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CLIMUS

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Climate and Community-Led Initiatives for Sustainable Urban Settlement. A Collaborative Study in Palmarejo, Praia, Cabo Verde

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Keywords
Urban Thermal Comfort; Public Space Design; Collaborative Assessment; Urban Climate; Urban Planning

Partner Institutions
CIDLOT/FCT - Universidade de Cabo Verde (UNICV)
CEG/IGOT - Universidade de Lisboa (ULisboa)

Expected Future Partner Institutions
Câmara Municipal da Praia

OBJECTIVES

Contribute to the mitigation of thermal stress in Atlantic cities within the Sahelian region through:

i) Assessing bioclimatic conditions and thermal comfort.

ii) Identifying urban factors aggravating thermal stress.

iii) Evaluating the effectiveness of thermal stress mitigation interventions in public spaces through modeling.

iv) Raising awareness about the importance of bioclimatic comfort as a factor for urban environmental quality and the need to reconsider city planning, involving the university student community.

To ensure feasibility, the project will focus on a heterogeneous area of Cidade da Praia (Cabo Verde) in terms of land use patterns, urban morphology, and topography. Students from the University of Cabo Verde will be actively involved.

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ABSTRACT + IMAGES

The interaction between the ongoing increase in air temperature and the expanding urban areas has led to notable alterations in the thermal conditions within African cities. Due to the Urban Heat Island (UHI) effect, city dwellers may be more susceptible to heat-related risk than residents in rural areas. In 2100, over 300 million African urban residents are projected to be exposed to 15-day heat waves over 42ºC. If we also consider the UHI, this number could potentially be up to 950 million (Li et al., 2023).

Within this perspective, factors related to the intensity and frequency of heat, and solutions to reduce heat overload, such as those based on the dynamics of land use and occupation and green-blue infrastructures, are currently a main concern to improve the quality of the urban environment (Nyika & Dynka, 2002).

According to the Cabo Verde “National Climate Change Adaptation” report, air temperature can increase up to 1ºC until 2040, and 3ºC until the end of the century. In 2060, the annual number of “hot days” and “hot nights” could be 16-32% e and 23-49% higher than in the period 1970-1999 (MAA, 2021). However, even recognizing the potential effect on human health, heat stress does not appear as a pressing concern in this report, nor does the quality of the thermal environment in urban areas.

As in other African countries, in Cabo Verde there is an accelerated growth of the urban population. In 2021, about 29% of the country's population lived in the city of Praia. Additionally, as of 2010, around 80% of the dwellings were located in informal settlements (ONU-Habitat, 2013).

The knowledge of thermal conditions and bioclimatic comfort in the city of Praia is still incipient. However, the only studies carried out so far (Lopes et al, 2014) have revealed that: i) between July and October, the hot and rainy season, more than 80% of the days record “moderate to strong heat stress” conditions, during the daytime period; ii) in the less ventilated streets of city quarters with no shade or vegetation the heat stress can attain “extremely heat stress” levels, especially during very hot days as was shown in the micrometeorological simulation done for one day of August in Palmarejo, a so called “planned” neighborhood (fig.1); iii) the temperature inside the city can be much higher than on the surrounding areas - mobile measurements taken in February 2017, have revealed in the downtown areas located at the bottom of the valleys the air temperature is circa 4ºC higher than in the more exposed area in the Airport (fig. 2).

If the heat stress reaches extreme levels in well-ventilated neighborhoods, the situation becomes even more severe in the unplanned “informal areas”, primarily located at the bottom of valleys. Urban planning that considers the climatic conditions is crucial (Lopes et al., 2014).

The objective of this research is to identify and discuss potential design solutions for public space and propose future actions in urban planning, that can effectively improve thermal comfort , based on deepening the knowledge of thermal conditions in the city of Praia and the factors that could explain them.

As an exploratory project, this research will focus only on the western part of the city, more specifically on the "Palmarejo area", whose diversity of urban and topographic characteristics will allow a comprehensive analysis of the main factors influencing thermal comfort. The study encompasses both consolidated and expanding planned areas situated in an interfluve position. Furthermore, it also includes consolidated and emergent non-planned neighborhoods, which are located in the valleys that delineate the interfluve.

Due to the absence of meteorological observations inside the city, we will implement a small and low-cost urban mesoscale network of thermo-hygrometers and promote mobile measurements of temperature, relative humidity, and wind across the area. Surface temperatures will be also gathered, to know the surface's response to insolation conditions.

