PLEA
STGO
2022

November 22 - 25, 2022

WILL CITIES SURVIVE?

The future of sustainable buildings and urbanism in the age of emergency.

BOOK OF PROCEEDINGS VOL 2 ONSITE SESSIONS

Conference Chairman
Waldo Bustamante

Co-Chair
Felipe Encinas
Magdalena Vicuña

Editorial Team
Waldo Bustamante
Mariana Andrade
Pablo Ortiz E.

Hosting Organization
Pontificia Universidad Católica de Chile
Avenida Libertador Bernardo O'higgins 340

Graphic Design Project
Nicolás Gutierrez

November 22 - 25, 2022
Santiago de Chile

ISBN
978-956-14-3069-3

PLEA STGO 2022: WILL CITIES SURVIVE?

PLEA STGO 2022: WILL CITIES SURVIVE?

PLEA STGO 2022

November 22 - 25, 2022

ORGANISED BY

Passive and Low Energy Architecture (PLEA)
plea-arch.org

Centro de Desarrollo Urbano Sustentable
cedeus.cl

Facultad de Arquiectura, Diseño y Estudios Urbanos UC
fadeu.uc.cl

Universidad de Concepción
udec.cl

Agencia Nacional de Investigación y Desarrollo
anid.cl

ABOUT

PLEA Association is an organization engaged in a worldwide discourse on sustainable architecture and urban design through annual international conferences, workshops and publications. It has created a community of several thousand professionals, academics and students from over 40 countries. Participation in PLEA activities is open to all whose work deals with architecture and the built environment, who share our objectives and who attend PLEA events.

PLEA stands for "Passive and Low Energy Architecture", a commitment to the development, documentation and diffusion of the principles of bioclimatic design and the application of natural and innovative techniques for sustainable architecture and urban design.

PLEA serves as an open, international, interdisciplinary forum to promote high quality research, practice and education in environmentally sustainable design.

PLEA is an autonomous, non-profit association of individuals sharing the art, science, planning and design of the built environment.

PLEA pursues its objectives through international conferences and workshops; expert group meetings and consultancies; scientific and technical publications; and architectural competitions and exhibitions.

Since 1982 PLEA has been organizing highly ranked conferences that attract both academia and practicing architects. Past Conferences have taken place in the United States, Europe, South America, Asia, Africa and Australia.

After almost a decade the PLEA conference is coming back to South America, Santiago (Chile), to be organized by the Pontifical Catholic University of Chile (PUC). Inevitably, the theme of PLEA 2022 is inspired by the current pandemic which has put the whole world on alert and makes us rethink our built environment in terms of health and safety. Whereas due to its current social unrest and significant social divide Santiago and South America in general provides a great ground to talk about inequalities and revisit social movements, that spanned around the globe from Lebanon, France to Chile and other countries just before the pandemic hit.

The aim of the PLEA 2022 is to question the whole idea of a city, the way we inhabit and use them generating the definitive inflection point that a sustainable city requires.

GOAL AND THEME

For decades, the climate crisis has been demanding our action and commitment. Numerous efforts to reach an international consensus via climate summits, such as COP25, and Paris Agreement have not had any expected results yet. However, even though the COVID-19 pandemic has intensified the sense of urgency, many talks about climate change were put on hold during 2020, when the new virus put the world on alert.

In no time it has become a global issue and provoked various reactions from political leaders around the world—from absolute denial to the harshest restrictions—adjusting and learning in the process by trial and error.

This process has not been easy as COVID-19 highlighted critical deficiencies in our built environment and urban design. Even though infections battered affluent areas too, the pandemic hit the hardest when the virus reached sectors with high rates of poverty. Dense neighborhoods and overcrowded buildings could facilitate the rapid spread of infections due to the difficulty of generating social distancing and the application of extensive quarantines.

Yet, various changes have been adopted rapidly. Hygiene protocols, wearing masks, social distancing and other strategies has become part of our ordinary life. On top of that, the use of public spaces, streets, parks, homes and all buildings had to be adjusted to control the spread of the virus transforming our habits and conception of them. Numerous studies showed great variations in the use of transportation during the pandemic too. But the questions are: are those changes here to stay? What does the future hold for our built environments?

Some even go as far as to question: Will cities survive? While many intellectuals and academics call for the end of cities (at least as we know them), some stakeholders urge to return to normality, or so-called status quo.

Is this the last opportunity to effectively build a healthy, livable and equitable city? It is clear that cities can no longer be conceived as before and it is time to question the way we inhabit and use them. What are the standards, mechanisms and criteria to define a sustainable city and building? Do they respond to the problems and deficiencies in the age of emergency? History shows us how cities reacted to and changed after health crises similar to COVID-19; this is the time to question everything around us and strive for environmentally sustainable and socially just cities.

The aim of PLEA 2022 is to be a relevant part of the discussion and bring about proposals to the developing and developed world. It is a great chance to talk about the changes that affected cities around the globe since the start of the pandemic and bring the scientific knowledge generated in this short time to the discussion.

Social inequality should also be a part of the debate as both health and climate emergencies may further increase the injustice and, at the same time, the inequality may make such crises worse. Latin America, as the most unequal region, and Chilean case might serve as a great example of such issues and could become a source of inspiration to find the definitive inflection point that a truly sustainable city requires.

WELCOME TO SANTIAGO DE CHILE

Dynamic and cosmopolitan Santiago is a vital and versatile city. Home to many events showcasing the very best of Chilean culture, it also hosts superb international festivals of sound, flavor and color. The Chilean capital breathes new life into all its visitors!

The city's diversity shines through in its many contrasting neighborhoods. Set out to explore the city streets and you'll discover beautiful and original art galleries, design shops and handicraft markets, as well as a great selection of restaurants, bars and cafes. Night owls can enjoy a taste of lively Latino nightlife in hip Bellavista!

Visit downtown Santiago to get a real feel for the city. Learn more about the country in its many fine museums, or wander around the famous Central Market – a gourmet's delight.

Fans of the great outdoors can head for the hills that surround the city and marvel at panoramic views of Santiago with the magnificent Andes as a backdrop. Take the opportunity to grab a picnic and visit one of the city´s many parks.

In Chile there are places that have not seen a drop of rain in decades, while there are others where the rain brings out the green in the millenial forests.

This diversity captivates and surprises its visitors. Because, as a consequence of its geography, Chile has all the climates of the planet and the four seasons are well differentiated. The warmest season is between October and April and the coldest, from May to September.
The temperature in Chile drops down as you travel south. In the north, the heat of the day remains during the day while the nights are quite cold. The central area has more of a Mediterranean climate and the south has lower temperatures and recurring rainfall throughout the year.

The conference will be held at the Centro de Extensión de la Pontificia Universidad Católica de Chile, located at Avenida Libertador Bernardo O'Higgins 390, Santiago, Metropolitan Region. Universidad Católica subway station, Line 1

The Center is located in the center of the city of Santiago, with excellent connectivity to the rest of the city and the most characteristic neighborhoods of the capital, either through the Metro network (Line 1) or other means of public transport such as Transantiago (Santiago's public bus network).

To make your hotel reservations, we recommend looking in the Providencia or Las Condes districts, close to Metro Line 1. We also have some suggestions for accommodation close to the conference venue.

WILL CITIES SURVIVE?: TRACKS

1. Sustainable Urban Development
– Regenerative Design for Healthy and Resilient Cities
– Sustainable Communities, Culture and Society
– Low Carbon Neutral Neighbourhoods, Districts and Cities
– Urban Climate and Outdoor Comfort
– Green Infrastructure
– Urban Design and Adaptation to Climate Change

2. Sustainable Architectural Design
– Resources and Passive Strategies
– Regenerative Design
– Energy Efficient Buildings
– Net-zero Energy and Carbon-neutrality in New and Existing Buildings
– Vernacular and Heritage Retrofit
– Building Design and Adaptation to Climate Change

3. Architecture for Health and Well-being
– Comfort, IAQ & Delight
– Thermal Comfort in Extreme Climates
– IAQ and Health in Times of Covid-19
– Comfort in Public Spaces

4. Sustainable Buildings and Technology
– Renewable Energy Technologies
– Energy Efficient Heating and Cooling Systems
– Low Embodied Carbon Materials
– Circular Economy
– Nature-based Material Solutions
– Water Resource Management and Efficiency

5. Analysis and Methods
– Simulation and Design Tools
– Building Performance Evaluation
– Surveying and Monitoring Methods
– User-building Interaction and Post-occupancy Evaluation

6. Education and Training
– Architectural Training for Sustainability & Research
– Professional Development
– Sustainable Initiatives and Environmental Activism
– Methods and Educational Practices
– Strategies and Tools

7. Challenges for Developing countries
– Energy poverty
– The Informal City
– Climate Change Adaptation
– Affordable Construction and Architecture Strategies
– Urban Planning and Urban Design Policies for Sustainable Development
– Housing and urban Vulnerability

CRISTINA DORADOR

Keynote speaker
CHILE

Between July 2022 and July 2022 she served as a member of Chile's constitutional convention. She is currently back to teaching at the Universidad de Antofagasta.

