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Impact of Urban Green Spaces on Outdoor Thermal Comfort and Psychological Behavior of Users during the Hottest Period in Biskra City

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Abstarct

The vegetation constitutes a crucial element, which influences on several levels such as the aspect the esthetics and the attractiveness of the spaces, the indoor and outdoor thermal comfort as well as the psychological aspect of users. Green spaces are considered places of relaxation and leisure, which represent the lungs of the city by creating a microclimate suitable for users. The dominance of concrete in the city has caused problems through the significant reduction of the surface of green spaces, which directly influences the outdoor thermal and psychological behavior of persons. The objective of this research is to study the influence of green spaces on the outdoor thermal and psychological comfort of users during the hottest period in Biskra city (Algeria). The investigation was based on an empirical approach, a quantitative method by taking measurements with a "Testo 865" thermal camera as well as a qualitative study by observation and interview with users using human biometeorological indices such as the Physiologically Equivalent Temperature "PET", the Thermal Perception "TP" and the Physiological Stress "PS". The results confirm the importance of urban green spaces and their positive impact on the assurance of outdoor thermal comfort, and the good behavior of users and demonstrate the major role of vegetation despite the difficult climatic conditions of the city of Biskra. For this purpose, the use of trees is recommended, in particular the "Ficus" type, because of its proven physical and psychological benefits for people.

Key words: Green spaces, Hot areas, Psychological behavior, Thermal comfort, User satisfaction.

INTRODUCTION

The vegetation is considered the source of life where its integration in the interior or exterior area makes the space lively and attractive. It is a vital element, which plays a very important role in the life of human beings in all aspects. A journey through history allows us to understand the importance of green spaces in different civilizations and eras (Benmechiche et al. 2021).

The absence of vegetation in urban spaces generates the problem of the urban heat island and considerably increases the heat stress of users (Wong et al. 2021). The urban green spaces are the only place that attracts the inhabitants of the city, especially during the summer period given its characteristics and the high density of the trees, which offer more shade and minimize the outdoor temperatures. It is significantly considered an area for relaxation, discussion, and leisure for all categories in the city (children and adults).

The public green spaces are the most prominent zones of urban life that play a key role in integrating different segments of society and in developing the perception of the city (Cekmeceli and Erdönmez2018; Chen et al. 2021).In terms of environmental protection and the reduction of the urban heat island effect, several researchers consider that improving the external thermal conditions of users in urban spaces also influences climate change, which is one of the most important issues in the world (Vukmirovic et al. 2019; Sadeghi and Bahadori 2021).This makes the need for the development of research on this subject in different types of climates in the world in order to ensure the objectives sought in a manner appropriate to the climatic specificities of each region.

Urban Heat Island Effect

The rapid development of the city has created several problems of a physical and psychological nature. Among these problems the Urban Heat Island effect "UHI".Is defined as metropolitan areas having higher air and surface temperatures than their surrounding countryside (Francesco et al. 2016;Parsaee et al. 2019).

Figure 1 presents the factors of urban heat island effect and the impact of vegetation developed by Wong et al.(2021). The factors that contribute to the urban heat island effect, highlighting significant changes in heat and air flow when rural land is urbanized. The red boxes represent (urban space) warming mechanisms, while the blue boxes (green space) represent cooling mechanisms and its advantages.

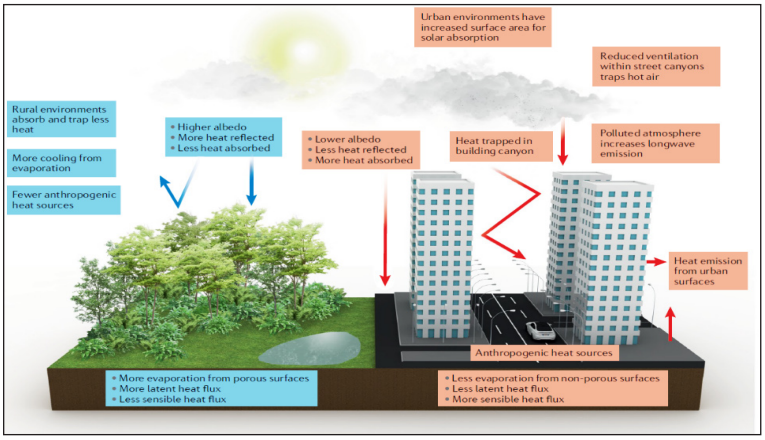

Figure 1. Factors of urban heat island and the role of vegetation (Source: Wong et al. 2021)

In the literature, several researchers confirm that the external thermal comfort of the human and user behavior being is strongly linked to the urban context and the presence of vegetation (Cohen et al. 2013; Charalampopouloset al. 2017; Santos Nouri et al. 2018).The changes air and surface temperature during the day and night depending on the urban or rural area and the presence of vegetation are illustrated in figure 2.

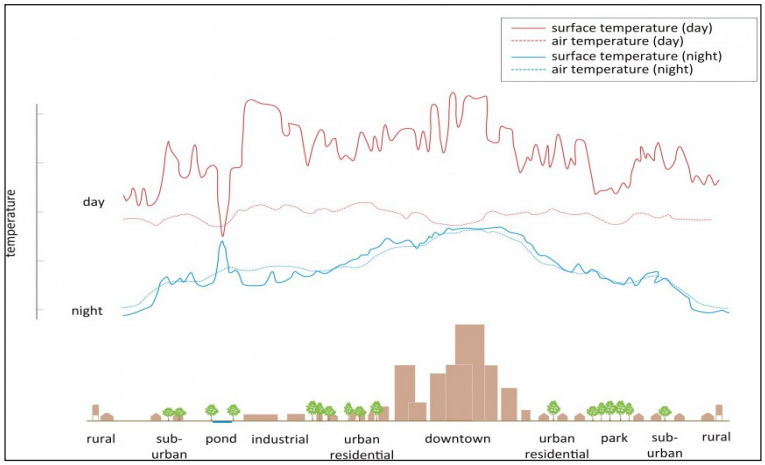

Figure 2. The changes air and surface temperature during the day and night in the urban and natural context (Source: www.mynasadata.larc.nasa.gov)

