Strategies to mitigate the urban heat island effect in Mediterranean promenades of France, Italy, and Albania

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Abstract
Cities are currently confronting with a variety of challenges stemming from climate conditions, urbanization, and urban planning, resulting in increasing social, health, and economic issues. This study specifically examines the Mediterranean coastline promenades in Albania, France, and Italy as a unique type of built environment. The aim of this study is to examine the influence of different cooling system scenarios on the thermal comfort experienced by pedestrians, while considering climate data. We generate multiple scenarios by analyzing ways to mitigate urban heat island (UHI) effects. These strategies include revitalizing promenades by replacing current pavements, utilizing water bodies and sprays, increasing the presence of artificial shade, considering the proper greenery, and implementing advanced cooling systems using smart technologies.

Keywords:

Mediterranean coastal promenades, urban heat islands, outdoor thermal comfort

1. Introduction

In recent decades, climate change, urbanization, urban structure, architecture, and urban planning have all had a significant impact on urban thermal comfort. Over the past few decades, developed nations have conducted extensive research on climate change, urban heat islands (UHI), and cooling systems in the built environment (M. Giorio, 2023). Urban areas are currently grappling with a wide range of difficulties stemming from climate conditions, urbanization, and urban planning, resulting in rising social, health, and economic concerns. Distinct urban features have a direct impact on the microclimate of outdoor areas, as well as the general climate of the city. The Intergovernmental Panel on Climate Change (IPCC) reports that the average global temperature has increased by around 1.1°C since the late 19th century, with the recent decades having the most dramatic increase in temperature (Change, 2021). The Climate Pulse interactive web application, which is developed and maintained by the Copernicus Climate Change Service (C3S), allows users to observe the variations in daily surface air temperature from the past to today, as shown in Figure 1. Urban areas have a direct impact, not only on the microclimate of outdoor spaces, but also on the overall climate of the city. Particularly in urban settings, microclimates naturally form and can exist on various scales. This study will primarily focus on the micro-scale, based on Oke's climatic scale classification (Oke, 1987), specifically in relation to urban-level readings. Oke defines the space encompassing buildings, streets, trees, squares, and parks as the urban canopy layer (UCL), which extends from the ground to the top of buildings. Within this layer, the microclimate varies depending on the region's environmental conditions. Figure 2 displays a drawing of the UCL study's urban size.

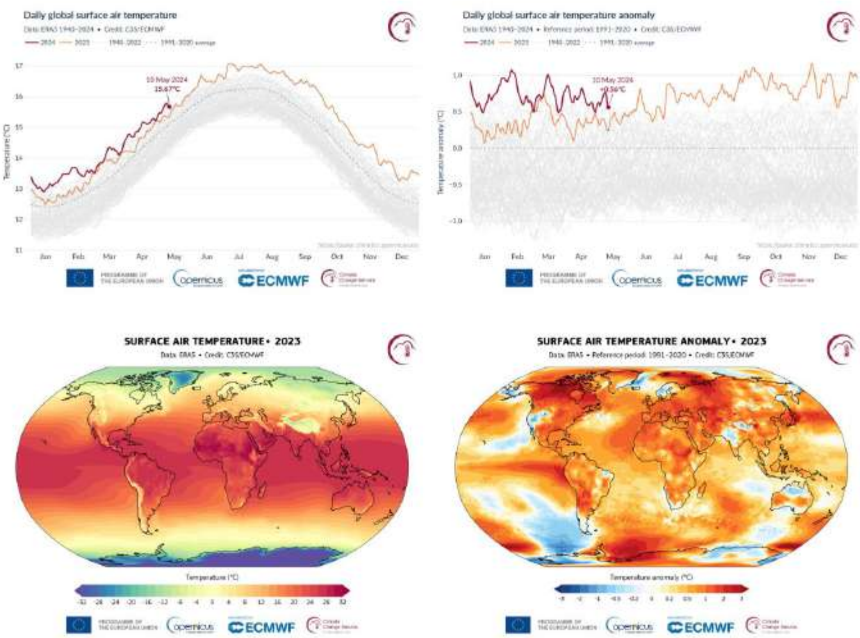

Figure 1 Daily global surface air temperature and anomaly rate **(Copernicus, 2024)**

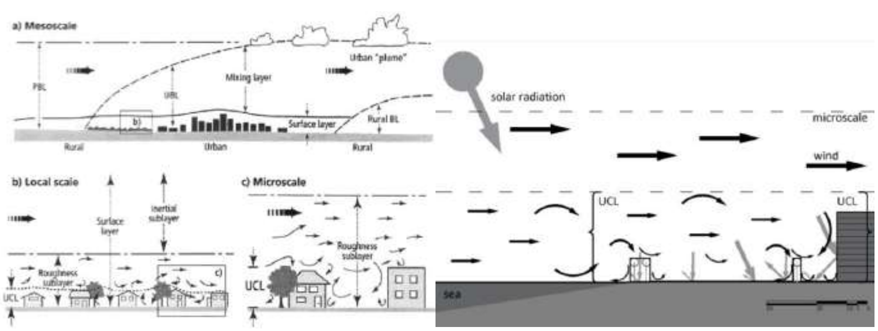

Figure 2 Climate Scale in urban areas, according to Oke 1987 (lef); The urban scale in the study (right) (source: author)

The presence of urban water bodies has a significant impact on lowering air temperatures by up to 6 °C in their vicinity, particularly in the summer months. This effect yields comparable outcomes to the situation observed in the microclimate parks (Grant, 2016, p. 76). As a result, in coastal cities, particularly in the sections of the promenade along the coast, the sea breeze plays a significant role in shaping the microclimate. (Fig. 2.1-2). Nevertheless, we observe that the sea breeze effect occurs in the late evening hours.

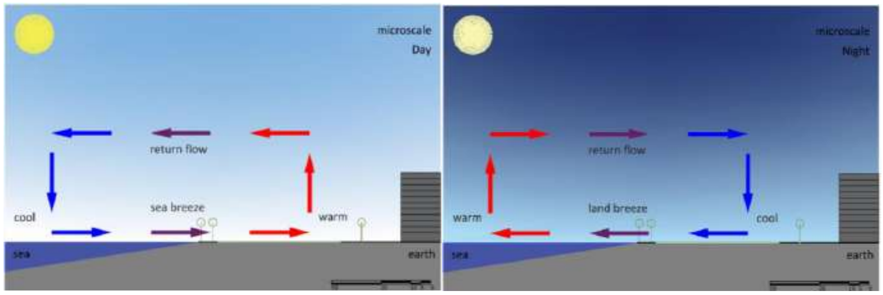

Figure 3 Sea breeze (left), Land breeze (right) (source: the author)

This study will exclusively focus on outdoor thermal comfort, which is described as "the psychological state that reflects satisfaction with the thermal conditions" (ASHRAE, 2005). Thermal comfort significantly affects the usability and livability of a space (Nikopoulou, M., Beker, N., Steemer, K., 2001). The livability of a space is determined by users themselves, taking into account their identity and how often they utilize the space. A livable place refers to an area that is accessible to pedestrians and is used at any time of the day or year. What makes a space attractive to a pedestrian or resident then? While functionality and design are undoubtedly crucial, it is equally necessary to prioritize user comfort. In the preface of the book "Cities for People" by Jan Gehl, Richard Rogers asserts that a well-planned city, with thoughtfully built streets, squares, and parks, brings enjoyment to both tourists and residents who live, work, and engage in recreational activities there on a daily basis (Gehl, 2010). Aside from its functionality and aesthetics, it is crucial that you experience a sense of comfort while standing or walking in it.

