FAHRENHURBS PLATFORM: A TOOL FOR MANAGERS ABOUT EXTREME HEAT

Alice Gonçalves Coutinho de Faria (alicegcdf@gmail.com)

Daniel Vito Ramos (danielvitoramos@gmail.com)

Laura Rodrigues de Souza (laura.souza2@ufu.br)

Luiz Carlos Freitas Silva (luizcw2410@gmail.com)

Maísa Gonçalves da Silva (maisasilva.eseba@gmail.com)

Saulo Coutinho de Faria (saulocoutinho@gamil.com)

Team: GEPITronautas

Challenge: Data Pathways for Healthy Cities and Human Settlements: Climate change brings new complexities to consider when maintaining the well-being of society and the environment in cities. Natural resources, ecosystems, and existing infrastructure must be monitored to ensure that the quality of human life remains high. Your challenge is to demonstrate how urban planners can use NASA Earth observation data to develop smart urban growth strategies that preserve the well-being of people and the environment (Earth Sciences Division).

Abstract: Climate change requires the attention of public administrators. Temperature changes significantly affect quality of life. Managers are dealing with urban infrastructure issues and the expansion of urban spaces. According to the IBGE (Brazilian Institute of Geography and Statistics), 87% of the Brazilian population lives in urban areas. Various factors impact extreme heat indices; urban expansion, often uncontrolled, raises ambient temperatures. Therefore, the development of a website is proposed to organize and provide authorities with access to information on this issue, enabling the implementation of measures to create new neighborhoods. The methodology for this project was structured based on data provided by NASA on climate change, from which the "High-Resolution Annual Global Extreme Heat Estimates" was selected, containing information from 1983 to 2016. Using this material, a prototype application called FahrenHurbs was developed, integrated with the website, which uses an average of 28°C as a metric for extreme temperatures. Using this data, the interface was developed to integrate and organize all the data. This will hopefully provide urban planners with the resources to develop smart urban growth strategies that preserve the well-being of people and the environment.

Keywords: Extreme Heat, Climate Change, Cities and Solutions.

Introduction

Climate change is a challenge that must be considered in public administrators' discussions. Population growth and the consequent expansion of urban spaces are a trend, especially in medium- and large-sized cities.

According to a survey conducted by the IBGE (Brazilian Institute of Geography and Statistics), in 2022, more than 87% of the Brazilian population lived in urban areas, corresponding to approximately 203.1 million people (IBGE, 2025). This represents an increase of more than 16 million people compared to the previous survey, representing an increase of 0.82% per year. This percentage is accentuated when considering the Brazilian regions, with the Southeast region (94.44%) having the highest urban population (IBGE, 2025), where this project is being developed. This motivated the researchers to develop a research proposal aimed at solving problems related to population growth.

Therefore, to accommodate this population growth, new neighborhoods are likely to emerge in cities, requiring urban planning by various public sectors, considering sanitation, urban mobility, energy, green spaces, among other aspects.

The public administrator's concern is that growth contributes to the population's quality of life, enabling urban development. It is important to emphasize that growth must be aligned with progress, with a view to smart cities, where modernization and technology aim to improve the population's quality of life, always considering the criteria of sustainable development.

"Smart cities are related to the concept of sustainable development (FGV, 2019, our translation)." These are cities that align technological development with sustainability, while also considering the population's quality of life and natural resources.

> These cities, a projection of the future urban environment, have characteristics that have evolved over time. [...] However, when a city has better data management, it is possible to achieve holistic solutions involving different urban systems (FGV, 2019, our translation).

"Science has no doubt that climate change is generating significant impacts for Brazil and the planet as a whole (ARTAXO, 2022, p. 2, our translation)." Climate change affects different sectors, impacting the economy, ecosystems, natural resources, infrastructure, health, among other areas, and can compromise the well-being of society and the environment in cities. Among the different effects of climate change, this work will focus on the impacts on temperature variations, considering extreme heat. Urban development patterns produce many impacts related to urban climate, notably the phenomenon of extreme heat, which results in impacts such as health needs; energy supply, which is impacted by high temperatures in addition to high consumption; water supply, which increases significantly during this period; and transportation, which increases the number of vehicles in circulation, as there is a preference for private transportation over public transportation on days of extreme heat. These are some of the impacts of this phenomenon, which are exacerbated by temperatures that exceed the global average. As well as the impacts of this factor, such as the number of days of the event and the population affected by the phenomenon.