This image depicts a line graph illustrating how surface temperature values vary depending on whether the area urban or rural. A typical urban heat island profile, with hotter air in densely populated areas and cooler air in rural areas is with more greenery coverage. Trees provide shade and help to keep surface and air temperatures cool in natural settings with vegetation. The study of the comfort of public spaces demonstrates that green spaces are very important areas not only in terms of the comfort of users but also in terms of the fight against climate change in order to achieve the objectives of sustainable development (Vukmirovic et al. 2019; Xin et al. 2020).Wong et al. (2021) carried out a study to assess the influence of vegetation as a strategy to mitigate outdoor temperatures and the effect of the urban heat island problem where they found that green spaces have a positive impact by reduction of surface temperature by 2 to 9°C.These values remain variable according to several criteria in relation to the type of climate and the design characteristics of urban green spaces.

Urban Green Spaces

Urban green spaces are any type of public or private open space in a city that is completely or mostly vegetated (Rakhshandehroo et al. 2017). The role of these spaces is to offer users physical and psychological comfort in order to avoid stress and give a feeling of satisfaction. The adequate design of urban green spaces must take into consideration several parameters. Figure 3 shows the clusters and indicators of public space comfort.

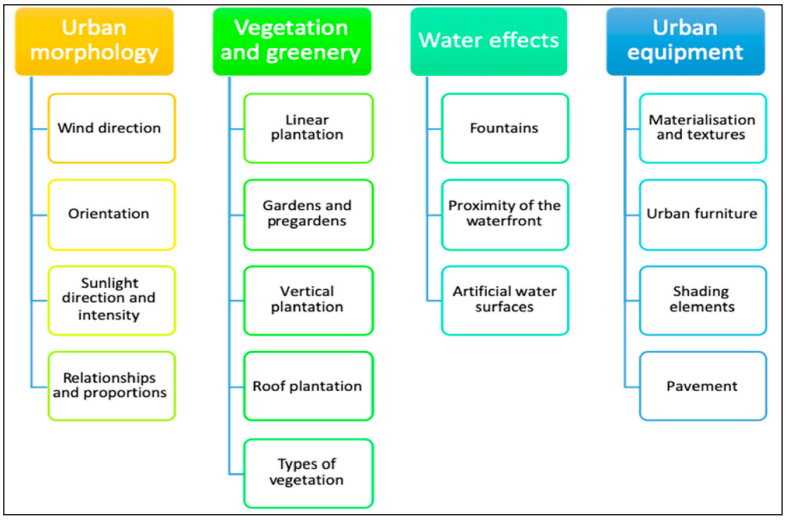

Figure 3. Clusters and indicators of public space comfort (Source: Vukmirovic et al. 2019)

The outdoor thermal comfort depends on multiple factors (urban morphology, water, equipment, vegetation and greenery) where vegetation plays a crucial role Vukmirovic et al. (2019)affirm that the exploitation of vegetation as an element of protection contributes to the assurance of physical comfort as well as directly affecting the psychological state of users and causing a feeling of satisfaction. The appropriate choice of vegetation and its characteristics (size, dimensions, resistance, growth, density) ensures the well-being of users and promotes the sensory experience (Nouri et al. 2017).

The density and characteristics of green spaces have a direct influence on the physical and psychological comfort of users (the state of outdoor thermal comfort and behavior). For these reasons, the design of green spaces must be carried out with reflection while taking into consideration several parameters (the dimensions, the climatic specificities of the region, the nature of the soil, the type of tree and its resistance).In this perspective, Sadeghi and Bahadori (2021) confirm that the outdoor thermal comfort depends on multiple physical factors of the environment, as well as climatic factors. The type of vegetation and the ratio between the circulation space and the green space directly influence the outdoor thermal comfort. The findings approve that the most important point in this type of study is the analysis of meteorological conditions and the thermal aspect of urban public spaces.

Wong et al. (2021) and Peng et al.(2021) see that studies are focused on temperature reduction through vegetation but future research should focus on understanding thermal comfort and user behavior. According to several researchers, users' sensitivity to stress will be reduced in urban green spaces (De Vrieset al. 2013; Yang et al. 2020; Chen et al. 2021). In this context and for all its reasons, the treatment of this theme in different cultures and regions is essential in order to study its influence on the behavior of people.

Outdoor Thermal Comfort and User Behavior

Thermal comfort is defined as a state of satisfaction with the thermal environment (Liébard and De Herde 2005). According to Morten (2010), thermal comfort is defined as a state in which there is no motivation urges to change the environment through behavior. Thermal comfort evaluation in the outdoor environment includes thermal sensation and comfort assessment (Xin et al. 2020).In this perspective, it is critical to understand that thermal comfort is defined as a mental state expressing satisfaction with the thermal environment (Tamura et al. 2016). According to another view,thermal comfort is defined as the absence of any discomfort or dissatisfaction, or when individuals do not feel cold or hot (Givoni et al.2003;Nikolopoulou et al. 2003).

In recent years, an increasing number of studies have used thermal comfort indices to assess the thermal state of users. Thermal comfort indices reflect the effects of both meteorological and human factors, such as activity and clothing level, it usually expressed in terms of equivalent temperature (Xin et al. 2020).The thermal sensation scale can be used to

indicate outdoor human thermal sensation under certain conditions. Thermal indices are now widely used in designing outdoor urban spaces by simulating residents' thermal perception (Pantavou et al. 2014). Thermal comfort indices are created as indicators of thermal sensation, stress, and comfort in a variety of microclimates (Pantavou et al. 2014). Figure 4 presents the six parameters influencing the thermal comfort of the human being and the Predicted Mean vote "PMV" index.

