



# INTERNATIONAL CONGRESS ON LANDSCAPE ARCHITECTURE

## "City and Human"

November 28-29, 2024 Ege University, Izmır, TURKIYE


# PROCEEDINGS BOOK





**Editors:** Prof. Dr. Emine MALKOÇ TRUE
Assist. Prof. Dr. Merve ÖZEREN ALKAN

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# SCHOOLS EXPOSED TO EXTREME TEMPERATURES IN KONAK DISTRICT, IZMIR

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## ABSTRACT

Heat-related challenges affect the physical and mental health of children. The World Health Organization (WHO) and UNICEF's reports suggest the connection between extreme heat and children's health is evident. Extreme heat, exacerbated by climate change, has become one of the deadliest weather causes. Statistics show that although southern European and Mediterranean countries are used to the heat, they are not able to cope with the high temperatures. Therefore, cities need to brace for higher temperatures and make plans to protect their vulnerable resident's and increase climate resiliency. This paper aims to define schools that are exposed to high temperatures in Konak which is a highly urbanized district in the city of Izmir, Türkiye. For this purpose, two parameters, surface temperature data derived from Landsat 8 OLI/TIRS (between 2000 and 2023) and school data have been used to identify the schools located in different surface temperature zones. The outputs of the research indicate that the majority of the 657 schools are located in extremely high heat hotspots. There are 79,974 students and 11,810 teachers in these schools that are exposed to high temperatures. Moreover, the schools' environments are not prepared for extreme heat related events. These results are discussed in this paper on the basis of predicted heat-related problems for the education sector and possible adaptation actions in Konak.

**Keywords:** Children, high temperature, schools, Konak.

## Introduction

The past nine years were the warmest on record globally and it is predicted that the global temperatures will continue to increase (World Meteorological Organization, 2024). According to WMO, Europe has been warming twice as fast as the global average since 1980s. Compared to pre-industrial levels the

global temperature increased 1.4°C, while Europe has experienced a 2.6°C rise. Twenty three of the 30 most severe heatwaves in Europe have taken place since 2000 and five were recorded in the last five years (Copernicus Climate Change Service, 2024). Moreover, the frequency and severity of extreme heat is increasing in Europe. The consequences of extreme heat in cities are uncomfortable and dangerous. Children tend to be more vulnerable to climate-related heat than the general population.

As in many climate-related hazards, inequalities play an important role for heat exposure. Children who live in dense urban areas tend to be more vulnerable and therefore may be exposed to higher temperatures (EEA, 2018; Luthen & Wakefield, 2021). In Europe 43% of the schools are located in urban heat islands at least 2℃, warmer than their surroundings (European Climate and Health Observatory, 2022).

Playing and exercising outside boosts children's physical and mental health in many ways. However, exposure to or above 32℃, possess a significant health risk. For instance, rising temperatures can impact the long-term development of all children. Exposing children to unbearably high temperatures impact the children's physical and mental health and results in both short- and long-term metabolic problems such as dehydration, heat-stroke as well as learning loss (Early Childhood Scientific Council on Equity and the Environment, 2023). According to research published by Save the Children, children born after 2020 will experience 6.8 times more heatwaves across their lifetimes than children born in 1960s (Luthen & Wakefield, 2021).

Children spend long hours at school and together with school staff they are exposed to high temperatures in school facilities. It is crucial to ensure that children are safe and comfortable while they're at schools and on campuses. Extreme heat has and heatwaves resulted in canceling school days all around the world. In 2024 many countries in Asia. America and Africa such as Bangladesh, Phillipnes, India and Japan, have closed schools during the excessive heat events.

As climate change progresses heat-related problems that schools have been facing became an important research subject (Salthammer et al., 2016; Wargocki et al., 2019). As a Mediterranean city, Izmir has experienced extreme temperatures and heatwaves in recent years. The impacts of high temperatures on schools have not been studied. For this reason, this research has been designed to look for a relationship between urban heat islands and schools in the densely urbanized district of Konak in the of the city of İzmir. The research question is defined as "how much are schools exposed to high temperatures in Konak?".