Acquiring such data will be of utmost importance for understanding the thermal patterns and assessing bioclimatic comfort conditions in the area. The evaluation of thermal comfort will involve the utilization of bioclimatic indices, supplemented by surveys among the population regarding their thermal sensations. To gain insights into the urban thermal environment and comfort, various urban factors including major land cover typologies, urban morphology, and built-up characteristics will be collected.

This urban mesoscale approach can help to identify critical heat zones and can serve to support urban-scale UHI mitigation strategies. These strategies will be focused on public space design solutions, with a collaborative discussion on measures to increase surface greenery/vegetation and improve surface reflectivity.

The efficacy of the measures in terms of bioclimatic improvements, specifically the thermal amelioration effects of the suggested interventions in public spaces, will be assessed through the utilization of micrometeorological scale models.

These results can serve as a baseline to produce recommendations and the adoption of measures in urban planning.

After proper evaluation, the methodological approach of this research can serve as a guideline for future comprehensive studies encompassing the entire city.

This research will be developed by an interdisciplinary team consisting of urban planners, urban climatologists, landscape architects, and geographers. Some tasks will be carried out with the involvement of the University of Cape Verde community in contact with the local residents.

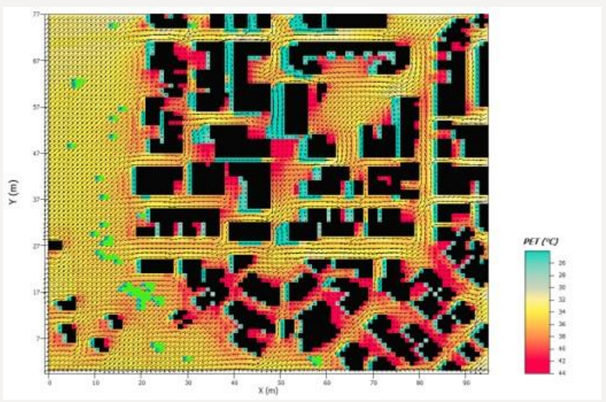


Figure 1. Physiological Equivalent Temperature in Palmarejo at 2m high. 15th August 2012, 12:00h

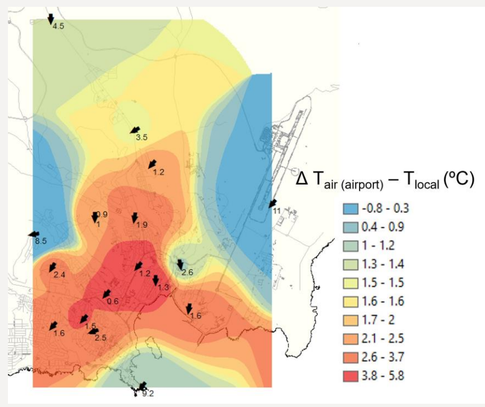
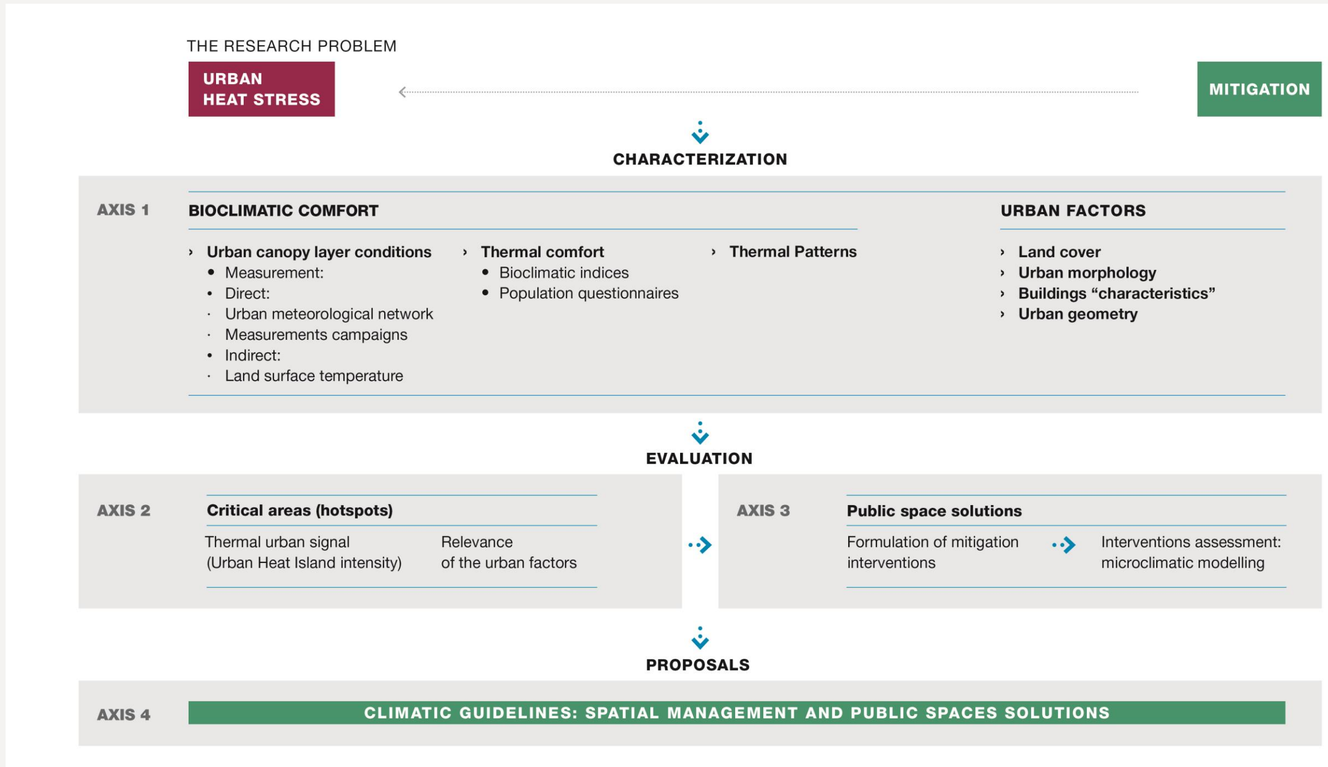