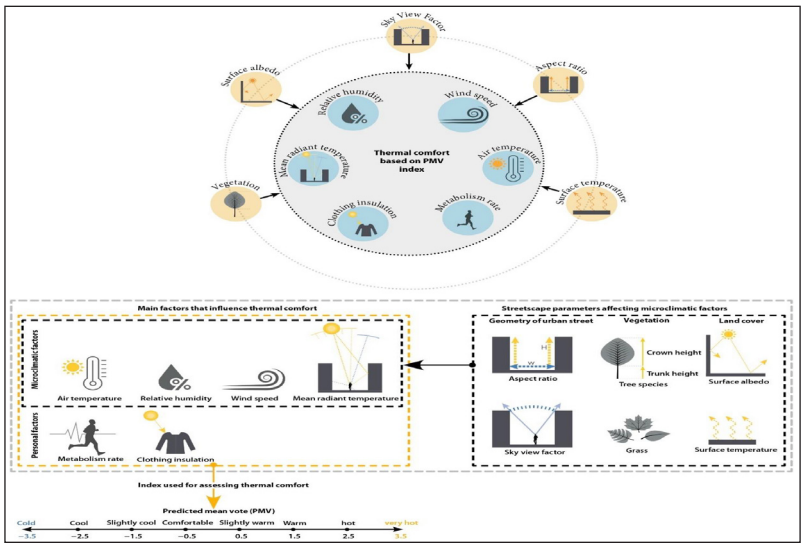

Figure 4. Relationship between microclimatic and "PMV" index parameters (Source: Sadeghi and Bahadori2021)

The comfort equation includes four microclimatic parameters among its six parameters, namely air temperature (Ta), mean radiant temperature (Tr), relative humidity (Rh), and wind speed (V), which influence heat transfer to or from the body. The metabolic rate and clothing insulation are two other parameters.

The most used indices are the Predicted Mean Vote "PMV", Physiologically Equivalent Temperature "PET", Standard Effective Temperature "SET" and Universal Thermal Climate Index "UTCI" (Kántor et al. 2012; De Freitaset al. 2017; Xin et al. 2020; Peng et al. 2021). These indices are based on the heat-balance model, linking physical environmental variables to physiological responses of individuals (De Freitaset al. 2017; Binarti et al. 2020; Peng et al. 2021). Kilnarová (2017) carried out a study on the quality of public spaces using the observation technique and the data evaluation. There is a possibility to carry out studies on urban spaces using this research technique.

According to the work of the literature review, the most effective way to assess the impact of the environment on the user from the thermal point of view is the use of thermal indices centered on the balance sheet of the body of the human being (Pantavou et al. 2014; Santos Nouri et al. 2018). Recently, the Physiologically Equivalent Temperature "PET" is the method most used by researchers. Figure 5 presents a schema descriptive of the Physiologically Equivalent Temperature "PET" and the internationally accepted threshold values for different levels of Physiological Stress "PS".

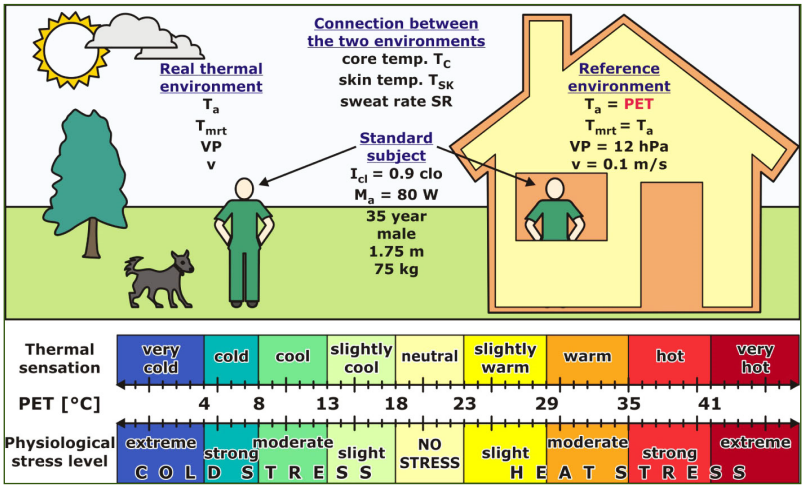

Figure 5. Schema descriptive the "PET" and the internationally accepted threshold values for different levels of Physiological Stress "PS" (Source: Kántor et al. 2016)

The theme of the environment and its impact on physical and psychological comfort continues to capture research in this area (Chen et al. 2021; Peng et al. 2021).For this reason, it is essential to carry out in-depth studies in each region according to the climatic characteristics and the needs of the users in order to ensure the objectives assigned to urban green spaces on people and the environment.

MATERIALS AND METHODS

This study is composed of two parts using two complementary approaches by a quantitative empirical study (physical study) through measurement as well as a qualitative study (psychological study) by observation and interview. The objective is the evaluation of the influence of urban green spaces located in hot climates on the outdoor thermal comfort and the psychological behavior of people during the hottest period. The case study of this research is the public garden "July 05, 1962or el Baylek garden" of the city of Biskra in Algeria.

Study Area

Study area of this research is the cities with hot and arid climate and more precisely the climatic context of the city of Biskra. The city of Biskra(the desert gate) is located in center East of Algeria at a latitude of34°48' North, a longitude of 5°44' East and an altitude of 86 meters.Figure 6 presents a geographical map of Algeria and the location of the city of Biskra.