Chilean scientist, doctor and politician who conducts research in microbiology, microbial ecology, limnology and geomicrobiology. She is also an associate professor in the Department of Biotechnology of the Faculty of Marine Sciences and Natural Resources at the University of Antofagasta. From July 2021 to July 2022 she served as a member of the Constitutional Convention representing District No. 3, which represents the Antofagasta Region.

Her achievements include the coordination in Chile of the Extreme Environments Network for the study of ecosystems in the geographic extremes of Chile and having developed biotechnological tools to value the unique properties of some altiplanic

microbial communities such as resistance to ultraviolet radiation to elaborate cosmetic creams, joining the field of cosmetic Biotechnology. She has also led application projects such as the development of textile material using the photoprotective properties of altiplanic bacteria.

She was a member of the transition council of the National Commission for Scientific and Technological Research in 2019 that gave rise to the National Agency for Research and Development of Chile, and has been recognized nationally and internationally as one of the most relevant researchers in Chile.

ADRIANA ALLEN

Keynote Speaker
ARGENTINA

Professor of Urban Sustainability and Development Planning at The Bartlett Development Planning Unit (DPU), University College London and President of Habitat International Coalition (HIC).

Adriana has over 30 years of international experience in research, graduate teaching, advocacy and consulting in over 25 countries in the global South, she has specialized in the fields of development planning, socio-environmental justice and feminist political ecology.

She is currently President of Habitat International Coalition (HIC), as well as a regular advisor to UN agencies, positions from which she is actively engaged in promoting urban justice through advocacy and policy evidence, social learning and fostering international collaboration both within UCL and globally.Through the lens of risk, water and sanitation, land and housing, food and health, her work examines the interface between everyday city-making practices and planned interventions and their capacity to generate transformative social and environmental relations.

Adopting a feminist political ecology perspective, her work combines qualitative, digital/mapping, and visual research methods to decolonize urban planning practices and elucidate the "cracks" in which transformative planning can be reinvented, nurtured, and pursued. Her work focuses on three interrelated themes: urban justice, everyday city-making, and transformative planning.
Over the years, she has worked at the interface between insurgent practices and planned interventions and their capacity to generate socio-environmentally just cities.

This work stems from her engagement with the analysis of governance approaches to address structural deficits at the interface between "policy-driven" and "needs-driven" approaches and emerging improvements at scale – in water and sanitation, as well as in other areas such as food security, land, housing and health. Since 2008, she has explored the intersection of urbanization and climate change, with a particular focus on the generation and distribution of risks, vulnerabilities and capacities for action in southern cities. A third strand of her research focuses on urban planning as a field of networked governance and pedagogical strategies to decolonize planning education and shape pathways for urban equality.

ANACLAUDIA ROSSBACH

Keynote speaker
BRAZIL

Economist with a track record of more than 20 years working on the issues of slums, social housing and urban policy.

She is currently Director for Latin America and the Caribbean at the Lincoln Land Institute of Policy. She also serves as a member of the editorial board of Vivienda magazine of INFONAVIT – México. And previously she worked as a consultant on housing and urban development issues for the IDB (Inter-American Development Bank).

She worked in the Prefecture of São Paulo, supporting the Brazilian Ministry of Cities in the design and implementation of the Brazilian housing policy. She founded and served on the board of directors of the NGO INTERAÇÃO, which supported the development of high-impact projects in communities in the state of São Paulo and Recife.

As a senior consultant to the World Bank, she provided technical assistance for the development and implementation of Brazilian housing policy and slum upgrading for 10 years, including two major programs: the "PAC Favelas" slum upgrading and the "Minha Casa, Minha Vida" housing subsidy.

She acted as a senior specialist in social housing for the World Bank and other research and project organizations in Brazil and several countries around the world such as the Philippines, China, India, South Africa and Mozambique, among others.

She was Regional Manager for Latin America and the Caribbean for the Cities of Alliance Global Informality Program where the exchange of experiences and knowledge through different networks was consolidated and structured.

The main achievements in Latin America are the Urban Housing Practitioners Hub (UHPH), which brings together practitioners and networks working in the field of social housing. In the global south, multi-sectoral and disciplinary communities of practice on the theme of slum upgrading in the global south with emphasis on the countries: Mexico, Guatemala, El Salvador, Paraguay, Brazil, South Africa and India.

GIANCARLO MAZZANTI

Keynote Speaker
ARGENTINA

Born in Barranquilla, a port city in northern Colombia, Giancarlo Mazzanti is an architect graduated from Pontificia Universidad Javeriana with postgraduate studies in industrial design and architecture in Florence, Italy.

He has been a visiting professor at several Colombian universities, as well as at world-renowned academic institutions such as Harvard, Columbia and Princeton, and is the first Colombian architect to have his works in the permanent collection of the Museum of Modern Art in New York (MoMA) and the Centre Pompidou in Paris.

Giancarlo has more than 30 years of professional experience and his studio, El Equipo Mazzanti has gained notoriety due to its design philosophy based on modules and systems, which generate flexible elements capable of growing and adapting over time, seeking an architecture that is closer to the idea of strategy than to a finite and closed composition. The idea of architecture as an operation was born from exploring the different forms of material and spatial organization, considering concepts such as repetition, the indeterminate, the unfinished, instability, arrangement and patterns.

Equipo Mazzanti also stands out for its research on play and its link to the world of architecture. It is precisely this interest in the play-architecture relationship that has led it to seek new collaborations with professionals from different areas of knowledge, finding new opportunities for cooperation and developing projects and exhibitions that have been presented throughout the world under the We play You play brand.

Social values are at the core of Mazzanti's architecture, who seeks to realize projects that give value to social transformations and build communities. He has dedicated his professional life to improving the quality of life through environmental design and to the idea of social equality.

His work has become a reflection of the current social changes occurring in Latin America and Colombia, demonstrating that good architecture manages to build new identities for cities, towns and inhabitants, transcending reputations of crime and poverty.

CHAIR COMMITTEE

Waldo Bustamante
Mechanical Civil Engineer from the University of Chile. Master in Urban Development from the Pontifical Catholic University of Chile and PhD in Applied Sciences from Catholic University of Louvain, Belgium. Professor at the Faculty of Architecture, Design and Urban Studies from the Pontifical Catholic University of Chile. Director of the Centre for Sustainable Urban Development (CEDEUS).

Felipe Encinas
Architect from the Pontifical Catholic University of Chile. Master of Science from the University of Nottingham in the United Kingdom and a PhD in Architecture and Urbanism from the Catholic University of Louvain, Belgium. Academic Secretary at the Faculty of Architecture, Design and Urban Studies (FADEU). Researcher at the Centre for Sustainable Urban Development (CEDEUS) and Associate Professor at the School of Architecture in the Pontifical Catholic University of Chile.

Magdalena Vicuña
Architect from the Pontifical Catholic University of Chile. Master in Community Planning from the University of Maryland in the United States and PhD in Architecture and Urban Studies from the Pontifical Catholic University of Chile. Director of Research and Postgraduate Studies at the Faculty of Architecture, Design and Urban Studies (FADEU). Associate Professor at the Institute of Urban and Territorial Studies and Associate Researcher at CIGIDEN.

INTERNATIONAL ADVISORY COMMITTEE

Alessandra R. Prata Shimomura
Universidade de São Paulo. BRASIL.

Carlos Javier Esparza López
Universidad de Colima. MÉXICO.

Edward Ng
Chinese University of Hong Kong. HONG KONG.

Heide Schuster
BLAUSTUDIO. GERMANY.

Jadille Baza
Presidenta del Colegio de Arquitectos de Chile. CHILE.

Joana Carla Soares Goncalves
Architectural Association School of Architecture, UK. University of Westminster, UK. Bartlet School of Architecture, UCL, UK.

Jorge Rodríguez Álvarez
Universidade da Coruña, ESPAÑA.

Juan Carlos Muñoz
Ministro de Transporte y Telecomunicaciones. CHILE.

Luis Edo Bresciani Lecannelier
Pontificia Universidad Católica de Chile. CHILE.

Luis Fuentes Arce
Pontificia Universidad Católica de Chile. CHILE.

Mario Ubilla Sanz
Pontificia Universidad Católica de Chile. CHILE.