Research on urban thermal comfort is predominantly undertaken in developed countries and to a lesser extent in underdeveloped ones. These studies typically focus on analyzing public spaces in urban areas, with a specific emphasis on a single factor. This study, on the other hand, specifically examines the Mediterranean coastline promenades in Albania, France, and Italy as a unique type of constructed environment. The aim of this study is to examine the effect of different cooling systems on thermal comfort at the street level, while considering climate data. This study initially highlights the issues that arise from an analytical examination of the promenades in six cities located in the Mediterranean basin. The research specifically focuses on doing field measurements and computer simulations of one case study, namely the promenades in Durres. These case studies are notable for their Mediterranean climate according to the Köppen-Geiger climate classification (M. Kottek, 2006). Subsequently, we create scenarios using computer simulation, taking into account the intricate specifics of the built environment. Subsequently, we assess the outcomes by considering the degree of urban thermal comfort. The study aims to find out the impact of physical elements in the built environment on the improvement of urban thermal comfort, while also considering climatic aspects. When evaluating the level of urban thermal comfort, especially in coastal promenades, it is essential to evaluate both the physical and climatic factors together, as they are interconnected. The study will examine the impact of urban design and architecture on the thermal comfort of pedestrians in urban areas. Furthermore, this methodology can serve as a fundamental approach not just for promenades in Albania, but also for all public spaces, including promenades and squares, in the Mediterranean basin and other regions with different climate conditions. It is important assess thermal comfort in promenade, to encourage more outdoor activities for all day long and to prevent people staying indoor using air condition (Liang Chen; Edward Ng, 2012). Architects, urban designers, and decision-makers should reconsider public spaces being aware of thermal comfort and prioritizing it. It

2. Methodology

The study combines quantitative and qualitative methods, integrating three complex methodologies: experimental, semi-experimental, and comparative research. An assessment of the urban texture is undertaken in the coastal promenades of Durres and Vlora in Albania, Cannes and Nice in France and Genoa and Sanremo in Italy. Following a comprehensive analysis of the urban environment, measurements were taken and computer simulations were conducted for a section of the promenade in the city of Durres, located in Albania. The field measurements in the promenade of Durres were carried out through thermal camera, and weather instruments (Fig.4). We measured the temperature using a digital thermometer and compared it with the temperature obtained from the local weather station. At the same time, thermal camera measurements were added to these measurements. An infrared camera identifies the infrared energy emitted, transmitted, or reflected by all materials at temperatures above absolute zero (0°Kelvin) and converts the energy factor into a temperature reading or thermogram (FLIR, 2018). After the site measurements we utilized the ENVI-met software to conduct computer simulations. The software enables urban planners, architects, and engineers to create sustainable living conditions in a dynamic environment by thoroughly examining all components of the microclimate system and evaluating the effectiveness of urban design (Anon., 2021). It calculates the values of the degree of thermal comfort by setting the parameters for geographical position, solar access, wind, air temperature, and humidity (Arens, E. and Bosselmann, P., 1989). The index of physiologic equivalent temperature (PET) measures the level of thermal comfort (Matzarakis, A.; Mayer, H.; Iziomon, M.G., 1999).

Figure 4 Instruments used for site measurements

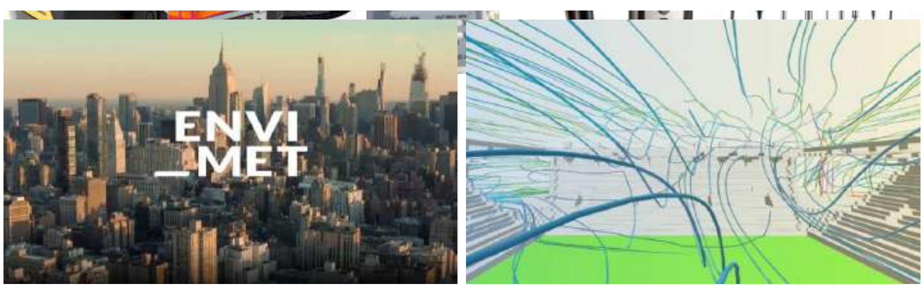

Figure 5 ENVI_met software for computer simulation

The initial scenario is executed considering the current conditions, with an emphasis on PET (Physiological Equivalent Temperature) and STS (Simulation-derived Material Surface Temperature). We generate different scenarios by analyzing diverse mitigation strategies for tackling UHI (Urban Heat Island) , such as revitalizing promenades with cool pavements (Ani Tola, Paul Louis Meunier, Parashqevi Tashi, Elton Hala, 2017), integrating green areas and trees (Fazia Ali-Toudert, Helmut Mayer, 2005), utilizing water bodies and water spray systems, enhancing the availability of both artificial and natural shade (P J Littlefair, M Santamouris, S Alvarez, A Dupagne, D Hall, J Teller, J F Coronel, N Papanikolaou, 2000), and implementing smart cooling technologies. We evaluate the outcomes of these scenarios by comparing them to the current situation specifically examining the two parameters indicated earlier, PET and STS. A typical summer day is selected to replicate the present state of the promenade in the city of Durres. The field measurements and simulations of the existing condition (scenario 0) of the promenade are analyzed to determine the level of thermal comfort. Subsequently, a hypothetical scenario (scenario 1) is developed under the same weather circumstances to examine the impact of each parameter in reducing thermal stress. Scenario 1 is compared to scenario 0 in order to determine the impact of pavement material properties, water bodies and sprays, as well as natural and artificial shades on outdoor thermal comfort at the pedestrian level.

3. Case studies

Globally, Mediterranean cities are renowned for their "La Dolce Vita" lifestyle, characterized by leisurely strolls along the coastline and a greater preference for outdoor activities due to the delightful Mediterranean climate. The architects, urbanists, and decision-makers must not overlook the substantial potential of this. In order to get optimal results, it is crucial to consider not only the visual and functional aspects but also the methods to guarantee consistent thermal comfort and livability throughout the entire year (Massa, 2005). Assessing the thermal comfort of the promenade is critical for encouraging long-term outdoor activities and decreasing dependence on indoor air conditioning. The chosen cases in this research consist of the Genoa and Sanremo promenades in Italy, the Cannes and Nice promenades in France, and the Durres and Vlora promenades in Albania (Fig. 6). Before choosing them, we carefully considered the Mediterranean lifestyle and the city's development. The objective was to identify promenades in Mediterranean cities that shared the same geographical region, had similar terrain characteristics, but featured distinct urban layouts and somewhat different climate conditions. Another factor considered was the size of the urban population and the level of development in the same tourism sector. Furthermore, these cities have nearly identical needs for promenades and share similar urban structures and features. Sea breezes frequently create the impression that urban microclimate is not a concern in coastal communities. Furthermore, it is generally believed that significant levels of anthropogenic heat, which have an impact on the urban microclimate, are mostly found in major cities. Previous case studies have shown that coastal cities, whether located downtown or near the coast, also experience significant levels of thermal discomfort.