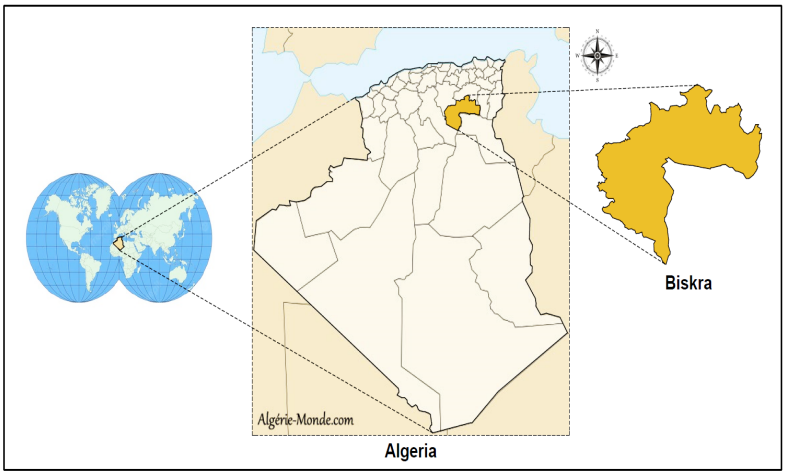

Figure 6. The geographical location of Biskra (Source: www.algerie-monde com, treated by authors 2022)

Biskra is classified among the hot and arid zones with large daily thermal amplitudes. Figure 7 describes the meteorological characteristics of Biskra generated by Meteonorm software (V7).

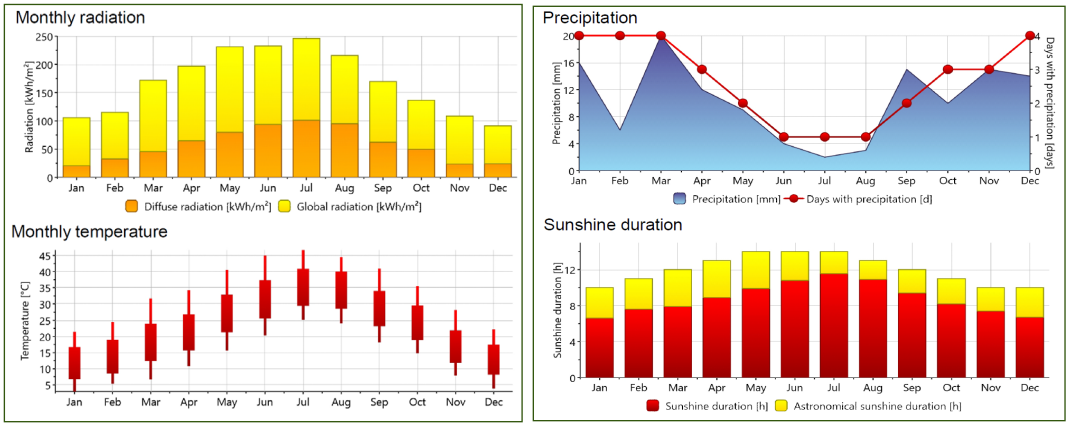

Figure 7. The meteorological characteristics of Biskra(Source: www.meteonorm.com)

According to meteorological data from the Biskra weather station, the annual average temperature is 22.5°C, with monthly average temperatures reaching up to 35°C in July and maximum temperatures exceeding 45°C.Regarding the monthly radiation, throughout the year, radiation levels are high, especially in the summer, when it exceed 240 KWh/m^2 of global radiation. This city is characterized by a sunshine duration that exceeds 12 hours and very low precipitation, which does not exceed 2 mm during the hottest period.

Case Study

The city of Biskra has several green spaces. The case study in this research is the public garden "July 5, 1962" also known "JenaneBaylek" according to the appellation of the citizens of the city. This choice is based on several criteria such as the location in the center of the city, accessibility to the public of all categories, the largest surface area compared to other public gardens and the type of tree used (Ficus). Figure 8 presents the map of the city of Biskra with the location of large green spaces and the case study with classification according to surface.

The public garden "July 5, 1962", is the largest green space in Biskra with an area exceeding 4 hectares. According to the "plant Atlas of the Biskra area", this garden has a very varied dense plant cover that includes the Carob tree, Guitar wood, Ficus, Sycamore fig tree, Osage orange tree, White mulberry (Maaoui 2014).

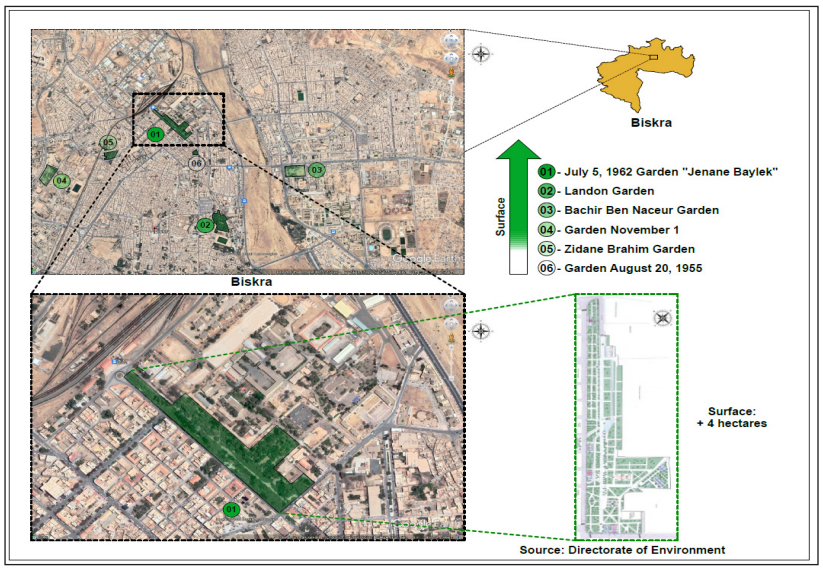

Figure 8. The map of the situation of green spaces and the case study in Biskra (Source: Google Earth and Directorate of Environment, treated by authors 2022)

Figure 9 presents photos of the study garden with its location and the shade cast by the trees.

Figure 9. Photos of the case studied and its location (Source: Authors 2021)

The high density of trees provides shade and protection for users against solar radiation. Figure 10illustrates a photo taken by a professional Canon camera with fisheye lenson the opening of the sky in the case study.

The opening of the sky in this garden varies according to the density of the vegetation with an average opening in the central circulation street and a weak opening in the places where there are benches. Overall, the spaces are shaded and protected against solar radiation.