**Materials and Methods**

This study was conducted in the Meles-Arap basin in Konak, the central district of the city of İzmir (27º4'22" – 27º14'59" E, 38º18'15" – 38º26'48" N). This highly urbanized district is located in the heart of the city (Figure 1). According to the Turkish Statistical Institute, Konak has 1,453,570 inhabitants and 18% of this population are children (age between 0-14) (TurkStat, 2024). The city has experienced hot summers. The annual mean temperature is 18.0℃. Maximum temperatures and Mean summer temperatures are 43.2℃ and 32.3℃, respectively. (MGM, 2024).

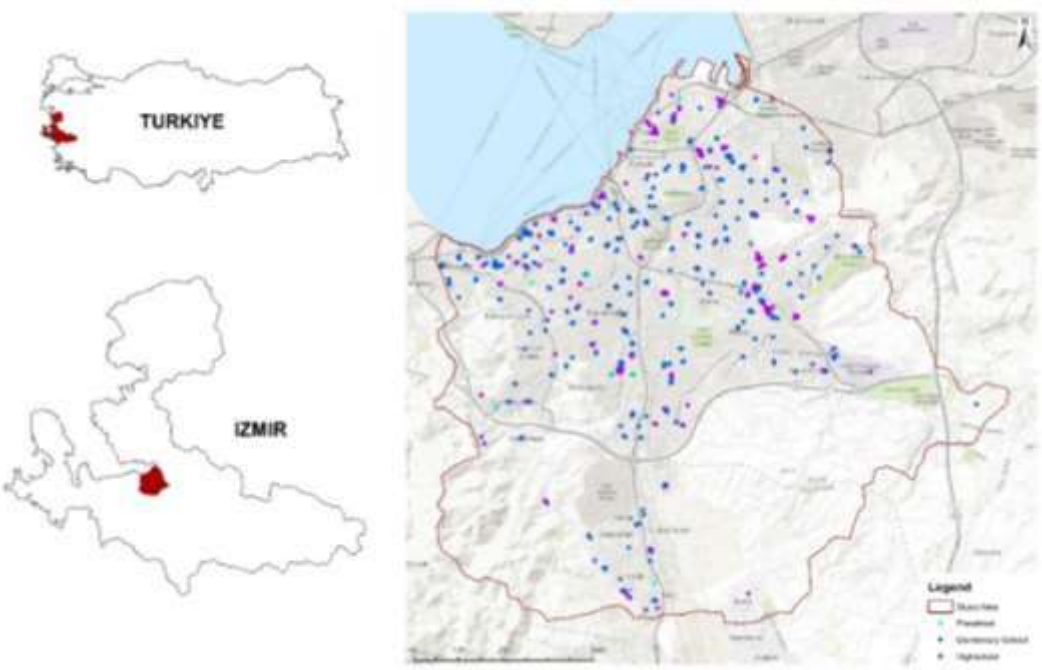


Figure 1. The location of the study area

The schools located in different surface temperature zones are defined based on two parameters: land surface temperature (LST) and school map. LST is calculated by using Landsat-8 OLI/TIRS satellite images from the average of June, July, August months between 2000 and 2023 based on the steps given in Table 1 (Sobrino et al., 2004; Akyürek 2020; Mercan 2020). LST is classified into 5 levels as low (25ºC-28ºC), moderate (28ºC-32ºC), high (32ºC-34ºC), very high (34ºC-35ºC) and extremely high (over 35ºC) to determine the level of heat islands. Low and moderate classes are defined as hotspot, high, very high and extremely high classes.

**Table 1.** LST calculation steps (Sobrino et al., 2004; Akyürek 2020; Mercan 2020).

| **Steps** | **Equations** |
|---|---|
| Conversion to Top of Atmosphere (TOA) Radiance | $L\lambda = ML \times Qcal + AL$<br>L: TOA spectral radiance (watts / (m2*sr*µm))<br>ML: Radiance multiplicative Band 10<br>AL: Radiance Add Band 10<br>Qcal: Quantized and calibrated standard product pixel values (DN) |
| Conversion to Top of Atmosphere (TOA) Brightness Temperature (BT) | $BT = \frac{K_2}{\ln\left(\frac{K_1}{L}+1\right)} - 273{,}15$<br>BT: Top of atmosphere brightness temperature (°C)<br>L: TOA spectral radiance (watts / (m2*sr*µm)<br>K1, K2: Thermal conversion constant for Band 10 |
| Normalized Difference Vegetation Index (NDVI) | $NDVI = \frac{NIR - RED}{NIR + RED}$ |

