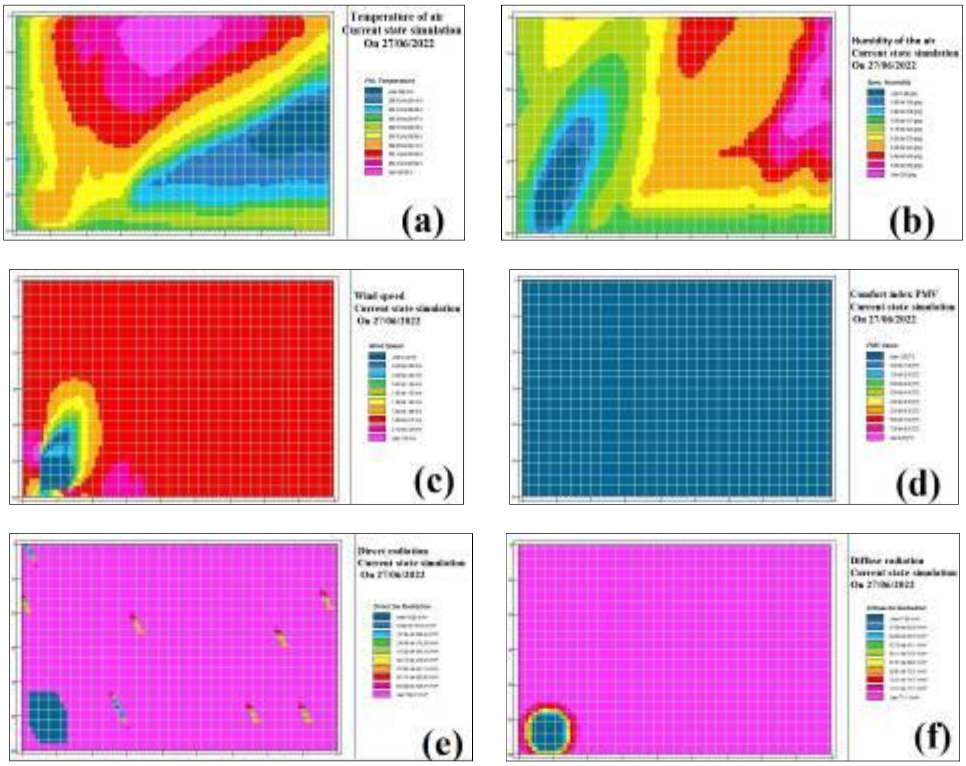
- **Simulation scenarios**

Table 3 : Detailed framework of all scenarios and full descriptions of each process.

First scenario : Curent situation	
	
File:Construction/vegetation editor.Source : envit-met	**File:** Floor editor. Source : Envit-met.

Model of simulation results in Envi-met program : **Current state simulation**

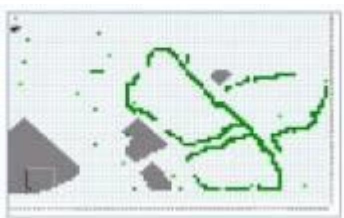
(a) Air temperature(°C), (b) Relative Humidity (%), (c) Wind Speed(m/s), (d) PMV Comfort Index, (e) Direct Radiation (W/m²), (f) Diffuse Radiation (W/m²)



Second scenario : Proposed state

The proposed state of the park

Construction/vegetation and soil editor. Source: Envit-met



Fichier :Construction/vegetation editor. Source: Envit-met

Fichier : Soil editor. Source: Envit-met.