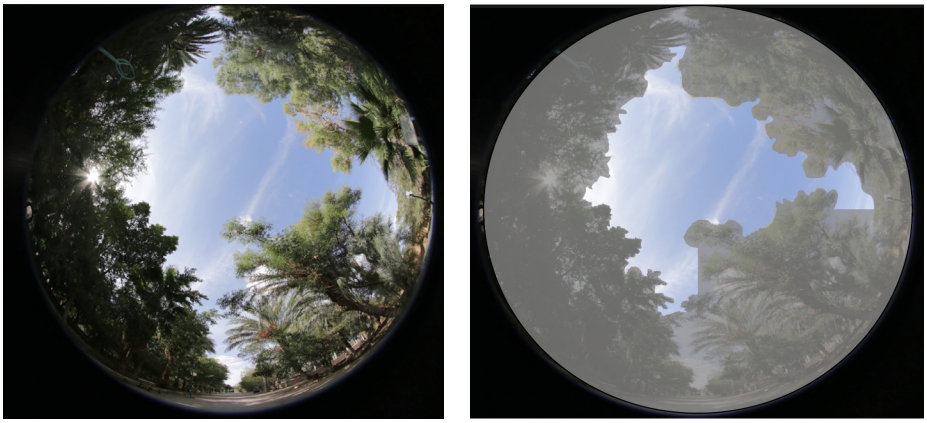

Figure 10. Photo on the opening of the sky in the case study (Source: Authors 2021)

Physical Study Protocol

The physical study through a quantitative approach consists of the development of field measurements with a thermal camera during a very hot representative day in in July 22, 2021 (the most unfavorable situation). The thermal photo measurements were taken under extreme conditions at 2 p.m. when the temperature and sunshine conditions reached extreme values. Figure 11 shows the measurement instrument used "Testo 865 Thermal Camera". The choice of the measurement location was made in two areas, pedestrian walking areas, and areas where there are benches (the places most used and frequented by users).

A thermal camera measures and records the various heat waves, or infrared radiation, emitted by a body or object. It generates an image that represents the intensity of the radiation, allowing the temperature to be calculated. The use of this method makes it possible to study the impact of vegetation and the shade cast by trees on the surface temperatures of objects, which gives an idea of the thermal comfort of users.

Figure 11. The measuring instrument "Testo 865 Thermal Camera"(Source: Authors 2021)

The thermal images obtained were processed (by the software TestoIRSoft V4.8) in order to plot the temperature histograms.

Psychological Study

The psychological study by a qualitative approach consists in the use of the observation technique on the ground and the interview with the users with a detailed protocol for each method. The interview gives the opportunity to study the behavior of users of green spaces (choice of location of benches in the garden, activities, thermal gestures and physiological stress). The interview with the users (field survey) makes it possible to evaluate their thermal sensation and their satisfaction with the green spaces.

The observation was carried out for 3 days (July 18, 19 and 20, 2021) during the hours when there is a large flow of people (from 9 a.m. to 12 p.m. and from 3 p.m. to 7 p.m.).About the interview, the population targeted by this study is

garden users of all categories and age groups. The choice of interviewees (sampling) was carried out in several places in the garden (several different areas). The total number of people interviewed is 30 people. The conduct of the survey was carried out during the month of in July 21, 2021 (the hottest month in Biskra) from 3 p.m. in order to obtain precise momentary answers.

The Physiologically Equivalent Temperature "PET" method has recently become the method most used by researchers. For this reason, the human bio meteorological index used in this study is the Physiological Equivalent Temperature"PET",which is a thermal comfort metric based on the energy balance of the human body. For more detail, the meteorological parameters and three popular thermal comfort indices were used to develop thermal sensation evaluation, Physiologically Equivalent Temperature "PET", Thermal Perception "TP" and Physiological Stress "PS". Table 1 presents the various ranges of the Physiologically Equivalent Temperature "PET" for different grades of Thermal Perception "TP" and Physiological Stress "PS" in human beings.

Table 1. The various ranges of the Physiologically Equivalent Temperature "PET" for different grades of Thermal Perception "TP" and Physiological Stress "PS" in human beings (Source: Santos Nouri et al. 2018)

Physiologically Equivalent Temperature (PET)	Thermal Perception (TP)	Physiological Stress (PS)
<4 °C	Very Cold	Extreme Cold Stress
4-8	Cold	Strong Cold Stress
8-13	Cool	Moderate Cold Stress
13-18	Slightly Cool	Slight Cold Stress
18-23	Comfortable	No Thermal Stress
23-29	Slightly Warm	Slight Heat Stress
29-35	Warm	Moderate Heat Stress
35-41	Hot	Strong Heat Stress
>41°C	Very Hot	Extreme Heat Stress

The questions asked to the users on the feeling and the satisfaction concerning the outdoor thermal comfort and the influence of the vegetation and the urban green spaces. The questions asked are of closed type (response with a scale) for more precision and reliability of the results using the "Likert scale". The results obtained were processed in the form of diagrams and tables.

RESULTS AND DISCUSSION

The results obtained in this study are divided into two parts according to the quantitative and qualitative aspects (physical and psychological comfort).

Physical Study Results

The results obtained by the quantitative field study using of the thermal camera during the hottest period (the month of July and more precisely on July 22, 2021) are shown in figures 12 and 13.The software TestoIRSoft (V4.8) was used to plot the temperature histograms to determine accurate temperature values (maximum, minimum and average).Figure 12 presents results obtained in the central pedestrian path in July 22, 2021.

The thermal images show that the surface temperatures are very high with an average surface temperature of 45.6 °C and a maximum value of 66.9 °C, which directly influences the outdoor temperature felt by users.