According to the Köppen-Geiger climate classification, the six cities chosen for this study have a typical Mediterranean climate with a temperate, dry summer (Cs category). Seas and cold ocean currents inextricably link the Mediterranean climate zones. This climate extends beyond the Mediterranean region to many parts of the world, albeit with varying temperatures (Köppen, 1918). The cities were chosen to represent Mediterranean climate zones, including historical Mediterranean basin cities such as Athens, Algeria, Barcelona, Beirut, Istanbul, Izmir, Jerusalem, Marseille, Rome, and Tunisia. Additionally, cities within Mediterranean climatic zones like Lisbon, Casablanca, Cape Town, Adelaide, Pert, Santiago, and Los Angeles, Tashkent, and Dushanbe were included (Figs. 8 and 9). Much of the Mediterranean coast enjoys a hot, summer Mediterranean climate. However, most of its southeastern coast has a hot desert climate, and much of Spain's eastern (Mediterranean) coast has a cold semi-arid climate, while most of Italy's northern (Adriatic) coast has a humid subtropical climate. Although they are rare, tropical cyclones occasionally form in the Mediterranean Sea, typically in September–November.

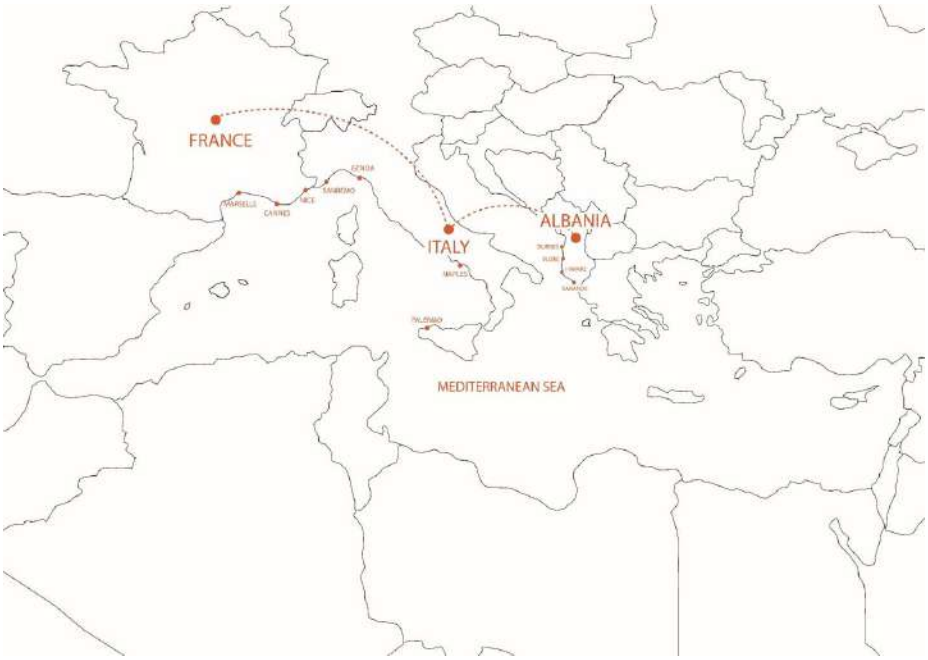

Figure 6 Case studies location in the Mediterranean basin

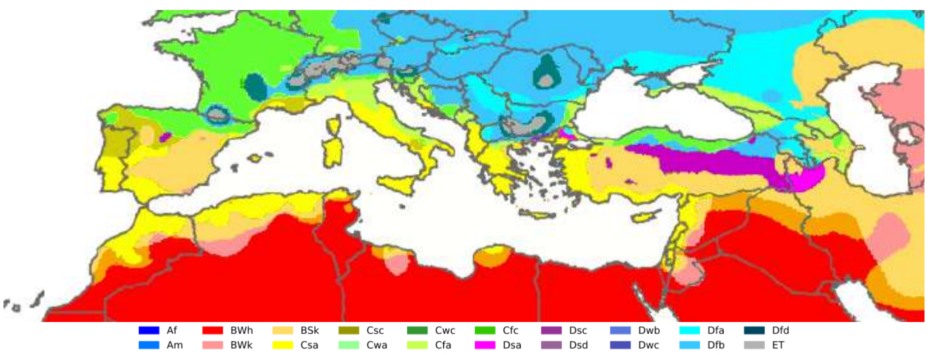

Figure 7 Climatic classification, Köppen – Geige World Map, Mediterranean Sea Area

3.1. Genoa Promenade in Italy

Genoa is a port city and the capital of northwest Italy's Liguria region. The population record in 2023 is 558,745. It is known for its central role in maritime trade over many centuries. The topography of the city rates with an elevation from 0-50m. The city promenade extends along the seaside and in between the sidewalk and buildings lies the road for vehicles, bus and motorcycles. From the photos, we can notice that the promenade is fully exposed to the sun, due to the urban design and its geographical position. The trees are missing, only some palm trees and shrubs are present.

Figure 8 Genova Promenade map and photos (source: google, 2024)

Genoa has a Mediterranean climate (Csa) in the Köppen climate classification, with plentiful precipitation due to its location on a common storm track. Due to its position between the sea and mountains over 1000 meters high, each neighborhood of Genoa has specific climatic characteristics. In Genoa, the summers are short, warm, humid, and mostly clear and the winters are long, cold, and partly cloudy. Over the course of the year, the temperature typically varies from 5°C to 27°C and is rarely below 2°C or above 30°C.

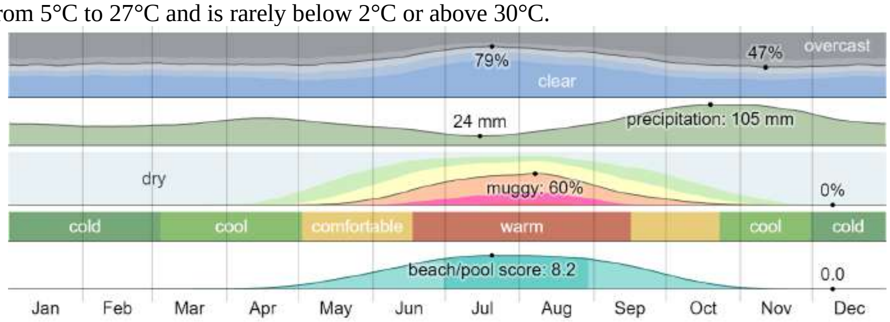

Figure 9 Climate Data, Genoa (weatherspark, 2024)

3.2. Sanremo Promenade in Italy

Sanremo is a coastal city in northwestern Italy. The population record in 2021 is 55,000Its green spaces include the park of Villa Ormond, with a Japanese garden, palm trees and ancient olive groves. The topography of the city rates with an elevation from 0-15m. The promenade is located in the southern part of the city, where by the coast are the beaches and smalls piers. The promenade is fully exposed to the sun due to its geographic position but also the urban design. We can clearly notice from the photos that there is vegetation but only palm trees by the coast.

Figure 10 Sanremo Promenade map and photos (source: google, 2024)

Sanremo experiences a hot-summer Mediterranean climate (Köppen climate classification Csa). In Sanremo, the summers are short, warm, humid, dry, and mostly clear and the winters are long, cold, and partly cloudy. Over the course of the year, the temperature typically varies from 7°C to 28°C and is rarely below 4°C or above 31°C.