Figure 2. Thermal patterns and wind (direction and speed): 6, 7 and 8 February 2017



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SCIENTIFIC RELEVANCE FOR THE DISCIPLINE

The research objectives of the project encompass diverse scientific contributions:

i) Assessing Bioclimatic Conditions and Thermal Comfort, contributes to urbanism by comprehending conditions and comfort levels, identifying heat-stressed areas, and developing targeted interventions. Findings inform urban planning, and design decisions; ii) Identifying Urban Factors Aggravating Thermal Stress, analyzes factors like the urban heat island effect, impervious surfaces, inadequate green spaces and poor building layouts. Insights enable evidence-based policies, mitigating urban thermal stress; iii) Evaluating the Effectiveness of Thermal Stress Mitigation Interventions in Public Spaces through Modeling, optimizes resource deployment for interventions, benefiting the city of da Praia and serving as a prototype for the Atlantic cities within the Sahelian region; iv) Raising Awareness among the university student community, engages Cape Verdean students, fostering future urban planners committed to sustainability. They advocate for bioclimatic considerations, promoting a culture of sustainability and project impact.

Together, these contributions advance urbanism by informing decisions, implementing interventions, and empowering the youth for sustainable, resilient cities.

EXPECTED ECONOMIC AND SOCIAL IMPACT

The research objectives of the project encompass diverse social and economic impacts:

i) Assessing bioclimatic conditions and thermal comfort improves residents' well-being and quality of life. It reduces energy consumption and healthcare costs.

ii) Identifying factors aggravating thermal stress enhances urban livability. It saves energy and eases infrastructure strain.

iii) Evaluating interventions in public spaces creates comfort, community engagement, and attracts investments, tourism, and economic activities.

iv) Raising awareness empowers students to advocate for sustainable practices, enhancing environmental quality, well-being, and economic growth.

These objectives foster positive social changes, including well-being, energy efficiency, and urban livability.

RESEARCH PLAN AND TASKS

The project CLIMUS aims to serve as a foundational study on thermal comfort and mitigation strategies, by applying public spaces design solutions, in the city of Praia, as an example of an Atlantic city in the Sahelian region. It is focused in the “Palmarejo area”, an area located in western part of the city that offers diverse urban and topographic characteristics that will enable a comprehensive examination of the fundamental factors influencing thermal comfort.

In addition to its scientific objectives, the project aims to raise awareness about the risks of thermal stress and foster discussions on mitigating measures especially given the predicted increase in intensity and frequency of extreme heat events. Community involvement will be crucial in the analysis and decision-making processes. In this regard, the project will engage the university community, including researchers, future technicians, and decision-makers, in key phases of the project's development. Their participation will range from data collection and the characterization of urban spaces to identifying intervention measures in the urban environment through co-production strategies. As such, the University of Cabo Verde plays a pivotal role as a key partner in this project.

The project, spanning for 12 months, is divided into four main axes:

AXIS 1: Characterization of bioclimatic conditions and urban factors | with 3 tasks

The primary focus of this axis is on collecting and pre-processing climate information and urban space characteristics. To aid in achieving this objective, a training workshop will be organized at the University of Cape Verde, focusing on providing participants with the necessary techniques for conducting itinerant measurements to gather meteorological data, collecting information regarding urban characteristics, and conducting surveys among local residents.