The temperature histograms that the highest percentage of each situation is varied between 40 and 45°C of the exposed surfaces, which gives an idea of the difficult conditions in hot and arid zones. On the other hand, the surface temperature range of the shaded areas is less and varied between 34.9 and 41 °C (a difference of 4 to 5.1°Cin the same area).The concrete in the circulation space has an excessive surface temperature, which considerably increases the air temperature and has a negative influence on the thermal comfort of users. On the other hand, the shaded surfaces have lower temperatures than the surfaces exposed under the influence of the shade of the trees. Figure 13 illustrates the results obtained in the seating areas where there are benches in July 22, 2021.

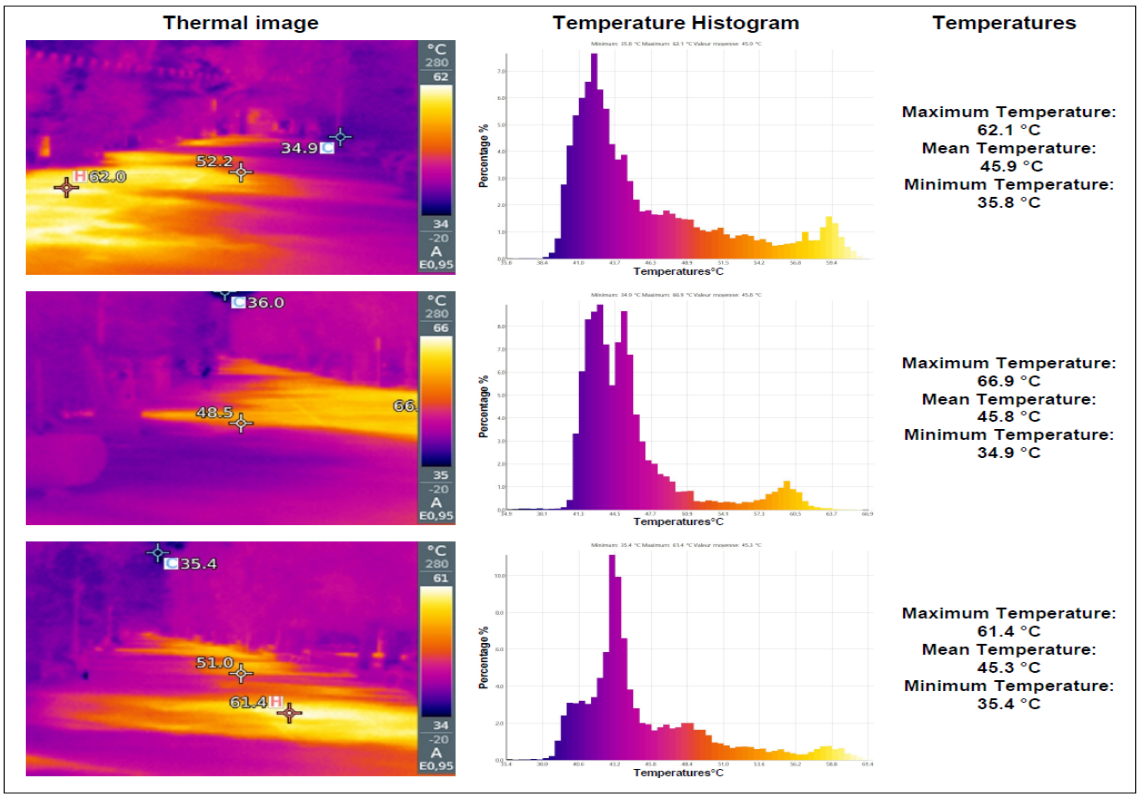

Figure 12. The results obtained in the central pedestrian path in July 22, 2021 (Source: Authors 2021)

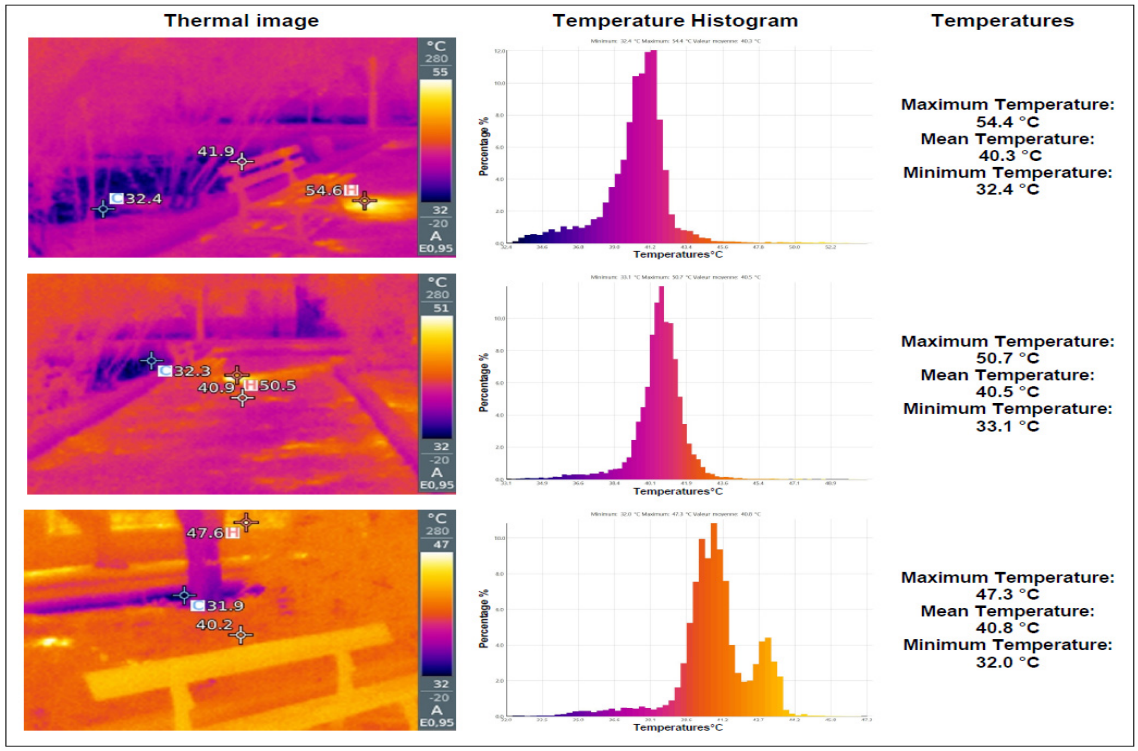

Figure 13. The results obtained in the seating areas where there are benches in July 22, 2021(Source: Authors 2021)

The thermal images indicate that the surface temperatures are lower in the shaded surfaces where there are banks with an average surface temperature of 40.5°C and a maximum value of 54.4°C. These conditions have a direct influence on the outdoor temperature in this zone and the comfort of users. The reading of the thermal images confirms that the

green spaces attenuate the surface temperatures in a considerable way, in this case with a value exceeding 12°C and an attenuation percentage exceeding 18% (depending on the location and the nature of the surface).