> As a result of urban expansion, the importance of urban climate studies is debated and, in this context, they are fundamental to understanding UCI across scales of analysis, integrating everything from the environmental quality of citizens to the impacts of UCI on regional climate (UMMUS EICHEMBERGER et al., 2008). The negative effects of UCI include environmental degradation such as poor air quality, increased energy consumption for building cooling, respiratory diseases, and low productivity (WERNECK, 2018, p. 18, our translation).

In urban spaces, built-up areas and circulation routes prevent heat accumulated at the surface from being transported to the upper atmosphere, which prevents heat loss—that is, the circulation of cold air—which occurs more readily in rural areas. Therefore, urban areas experience higher temperatures than rural areas, varying by around 1°C compared to small urban areas, but this difference can exceed 4°C in large urban centers (LOPES et al, 2022). "The intensity of urban heat depends on its spatial location, as well as local characteristics (LOPES et al, 2022, p. 285, our translation)."

Many Brazilian cities are "highly susceptible to the most severe impacts of climate change, such as [...] intensification of temperature rise due to the urban heat island (ARTAXO, 2022, p. 14, our translation)." Problems resulting from these climate changes threaten to exceed the capacity of Brazilian cities to absorb losses and recover from their impacts, thus justifying reflection on solutions to minimize their impacts.

> These impacts tend to exacerbate the risks commonly encountered in Brazilian cities, as well as the inadequacies in local governments' capacity to address internal infrastructure and the failure to provide necessary basic services, exacerbating the vulnerability of certain social groups and communities. Therefore, mitigation and adaptation strategies in urban centers

> must consider aspects such as habitability, thermal comfort, health, mobility, urban planning, transportation, access to water and energy, among other aspects (ARTAXO, 2022, p. 14-15, our translation).

Developing solutions to this problem can mean savings for the public coffers. Planning to improve the population's quality of life while considering the city's growth, with the emergence of new planned neighborhoods, tends to contribute to reducing the impacts of heat zones, thus making the city more sustainable. This justifies the work, considering the production of a website and possibly an application for public administration to process data. This will support the allocation of funds to minimize the impacts of extreme heat, enabling the planning of new neighborhoods.

Extreme heat refers to temperatures exceeding 28°C, the planet's average temperature. Urban heat islands are "one of the main causes of decreased bioclimatic comfort in areas where surface patterns are heterogeneous, especially in summer (LOPES et al, 2022, 281, our translation)." Several factors impact heat zones, such as season, built-up area, location, and vegetation, which can impede evapotranspiration, favoring increased radiative absorption and, consequently, a significant increase in surface temperatures.

The proposal aims to support public administrators by presenting elements that can inform the development of smart growth strategies, creating new neighborhoods that preserve the well-being of people and the environment, focusing on the analysis of NASA (National Aeronautics and Space Administration) data on extreme heat.