| | |
|---|---|
| | NIR: DN values from Near Infrared (Band 5)<br>RED: DN values from the RED (Band 4) |
| Land Surface Emissivity (LSE) | $$\varepsilon = 0{,}004 \times P_v + 0{,}986$$<br>Ɛ: Land Surface Emissivity (LSE)<br>$P_v$: Proportion of Vegetation<br>$$P_v = \left(\frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}}\right)^2$$<br>$NDVI_{min}$: Minimum DN values from NDVI Image<br>$NDVI_{max}$: Maximum DN values from NDVI Image |
| Land Surface Temperature (LST) | $$LST = \frac{BT}{\left(1 + \left(10{,}8 \times \frac{BT}{P}\right) \times \ln(\varepsilon)\right)}$$<br>P= $1.438*10^{-2}$ mK |

The vectoral school map for public and private schools registered by the Ministry of Education is derived from data from the Ministry of Education and Directorate General for Mapping. The school map is classified into three classes: preschool (kindergarden), elementary school (primary school and mid school), and high school. Then the obtained LST map is intersected with school map in ArcGIS 8 to assign the schools exposed to high surface temperature.

**Findings and Discussion**

Results showed that the number of schools in the study region are 657 in total (14 preschools, 445 elementary schools, and 198 high schools). They are almost evenly distributed in the urban zone (Figure 2). All 14 preschools and most of the elementary schools and high schools are located in extreme hotspot areas where surface temperature is over 32C. Only 6 high schools and 15 elementary schools are located in hotspot areas (Table 2).

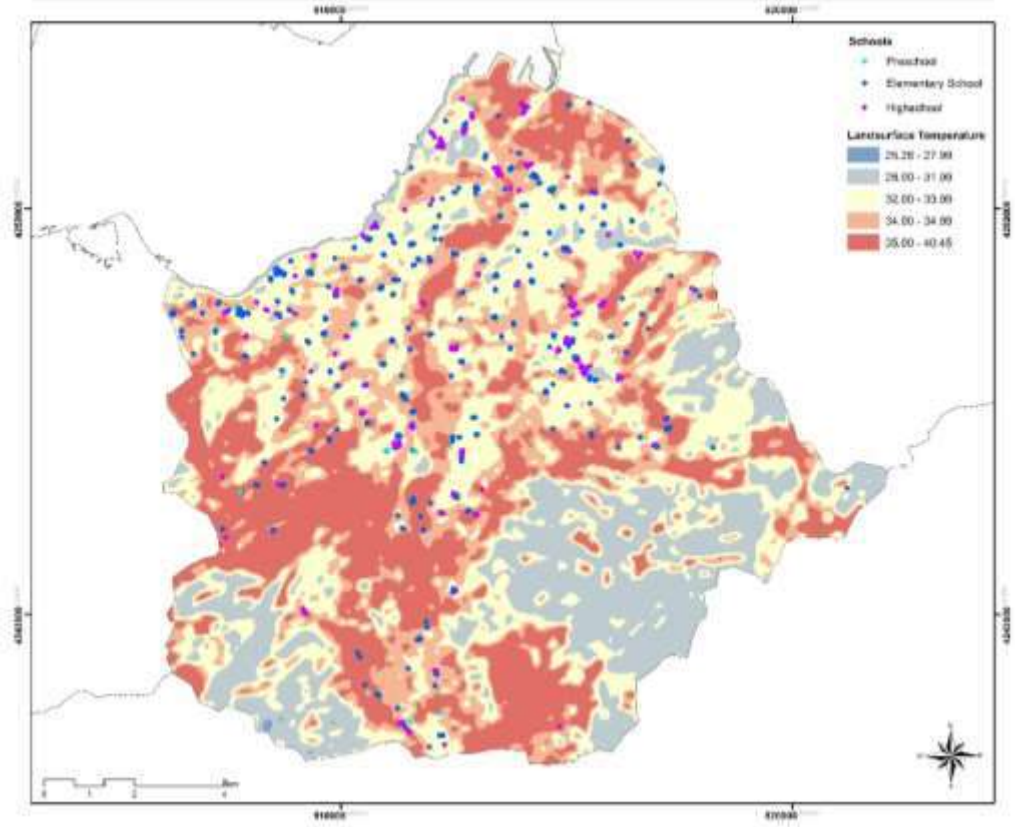


Figure 2. Schools in LST zones

Almost all schools (97%) are located in extreme heat hotspots. This means that the risk for the schools in the study region is two times higher than European countries. According to the European Environment Agency nearly half of the schools are at risk of exposure to high temperatures (EEA, 2022). That shows the seriousness of the situation in Konak. One fifth of the population in the study region are children and they are exposed to high temperatures at a young age while getting their education (Table 2).