In the temperature histograms, the highest percentage is varied between 38 and 42 °C of the exposed surfaces, which indicates that the shading attenuates the surface temperature values. In addition to the low value of the minimum surface temperatures of the most shaded areas compared to the exposed surfaces, it is seen that the vegetated surfaces with water have lower surface temperatures varied between 31.9 and 32.4 °C, which explains the good influence of water in green spaces on the thermal comfort of users. The high density of trees increases the shade cast and reduces surface and air temperatures as well as protects people against solar radiation, which has a positive influence on the outdoor thermal comfort of users and their satisfaction. The presence of water surfaces in green spaces has a positive influence on the outdoor thermal comfort of users.

Psychological Study Results

The results obtained by the sociological study through interview and observation are shown in the figures and tables below. Table 2 presents the survey respondents' socio-demographics and physiological characteristics of the people interviewed.

Table 2. The survey respondents' socio-demographics and physiological characteristics (Source: Authors 2021)

Variable	Category	Number of people /30	Percentage
Sex	Female	08	26.7 %
	Male	22	73.3 %
Age	15 - 20	04	13.3
	20 - 30	07	23.3
	30 - 40	08	26.7
	40 - 50	06	20.0
	>50	05	16.7
Education	High school or secondary	09	30.0
	Licence	07	23.3
	Master	11	36.7
	Ph.D	03	10.0

Reading table 2 gives an idea of the socio-demographic and physiological characteristics of the people interviewed. The majority of visitors to this garden are men with a percentage of 73.3% compared to the sample studied. Concerning the age, the age category (from 20 to 40 years) represents 50 % of the people interviewed. With regard the education, the sample studied encompasses all categories.

Table 3 illustrates the ranges of the Physiologically Equivalent Temperature "PET" for different grades of Thermal Perception "TP" and Physiological Stress "PS" of the population studied.

Table 3. The various ranges of the Physiologically Equivalent Temperature "PET" for different grades of Thermal Perception "TP" and Physiological Stress "PS" of the population studied (Source: Authors 2021, Santos Nouri et al. 2018as a reference)

Physiologically Equivalent Temperature (PET)	Thermal Perception (TP)	Physiological Stress (PS)	Number of people interviewed/30	Percentage %
<4 °C	Very Cold	Extreme Cold Stress	Not applicable	Not applicable
4-8	Cold	Strong Cold Stress	Not applicable	Not applicable
8-13	Cool	Moderate Cold Stress	Not applicable	Not applicable
13-18	Slightly Cool	Slight Cold Stress	Not applicable	Not applicable
18-23	Comfortable	No Thermal Stress	00	00 %
23-29	Slightly Warm	Slight Heat Stress	02	6.7 %
29-35	Warm	Moderate Heat Stress	14	46.7 %
35-41	Hot	Strong Heat Stress	10	33.3 %
>41°C	Very Hot	Extreme Heat Stress	04	13.3 %

The majority of people interviewed (14 people with a percentage of 46.7 %) have a Thermal Perception (TP) "warm" which indicates their Physiological Stress (PS) "Moderate Heat Stress" and explains their acceptable thermal situation in the garden as well as the positive effect of vegetation on the attenuation of outdoor temperatures. Other people (10 people with a percentage of 33.3%) have a Thermal Perception (TP) "have a Thermal Perception (TP) "warm" which indicates their Physiological Stress (PS) "Strong Heat Stress" given the very difficult hot and arid areas and the subjectivity of comfort.

Figure 14 demonstrates the results obtained in the sociological survey with the use of the interview with users and a correlation between the Thermal Perception "TP" and the Physiological Stress "PS".

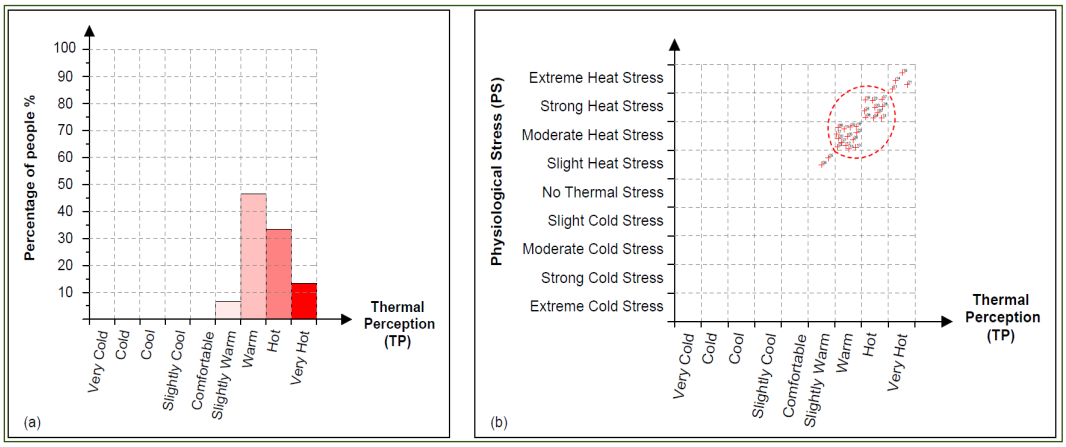

Figure 14. The results obtained in the interview and a correlation between the Thermal Perception "TP" and the Physiological Stress "PS" (Source: Authors 2021)

The first graph (a) represents the percentage of people and their Thermal Perception "TP" where most people with a percentage of 46.7 % expressed their thermal sensation as "warm" which confirms the positive impact of green spaces and vegetation on the environment's external thermal comfort of users according to the opinion of half of the people interviewed (approximately 50 %).A very low percentage expresses a feeling of "Slight Heat Stress" and "Extreme Heat Stress" which is logical because of the subjectivity of the notion of thermal comfort.