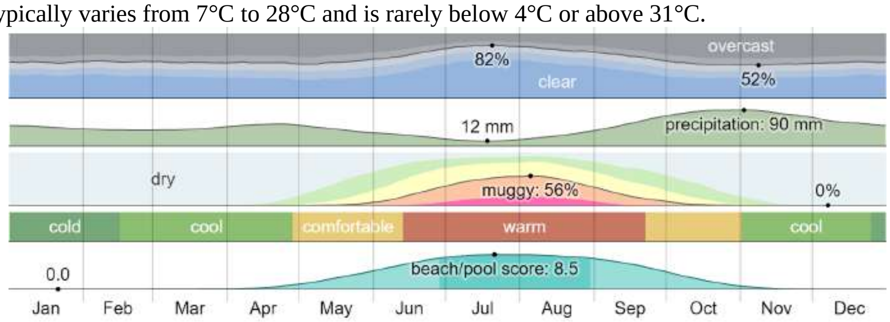

Figure 11 Climate Data, San Remo (weatherspark, 2024)

3.3. Cannes Promenade in France

Cannes, a resort town on the French Riviera, is famed for its international film festival. Its Boulevard de la Croisette, curving along the coast, is lined with sandy beaches, upmarket boutiques and palatial hotels. City elevation is 0-260m. The population record in 2021 is 73,255. The promenade is located in the southern part of the city. From the photos we can notice the presence of pine trees with big crown, alongside the promenade. In between the promenade and the buildings are located the path for cycling and separately the lane for vehicles.

Figure 12 Cannes Promenade map and photos (source: google, 2024)

Cannes has a subtropical Mediterranean climate (Köppen: Csa) and the city enjoys 11 hours of sunshine per day during summer (July), while in winter (December to February) the weather is mild. Cannes summers are long and warm, with summer daytime temperatures regularly hitting 30 °C, while average temperatures are about 25 °C (Anon., 2023). Temperatures remain high from June to September, the busiest time of the year. Over the course of the year, the temperature typically varies from 4°C to 28°C and is rarely below 0°C or above 30°C.

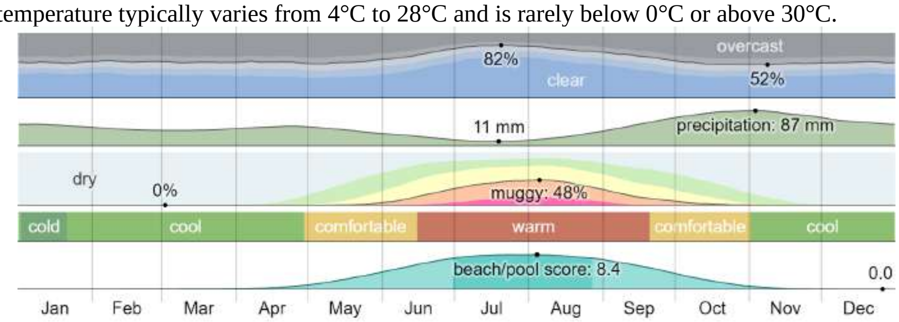

Figure 13 Climate Data, Cannes (weatherspark, 2024)

3.4. Nice Promenade in France

Nice, capital of the Alpes-Maritimes department on the French Riviera, sits on the pebbly shores of the Baie des Anges. Founded by the Greeks and later a retreat for 19th-century European elite, the city has also long attracted artists. The population record in 2021 is 348,085. The promenade is located in the southern part of the city. From the photos we can notice that the promenade is fully exposed to the sun due not only its geographic position but also for its design. There are only some palm trees alongside the road between the promenade and the buildings.

Figure 14 Nice Promenade map and photos (source: google, 2024)

Nice has a hot-summer Mediterranean climate (Köppen: Csa), enjoying mild winters with moderate rainfall. It is one of the warmest Mediterranean climates for its latitude. Summers are warm to hot, dry, and sunny. The temperature is typically above 26 °C but rarely above 32 °C. Summer temperatures, therefore, are often higher in the city. The average maximum temperature in the warmest months of July and August is about 27 °C (Anon., 2023). Over the course of the year, the temperature typically varies from 5°C to 28°C and is rarely below 2°C or above 30°C.

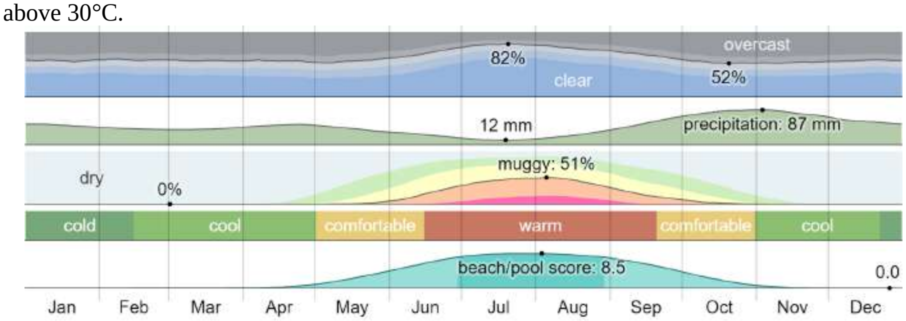

Figure 15 Climate Data, Nice (weatherspark, 2024)

3.5. Vlora Promenade in Albania

Vlorë is the third most populous city of the Republic of Albania. Located in southwestern Albania, Vlorë sprawls on the Bay of Vlorë and is surrounded by the foothills of the Ceraunian Mountains along the Albanian Adriatic and Ionian Sea. The population record in 2021 is 187,675 (Instituti Kombetar i Statistikave, 2021). The promenade is located in the southeastern part of the city, east part of the port. The first phase of the promenade was reconstructed on

2017, by considering not only a sidewalk, but also having different activities. From the photos we can notice also a green park and Aleppo pine trees alongside the promenade in 2 rows.

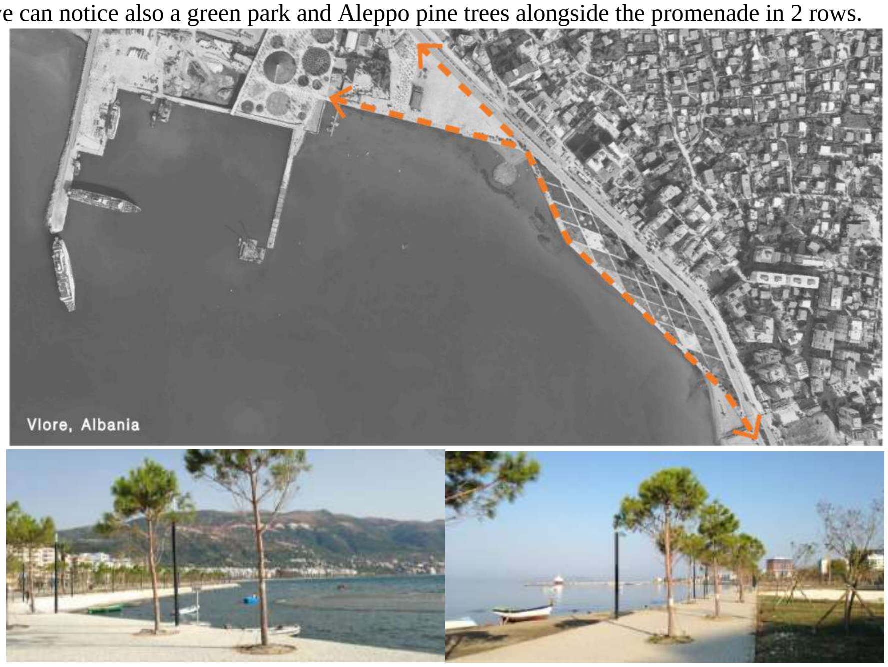

Figure 16 Vlora Promenade photo 2018

In Vlorë, The summers are predominantly hot and dry, the winters relatively mild, and falls and springs mainly stable, in terms of precipitation and temperatures (Anon., 1992). According to the Köppen climate classification, has a hot-summer Mediterranean climate (Csa) zone. Over the course of the year, the temperature typically varies from 6°C to 30°C and is rarely below 1°C or above 33°C.