Model of simulation results in 2D Envi-met program (a) Air temperature(°C) (b) Relative Humidity (%)

(c) Wind Speed(m/s) (d) Direct Radiation (W/m²) (e) Diffuse Radiation (W/m²)

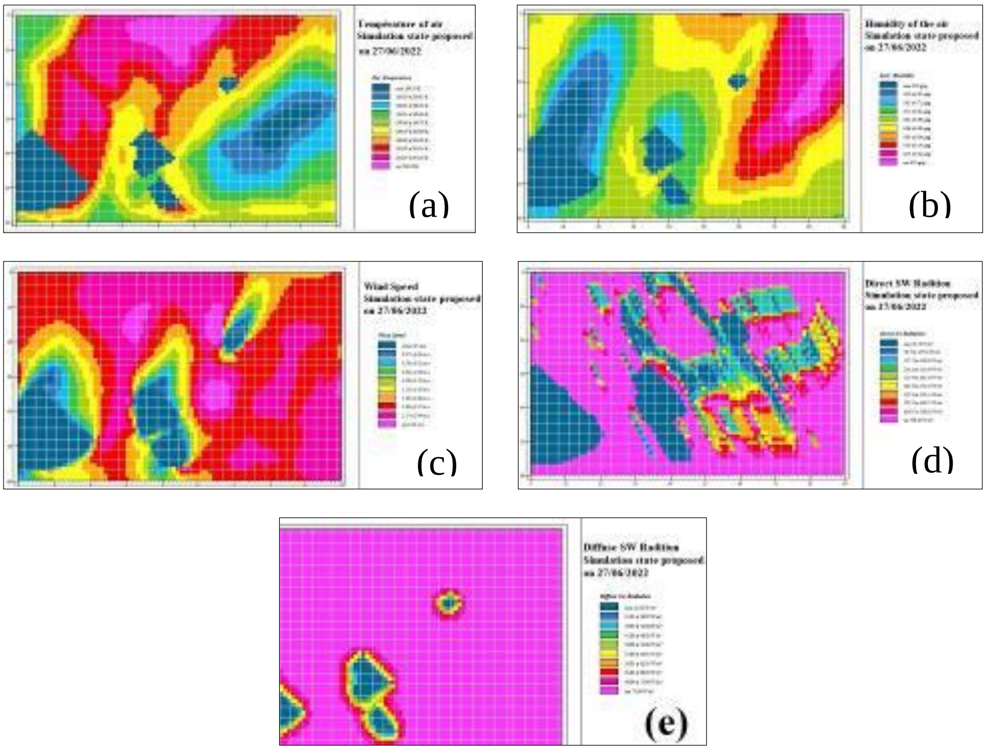


Table 4: PMVScale thermal (Wimalarathne., Perera., & Emmanuel., 2018).

PMV	Value
-3.5 Very Cold	
-2.5Cold	
-1.5 Cool	
-0.5 Slightly cool	
0	Comfortable
+0.5Slightly warm	
+1.5	Warm
+2.5Hot	
+3.5	Very hot

Table 5: Calculate climate parameters **(current state)**

thermal comfort Factors **Hours**	**8:00**	**14:00**	**16:00**	**18:00**	**20:00**	**22:00**	**00:00**	**04:00**	**08:00**
Air temperature (°C)	36.9	42.31	42.24	40.90	37.94	37.02	36.10	35.88	36.83
Relative Humidity (%)	18	16	20	19	26	27	26.24	27.13	23.18
Wind Speed(m/s)	2.45	2.2	2.00	2.10	2.30	1.9	1.8	1.9	2.00
PMV Comfort Index	2	2	2	2	2	2	2	2	2
Direct Radiation (W/m²)	709.37	927.32	843.30	590.16	/	/	/	/	709.55
Diffuse Radiation (W/m²)	61.50	97.22	81.275	45.62	70.25	/	/	/	61.34

Table 6: Calculate climate parameters **(Proposed state)**

thermal comfort Factors / **Hours**	**8:00**	**14:00**	**16:00**	**18:00**	**20:00**	**22:00**	**00:00**	**04:00**	**08:00**
Air temperature (°C)	30.08	35.52	34.99	32.78	30.54	28.89	27.01	25.73	27.87
Relative Humidity (%)	25.60	20.57	27.26	29.90	33.27	34.11	35.02	35.84	31.35
Wind Speed(m/s)	0.27	0.27	0.95	1.25	0.28	0.3	0.3	0.85	0.9
PMV Comfort Index	0	0	0	0	0	0	0	0	0
Direct Radiation (W/m²)	578.76	701.29	696.13	489.93	/	/	/	/	376.67
Diffuse Radiation (W/m²)	31.83	51.10	70.20	40.74	/	/	/	/	30.52

3.2. In-Situ Measurements

Two measurement stations were selected, the first (ST01) located in the wooded part of the garden (the density of vegetation is average), and the second (ST02) in the arid part (where the density of vegetation is very low). It was measured using Testo 480 (Fig. 10) over a daily period of (27/06/2022 and 28/06/2022), selecting peak times when temperature values go from high to low or vice versa poured.