Pablo La Roche
Cal. Poly Pomona / CallisonRTKL Inc. USA.

Paula Cadima
Architectural Association Graduate School. UNITED KINGDOM.

Rajat Gupta
Oxford Brookes University. UNITED KINGDOM.

Rodrigo Ramirez
Pontificia Universidad Católica de Chile. CHILE.

Sanda Lenzholzer
Wageningen University. THE NETHERLANDS.

Sergio Baeriswyl
Presidente del Consejo Nacional de Desarrollo Urbano. CHILE.

Simos Yannas
Architectural Association Graduate School. UNITED KINGDOM.

Susana Biondi Antúnez de Mayolo
Pontificia Universidad Católica de Perú. PERÚ.

Ulrike Passe
Iowa State University. USA.

LOCAL ORGANISING COMMITTEE

María José Molina
Commercial Engineer from the Pontifical Catholic University of Chile. Master in Local and Regional Development from the Institute of Social Studies of Erasmus University Rotterdam, The Netherlands. Executive Director of the Centre for Sustainable Urban Development (CEDEUS).

José Guerra
Architect from the Catholic University of the North. PhD in Architecture, Energy and Environment from the Polytechnic University of Catalonia. Director of the School of Architecture from the Catholic University of the North. Director of the Research Center for Architecture, Energy and Sustainability (CIAES) at the Catholic University of the North.

Sergio Vera
Civil Engineer from the Pontifical Catholic University of Chile. PhD from Concordia University and Master of Science, Pontifical Catholic University of Chile. Director of the Interdisciplinary Center for the Productivity and Sustainable Construction (CIPYCS). Assistant Professor and Director of the Department of Engineering and Construction Management at the Pontifical Catholic University of Chile.

María Isabel Rivera
Architect from the University of Concepcion. Master of Architecture from the University of Washington, USA. PhD in Architecture from the University of Oregon. Researcher of the Centre for Sustainable Urban Development (CEDEUS) and Assistant Professor of the Department of Architecture, University of Concepcion.

Maureen Trebilcock
Architect from the University of Bio Bio. Master of Arts in Green Architecture and PhD from the University of Nottingham. Director of the PhD program in Architecture and Urbanism at the University of Bio Bio.

Nina Hormazábal
Architect from the University of Washington. Master of Architecture from the University of California, Berkeley. PhD in POE and Energy Efficiency in Housing from the University of Nottingham. Professor and Researcher of the Laboratory of the Bioclimatic Area in the Department of Architecture of the Federico Santa María Technical University.

M. Beatriz Piderit
Architect from the University of Bio-Bio. Master in Applied Sciences and PhD from the Catholic University of Louvain, Belgium. Associate Professor and researcher at the Faculty of Architecture of the University of Bio-Bio. Researcher of the research group in "Environmental Comfort and Energy Poverty" of the University of Bio-Bio.

Claudio Carrasco
Architect from the Universidad de Valparaiso. PhD in Architecture, Energy and Environment from the Polytechnic University of Catalonia. Master in Geographical Information Systems from MappingGIS. Professor at the Department of Architecture of the Federico Santa María Technical University. Professor and Researcher of the Civil Construction School and the City Science Laboratory (CSLab) at the Faculty of Engineering of the Universidad de Valparaiso, Chile. Associate Research of the Climate Action Center (CAC) of the Pontifical Catholic University of Valparaíso, Chile.

Massimo Palme
Materials Engineer from the University of Trieste. Master in Geographical Information Systems from MappingGIS. PhD in Architecture, Energy and Environment from the Polytechnic University of Catalonia. Professor at the Department of Architecture of the Federico Santa María Technical University.

SCIENTIFIC COMMITTEE

Khandaker Shabbir Ahmed
Bangladesh University of Engineering & Technology. BANGLADESH.

Noelia Alchapar
CONICET Mendoza. ARGENTINA.

Fazia Ali-Toudert
Ecole Nationale d'Architecture Paris Val de Seine. FRANCE.

Hector Altamirano
University College of London. UNITED KINGDOM

Sergio Altomonte
Université Catholique de Louvain. BELGIUM.

Servando Álvarez
Universidad de Sevilla. SPAIN.

Mohammad Arif Kamal
Aligarh Muslim University. INDIA.

Shady Attia
University of Liege. BELGIUM.

Julieta Balter
CONICET Mendoza. ARGENTINA.

Gustavo Barea Paci
CONICET Mendoza. ARGENTINA.

Jonathan Bean
University of Arizona. USA.

Susana Biondi
Pontificia Universidad Católica del Perú. PERÚ.

Philomena Bluyssen
TU Delft. HOLLAND.

Denis Bruneau
ENSAP Bordeaux. FRANCE.

Vincent Buhagiar
University of Malta. MALTA.

Victor Bunster
Monash University. AUSTRALIA.

Waldo Bustamante
Pontificia Universidad Católica de Chile. CHILE.

Paula Cadima
Architectural Association. UNITED KINGDOM

Isaac Guedi Capeluto
Technion – Israel Institute of Technology. ISRAEL.

Alexandre Carbonnel
Escuela Arquitectura. Universidad de Santiago. CHILE

Claudio Carrasco
Universidad Técnica Federico Santa María – Universidad de Valparaíso. CHILE

Giacomo Chiesa
Politecnico di Torino. ITALY.

Helena Coch
Universitat Politècnica de Catalunya. SPAIN.

Florencia Collo
Atmos Lab. ARGENTINA.

Erica Correa Cantaloube
CONICET Mendoza. ARGENTINA.

Manuel Correia Guedes
University of Lisbon. PORTUGAL.

Robert Crawford
University of Melbourne. AUSTRALIA.

Marwa Dabaieh
Malmö University. SWEDEN.

Richard De Dear
University of Sydney. AUSTRALIA.

Silvia De Schiller
Universidad de Buenos Aires. ARGENTINA.

Claude Demers
Laval University, Québec. CANADA.

Samuel Domínguez
Universidad de Sevilla. SPAIN.

Denise Duarte
Universidade de São Paulo. BRAZIL.

Felipe Encinas
Pontificia Universidad Católica de Chile. CHILE

Evyatar Erell
Ben Gurion University of the Negev. ISRAEL.

Carlos Esparza
University of Colima. MEXICO

Juan Carlos Etulain
Universidad Nacional de la Plata. ARGENTINA.

Arnaud Evrard
Université Catholique de Louvain. BELGIUM.

Lone Feifer
Active House Alliance. CANADA.

Jesica Fernández-Agüera
Universidad de Sevilla. SPAIN.

Gilles Flamant
Centro de Desarrollo Urbano Sustentable. CHILE.

Brian Ford
Natural Cooling Ltd. UNITED KINGDOM.

Miguel Ángel Gálvez Huerta
Universidad Técnica Federico Santamaría. CHILE.

Carolina Ganem
CONICET Mendoza. ARGENTINA.

Rodrigo García
Universidad del Bío-Bío. CHILE.

José Roberto García Chávez
Universidad Autónoma Metropolitana. MÉXICO.

Aritra Ghosh
University of Exeter. UNITED KINGDOM.

Mark Gilliott
University of Nottingham. UNITED KINGDOM.

Jorge Gironás
Pontificia Universidad Católica de Chile. CHILE.

Vanessa Gomes Silva
University of Campinas. BRAZIL.

Margarita Greene
Pontificia Universidad Católica de Chile. CHILE.

José Guerra
Universidad Católica del Norte. CHILE.

Rajat Gupta
Oxford Brookes University. UNITED KINGDOM.

Rafael Herrera-Limones
Universidad de Sevilla. SPAIN.

Marcos Hongn
Universidad de Salta. ARGENTINA.

Cecilia Jiménez
Pontificia Universidad Católica del Perú. PERÚ.

Nina Hormazábal
Universidad Técnica Federico Santa María. CHILE.

Cecilia Jiménez
CJD Arquitectos. PERÚ.

Alison Kwok
University of Oregon. USA.

Mauricio Lama
Pontificia Universidad Católica de Chile. CHILE

J. Owen Lewis
International Development Ireland. IRELAND.

Florian Lichtblau
Lichtblau Architects. GERMANY.

María Lopez de Asiain
Universidad de Las Palmas de Gran Canaria. SPAIN.

Sanyogita Manu
CEPT University. INDIA.

Leonardo Marques Monteiro
Universidade de São Paulo. BRAZIL.

Andrea Martinez
Universidad de Concepción. CHILE.

Juan Manuel Medina
Universidad de Los Andes. CHILE.

María del Pilar Mercader-Moyano
Universidad de Sevilla. SPAIN.

Ranny Michalski
Universidade de Sao Paulo. BRAZIL.