Task 1.1 - Data collection and observation

Establish an urban climatological network and carry out itinerant measurements to collect meteorological data in locations representative of morphological conditions and urban fabric. Additionally, a dataset of surface temperature imagery will be compiled, ensuring that it encompasses typical atmospheric situations.

Task 1.2 - Bioclimatic conditions

The bioclimatic conditions will be evaluated by calculating thermo-physiological indices, namely UTCI and PET, based on meteorological data, and on the thermal sensation of the residents in the area, obtained through questionnaires conducted by the University of Cabo Verde.

Additionally, bioclimatic indices will be benchmarked, and the comfort classes within the area will be evaluated.

Task 1.3 - Urban factors

The urban morphology and buildings will be characterized and urban geometry indices relevant for energy and radiation balances as well as for natural ventilation will be calculated.

To address the potential impact of surrounding vegetated areas and bare soils on the built-up areas, a comprehensive characterization will be conducted.

The survey of building characteristics (e.g. height, materials, and colors) will be carried out with the active involvement of the University of Cabo Verde community.

AXIS 2: Identification of critical areas | with 2 tasks

This axis aims to analyze and identify areas with the highest thermal stress levels and the factors contributing to these conditions.

Task 2.1 - Involves identifying critical areas within the "Palmarejo area" by employing spatial modeling techniques applied to the data collected in Axis 1, which includes meteorological elements and thermal comfort conditions.

Task 2.2 - Analyzing the spatial and temporal relationship between thermal comfort patterns and urban factors will help to point out the influence of these factors. Understanding the impact of urban factors on thermal conditions is crucial when considering interventions in public spaces.

AXIS 3: Evaluation of intervention measures in public space to mitigate heat stress | with 2 tasks

This axis aims to develop intervention hypotheses in the public space to mitigate the excessive heat, specifically in areas experiencing the highest thermal stress. The interventions will be collaboratively proposed and evaluated using bioclimatic simulation models.

The evaluation will involve the use of models and the implementation of scenarios that simulate changes in public spaces, including modifications to surface materials and/or the addition of greenery.

Task 3.1 - Identification and selection of measures to be implemented in critical areas, through the utilization of the Nominal Group Technique.

Task 3.2 - Evaluation of the impact of the measures on thermal comfort: will be conducted by estimating their effects using the ENVI-met microclimatological model. Results from the simulations will be compared, to evaluate its effectiveness.

AXIS 4: Proposals | with 1 task

The final axis intends to co-produce "climate guidelines" for planning and interventions in public space

Task 4.1 - Formulation of Hypotheses for Mitigating Measures:

This task involves developing hypotheses for potential mitigating measures that can address the identified challenges related to heat stress in public spaces. These hypotheses will serve as a foundation for future research and practical implementation. By fostering collaborative efforts among stakeholders, the ultimate aim is to explore innovative and effective strategies that can enhance thermal comfort and effectively mitigate the impacts of excessive heat in public spaces. This will involve considering various elements of urban design, such as shading, green infrastructure, ventilation, and materials, to create more resilient and climate-responsive urban environments. Through a multidisciplinary approach, the goal is to develop practical and context-specific solutions that prioritize the well-being and comfort of the public while promoting sustainable and resilient urban development.

		Months											
		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12
TASKS													
AXIS 1	Task 1.1	■	■	■	■	■	■	■	■	■	■	■	■
	Task 1.2			■		■	■	■	■	■	■		
	Task 1.3		■	■	■	■	■						
AXIS 2	Task 2.1						■						
	Task 2.2							■					
AXIS 3	Task 3.1								■				
	Task 3.2								■	■	■		
AXIS 4	Task 4.1											■	■

EXPECTED SCIENTIFIC RESULTS

The anticipated scientific outcomes of the research project include:

i) A comprehensive scientific report detailing the findings from the workshop on heat mitigation proposals;

ii) Co-authorship of two research papers in indexed and open access journals;

iii) Dissemination of data and results through open access database repositories (e.g. Zenodo);

iv) Development of a research project proposal based on the project’s outcomes, aimed at securing funding from national or international calls. This proposal will build upon the knowledge and insights gained from the research of this exploratory project, fostering further advancements in the field.

BUDGET: € 7.500,00

Concerning Missions:

i) Travel expenses for local data acquisition and strengthening cooperation with partners (kickoff and training workshop)

(ii) travel expenses for the participation of 3 team members in the final workshop

Concerning Acquisition of S&T tools and equipment:

i) Data loggers to measure air temperature, relative humidity, and wind.