Fig. 10. Measurement instruments: Testo 480-AG 5011ST

Table 7: In si-tu experiment using a meas ring instrument called (Testo 480)

thermal comfort Factors / **Hours**	**8:00**	**14:00**	**16:00**	**18:00**	**20:00**	**22:00**	**00:00**	**04:00**	**08:00**
(a) Station 01(In the wooded area) (b) Aerial view of the garden,									
Air temperature (°C)	32.10	37.51	36.05	34.59	33.44	31.04	29.14	28.24	31.46
Relative Humidity (%)	24.59	19.67	26.36	28.80	32.17	32.89	33.45	34.01	29.08
Wind Speed (m/s)	0.9	0.5	1.2	1.6	0.5	0.5	0.4	0.5	0.6
Station 02(In the unwooded area)									
Air temperature (°C)	37.02	43.10	43.23	40.90	38.95	36.64	36.01	36.09	36.95
Relative Humidity (%)	18.90	16.55	20.50	19.95	26.29	26.88	27.11	28.33	24.22
Wind Speed (m/s)	2.42	2.10	1.95	2.00	2.10	2.00	1.9	1.9	2.10

4. Results

4.1. In-Situ Measurements

Using a measuring tool (Testo 480), we measured the thermal parameters (temperatures, relative humidity and wind speed) on the site where two measuring stations were chosen in the garden, the first station in wooded area and the second in an arid area without trees directly exposed to the sun and all climatic factors, This field measurement was carried out to study the effect of afforestation of garden spaces on thermal comfort in a hot and arid climate and to validate the results of the simulation scenarios (Table 7).

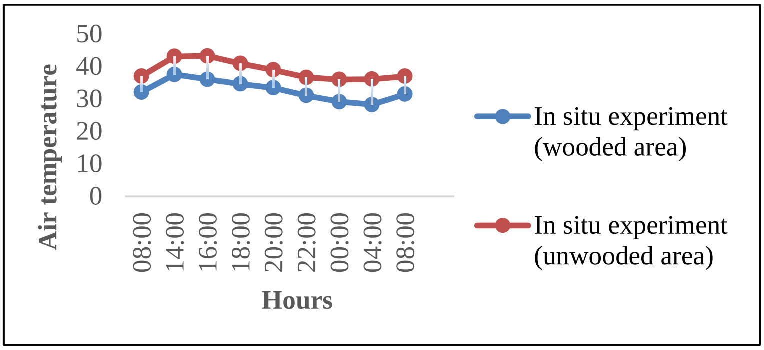


Fig. 11. Air temperature (°C) on-site measurement using (Testo 480))

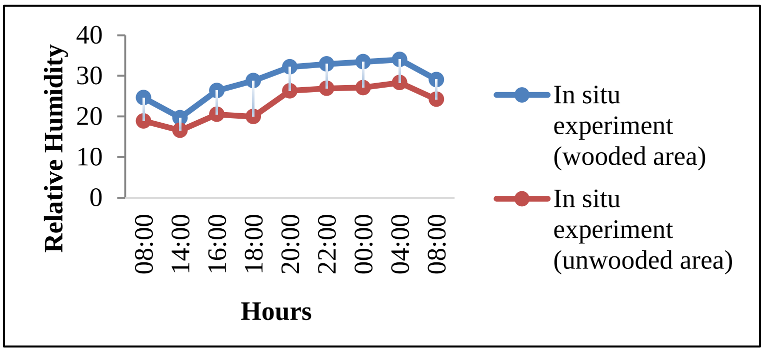


Fig. 12. Relative Humidity (%)) on-site measurement using (Testo 480))

4.2. Validation of the ENVI-met program

Simulations help in understanding and analyzing climatic parameters over a relatively large area such as gardens and squares(Koc, Osmond, & Peters, 2018).