Aurora Monge-Barrio
Universidad de Navarra. SPAIN.

Michele Morganti
Universitá di Roma La Sapienza. ITALY.

Rafael Moya
Universidad de Concepción. CHILE.

Julia Mundo-Hernandez
Benemérita Universidad Autónoma de Puebla. MEXICO.

Emanuele Naboni
The Royal Danish Academy of Fine Arts. DENMARK.

Edward NG
The Chinese University of Hong Kong. HONG KONG – CHINA.

Diego Palma
Pontificia Universidad Católica de Chile. CHILE.

Massimo Palme
Universidad Técnica Federico Santa María. CHILE.

Ulrike Passe
Iowa State University. USA.

Pablo Pastén
Pontificia Universidad Católica de Chile. CHILE.

Andrea Pattini
CONICET Mendoza. ARGENTINA.

Alexis Perez-Fargallo
Universidad del Bío-Bío. CHILE.

Marco Perino
Politecnico di Torino. ITALY.

María Beatriz Piderit Moreno
Universidad del Bío-Bío. CHILE.

Eduardo Pimentel Pizarro
Universidade São Judas Tadeu. BRAZIL.

Adrian Pitts
University of Huddersfield. UNITED KINGDOM.

André Potvin
Laval University, Québec. CANADA.

Alessandra Prata Shimomura
FAUUSP. BRAZIL

Jesús Pulido
University of Tokyo. JAPAN.

Rajan Rawal
CEPT University. INDIA.

Dana Raydan
Raydan Watkins Architects. UNITED KINGDOM.

Alexandra Rempel
University of Oregon. USA.

María Isabel Rivera
Universidad de Concepción. CHILE.

Susan Roaf
Heriot-Watt University. SCOTLAND.

Lucelia Rodrigues
University of Nottingham. UNITED KINGDOM.

Carolina Rodriguez
Universidad Piloto de Colombia. COLOMBIA.

Jorge Rodriguez
Universidade de A Coruna. SPAIN.

Jean-François Roger-France
Université Catholique de Louvain. BELGIUM.

Jeannette Roldán Rojas
Facultad de Arquitectura y Urbanismo. Universidad de Chile. CHILE

Carlos Rubio
Universidad de Sevilla. SPAIN.

Khaled Saleh Pascha
University of Applied Sciences Upper Austria, AUSTRIA.

Agnese Salvati
Universidad Politécnica de Cataluña. SPAIN.

Mattheos Santamouris
University of Athens. GREECE.

Marc E Schiler
University of Southern California. USA.

Heide Schuster
BLAUSTUDIO – Sustainability in Architecture and Urban Design. GERMANY.

Valentina Serra
Politecnico di Torino. ITALY.

Denise Silva Duarte
University of Sao Paulo. BRAZIL

Masanori Shukuya
Tokyo City University. JAPAN.

Joana Soares Goncalves
Architectural Association School of Architecture. UNITED KINGDOM.

Victoria Soto Magan
Swiss Federal Institute of Technology. SWITZERLAND.

Thanos Stasinopoulos
Izmir University of Economics. TURKEY.

Tomás Swett
Universidad del Desarrollo. CHILE

Kheira Anissa Tabet Aoul
United Arab Emirates University. UNITED ARAB EMIRATES.

Hideki Takebayashi
Kobe University. JAPAN.

Maureen Trebilcock
Universidad del Bío-Bío. CHILE.

Leena E. Thomas
University of Technology. AUSTRALIA.

Ola Uduku
Manchester Metropolitan University. UNITED KINGDOM.

Juan Vallejo
University of Westminster – Natural Cooling Ltd. UNITED KINGDOM.

Sergio Vera
Pontificia Universidad Católica de Chile. CHILE

Magdalena Vicuña
Pontificia Universidad Católica de Chile. CHILE.

Rufei Wang
Atelier Ten USA LLC. UNITED STATES.

Paulina Wegertseder
Universidad del Bío-Bío. CHILE.

Barbara Widera
Wroclaw University of Technology. POLAND.

Jan Wienold
École Polytechnique Fédérale de Lausanne. SWITZERLAND.

Feng Yang
Tongji University. CHINA.

Simos Yannas
Architectural Association. UNITED KINGDOM.

Aram Yeretzian
American University of Beirut. LEBANON.

Gabriela Zapata-Lancaster
Cardiff University. UNITED KINGDOM.

Daniel Zepeda
University of A Coruña. SPAIN.

Antonio Zumelzu
Universidad Austral de Chile. CHILE.

S01 SESSION 01 page 43

Sustainable Urban Development (1) | ANDES HALL | Chair Agnese Salvati

1669	Modelling Resilient Construction through a Mixed-Use Development within an Urban Environment	Murray, Martin; Colclough, Shane; Griffiths, Philip
1329	Water Sensitive Urban Design Systems Thermal Behavior II: Thermal Analysis of WUD's Which Do Not Retain Water	Pérez Cambra, María del Mar; Martínez Santafé, María Dolors; Roca Cladera, Josep
1430	Cooling Cities. Innovative Water-Based Cooling Systems in the Era of Urban Heat: Solutions For Outdoor Climate Adaptation	Moredia Valek, Adrian; Dessi, Valentina
1458	Sky View Factor And Urban Heat Island Mapping. Applications In Barcelona	Salvati, Agnese; Casals, Jordi; Lopez Besora, Judit; Coch, Helena

S02 SESSION 02 page 69

Education and Training (1) | ANTARCTICA HALL | Chair Jonathan Bean

1535	Climate Positive Innovation and Design: Graduate Education to Drive Change in the Built Environment	Bean, Jonathan Yorke
1351	The Use of BIM Tools in E-learning for Architecture During the Covid-19 Pandemic. A Case Study at the University of Brasilia	Blumenschein, Raquel Naves; Muza, Pedro Henrique
1482	The Mini Wind Lab Project: An interactive, numerical, physical wind simulation platform concept for teaching	Moya Castro, Rafael
1627	A Shared Curriculum For Daylighting Education To Meet The Educational Needs Of Society	Gentile, Niko; Giuliani, Federica; Sarey Khanie, Mandana; Sokół, Natalia; Lo Verso, Valerio Roberto Maria; Caffaro, Federica; Kofod Pedersen, Mikkel; Pompili, Federica; Mattsson, Pimkamol
1655	New Demand for Training In Energy Efficiency In The Built Environment - The Development Of New Postgraduate Programs In Latin America	Dub, Angela; de Schiller, Silvia; Evans, Jobn Martin; Guillén Gutiérrez, Guido
1142	Sustainable Attitudes Project: The University Acting in the Education and Popularization of News Energy-saving Lamp Technologies	Brandao, Helena Camara Lace

S03 SESSION 03 page 103

Sustainable Architectural Design (1) | ATACAMA HALL | Chair Ulrike Passe

1392	Adequacy of Weather Data Standards to Assess Building Passive Performance During Summer: An Application to French Buildings	Piñas Moya, Mc Joshua Miguel; Gobert, Robin; Alessandrini, Jean-Marie; Sabre, Maeva; Kraiem, Samy; Lefebvre, Gilles; Liu, Wei; Pelé, Charles
1243	Optimization-based Design Of Insulating Cementitious Foams Combined With Phase Change Materials For NZEBs	Bre, Facundo; Caggiano, Antonio; Koenders, Eduardus A. B.
1469	Catalogue of Urban Surface Finish Materials. Optimizing Solar Energy Management in Latin American Cities Located in Different Climatic Zones	Perez, Gloria; Medina-Lagrange, Orisell; Martin-Consuegra, Fernando; Alchapar, Noelia; Flores Sasso, Virginia; Martinez, Patricia; Pezzuto, Claudia; Prado, Luis; Alonso, Carmen; Arnsdorff, Max; Frutos, Borja; Guerrero, Ana; Martinez-Ramirez, Sagrario; Ojeda, Juan; Ruiz-Valero, Letzai
1414	Automatic Mesh Generator For Urban Computational Fluid Dynamics Simulations	Gimenez, Juan Marcelo; Bre, Facundo

S04 SESSION 04 page 129

Architecture for Health and Well-being (1) | RAPA NUI HALL | Chair Maureen Trebilcock

1346	Lighting Planning For A Resilient Urban Environment: Visual Comfort And Well-being In The City During The Night	Vital, Rebeka; Peretz, Hanan
1407	Effect Of Window Glazing Colour And Transmittance On Human Visual Comfort	Jain, Sneha; Wienold, Jan; Andersen, Marilyne
1145	Folk Memories And Temperature Measurements For Thermal Comfort in Vernacular Courtyard Houses Of Saudi Arabia´s Hot Arid Climate: Resident´s Memories Of Living In Al-Khabra Vernacular Mud Brick Houses	Alghafis, Mohammed Fahad; Sibley, Magda; Latif, Eshrar
1652	Well-being In Office Spaces From The Occupants' Perspective. A Qualitative Approach	Trebilcock-Kelly, Maureen; Soto-Muñoz, Jaime; Wegertseder-Martínez, Paulina; Ramírez-Vielma, Raúl