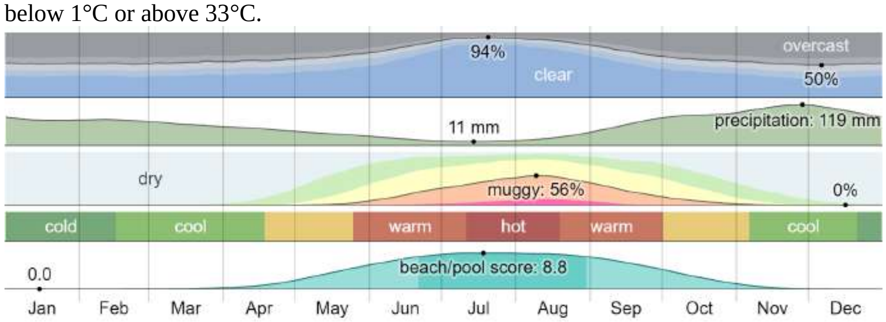

Figure 17 Climate Data, Vlore (weatherspark, 2024)

3.6. Durres Promenade in Albania

Durrës is the largest port city in Albania, and lies in the western part of the capital Tirana. It is also a main port city on the Adriatic Sea in western Balkan. It's known for its huge Roman amphitheater. Nearby is a 9th-century church with mosaic-covered walls. The bay of Durrësi has shallow waters. The population record in 2021 is 292,029 (Instituti Kombetar i Statistikave, 2021). The promenade is located in the southern part of the city, western part of the port. On 2020 one part of the promenade was reconstructed by replacing the pavement, changing the geometry, adding greenery and trees with a small crown. Even having a new promenade, it is still fully exposed to the sun.

Figure 18 Durres Promenade photo 2020

According to the Köppen climate classification, Durrës is classified under the periphery of the hot-summer Mediterranean climate (Csa) zone. The summers are predominantly hot and dry, the winters relatively mild, and falls and springs mainly stable, in terms of precipitation and temperatures. Over the course of the year, the temperature typically varies from 4°C to 30°C and is rarely below -1°C or above 33°C.

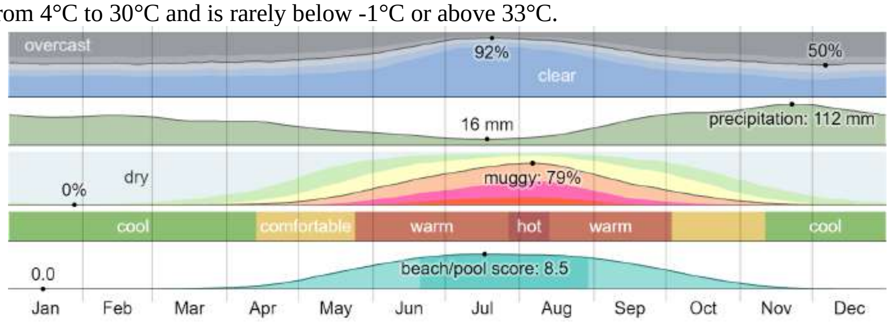

Figure 19 Climate Data, Durres (weatherspark, 2024)

4. Results and discussion

The field study begins with on-site measurements conducted in Durres Promenade utilizing thermometers and weather data obtained from IGEO[1]. The entire Durres Promenade is oriented towards the sun, with limited presence of natural or artificial shade. The presence of light color

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materials and trees with small crown causes thermal and visual discomfort. Field measurements are capable of detecting thermal stress. Discrepancies in air temperature were observed between on-site measurements and data collected from the local weather station.

R0	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11
4/6	4b/1	4a/3	21/4	2/4	4/6	21/5	4a/3	1/4	2a/2	1/5	6/2
Cromof iber concret e, beige	Cromof iber concret e tiles, white	Concret e stairs and border, gray	Grass	Gray & white stone (75&25 %)	Cromof iber concret e, beige	Grass	Concret e stairs and border, gray	White stone	Gray & white stone (60&40 %)	White stone	Gravel

Figure 20 Durres Promenade map and photos

4.1. The field measurement results for the current condition were obtained on September 5, 2020.

We conducted field measurements on September 5, 2020, at 08:00, 12:00, 16:00, and 20:00, due to the completion of implementation works on the Durres' promenade. Initially, we obtained weather data from the local weather station via the IGEO, including air temperature, relative air humidity, wind speed, average radiation temperature, dew point, visibility, cloud height, water vapor tension, precipitation, wind gusts, and UV index. According to site measurements, the air temperature on site (Tup at 1.7 m) is higher than that from IGEO (Tair), with an average difference of 4.3 °C at 08:00, 5.7 °C at 12:00, 0.5 °C at 16:00, and 0.6 °C at 20:00, depending on the surface temperature of each material and sun hours of exposure. Furthermore, the average air temperature recorded at 0.0 m (Tdo at 0.0 m) compared to Tair is 4.2 ˚C higher at 08:00, 6.4 ˚C at 12:00, and 0.5 ˚C at 16:00, while it is 1.7 ˚C lower at 20:00 (Fig. 2). When comparing the relative humidity on site (H1) to that obtained from IGEO, it was 55% lower than the average. During the day, the STT per material on site is higher in a range of 2–24 ˚C than the Tair, mainly due to the absence of shade. After 19:00, the STT is lower than Tair 3.7-8.2 ˚C, due to the light-colored pavement materials (Tab. 1).

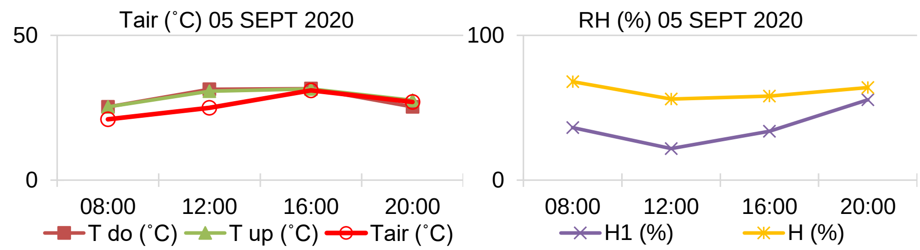
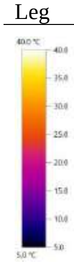
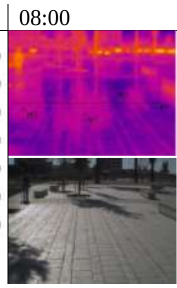
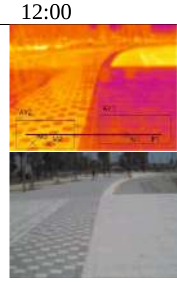
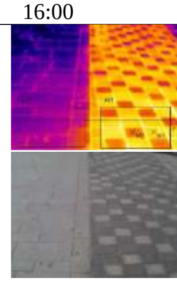
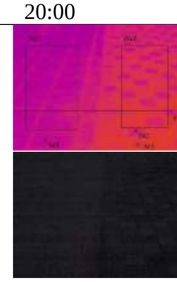


Figure 21 Air Temperature (left) and Relative Humidity (right), 5 Sep 2020, Durres Promenade

Table 1 Sample of Surface Temperature measured with Thermal Camera, 05 September 2020, Durres Promenade