In order to validate the ENVI-met model, we chose the climatic parameters (air temperatures and relative humidity) as a criterion for comparing the simulation results and measurement values at the site using the digital device (Testo 480), in the park the simulation values in its current state were almost identical to the values measured in Station 02 (the part of the garden is not wooded), where the difference in temperature ranged from: (0.12-0.79)°C.

When comparing the simulation values in the garden proposal with the measurement results in station 01 (the wooded part of thegarden), we found that the results are close with a decrease in temperatures for the simulation results for the garden proposal, which proves the efficiency of the ENVI-met simulation program in proving the success of the garden proposal idea.

As for the relative humidity values, they are almost identical to the simulation results of the garden in its current condition with the measurement results of the device (Testo 480) with the measurement values in station 02 (the part of the garden is not wooded), and it is the same for the simulation and measurement results of the device in station 01 (the wooded part of the garden), from this comparison it can be concluded that the simulation model by Envi-met is suitable for the current study (Fig. 13) and (Fig. 14).

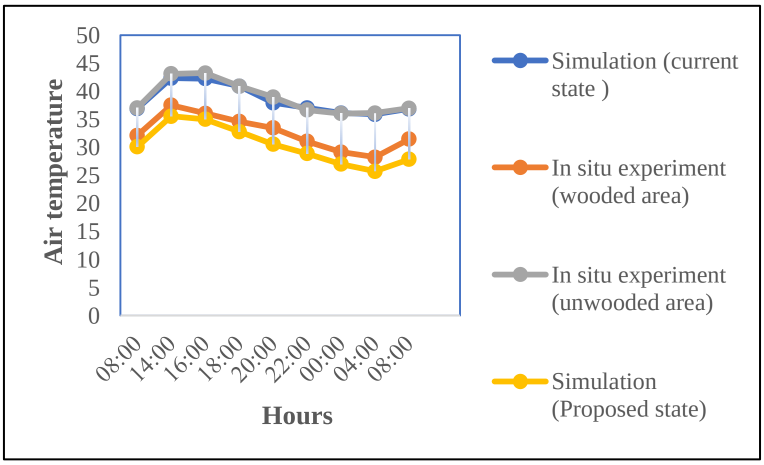


Fig. 13. Air temperature (°C)(Simulation values with (ENVI-met program) and on-site measurement using (Testo 480))

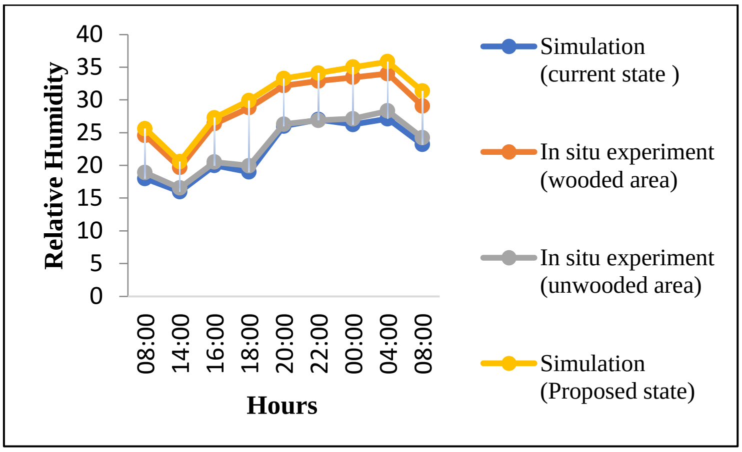


Fig. 14. Relative Humidity (%): Simulation values with (ENVI-met program) and on-site measurement using (Testo 480)

4.3. Evaluation of the climatic parameters to be calculated between the current and proposed state

• **Scenario 1:** (Current state of the garden)

Aims to measure the current thermal comfort level in sunny summer days, it simulates the current garden, including the existing vegetation cover(40%) and the water body (8%).