S05 SESSION 05

page 155

Sustainable Architectural Design (2) | PATAGONIA HALL | Chair Felipe Encinas

1640	How Much Does Your Building Weigh? An Exploration Into Different Early Design Stage LCA Workflows	Newmarch, Emily Ruth; Donn, Michael; Dowdell, David; Twose, Simon; Short, Fiona
1417	Courtyard As A Microclimate Modifier Of Buildings In Hot Climates. A parametric Study	Alqadi, Shireen Bader; Elnokaly, Amira; Kafafi, Ahmad; Irfayieh, Wala
1608	Daylight Discomfort Glare In Home Workspaces: Influencing Factors And Adaptation	Buhagiar, Vincent; Psaila Diacono, Kimberley
1507	Bioclimatic Residential Buildings Strategies for Tropical Savanna Climate, Brazil: Examples of Heritage Modernist Houses in Goiania	Abreu-Harbich, Loyde Vieira de; Araújo, Larissa Rodrigues; Hora, Karla Emmanuela Ribeiro
1107	A Technical and Energy Performance Approach for the Construction and Operation of the Zero-energy Renovation of a Residential Building in the Netherlands	Konstantinou, Thaleia; Boess, Stella

S06 SESSION 06

page 187

Sustainable Urban Development (2) | ANDES HALL | Chair Margarita Greene

1609	Vegetation as a Mitigation Strategy on Mediterranean Context: Outdoor Thermal Comfort From Simulated Data	Arriaga Osuna, Maria Fernanda; Martínez-Torres, Karen Estrella; Rincón-Martínez, Julio Cesar; González-Trevizo, Marcos Eduardo
1476	Urban Materials For Thermally Liveable Madrid. A Digital Twin Strategy To Characterize Developments	Giancola, Emanuela; López, Helena; Soutullo, Silvia; Sánchez, Nuria; Gamarra, Ana; Herrera, Israel; Zarzalejo, Luis; Naboni, Emanuele
1556	Evaluation of Thermal Performance of Urban Asphalt Pavements with Rubber Incorporation	Kowalski, Luiz Fernando; Amancio, Daiane Coragem; Viana, Juliana Fernandes; Silva, Felipe Pereira da; Teixeira, Ivonei; Masiero, Érico
1550	Can different vegetation influence on outdoor thermal comfort by cycling routes in tropical savanna climates?	Abreu-Harbich, Loyde Vieira de; Roriz, Júlia Wilson de Sá; Hora, Karala Emmanuela Ribeiro
1357	Evaluation of radiant Temperatures of Tree Canopies and their Effects on Close Surfaces	Garcia, Thiago dos Santos, Labaki, Lucila Chebel

S07 SESSION 07

page 217

Sustainable Buildings and Technology (1) | ANTARCTICA HALL | Chair Susel Biondi

1397	Integration Of Sustainability Tools And Building Information Modelling In The Early Stages Of Design	Berges Alvarez, Ileana; Muñoz Fierro, Jorge; Giraldi, Sebastian; Marín-Restrepo, Laura
1390	Development of an Artificial Neural Network Prediction Model for Reducing Particulate Matter (pm2.5) in School Facility	Kim, Tae Won; Choi, Young Jae; Byun, Jae Yoon; Moon, Jin Woo
1166	A Dynamic Feedforward Control Strategy for Energy-efficient Building System Operation	Chen, Xia; Cai, Xiaoye; Kümpel, Alexander; Müller, Dirk; Geyer, Philipp
1638	Energy Renovation Towards Net-Zero Carbon Emission Buildings: a case study in Sweden	Bernardo, Ricardo; Pizarro, Rafael

S08 SESSION 08

page 241

Sustainable Architectural Design (3) | ATACAMA HALL | Chair Carolina Ganem

1306	Potentials of Passive Housing Design in Emerging Countries with Mediterranean Climate: Latest Results and Design Recommendations for Central Chile	Mueller, Ernst
1493	Passive Design Optimization Towards Nearly Zero Energy Buildings Requirements. Operational Performance of a Low Energy Office Building in Continental Semi-arid Climate.	D Amanzo, Micaela; Andreoni Trentacoste, Soledad Elisa; Montiel Zamorano, Virginia Gloria; Betman, Alicia; Ganem Karlen, Carolina
1356	Net Zero Energy Buildings: Analysis of passive strategies for buildings retrofits in central-southern Chile	Valenzuela, Andrea Belen; Guiñez, Roxana Andrea; Bedoya, Daniel; Toledo, Romina Valentina
1260	An Innovative Environmental Test Chamber for Testing Passive Cooling Prototypes: A New Methodology for Research and Pedagogical Applications	Al-Hassawi, Omar Dhia; Drake, David
1323	The Complex Challenge of Sustainable Architectural Design. Assessing Climate Change Impact on Passive Strategies and Buildings' Opportunities for Adaptation. A case study.	Ganem Karlen, Carolina; Barea Paci, Gustavo Javier

S09

SESSION 09

page 275

Architecture for Health and Well-being (2) | RAPA NUI HALL | Chair Isabel Rivera

1665	Humanizing Social Housing: A Case Study of Indoor Environmental Quality in San Pedro de la Costa, Chile	Rivera, Maria Isabel; de la Barrera, Francisco; Barraza, Camila; Durán, Carla; Pavez, Jorge; Martínez, Andrea
1471	I Lived in a Passive House Building: Here's What I Learned. A Post-occupancy Evaluation Comparing Indoor Environmental Quality And Performance Between One Residential Unit Built To Passive House Standrads And Another Residential Unit Built To Conventional Standards	Shemesh, Sigal
1110	Analysis Of Urban Thermal Behaviour In Hot Dry Climate In Relation To Its Vegetation Before And After The COVID-19 Pandemic	Grajeda-Rosado, Ruth Maria; Vazquez-Torres, Claudia Erendira; Sotelo-Salas, Cristina
1663	Neurourbanism: Analysis of Public Space of Small Town Peruíbe -SP	Oliveira, Halana Duart; Morelli, Denise Damas de Oliveira
1416	Co-producing Healthy Communities: A Methodological Approach to Prevent Arbovirus Epidemics in a Brazilian Social Housing Neighbourhood	Garrefa, Fernando; Villa, Simone Barbosa; Bortoli, Karen Carrer Ruman de; Stevenson, Fionn; Vasconcellos, Paula Barcelos; Carvalho, Nathalia Lya de Melo

S10

SESSION 10

page 307

Analysis and Methods (1) | PATAGONIA HALL | Chair Vincent Buhagiar

1172	Urban Vulnerability Assessment And Urban Planning Management To Urban Heat Islands in France: A Multicriteria Analysis	Techer, Magalie; Ait Haddou, Hassan; Aguejdad, Rahim
1585	The microclimate effects of urban green infrastructure under RCP 8.5 projection and plant vitality. Will plants be enough?	Yoshida, Daniel Felipe Outa; Shinzato, Paula; Duarte, Denise Helena Silva
1199	Analysing the Effect of Cool and Green Roof Design Scenarios on Building Energy Loads and Air Temperature at Pedestrian Level in Hot Arid Climate	Elnabawi, Mohamed; Hamza, Neveen; Sedki, Ali
1468	Fos Gis to Support Regenerative Design Processes in Urban Areas	Clementi, Matteo; Romano, Manuela; Rogora, Alessandro
1213	Aerodynamic Analysis of Urban Blocks: Case Study in Open, Row and Vertical Block	Girotti, Carolina; Nazareth, Samuel Bertrand Melo; Shimomura, Alessandra R. Prata

S11

SESSION 11

page 339

Sustainable Urban Development (3) | ANTARCTICA HALL | Chair Magdalena Vicuña

1673	Mind the Gap: Bridging the Void between Energy Policy as Business and Social Policy as Equality.	Murray, Martin; Colclough, Shane; Griffiths, Philip
1434	Hygrothermal Characterization Of Water-absorbing Granules: A Preliminary Experimental Study For The Development Of An Evaporative Cooling Façade Module	Görgen, Fabian; Rossi-Schwarzenbeck, Monica
1300	Impact-Based Project Ideas for Sustainable Cities: The Case Of Digital Planning Tools In Piura, Peru	Fernandez, Trinidad; Schroeder, Stella
1305	Where Public Space Meets Climate Change. Linking Urban Projects With Lisbon's Metropolitan Adaptation Plan	Santos, João Rafael
1309	Targeting the Most Energy Vulnerable. Deprived Neighbourhoods at Risk of Winter Fuel Poverty and High Summer Urban Heat Island Intensity. A Study Case in Madrid (Spain)	Martin-Consuegra, Fernando; Núñez Peiró, Miguel; Alonso, Carmen; Sánchez-Guevara, Carmen; Pérez, Gloria; Arranz, Beatriz