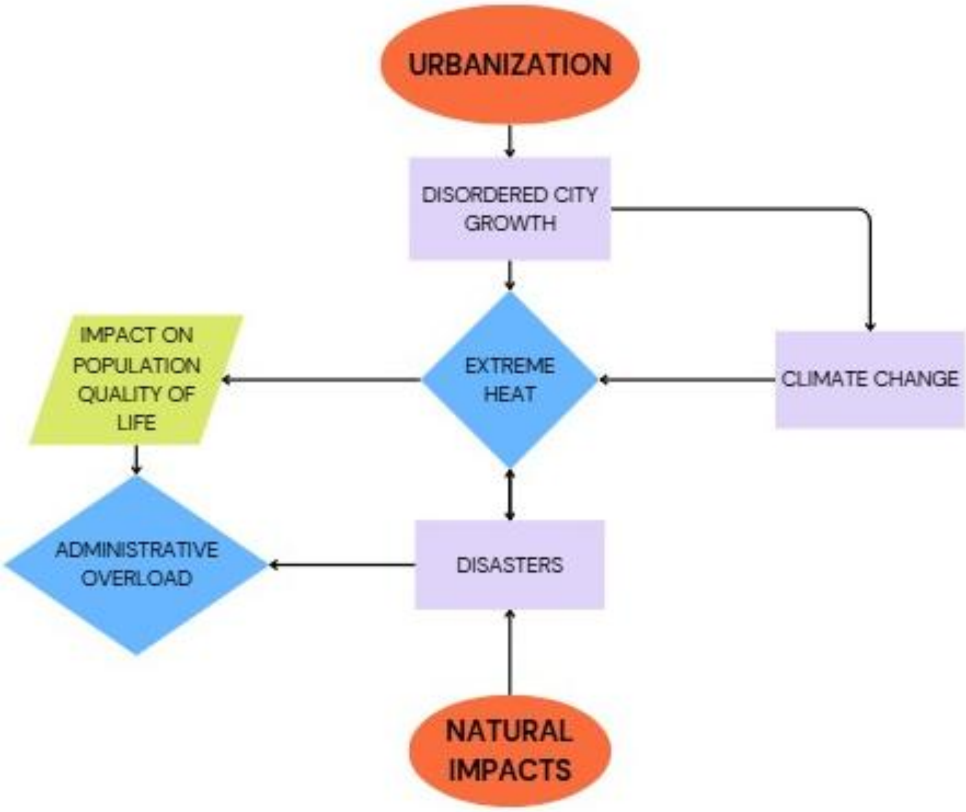
Methodology

The methodology used was a review of the data provided, considering the decision-making process of the study object. This step supported the selection of reference materials, considering the data on which the group based its solution to the problem.

> Computer simulation can be used as a research method to understand urban climate-related phenomena and evaluate mitigation strategies for the impacts of urban climate control (ICU) before their implementation. This resource has been widely applied in educational and research projects and can be an alternative to fieldwork for obtaining diagnostic information (WERNERC, 2018, p. 52, our translation).

To organize the actions, a mental map was created to organize how the problem of extreme heat impacts the population.