The graph (b) demonstrates a correlation between the Thermal Perception "TP" and the Physiological Stress "PS" where the average survey rating is between "warm" and "hot" but the majority of interviewees feel "warm" which explains their Physiological Stress "PS" by "Moderate Heat Stress" and indicates their satisfaction with the influence of green spaces on their state of outdoor thermal comfort.

Figure 15 illustrates the results obtained by the survey of the user overall satisfaction in the public garden studied in the form of a radar diagram.

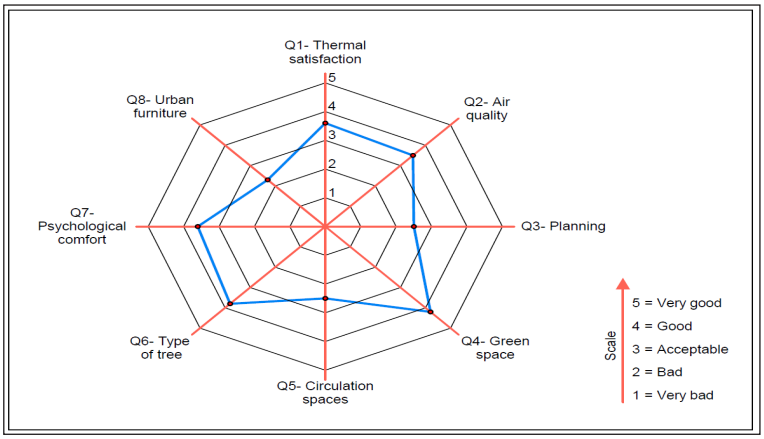

Figure 15. The radar diagram of the user's overall satisfaction in the public garden studied (Source: Authors 2021)

The overall reading of the radar diagram demonstrates the existence of two types of peaks, negative peaks explain user dissatisfaction (between bad and acceptable) and positive peaks confirm user satisfaction (between acceptable, good, and very good) according to each aspect studied (each question).In general, the users of the green public space studied are particularly satisfied with regard to the thermal aspect, the air quality, the quality of the green space, and the type of

trees as well as the positive impact of the green spaces on the psychological comfort of human beings and good behavior. On the other hand, they are dissatisfied with the planning and treatment of circulation spaces and in particular the number and quality of street furniture.

Another interview was carried out on trees with a tree specialist from the Center for Scientific and Technical Research on Arid Regions (CRSTRA) in Biskra and the publisher of the book «ATLAS: Ornamental plants of the Ziban» who confirmed that the type tree "Ficus" has strong resistance in hot climatic conditions like the city of Biskra.

The observation of the terrain gives an idea of the functioning of the green space studied and the behavior of users as well as their satisfaction. Regarding the use of space, the large flow of people is during the morning (from 9 a.m. to 12 p.m.) and the afternoon (from 3 p.m. to 7 p.m.).The first point noticed is the accessibility to the public space where people mainly use the main access to the garden. The second point is the choice of the place of sitting, where the users prefer the place with a great density of trees in order to protect themselves against solar radiation. A calm place with benches farthest from the space of central circulation, which is characterized by a large flow of circulation, which explains why users feel the comfort to the side the trees, and the shaded green spaces. During the period of watering the trees, users prefer the place where there is water, which explains the positive impact of water on the humidification of the place and the attenuation of outdoor temperatures.

Regarding the choice of benches, users prefer wooden benches to cement ones because of their thermal characteristics and the low surface temperature of wood compared to cement. With regard to thermal regulation gestures and the behavior of users, the field report proves that in certain situations, users change their places located at the side of the main circulation space made of concrete to find a more comfortable place because of the high temperature of the paving and the lack of shade in the benches in this part. In the same area and in some cases, people use an element (newspaper, paper, their hands, etc.) as a fan to create an air movement to dry the skin of the human being. On the other hand, these gestures are rare in well-shaded and protected spaces, which confirm that green spaces and vegetation contribute to improving the outdoor thermal comfort of users. Field observations confirm that good thermal conditions, green spaces and the integration of water in public spaces have a positive influence on the good behavior of garden users.

CONCLUSION

This article presents the main results obtained by a study based on a qualitative empirical approach by measurements taken in situ in a public garden, as well as a qualitative method by observation and an interview with users. The objective of this research is to study the impact of green spaces on outdoor thermal comfort and the psychological behavior of users in a hot and arid climate like the city of Biskra in Algeria. The quantitative (physical) and qualitative (psychological) in situ studies are complementary in order to better understand the subject, particularly the subjects that deal with the comfort of users and the subjective aspect.

The results of the physical study confirm that green spaces have a positive impact on the reduction of surface temperatures with a value exceeding 12°C (with a reduction percentage of more than 18%), which influences the reduction of air temperature and ensures the outdoor thermal comfort of users. The results obtained by the psychological study confirm that vegetation is the most important element in green spaces and in the city. The well-considered integration of trees ensures the protection of users against solar radiation and offers comfortable thermal conditions with a feeling of comfort for users as well as satisfaction, which directly influences their psychological state and the behavior of users.

The adequate choice of the type of tree according to the climatic specificities of the region as well as the density of the vegetation are two decisive points which directly influence the physical and psychological comfort of users in green spaces. The importance of the subject opens up several areas for future research such as the treatment of the acoustic aspect in urban green spaces.

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