S12

SESSION 12

page 371

Challenges for Developing Countries (1) | RAPA NUI HALL | Chair Joana Goncalves

1543	Symptomatic Urbanism: Analysing The Relationships Between Motorway Traffic And Health And Food	da Rocha, Emanuela Alves; Drach, Patricia Regina Chaves
1318	Improving The Environmental Conditions Of Favela Homes Through A Participatory Process: With Reference to Case-studies In São Paulo And Rio De Janeiro	Soares Goncalves, Joana Carla; Paixao, Patricia; Shimomura, Alessandra R. P.; Pizarro, Eduardo P.; Curcio, Gustavo; Diegues, Gustavo
1363	Microclimate Evaluation Method for Urban Planning in Legal Amazon Region	Sanches, João Carlos Machado; Domingos, Renata Mansuelo Alves; Guarda, Emeli Lalesca Aparecida; Assis, Eleonora Sad
1149	Optimization Of A Social Housing Model In Brazil: The EPS Application To Reduce The Impact Of Climate Change On Buildings' Thermal-Energy Performance	Cruz, Alexandre Santana; Bastos, Leopoldo Eurico Gonçalves; Besson, Axel
1513	City Lab: Support Infrastructure	Cardona Betancourt, Manuela; Aguirre Arango, Juan Camilo; Monroy Arango, Santiago; Velasquez Loaiza, Juanita Carolina; Gonzales Ceballos, Juan Carlos; Correa Vanegas, Gustavo
1433	Daylight Priority In Apartment Room-Layout Design When Daylight Access Is Limited Due To Dense Urban Surroundings: A Case From Dhaka City	Islam, Saiful; Uddin, Mohammed

S13 SESSION 13

page 409

Sustainable Buildings and Technology (2) | ANDES HALL | Chair Nina Hormazabal

1221	Comparative Study Of Two Passive Cooling Systems: Indirect Evaporative Cooling Vs. Radiant-Capacitive Cooling	Gonzalez-Cruz, Eduardo Manuel; Krüger, Eduardo
1561	Thermal Performance Of Ceramic Coatings Used On Vertical And Horizontal Surfaces	Castello, Ana Julia Pilon; Carvalho, Marcius Fabius Henriques; Pezzuto, Claudia Cotrim
1421	Reversible Building Design: Viewing A Building As A Material Bank	Ossio, Felipe; D'Alençon, Renato; Rücker, Moritz; Ahumada, Matías
1661	Characterization Of Native Macroalgae: "Pelillo" (Agarophyton Chilense) And "Lamilla" (Ulva Lactuca) For The Development Of A Prototype Thermal Insulating Material	Rojas Herrera, Carlos Javier; Uribe De La Cruz, Claudio Marcelo; Cárdenas Ramírez, Juan Pablo

S14 SESSION 14

page 435

Sustainable Architectural Design (4) | ATACAMA HALL | Chair Chris Whitman

1156	Adaptation of Passive Heating Strategies in the Peruvian Mesoandean Zone: Thermal Improvement In Social Housing	Pari Quispe, Diana Karen; Cronemberger Ribeiro Silva, Joára; Frederico e Silva, Caio
1224	Thermal Performance of Traditional Courtyard Houses in Warm Humid climate. Case Study of Colima, Mexico.	Toris Guitron, Maria Gabriela; Esparza López, Carlos J.; Escobar del Pozo, Carlos
1534	Hygrothermal Comfort In School Yard. A Case Study Leed In Rio De Janeiro	Pereira da Silva, Rita de Cassia; Nogueira de Vasconcellos, Virginia Maria
1496	Hygrothermal Evaluation of an Indigenous Dwelling on the Andean Highlands: Evidence Of How Atacameño Architecture Can Achive Better Indor Thermal Standards Than Those Set By The Chilean Regulation And The Average Chilean Dwellings	Escobar Doren, Irene Paulina
1165	Replacement Infill Panels for Historic Timber-Framed Buildings: Measured and Simulated Hygrothermal Behaviour	Whitman, Christopher J.; Prizeman, Oriel; Walker, Pete; Rhee-Duverne, Soki; McCaig, Iain; Gervis, Nigel

S15 SESSION 15

page 467

Sustainable Architectural Design (5) | PATAGONIA HALL | Chair Florencia Collo

1352	Innovative Transparent and Translucent Materials on Facades: Non-Visual Effects of Light	Walter Costa, Joao Francisco; David Amorim, Claudia Naves
1112	Performance Analysis Of Side Lighting Systems In Commercial Buildings In Southern Brazil	Gabriel, Elaise; Zambonato, Bruna; Meller, Gabriela; Grigoletti, Giane
1633	Green Facades and Its Shading Potential: the solar radiation attenuation promoted Promoted by Climber Species	Munoz, Luiza Sobhie; Fontes, Maria Solange Gurgel de Castro
1139	Building-integrated Solar Technology: Learning From More Than 30 Years Of Experience With Solar Buildings (Examples From International Competitions)	Krippner, Roland; Flade, Fabian
1111	Application Case of a Bioinspired Approach: Ideation, Prototyping and Assessment of a Novel Thermo-responsive and Deployable Building Skin	Hubert, Tessa; Durand-Estebe, Baptiste; Dugué, Antoine; Vogt Wu, Tingting; Aujard, Fabienne; Bruneau, Denis

S16 SESSION 16 page 499

Challenges for Developing Countries (2) | RAPA NUI HALL | Chair Susel Biondi

1136	Roadmap Towards Energy-Efficient Buildings at a City Perspective: Case Of Study Of Florianopolis, Brazil	Triana, Maria Andrea; Geraldi, Matheus Soares; Melo, Ana Paula; Lamberts, Roberto
1345	Participatory learning methods to improve energy efficiency in Chilean residential sector: Public programs to support self-management	Schueftan, Alejandra; Reyes, René; Aguilera, Florencia
1211	Design Research Role in Supporting Net-Zero Buildings	Moreno-Rangel, Alejandro; Tsekleves, Emmanuel; Young, Paul; Huenchuñir, Marcelo; Vazquez, Juan Manuel
1677	Factors That Promote the Offer of Green Financing for Real Estate Projects of High Energy Efficiency Housing	Palominos Gajardo, Paola Andrea; Marmolejo Duarte, Carlos Ramiro
1245	The Cost Of Rehabilitating A Historical Building: Application Of Roof Materials Alternatives Towards Thermal Comfort	Moon, Beatriz Se Keng; Gonçalves, Sara Breia; Barbosa, Sabrina Andrade

S17 SESSION 17 page 531

Sustainable Urban Development (4) | ANTARCTICA HALL | Chair Denise Duarte

1672	Analysis of Isolated Shrubby-Arborean Species as a Barrier to Winds for Urban Thermal Comfort: Methods to Obtain the Leaf Area Index	Padovani Zanlorenzi, Helena Cristina; Marques Monteiro, Leonardo
1223	How hot is your city design? Surface temperature portrait of São Paulo Metropolitan Region	Ferreira, Luciana Schwandner; Duarte, Denise Helena Silva
1457	Urban Oasis For Adaptation To Climate Change: Analysis Of Climate Adaptation Plans (CAP) Around The World	Sousa, Bruna Dallaverde; Yoshida, Daniel Felipe Outa; Duarte, Denise Helena Silva
1250	CityPlan Water Neutrality Framework for New Urban Developments	Puchol-Salort, Pepe; Mijic, Ana; Van Reeuwijk, Maarten; Boskovic, Stanislava; Dobson, Barnaby
1621	Exploring the Association Between Satellite Indices and Local Climate Zones in Brasília, Brazil	Werneck, Daniela; Romero, Marta