Leg	08:00	12:00	16:00	20:00
				

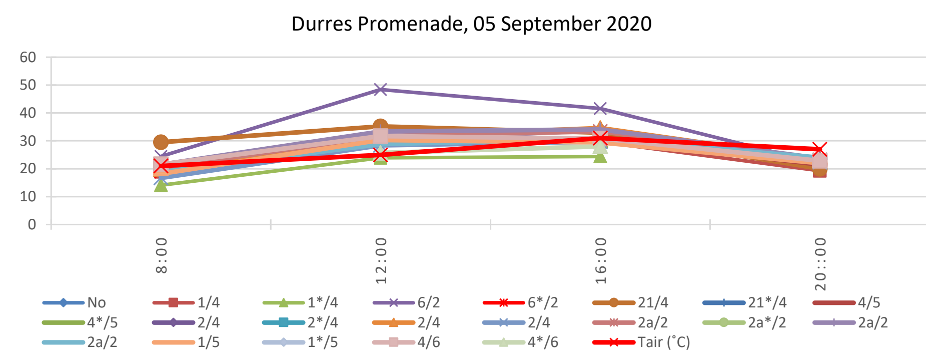


Figure 22 Durrës Promenade – Material Surface Temperature with thermal camera (STT), 05 September 2020

4.2. Simulation results

In each simulation, we entered Durres promenade's geographic position, time zone, and geometric pattern, as well as weather data from the local weather station. We only simulated a portion of the large-scale model, measuring X = 100 m, Y = 120 m, and Z = 40 m, using a grid of dx = 1 m, dy = 1 m, and dz = 1 m. We ran the simulation at the same time and under the same weather conditions as the field measurements. Results indicate a high degree of thermal stress on September 5, 2020, throughout the entire day until 8 p.m. After these result we chose July 20, 2020, a typical summer day, to run the simulation for the hypothetical scenarios. We used the current promenade simulation (Scenario 0) as a benchmark to validate the hypothetical scenario (Scenario 1). Scenario 0 depicts the existing promenade with light-colored paving materials, a grass surface without an irrigation system, and rare small-crown trees like palms, Tamaris gallica, and Eleagnus angustifolia. The model sets the trees at maturity rather than their current age. We have placed 12 receptors in this section of the promenade to monitor the simulation results as of July 20, 2020. In the scenario 0 we have kept the same design as the current situation. The paving materials in the southern part of the promenade are primarily gray, in other parts are white cube stone in 60%x40% and 75%x25% combinations, along with local white stone, beige-colored chromofiber concrete, gray-colored concrete curbs, and steps. The beach boasts a kelp-covered surface, while paving materials, including beige chromofiber concrete, green surfaces, and local white stone, adorn the north of it. Most of the promenade's greenery is low, but we have planted new trees like Tamarix galica and Eleagnus angustifolia alongside the existing palm trees to create high greenery.

In scenario 1 we modeled Durres promenade by incorporating all the urban design elements explored in previous studies. We added more green surfaces into replacement pavements with abundant Ceratanio Siliqua and Aleppo Pine; installing shades as canopies with varying levels to generate the Venturi effect (Fig. (Tola (Panariti), Ani; Veleshnja, Juljan; Meunier, Paul Louis; Bisha, Geri, 2023). We positioned water surfaces and sprinklers at a height of 30 cm near the curb on the promenade's edge. Receptor R10 is located close to the sunshades, while receptors R8 and R9 are close to the Ceratanio Siliqua trees and the artificial shades. Receptor R2 is close to the water sprinkler, whereas Receptor R5 is near the water surface. The other receptors maintain the same position and material surface as in scenario 0. By combining all four variables, we can determine the extent to which urban thermal comfort will change while keeping the promenade's built environment unaltered.

We independently ran both of these computer models under the same climate conditions, time, and date. Then, we looked at the simulation results for the sky view factor (SVF), the surface temperature from the simulation (STS), and (PET) one by one and in relation to each other to see if there was a dependency ratio between these three factors for the two scenarios.

Figure 23 Urban furniture considered in scenario 1

Table 2 2D and 3D presentation of 2 scenarios in the Durres Promenade

Scenario 0	Scenario 1

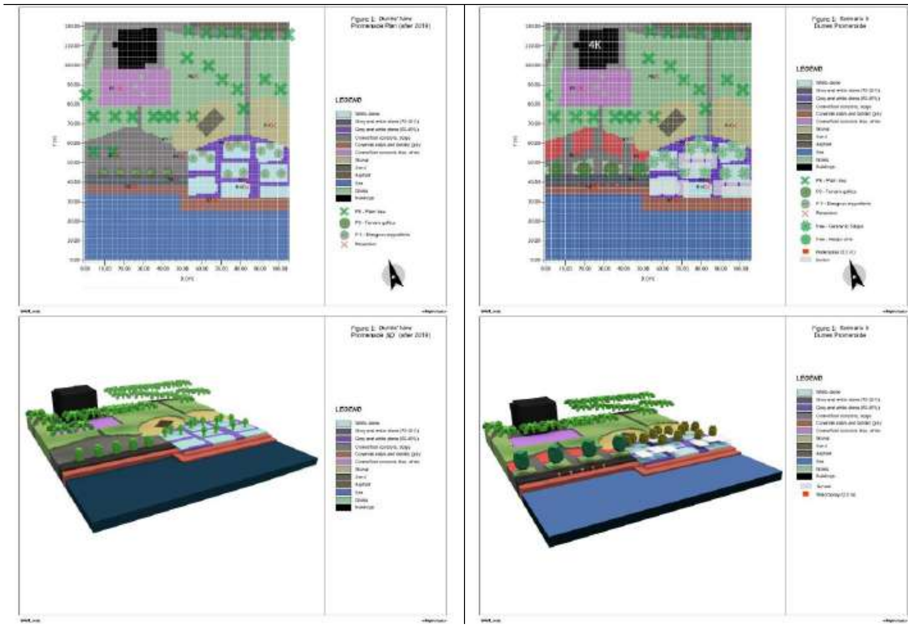
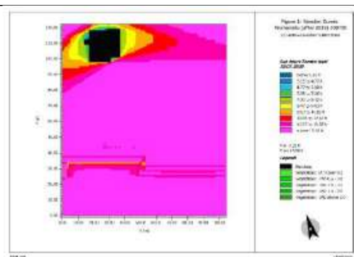
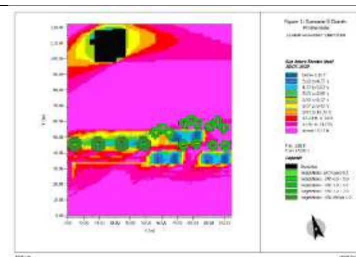
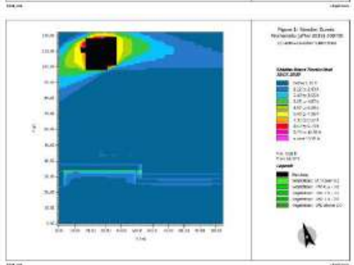
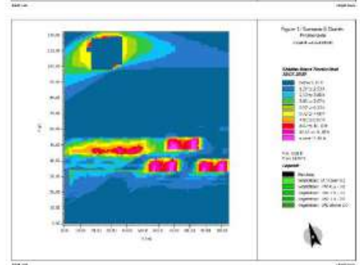
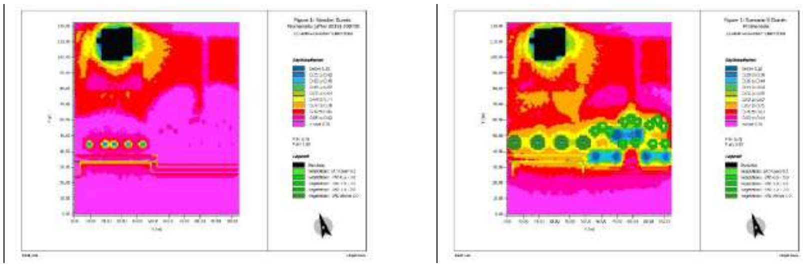


Table 2 presents the 2D and 3D models of scenarios 0 and 1, which include 12 receptors for reading the findings. The table provides information on sun hours, shade hours, and sky view factor (SVF).