Figure 1: Mind Map

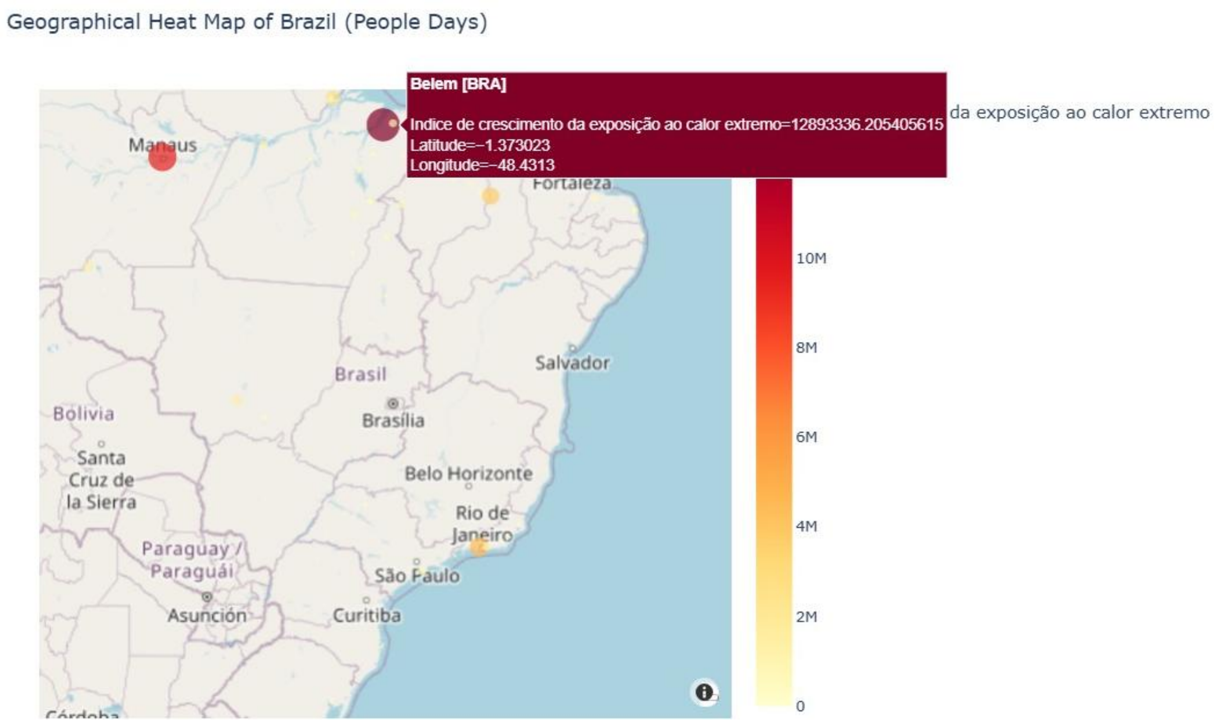


Source: Authors' own.

With this resource in mind, the researchers decided to create a website where public managers could visualize the impact of extreme heat events, using population as one of the baseline data. This data would be displayed on a map. Visually, the size of the circle relates to the number of people affected by the event, while the sidebar, with varying colors, relates to the intensity of the event, as shown in Figure 2.

Managers can also obtain more information by clicking the icon, which opens a tab with additional information, as shown in Figure 2, related to other factors that impact the extreme heat index.

Figure 2: Website Layout



Source: Authors' own.

The project works with the Sustainable Development Goals (SDGs), which were discussed during the United Nations (UN) General Assembly in September 2015 and included in the 2030 Agenda. Among the objectives related to the proposal, the following stand out: SDG 11 Sustainable cities and communities; SDG 13 Combat climate change.

Figure 3: Application Logo

Source: Authors' own.

An application is also expected to be developed that uses the information filtered by the website. The application icon is shown in Figure 3 and is called "FAHRENHURBS." The application name comes from Fahrenheit, a measure of temperature, and Hurbs, which means "city" in Latin. The logo's colors were based on the SDGs, a mix of 11, which is orange, and 13, which is green.

To develop the website and, subsequently, the application, data from the study "Annual Global High-Resolution Extreme Heat Estimates" (GEHE) were used, covering information from 1983 to 2016. The research group opted to review the data provided and select the material, as it provides compiled data that is already organized, streamlining the process, unlike the analysis and processing of raw data using satellite imagery. The choice of this model refers to the fact that

> [...] GEHE provides scientific researchers and decision-makers from a wide range of fields, including climate change, public and occupational health, urban planning and design, risk reduction, and food security, with insights into how humid heat has impacted human and environmental systems worldwide. The dataset can be used to identify how changes in extreme humid heat impact human health and well-being, as well as ecological systems, at scales ranging from local to national to global. (TUHOLSKE, 2021, our translation).

To determine the areas potentially exposed to extreme heat and, by extension, more susceptible to climate vulnerability, the study's data were processed and selected, including average temperatures above the 28°C limit, excess heat, dates on which these indices were observed, the period of occurrence, the duration interval, the intensity of the event, the location of the collected data, vegetation, built-up area, population, and other factors that significantly impact extreme heat in urban areas. Other data from the study were not considered in the development of the website and app; the research group already had a large amount of data to analyze, so it was decided to filter this data.

The temperature parameters are based on ISO (International Organization for Standardization) criteria, which relate to the risk of extreme heat, based on the planet's average temperatures. These are defined as days when WBGTmax > 28, 30, and 32 degrees Celsius, that is, when the temperature is characterized as extreme heat.