S18 SESSION 18 page 563

Sustainable Architectural Design (6) | ATACAMA HALL | Chair Joana Goncalves

1606	Wladimiro Acosta And The Helios System: 3 Case Studies. Comparative Analysis And Critical Review	Collo, Florencia
1331	2000 Meters Above Sea Level: Climate Adapted Urban Development Strategies In The Highlands Of Oman	Kader, Alexander; Kamal Ritu, Nusrat
1322	Lessons Learnt From The Brazilian Bioclimatic Modernism: The Case-Study Of The Sul American Bank Building (1966)	Soares Goncalves, Joana Carla; C. Kronka Mulfarth, Roberta; Loureiro Xavier Nascimento Michalski, Ranny; R. Prata Shimomura, Alessandra; Nascimento e Souza, Beatriz; Reis Muri Cunha, Guilherme; Pereira Marcondes-Cavaleri, Monica; Regina Sara, Sheila
1530	Exploring The Thermal Quality Of The Modernism Legacy's Architecture: Analytical Studies Of Acayaba's Single-Family Houses In São Paulo	Lima, Eduardo Gasparelo; Gonçalves, Joana Carla Soares; Michalski, Ranny Loureiro Xavier Nascimento

S19 SESSION 19 page 591

Architecture for Health and Well-being (3) | ANDES HALL | Chair Nina Hormazabal

1622	Engaging School Facilities: a literature review	Kwok, Alison G.; Coronado Cabrera, Maria Camila; Lee, Jean K.L.; Fretz, Mark; Van Den Wymelenberg, Kevin; Seely, John
1515	Thermal Performance In Educational Environments From The Consideration Of Climate Change In Medellín, Colombia	Patino Vasquez, Carolina; Palacio Zapata, David
1298	Overheating risk in naturally ventilated and conditioned elementary schools from the perspective of climate change	Gnecco, Veronica Martins; da Guarda, Emeli Lalesca Aparedida; Mizgier, Martin Órdenes; Lamberts, Roberto
1642	Acoustic Design in Open-plan Learning Environments: Dealing With Sound Intrusion For Speech Intelligibility	Ipinza Olatte, Constanza; Trebilcock Kelly, Maureen; Piderit Moreno, María Beatriz

S20 SESSION 20

page 617

Sustainable Architectural Design (7) | PATAGONIA HALL | Chair Ulrike Passe

1671	Strategies for a 2050-Ready Project in an Urban Environment: thus avoiding social inequalities.	Murray, Martin; Colclough, Shane; Griffiths, Philip
1371	Effect Of Neighborhood Density On Energy Consumption, A Comparative Study Of Two Inner-Urban Neighborhoods In Des Moines	Ghiasi, Sedigheh; Passe, Ulrike; Zhou, Yuyu
1396	Multi-level Microclimate Analyses of Mediterranean Grouped Individual Holiday Housing in Hot Summer Conditions	Sansen, Marjan; Martínez, Andrés; Devillers, Philippe
1268	Learning Sustainable Design from Modern Egyptian Architecture: How the Pre-HVAC Residential Buildings of Sayed Karim Embody Contemporary Sustainability Principles	El Kady, Mahmoud; Goubran, Sherif

S21 SESSION 21

page 643

Analysis and Methods (2) | PATAGONIA HALL | Chair Massimo Palme

1320	A First Look at Italian Cloisters Resilience to a Changing Climate: The case of San Sepolcro in Parma (IT)	Touloupaki, Eleftheria; Gherri, Barbara; Naboni, Emanuele
1257	Green Infrastructure To Reduce Cooling Loads and Heat Stress in Mediterranean Climates. A Building Performance Simulation And Machine Learning Approach	Palme, Massimo; Mangiatordi, Anna; Privitera, Riccardo; La Rosa, Daniele; Clemente, Carola; Carrasco, Claudio
1161	Comparative Analysis of Viçosa's Weather Files: Simulation Adequacy for Urban Microclimate	Lucarelli, Caio de Carvalho; Oliveira, Matheus Menezes; Carlo, Joyce Correna
1277	Indoor Comfort and Winter Energy Performance of Lightweight Steel-Framed Buildings in Extreme Climates: a Case Study in Barnaul (RU)	Callegaro, Nicola; Albatici, Rossano; Kharlamov, Ivan; Kulikova, Lyudmila; Saurina, Tatiana; Scavazza, Federica; Manzini, Giovanni
1177	Optimisation of Housing Design Options for Human-Centric Lighting: Impact Of Architectural Parameters On Daylight	Hoang, Kelvin; Peters, Terri
1335	Data-Driven Design for Climate Adaptation: Testing a Ladybug Tools workflow for the design of climate responsive shading canopies	Nicholson, Sinead Kelly; Nikolopoulou, Marialena; Watkins, Richard; Ratti, Carlo

S22 SESSION 22

page 681

Sustainable Urban Development (5) | ANTARCTICA HALL | Chair Magdalena Vicuña

1624	Outdoor Thermal Comfort Studies in the Pedestrian Corridor between two High-rise Buildings in the Mediterranean Climate	Saroglou, Soultana {Tanya}; Meir, Isaac A.
1466	Walkability And Solar Radiation Exposure For Diverse Users: Climate-responsive Urban Design To Enhance Accessibility To Outdoor Spaces	Tomasi, Marika; Nikolopoulou, Marialena; Giridharan, Renganathan; Romero, Juan Carlos; Löve, Monika; Ratti, Carlo
1404	Impact Of Urban Neighbourhood Layouts On Outdoor Thermal Comfort In European Cities With Temperate Climate	Wu, Yehan; Patuano, Agnes; Mashhoodi, Bardia; Lenzholzer, Sanda; Acred, Andy; Narvaez Zertuche, Laura
1226	Discussion on Sustaining Old Street without Losing Integrity of Local Identity. Focused on old street at Jeju, Korea	Yi, Yun Kyu; Yi, Yongkyu; Anis, Manal

S23 SESSION 23

page 707

Sustainable Architectural Design (8) | ANDES HALL | Chair Alejandra Schueftan

1179	A Life Cycle Perspective on Vertical Densification: Embodied Impact Assessment of Vertical Building Extensions	Reitberger, Roland; Schade, Carsten; Banihashemi, Farzan; Lang, Werner
1227	Obispo 204. Application of Sustainable Strategies in a Building in Old Havana	Quesada Campana, Talia
1490	Decarbonization at the Campus Scale: Evaluating the Life-Cycle Carbon Impacts of Deep Energy Retrofits of Three University Building Typologies	Hyatt, Allison; Pérez-Aguirre, Catalina; Yarnell, Adam; Grinham, Jonathan
1330	Redefining Happy Cities Of The Post-Pandemic Era	Kader, Alexander; Kamal Ritu, Nusrat
1241	Case Study Using Green Remodeling Certification	Hwang, Sang-Hee; Kim, Sung-Wan; Lee, Kyung-Hoi; Park, MyungKyu

S24 SESSION 24 page 741

Architecture for Health and Well-being (4) | RAPA NUI HALL | Chair Andrea Martínez

1148	Pre- and Post-COVID-19 Synergies between Research and Practice in Health and the Built Environment	Engineer, Altaf; Bernal, Sandra
1294	One Size Does Not Fit All. Questions and Insights to Develop New Occupant Centred Wellbeing And Comfort Models	Wegertseder, Paulina
1412	Adapting The Workspace To The New Reality In Mexico City	Ibarra Flores, Daniel
1483	Evaluation of Ventilation Rates in Residential and Non-residential Spaces During Occupation Using Carbon Dioxide Concentrations	Carrasco, Ignacio; Molina, Constanza
1201	Optimized design for a smart office indoor environment for mitigating electromagnetic radiation pollution. Future Cities	Raveendran, Reshna; Anissa Tabet Aoul, Kheira
1220	Regenerating Urban Surfaces to Achieve Healthy and Resilient Neighbourhoods: a Case Study of Trento, Italy	Codemo, Anna; Favargiotti, Sara; Albatici, Rossano

S25 SESSION 25 page 779

Sustainable Architectural Design (9) | ATACAMA HALL | Chair Gilles Flamant

1123	Eco-cooler for Vulnerable Communities. A Low-tech Passive Cooling Vernacular Approach for Hot Arid and Humid Climates	Dabaieh, Marwa; Kazem, Medhat; Michel Zakaria, Monica
1124	Z free home	Dabaieh, Marwa
1218	Natural Ventilation for Indoor Air Quality in Schools Regarding Thermal Comfort during the Winter Season in Chile	Ordenes, Martin; Flamant, Gilles
1639	Communicating Carbon: Visualising Embodied Carbon Results for Data Lead Design Decisions	Newmarch, Emily Ruth; Donn, Michael; Twose, Simon; Short, Fiona; Dowdell, David
1202	Energy Demand Reduction In Two Case Studies Based On The Same Residential Studio: Mediterranean And Hot Climates	Alqadi, Shireen Bader; Elnokaly, Amira; Abureesh, Noor; Rjoub, Sojoud; Alnatsheh, Zahra
1524	Seasonal Cooling/ Heating Effect Produced by Courtyards with Different Aspect Ratio in Tropical Climates	Callejas, Ivan Julio Apolonio; Krüger, Eduardo; Amarantes, Leticia Mendes do; Santos, Fernanda Aparecida Santana Dos; Silva, Deborah Torres da