• **Scenario 2:** (Optimal proposition)

It aims to measure the level of thermal comfort on sunny summer days, and it simulates the proposed situation, including vegetation cover (80%) and water surface (15%), where different types of pergolas were used in places exposed to weather factors to increase the shaded areas. Thoughtful selection and distribution of the plant improves the external thermal comfort (increasing shading helps in the intensity of use and exploitation of all garden spaces).

The simulation results in the garden proposal showed that there was a decrease in temperature and a rise in relative humidity after increasing the density of vegetation (palm trees, Ficus trees, Ash trees, Myoporum trees, and Bougainvillea climbers).

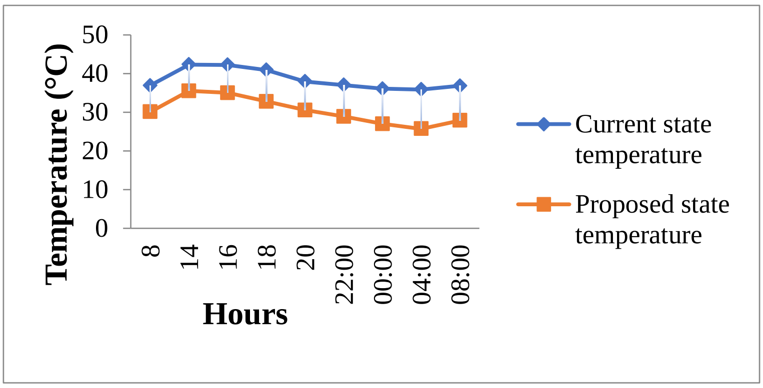


Fig. 15. Air temperature (°C) Current state and Proposed state

The air temperature curves (Tai), during the critical summer day and considering two states: current and proposed (Fig. 15).

We can say that the outdoor air temperature Tai is reduced for the proposed state. A significant difference between (7.28 and 10.15)°C introduced by type vegetation: (palm trees, Ficus type trees, Ash type trees, Myoporum tree, and Climbing vegetation (Exp: Bougainvillea) and shade, indeed , the proposed facilities offer greater comfort than that offered by the current state. We note that the effect of vegetation for this garden has maintained thermally improved outdoor environments.

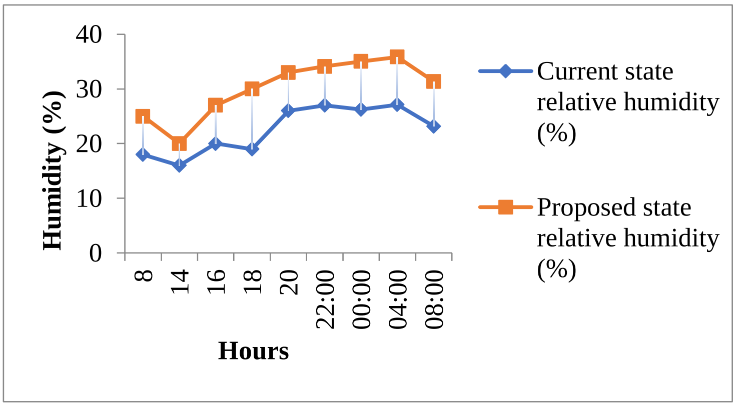


Fig. 16. Relative Humidity Current and Proposed State (%)

The results obtained from the air humidity of the current state are varied between (16, 18, 19, 20, 23, 26 and 27)%, this value is low compared to the recommended humidity range, after the intervention we notice that the values of the humidity of the air are of the order of (20,25,27,30,31,33,34,35, and 36)%, we note a improvement of the relative humidity values in the garden in its state before preparation and between the proposal to prepare it with a difference ranging from (4 to 9)%(Fig. 16).