The days with this temperature index are the markers used as coefficients, correlating with the magnitude of the event. This dataset also includes the annual rate of change in the number of extreme heat days that exceeded these thresholds.

In the search for a website or application that would facilitate the creation of Fahrenhurbs, the researchers tested three different websites: Kodular, Wix, and Thunkable. During the tests, the only one that proved easiest to use was Thunkable, due to its practicality, so we will attempt to use it to create the application. The other two sites presented website creation errors using AI (Artificial Intelligence) or were difficult to create due to paid plans, so the researchers chose to work with the tool that best suited the parameters established for their work.

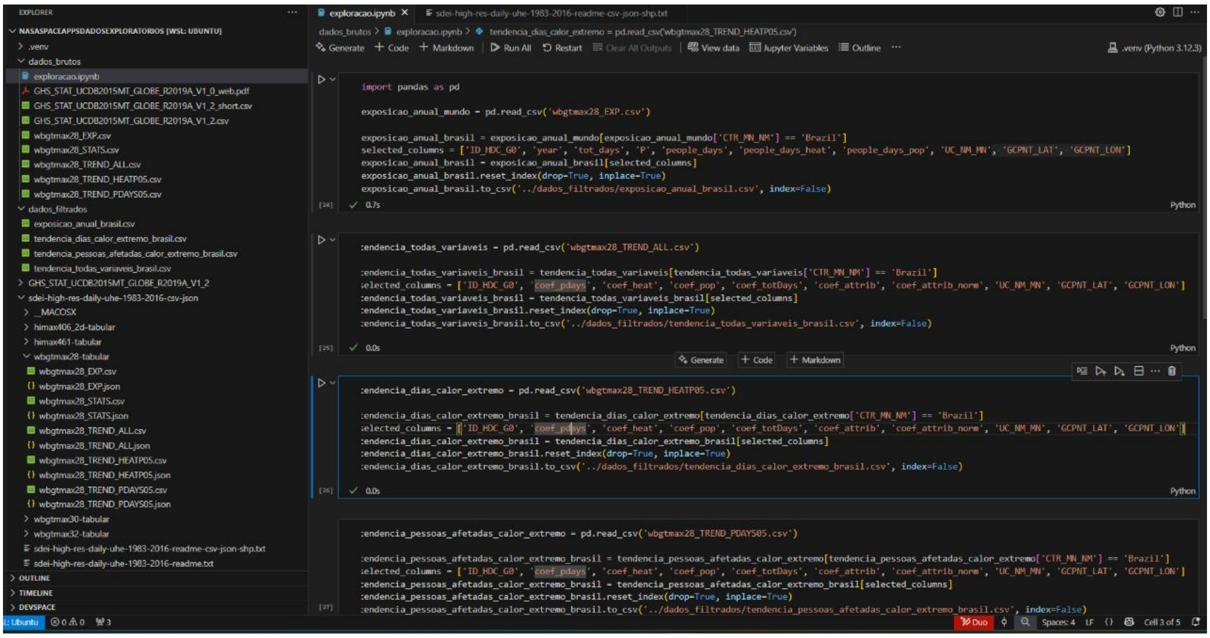
The application's initial interface features the home, explore, notifications, and profile pages. The categories include weather, strategy, emergency, risk areas, smart cities, and safety tips, as shown in Figure 4.

Figure 4: Application

Source: Authors' own.

The data were organized and processed as shown in Figure 5 to enable analysis. This process is necessary to compile the information and plot it on the website interface and later on the application. Python was used, "Managed by the PSF (Python Software Foundation), the Python programming language is extremely simple and robust. Its well-designed architecture provides good performance and code readability" (SILVA; SOUSA & SILVA, 2019, p. 55, our translation).

Figure 5: Data Analysis



Source: (TUHOLSKE et al, 2021).

The group chose to use this language because it is...

> [...] present in various everyday applications, supporting other tasks. The language is highly versatile and can be used in commercial settings or in more specific areas such as scientific development, geoprocessing, and mobile applications, either alone or integrated with other tools, further expanding the Python world (SILVA; SOUSA & SILVA, 2019, p. 55-56, our translation).