Table 3 Sun and shading hours, Sky View Factor 20 July 2020 for two scenarios

	Scenario 0	Scenario 1
Sun Hours		
Shading hours		

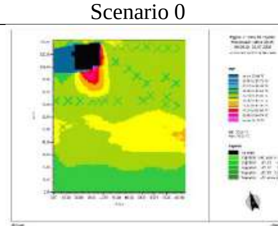
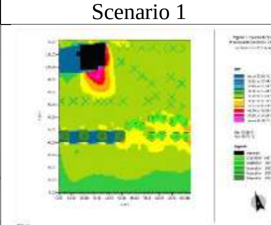
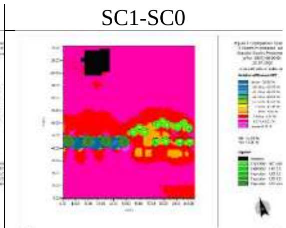
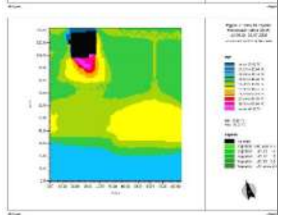
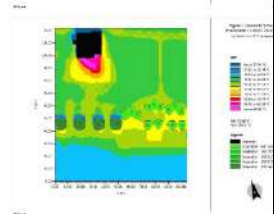
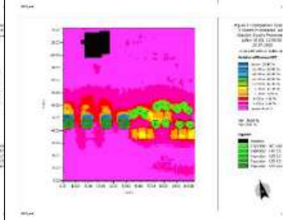
Sky View Factor



The simulation results indicate that the current Durres promenade (scenario 0) is exposed to the sun for more than 12.07–13.28 hours in the uncovered areas, where the SVF ranges from 0.78 to 0.92, and 1.28–10.27 hours in the spaces occupied by the shadow of the four-story structure, where the SVF ranges from 0.35 to 0.71. According to scenario 1 (mixed design), the part of the promenade is exposed to the sun for 3.1 to 11.97 hours, with SVF values ranging from 0.28 to 0.83 in the area close to the building. While in the part of the promenade covered by artificial shades, tree sun exposure varies from 3.1 to 8.17 hours with an SVF between 0.28 and 0.59 (Tab.3).

According to the simulation results, in Scenario 0, thermal comfort reaches a neutral level after 19:00, and there are three levels of thermal comfort from 08:00 to 18:00: warm, slightly warm, and very hot. Interpreting these results in terms of stress levels, we found moderate stress, strong heat stress, and extreme heat stress. In scenario 1, we achieve neutral thermal comfort after 19:00 on July 20, 2020, mirroring scenario 0. During the daytime hours from 08:00 to 18:00, there are five levels of thermal comfort, such as neutral, slightly warm, warm, hot, and very hot. Interpreted as a stress level, we have no thermal stress, moderate stress, strong stress, and very strong heat stress. Unlike scenario 0, where three levels of thermal stress were present, in scenario 5, the level of thermal stress decreases by one degree as it improves between the hours of 08:00 and 16:00. In addition, note that in scenario 5, the daytime PET has lower average values than in scenario 0, namely 2.4˚C at 08:00, 2.8˚C at 12:00, 2.5˚C at 16:00, 1.3˚C at 17:00, and 0.5˚C at 18:00. This difference is also observed after 18:00 to 04:00, but in values of 0.5-0.6˚C.

Table 4 PET section at 1.5 meter, ENVI-met, 20 July 2020, for Two Scenarios

Time	Scenario 0	Scenario 1	SC1-SC0
08:00			
12:00			

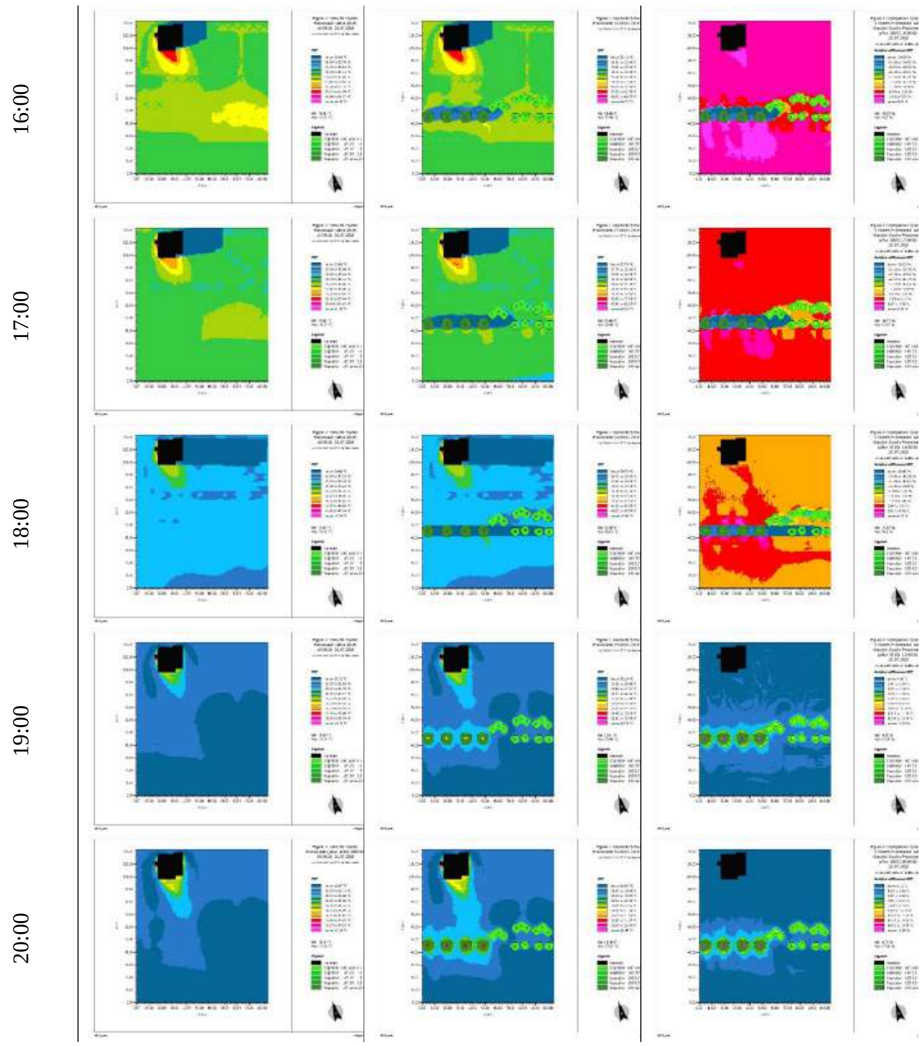


Table 5 Thermal stress levels

PET (°C)	17-26	27-29	30-37	38-42	>42
Thermal Comfort	neutral	slightly warm	warm	hot	very hot
Stress Level	No thermal stress	No thermal stress	Moderated heat stress	Strong heat stress	Extreme heat stress