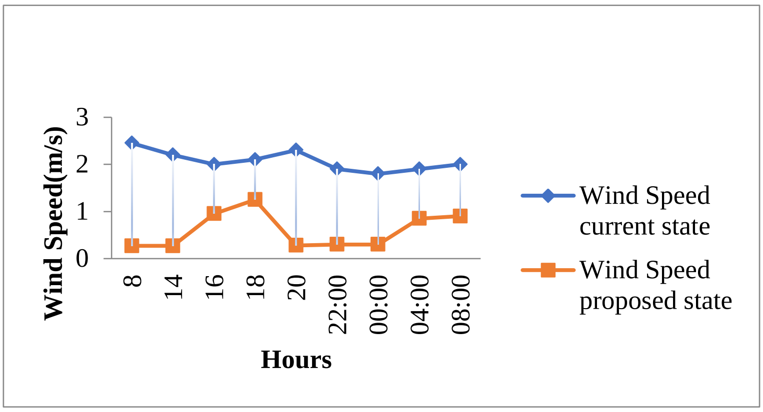


Fig. 17. Wind Speed current and proposed state

We notice that the simulated results of the wind Speed values of the proposed state are of the order of (0.27, 0.28, 0.30, 0.85, 0.90, 0.95, and 1.25) m/s, these values are lower by 1.10 m/s, which can be explained by: The proposed simulated zone is sheltered from the prevailing winds, with a difference of 1.10 for the air movement between the current state and the proposed state of the studied garden (Fig. 17).

The values obtained thanks to the simulation after the intervention are of the order of (590.16, 709.37,709.55, 843.30, and 927.32)W/m² compared to the results obtained before the intervention (376.67.489 .93, 578.76 W/m^2, 696.13 W/m^2 and 701.29)W/m^2, note that the difference between the two results is more significant since it is an estimated difference of (213.49 to 226.03)W/m^2,the improvement in the level of direct solar radiation is notable compared to the initial case (Fig. 18).

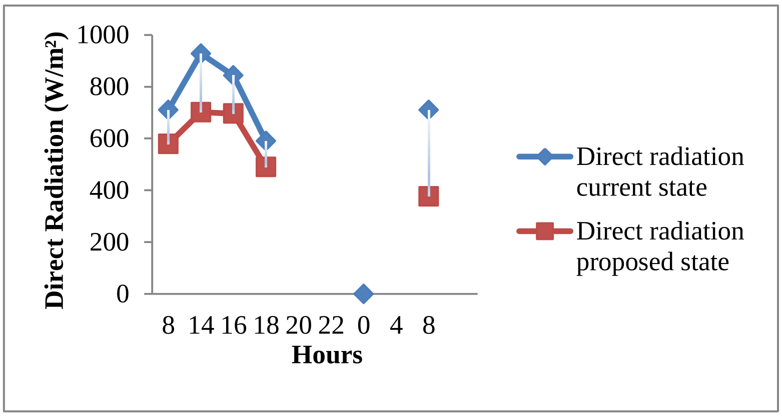


Fig. 18. Direct radiation current and proposed state (W/m²)

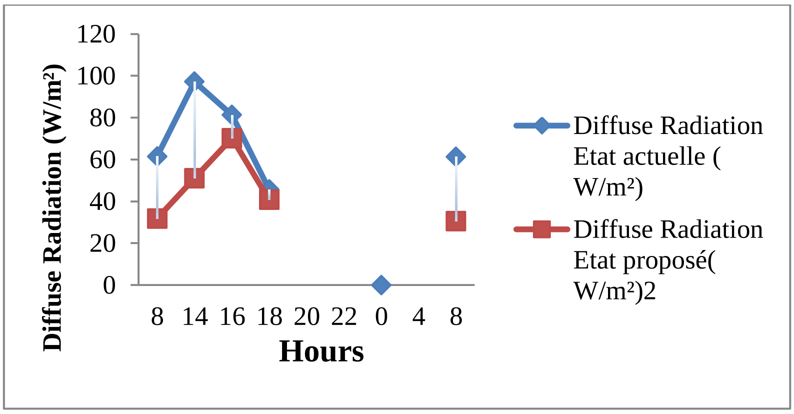


Fig. 19. Diffuse radiation Current and Proposed state (W/m²)

The diffuse radiation values obtained by simulation after the intervention are of the order of (30.52, 31.83, 40.74, 51.10, 70.20) W/m², compared to the diffuse radiation values for the initial state of the garden (45.62, 61.34, 61.50, 70.25, 81.28 and 97.22) W/m² was less dense with a difference of (15.10 to 27.02) W/m² (Fig. 19).