The program data is organized to present a range from 1983 to 2016, considering the population of cities, population growth, and consequently the number of people affected by extreme heat events, as can be seen in Figure 6.

Figure 6: Code – Analysis Range: Population Parameters

```
ID_HDC_G0 - CITY ID
year - YEAR
tot_days - Number of days that year event happened
P - Population of city that year
P1983 - Population in 1983
P2016 - Population in 2016
people_days - Person days (P x tot_days)
people_days_heat - Person days due to heat (P1983 x tot_days)
people_days_pop - Person days due to pop growth ((P - P1983) x tot_days)
CTR_MN_NM - Country Name
UC_NM_MN - City name (these are a little janky)
GCPNT_LAT - gps lat
GCPNT_LON - gpd long
region - UN region
sub-region - UN sub-region
intermediate-region - UN intermediate-region
P1983 - Pop 1983
P2016 - Pop 2016
```

Source: (TUHOLSKE et al, 2021).

Figure 7 refers to the intensity of the extreme heat event, considering various factors such as the number of days the event lasts, the temperature, and other factors that will result in the extreme heat event coefficient.

Figure 7: Code – Analysis Range: Event Intensity

```
ID_HDC_G0 - CITY ID
year - Year
duration - how long was the event (days)
avg_temp - avg temp of event
avg_intensity - avg temp above threshold
tot_intensity - total excess heat
event_dates - dates of the event (reads as list with json)
intensity - intensity of events daily (reads as list with json)
tmax - tempatures of events daily (reads as list with json)
UID - unique ID for each event (I made these)
CTR_MN_NM - Country Name
UC_NM_MN - City name (these are a little janky)
GCPNT_LAT - gps lat
GCPNT_LON - gpd long
region - UN region
sub-region - UN sub-region
intermediate-region - UN intermediate-region
P1983 - Pop 1983
P2016 - Pop 2016
```

Source: (TUHOLSKE et al, 2021).

In Figure 8, the event intensity data are correlated with the population, resulting in a parameter that allows comparison between two variables with different magnitudes (population and event intensity).

Figure 8: Code – Analysis Range: Event Intensity x Population

```
ID_HDC_G0 - CITY ID
coef_pdays - slope of exposure increase (person-days per year)
p_value_pdays - p value
coef_heat - slope of exposure due to heat (person-days per year)
p_value_heat  - p value
coef_pop - slope of exposure due to pop growth (person-days per year)
p_value_pop - p value
coef_totDays - slope of increase in hot days (e.g. days per year WBGT > 28)
p_value_totDays - p value
coef_attrib - coef of if the exposure trend is due to population or urban warming (ask me)
coef_attrib_norm - normalized above (ask me)
CTR_MN_NM - Country Name
UC_NM_MN - City name (these are a little janky)
GCPNT_LAT - gps lat
GCPNT_LON - gpd long
region - UN region
sub-region - UN sub-region
intermediate-region - UN intermediate-region
P1983 - Pop 1983
P2016 - Pop 2016
```

Source: (TUHOLSKE et al, 2021).

Determining this variable, which combines population and event intensity, makes it possible to compare events that occurred in different cities with different numbers of people affected, thus enabling decision-making by public officials. This action is necessary for the construction of the website, as well as the application interface, based on this entire analysis performed with the database.

Final Considerations

This study focuses solely on the problem of extreme heat, presenting data for public officials to use in decision-making, highlighting the negative effects of this phenomenon, which can consequently generate greater government spending. This would support decision-making with mitigation actions that can be propagated, exploring opportunities for cooling cities and creating new neighborhoods, which are planned to promote the advancement of smart city development. In this sense, studies on mitigation actions, focusing on extreme heat monitoring, are becoming the target of multidisciplinary research that discusses quality of life, materials development, climatology, and architecture and urban planning due to the economic, social, and environmental impacts resulting from the benefits of reduced air temperature. This is reflected in the planned growth of cities, ensuring a balance between economics and sustainability.