Results indicate that most of these children get their education at the school located in heat hotspots therefore exposed to high temperatures. The number of elementary schools is almost 2 times higher than high schools. The number of young children exposed to heat is much higher than older children (Table 2).

The outputs of the research revealed that many school yards and campuses have high LST because of lack of plant cover and high percentage of concreate surfaces. The city of Paris is also faced with the same problem (ESMAP, 2020). Therefore, the city has a strategy to create cool islands in the city to combat the urban heat island. School gardens are chosen as potential areas to transform to? green. This strategy could be an approach for the transformation of school yards, gardens and campuses in Konak.

This research focused on the high temperature exposure of school gardens by using two parameters: LST and school data. Heatwaves during the education period or number of students at each school are not taken into account. This could be considered a limitation in the research. The next step of this research is designed to combine these parameters together with some socio-economic parameters into this research.

**Table 2.** Number of schools exposed to high temperatures

| Schools | LST zones | | | | |
|---|---|---|---|---|---|
| | Hotspot | | Etreme hotspot | | |
| | <28 | 28-32 | 32-34 | 34-35 | >35 |
| Preschool | 0 | 0 | 6 | 5 | 3 |
| Elementary school | 0 | 15 | 214 | 162 | 54 |
| High school | 0 | 6 | 87 | 77 | 28 |

**Conclusion and Recommendations**

The majority of the schools in Konak are exposed to high and extremely high temperatures almost evenly distributed in the urban zone of the study area. That means it is imminet that local adaptation actions should be taken in order to protect both children and educators from the harmful effects of extreme heat in the school environment.

To support these local actions, it is urgent that local policymakers build a climate agenda to accelerate local adaptation actions that specifically address the problem of reducing urban heat islands in the school zone.

Many cities have adopted some regulations to reduce urban heat islands in the school zone. For instance, Paris has taken some actions like the urban oasis programme to increase plant cover of school yards. For this purpose, a pilot project has been developed in Paris to transform 10 school grounds into greener and cooler yards with drought resistant plants. The city aims to complete the remaining 770 Parisian school yards by 2040. Also, in Flanders (Belgium) as part of the school grounds greening project, school yards were transformed to green and biodiverse areas (ESMAP, 2020). Similar changes should be taken to address extreme heat in Konak. This implementation would not only enable the creation of cool islands in the highly urbanized city to protect the vulnerable population from extreme heat but also increase the percentage of green infrastructure in the city. Even though most of the gardens of the schools are small in the study area, transformation of these areas will create an integrative effect.

Converting grey school yards, gardens and their surroundings to green gardens by increasing tree cover will help to mitigate the effects of high temperatures and risk of heat exposure to students and school staff. Also working together with students in these adaptation actions such as tree planting, management and monitoring, not only help them to reduce the heat exposure but also involve them in this process. As Coskun Hepcan, (2022a) and World Cities Report (2022) underline that public participation plays a pivotal role in adaptation and building resilience.

In addition to these nature-based solutions that aim to improve physical conditions and ecologic resilience of school environments, grey and administrative solutions should be developed to enhance the resilience of the school buildings. Furthermore, children and staff should be informed about the possible effects of the exposure of extreme heat, and they should be notified with warnings before (early warning) and during the heat events at the school.

Like Paris many cities around the world adopted an urban cooling strategy in response to a particularly intense heat emergency. İzmir and Konak's climate strategies and adaptation plans should be renewed on this basis. This is also necessary to enhance equity in Konak. Regulations are necessary to create flexible and resilient urban environments to the heat-related shocks in the future as suggested in the New Urban Agenda (New Urban Agenda, 2017).

In conclusion, successfully implementing measures to create cool islands in schools' neighborhoods in the Konak district will lead to many benefits, including better health and improved productivity of children. These actions will help to reach Sustainable Development Goals such as SDG 3 Good Health and Well-being, SDG 4 Quality Education, SDG 11 Sustainable Cities and Communities, SDG 13 Climate Action.

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