4.4. Plant elements

- **Types of vegetation adapted to the arid and semi-arid region**

The lack of vegetation cover contributes to the rise in temperatures (Elbondira, Tokimatsu, Asawa, & Ibrahim, 2021), the selected plants are natural elements such as: palm, trees, climbing plants, shrubs, lawn, and grass, in general the plants must be chosen from a list of local species, to improve outdoor comfort in the public garden, in order to respect the quality of the landscape and avoid its becoming commonplace.

- **The distribution of vegetation cover for a proposal state in the garden**

The distribution of the proposed plant cover is chosen according to the orientation of the garden spaces and for protection against the sun and against the prevailing wind.

- **North and North-West Zone:** Planted deciduous type leaf trees to capture the cold winds. Examples: Palm trees, Ash trees, Ficus trees, Myoporum trees, and Climbing vegetation.

- **North-East Zone:** Palm trees, Ficus trees, Antanier shrubs (flowers)

- **South Zone:** Planted myoporum trees, Palm trees, Ash trees and Ficus trees, with:

Myoporum trees (H= 4m-6m), Palm trees (H=2m-infiniti), Ash trees (H=10m-40m), Lantana trees (H= 0.5m-2m) (Fig. 20) (CRSTRA arides, 2014).

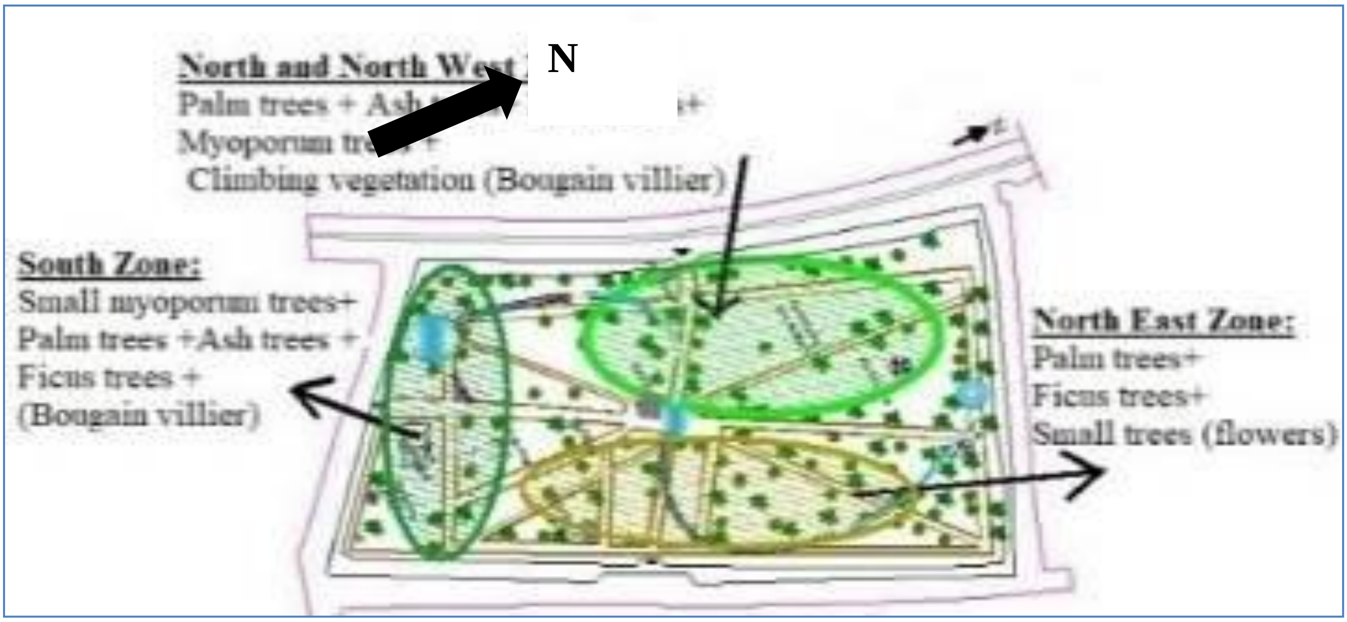


Figure 20. Types of vegetation adapted to the arid and semi-arid region

5. Discussion

In desert cities, outdoor thermal comfort is the most important factor on which the frequency and operation of gardens depends (Karimi, Sanaieian, Farhadi, & Maleki, 2020), Its users seek comfort and shade.