Thus, it is hoped to provide urban planners with resources, considering NASA's Earth observation data, to develop smart urban growth strategies that preserve the well-being of people and the environment.

Urban planners are responsible for shaping the best way to support communities in their landscapes. Rapidly growing cities must implement balanced projects to enable successful economic development and climate resilience. Earth observation data resources can inform urban planning strategies. Data on extreme heat can help planners assess the sustainability of urban environments over time and support better decision-making for long-term growth.

Bibliographic References

ARTAXO, Paulo. Mudanças climáticas: caminhos para o Brasil: a construção de uma sociedade minimamente sustentável requer esforços da sociedade com colaboração entre a ciência e os formuladores de políticas públicas. Ciência. Culto. vol.74 no.4. São Paulo, 2022. Disponível em <http://cienciaecultura.bvs.br/scielo.php?script=sci_arttext&pid=S0009-67252022000400013#:~:text=*%20%22O%20observado%20aumento%20da%20frequ%C3%AAncia%20e,bem%20como%20redu%C3%A7%C3%A3o%20de%20riscos%20e%20danos.%22>, acesso 04 de outubro de 2025.

FGV. FUNDAÇÃO GETÚLIO VARGAS. O que é uma cidade inteligente? Disponível em: https://fgvprojetos.fgv.br/noticias/o-que-e-uma-cidade-inteligente. 2019. Disponível em <» https://fgvprojetos.fgv.br/noticias/o-que-e-uma-cidade-inteligente>, acesso 05 de outubro de 2025.

IBGE – Instituto Brasileiro de Geografia e Estatística. **Censo 2022.** Produção: Breno Siqueira e Vinícius Britto, Arte: Claudia Ferreira. Produção de 14 de novembro de 2024. Editorado em 13 de junho de 2025. Disponível em < https://agenciadenoticias.ibge.gov.br/agencia-noticias/2012-agencia-de-noticias/noticias/41901-censo-2022-87-da-populacao-brasileira-vive-em-areas-urbanas>, acesso 04 de outubro de 2025.

LOPES, Hélder Silva; REMOALDO, Paula C.; RIBEIRO, Vítor; MARTIN-VIDE, Javier. 2022. "Análise do ambiente térmico urbano e áreas potencialmente expostas ao calor extremo no município do Porto (Portugal)." *Cuadernos de Geografía: Revista Colombiana de Geografía* 31 (2): 281-302. Disponível em < http://www.scielo.org.co/scielo.php?pid=S0121-215X2022000200281&script=sci_arttext>, acesso 04 de outubro de 2025.

SILVA, R. O., SOUSA & SILVA, I. R. (2019). Linguagem de Programação Python. *TECNOLOGIAS EM PROJEÇÃO*, *10*(1), 55–71. Disponível em < https://www.projecaociencia.com.br/index.php/Projecao4/article/view/1359>, acesso 04 de outubro de 2025.

TUHOLSKE, C., K. CAYLOR, C.; FUNK, A.; VERDIN, S.; SWEENEY, K.; GRACE, P.; PETERSON, T.; 2021. Global High Resolution Daily Extreme Urban Heat Exposure (UHE-Daily), 1983-2016. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). https://doi.org/10.7927/fq7g-ny13. Disponível em < https://search.earthdata.nasa.gov/search/granules/collection-details?p=C3540909361-ESDIS&pg[0][v]=f&pg[0][gsk]=-start_date&q=CIESIN%20ESDIS&tl=946684800!5!!>, acesso 04 de outubro de 2025.

WERNECK, Daniela Rocha. Estratégias de mitigação das ilhas de calor urbanas: estudo de caso em áreas comerciais em Brasília – DF. 2018. xv, 118 f., il. Dissertação (Mestrado em Arquitetura e Urbanismo) - Universidade de Brasília, Brasília, 2018. Disponível em <https://repositorio.unb.br/handle/10482/31816>, acesso 05 de outubro de 2025.