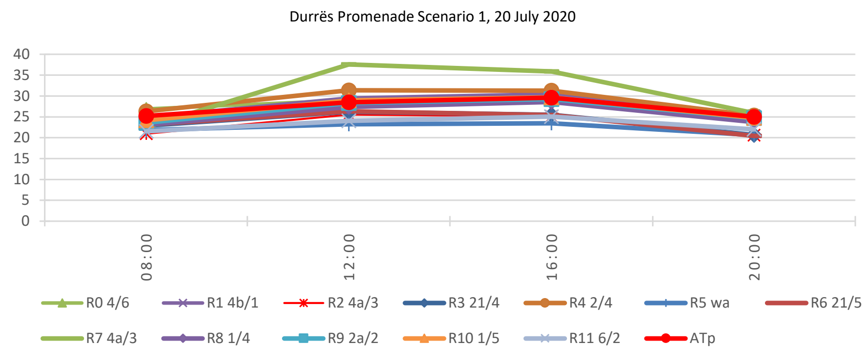


Figure 19: Durres Promenade Scenario 1, 20 July 2020, comparing STS with ATp

5. Conclusions

Site measurements obtained with a digital thermometer and thermal camera have revealed that the temperature measured on-site is 2,8 to 7 degrees Celsius higher than Tair as a result of urban heat emission and the lack of shading. Due to the promenade's complete sun exposure without any shade, surface materials like concrete and gray stones radiate intensely throughout the day. The on-site humidity is less than 55 percent, which is less than the humidity measured by the local weather station.

The simulation results reveal an improvement in the relative PET difference between scenario 1 and scenario 0, particularly in areas with altered paving materials, water surfaces and sprinklers, trees with a large crown, and artificial shade. The temperature ranges from 0.1-13.7 °C at 8:00, 0.3-9.2 °C at 12:00, 0.1-12.1 °C at 16:00, 0.1-10.7 °C at 17:00 and 0.4-5.7 °C at 18:00, and further represents a difference of 0.1-2.4 °C. Depending on the direction of the shade, STS presents values 0.3–8.9 °C lower than in scenario 0, in areas where natural and artificial shades have replaced the paving materials. According to the results of the simulations, proper consideration of the types and positions of greenery and artificial shading during the planning phase would improve the thermal comfort at pedestrian level in the built environment of the Durres coastal promenade by between 12 and 45 percent. For the greenery, it is necessary to note that the outdoor thermal comfort will appear sooner the larger the trees are on the site. Examining the relationship between STS and PET reveals that some light-colored materials have reduced STS compared to dark-colored materials, but PET has higher values. This is due to the complete exposure of these "white" surfaces to sunlight, which in turn raises the air temperature on site through reflection. Promenades, particularly during midday and afternoon hours in the summer, have become a "dead space" (Ranasinghe, 2004) due to temperature stress, rendering them unsuitable for pedestrian use, irrespective of any activities or events that may take place there.

Table 6 the relative difference of STS and PET between scenarios 1 and Scenario 0

Date	**20 July 2020**												
Output	**ΔSTS (°C) (SC1-SC0)**				**Δ PET (°C) (SC1-SC0)**								
Time	**8:00**	**12:00**	**16:00**	**20:00**	**8:00**	**12:00**	**16:00**	**17:00**	**18:00**	**19:00**	**20:00**	**0:00**	**4:00**
Receptor													
R0	0.1	-3.6	-2.2	0.0	-0.3	-4.5	-8.7	-0.4	1.2	0.6	0.8	0.6	0.8
R1	0.1	0.0	0.0	0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
R2	-4.4	-6.1	-6.7	-4.6	-0.9	-1.1	-0.2	0.4	0.7	0.6	0.6	0.6	0.6
R3	0.2	0.1	0.1	0.1	0.0	-0.7	-0.5	-0.1	0.2	0.3	0.2	0.3	0.3
R4	0.1	-0.1	-0.1	0.1	-13.7	-8.4	-12.1	-10.7	-3.9	2.2	2.4	2.2	2.3
R5	-4.5	-8.9	-8.1	-4.2	-1.5	-4.6	-3.0	-1.4	0.4	0.8	0.8	0.6	0.8

R6	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.2	0.2	0.0
R7	-5.9	0.7	0.6	-1.1	-1.5	-2.2	-0.4	0.4	1.2	1.0	1.0	0.9	1.0
R8	0.0	-0.2	0.1	0.1	-6.5	-9.2	-4.2	-3.0	-0.4	1.2	1.3	1.1	1.2
R9	-0.3	0.2	0.2	0.3	-2.5	-1.1	-0.2	-0.1	0.0	0.0	0.1	0.1	0.1
R10	1.2	1.5	1.3	1.2	-1.5	-0.9	-0.8	-0.5	-5.7	0.3	0.3	0.4	0.2
R11	0.0	0.0	0.0	0.0	0.0	-0.3	-0.3	-0.2	0.0	0.0	0.1	0.1	0.0
Average	**-1.1**	**-1.4**	**-1.3**	**-0.7**	**-2.4**	**-2.8**	**-2.5**	**-1.3**	**-0.5**	**0.6**	**0.6**	**0.6**	**0.6**

6. Recommendations

The results obtained for the coastal promenades presented in this study serve as guidelines for the measurable improvement of the level of urban thermal comfort in any new or built urban areas.

When designing new or newly built urban spaces, it is advised to:

First, examine the climatic factors such as air temperature, solar radiation, relative humidity, wind speed and direction, precipitation, cloudiness, atmospheric pressure, direct and reflected short-wave radiation, as well as the UV index.

Consider appropriate paving materials (neither too open nor too dark), the presence of water (water surface and water sprinkler), the proper selection of the type of vertical greenery (tree with large crown) and its position (ways of placement to make shadows), maintenance of grassy surfaces, and placement of artificial shades (tents of unleveled pieces to create the Venturi effect).

Perform environmental and thermographic analyses using field measurements and computer simulations to predict the level of thermal comfort in urban spaces during each season of the year.

7. Further studies

This study focused on specific days during the summer months. Despite only running the scenarios for the Durres Promenade, the cities of Vlora, Genoa, Sanremo, Nice, and Cannes are very likely to experience a common summer day, such as July 20, 2020. Future research should examine the role of urban design in outdoor thermal comfort in any season of the year, whether in Mediterranean cities or elsewhere. It would also be essential to investigate the relationship between architecture and urban planning. Because of the complexity of an urban environment, it is necessary to employ computer models to predict and understand how urban design might affect the urban microclimate and the level of outdoor thermal comfort. This study used the computer software ENVI-met and BioMet to jointly evaluate climate conditions and various urban aspects. Note that the larger the simulation space with a small modeling scale, the closer the conclusion is to reality. Large-scale modeling necessitates the use of computer equipment or specialized modeling labs with high computational capacity. This enables the acquisition of results for every day of the year within a shorter timeframe.

This future study will deepen and widen architects', urban designers', and decision-makers' understanding of urban thermal comfort analysis and the factors that affect it. It will provide the necessary guidelines for sustainable urban development, improving the quality of urban spaces and cities by making them healthy and livable, so that people can breathe and enjoy them at any time of the year. Other countries in the Mediterranean basin will adopt it, and it could serve as a fundamental approach for countries with diverse climates.

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