In this study, two integrated approaches were used, the numerical simulation approach using the ENVI-met program and the Hyliodon device, and the experimental method by in situ measurement using the Testo480 device.

The first part of the study was carried out by numerical simulation and was divided into two scenarios:

- **The first scenario** simulates the garden in its current situation, considering the percentage of vegetation cover of 40% and the percentage of water surface of 5%.The results proved the lack of thermal comfort in the garden according to (table 4), where the values of (PMV=2) and the average temperature between (35.88 to 42.31)°C, which are high values compared to compared to the optimal values obtained for certain researchers (Alain Liébard & André , 2006).

Prior to the completion of the garden proposal, unforested areas, walkways and spaces between unshaded trees were identified, along with a proposal for the design of umbrellas based on the dimensions of areas exposed to direct sunlight such as walkways and between trees and in areas where the shade changes, such as children's play areas.

- **The second scenario** simulates the garden proposal in which by adding 40% of the designed ground cover and shades and 10% of the water surface, the results improved, so that the values of (PMV = 0) were included in the thermal comfort zone (Wimalarathne., Perera., & Emmanuel., 2018). The temperature also decreased on average by (6.79 to 10.15)°C, which indicates that the climatic criteria are improved after increasing the percentage of ground cover and shaded areas, where the Hyliodon apparatus was used to select suitable pergolas by measuring the appropriate shade length for each area.

In the second part of the study, measurements were taken from the site by measuring and comparing climatic parameters (temperatures, relative humidity values and wind speed) in two different areas of the garden, a wooded area and an arid area using the Testo480 device The simulation results for the garden in its current state and the measurement results in the forested area were close to the simulation results for the garden proposal These results confirmed the accuracy and the correct choice of the ENVI-met simulation program.

This study proved that the vegetation cover has a significant impact on the thermal comfort in public gardens, which controls the increase and decrease in the frequency of visitors to public gardens and their use of all its spaces, and the increase in the plant cover improves thermal comfort in public gardens in a hot and dry climate.

6. Conclusion

In this paper, the effect of vegetation cover on the external thermal comfort of a public garden is studied, located in a semi-desert city characterized by a hot and dry climate in summer (Biskra, Algeria), and it suffers from partial exploitation of its spaces by visitors, and as expected in our hypothesis, the main cause of this problem It is the lack of thermal comfort in all areas of the garden, and the research methodology combined the experimental modeling approach using the Testo480 device and the digital simulation using the ENVI-met program and the Hyliodon device, where the measurement results ranged in the site in the wooded area between (28.24 to 37.51°C) and in the non-forested area from (36.01 to 43.23°C before Any intervention, which confirms that the percentage of vegetation cover has a significant impact on temperatures. The on-site measurement also confirmed the validity and accuracy of the simulation that was applied to the garden plan in its original state and to its proposed scheme after the intervention. The simulation results for the garden in its current state were (35.88 to 42.31) °C, and the simulation results for the proposal to prepare the garden were (25.73 to 35.52)°C, which shows the results of the significant decrease in temperatures after preparing the garden with a difference of (7.71 to 10.28) °C, the intervention from our side was concerned Gearing arid areas that need shading and adding some pergolas in the corridors and between trees in order to increase the shaded areas. Simulations can support finding appropriate solutions to improve the external thermal comfort in gardens in general, and this study also helps and supports garden designers, architects and landscape designers, to choose the appropriate configuration: from vegetative coverage and how to increase shading for outdoor spaces in gardens, thus increasing and regulating the proportion of Exploitation by users, especially in dry and hot climates, where residents need such spaces.

This study dealt with investigating the effect of vegetation cover and increasing the percentage of shading on thermal comfort in gardens located in hot and dry climates, and it can be used as a reference for future studies with adding or changing variables such as studying the effect of water or the effect of changing the floor covering, etc.).

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