S26 SESSION 26 page 819

Sustainable Architectural Design (10) | ANDES HALL | Chair Gilles Flamant

1598	The Thermal Performance Of Lacaton&Vassal's Winter gardens, Revisiting Three Case Studies	Collo, Florencia; Dambron, Olivier; Alonso Candau, Rafael
1637	Energy performance simulation in a residential building in Santiago. Impact of passive design considerations, building envelope features, ventilation strategies and energy systems	Melano, Mario Leonardo; Flamant, Gilles; Simon, Francois; Echaíz, Josefina; Osorio, César; Rivera, Javier; Bustamante, Waldo; Figueroa, Angélica
1587	Analysis on Building Energy Performance with DSSC BIPV Window According to Lighting Control Method	Kim, Nam Hyeon; Hyun, Ji Yeon; Park, Bo Rang; Choi, Eun Ji; Moon, Jin Woo
1302	Evaluation of standards for office buildings to optimize thermal comfort under free running: Case of Concepción, Chile	Navarro-Ortiz, Matias; Matter-Jofre, Helena; Salazar-Vera, Carolina; Saravia-Monsalves, Ignacio

S27 SESSION 27 page 845

Sustainable Buildings and Technology (3) | ANTARCTICA HALL | Chair Massimo Palme

1140	Passive Displacement Coil Unit (PDCU) System and Thermal Comfort Performance Evaluation	Jusuf, Steve Kardinal; Neo, Poh Hong; Ng, George; Soh, Yong Loke
1109	Towards Occupant-driven District Energy System Operation: A Digital Twin Platform For Energy Resilience And Occupant Well-being	Mosteiro-Romero, Martin; Alva, Pradeep; Stouffs, Rudi; Miller, Clayton
1544	Multi-objective Optimization of Bio-based Thermal Insulated Panels using Evolutionary Algorithms	Iannantuono, Marco; Catalogne, Francesca; Cardenas-Ramírez, Juan Pablo
1394	Life Cycle Analysis of Typical Buildings iIn Chile: From Materials Production To Building Construction And Demolition	Frías, Katherin; Herrera, Pamela; Palme, Massimo; Chacana, Jaime

S28 SESSION 28

page 871

Education and Training (2) | RAPA NUI HALL | Chair Giovanni Vecchio

1119	Systems-oriented Building Design (S.O.B.D.): A New Way of Storytelling on the Design of High-performance Buildings for Sustainable Tomorrow	Kamari, Aliakbar
1130	The Power of Individual Choices. The Research on Individual Sustainable Initiatives and Environmental Activism Analysed in the Building Context	Widera, Barbara
1619	An Innovative Approach for Teaching Physics of the Built Environment	Chvatal, Karin Maria Soares; Mülfarth, Roberta Consentino Kronka; Dornelles, Kelen Almeida; Shimomura, Alessandra Rodrigues Prata; Mattia, Pedro Henrique Silva; Michalski, Ranny Loureiro Xavier Nascimento; Silva, Wellington Souza
1580	Toward Zero-carbon Built Environments: Best Practices for Integrated Design Studio Teaching	McGlynn, Michael James; Kirchmer, Kendra Danielle
1176	Climate Change Urbanism State of the Art: A Scientometrics Analysis	Vergara-Perucich, José Francisco; Aguirre-Nuñez, Carlos

S29 SESSION 29

page 903

Analysis and Methods (3) | PATAGONIA HALL | Chair Emanuele Naboni

1160	Effect of Building Properties and Lifestyle on Electricity Consumption in the Home: Case Study at a Mediterranean Desert City	Bogin, Diana; Kissinger, Meidad; Erell, Evyatar
1170	Assessment of the Building Stock Performance to Obtain Requirements for Energy Codes. A Building Stock Modelling Approach Aiming Efficient Cities	Geraldi, Matheus Soares; Triana, Maria Andrea; Pereira de Souza, Larissa; Mendes, Lorrany; Melo, Ana Paula; Lamberts, Roberto
1265	The Influence Of Colour And The Light In The Study Environment	Pereira de Carvalho, Gabrielle Galvao; de Oliveira Morelli, Denise Damas
1381	Window Design to Improve Natural Ventilation Performance Including Climate-based Metrics and Human Factor Analysis	Molina Botero, Laura; Orozco Mesa, Maria Jimena; Orozco Sosa, Maria Alejandra; Salazar Trujillo, Jorge Hernán
1586	Calculating The Carbon Footprint Of Different Construction Options During The Building Design Phase In The Latin American Context. The EVAMED Case Study	Arvizu-Piña, Victor; García González, Alberto; Tortolero Baena, Andrés; Armendáriz López, José; Arce Anguiano, Rodrigo; Carmona Guzmán, Mariana; Gazulla Santos, Cristina; Chargoy Amador, Juan Pablo

S30 SESSION 30

page 935

Sustainable Architectural Design (11) | ATACAMA HALL | Chair Isabel Rivera

1169	Building Façade Through the Ages: How Architectural Envelope Reflects Changing Awareness of Nature and Climate Responsiveness	Anis, Manal; Yi, Yun Kyu
1644	Responsive Brise-soleil: Design Concept and Performance Analysis	de Bem, Gabriel; La Roche, Pablo; Krüger, Eduardo; Augusto Alberto Moreira de Abreu, Alexandre
1192	Proposal of Climatic Zoning for Buildings in Mozambique	Benevides, Mariana Navarro; Teixeira, David Bruno de Sousa; Carlo, Joyce Correna
1367	Influence of urban morphology on thermal gain: Brazilian Context	Domingos, Renata Mansuelo Alves; Guarda, Emeli Lalesca Aparecida; Pereira, Fernando Oscar Ruttkay

S31

SESSION 31

page 961

Sustainable Architectural Design (12) | PATAGONIA HALL | Chair Héctor Altamirano

1441	What Interior Temperatures Can Be Expected In Irish Nzeb Dwellings? An Analysis Of Recorded Interior Temperatures In A Scheme Of Irish Nzeb Dwellings Built To The Passive House Standard	Colclough, Shane; OHegarty, Richard; Leblanc, Mathieu; Desbertrand, Tom; Hewitt, Neil; Kinnane, Oliver
1280	Rethinking the Work Environment: An analytical design applicability to office buildings in Santiago, Chile	Swett, Tomas; Soares Goncalves, Joana Carla; Bode, Klaus
1366	Influence of Cost-benefit of Different Construction Systems for Envelopment on Energy Consumption in a Housing of Social Interest	Domingos, Renata Mansuelo Alves; Pereira, Fernando Oscar Ruttkay
1646	One-Stop-Shops as a Model to Manage Housing Energy Retrofit. A General Approach to Europe and Spain	Marmolejo-Duarte, Carlos; Biere-Arenas, Rolando; Spairani-Berrio, Silvia; Spairani-Berrio, Yolanda; Pérez-Lamas, Carlos
1546	Assessment of a Retrofit Proposal for Workspace in a Brazilian Public University	Castro, Adriana Petito de Almeida Silva; Barbosa, Elisabeti; Albertin, Camila de Freitas; Labaki, Lucila Chebel

S32

SESSION 32

page 993

Sustainable Architectural Design (6) | ANTARCTICA HALL | Chair Carlos Esparza

1364	How Climate Trends With Urban Morphology Impact The Thermal Performance of Buildings	Guarda, Emeli Lalesca Aparecida; Domingos, Renata Mansuelo Alves; Machado, Rayner Maurício e Silva; Mizgier, Martin Ordenes; Pereira, Fernando Oscar Ruttkay
1196	Understanding Informal Production Of Public Spaces For A New, Sustainable Urban Planning Strategy. Case Study Of Community Gardens In Piura, Peru	Schroeder, Stella
1267	Brazilian Coastal Cities: A Case Study Related To The Impact Of Rising Sea Level	Bussolotti, Victor Moura; Pellegrini, Izabela Uliana; Alvarez, Cristina Engel de
1670	Urban Climate Model For Valparaiso, Chile. Adaptation Of The Urban Climate Model Of The Eixample Area Of Barcelona City	Carrasco, Claudio; Palme, Massimo; Isalgué, Antonio
1269	Climate Change and Megacities: South Asian Mega-cities are in Extreme Heat Stress	Debnath, Kumar Biswajit; Jenkins, David; Patidar, Sandhya; Peacock, Andrew D; Bridgens, Ben; Mitrani, Helen

S33

SESSION 33

page 1025

Sustainable Architectural Design (13) | ATACAMA HALL | Chair Felipe Victorero

1271	Recycling Waste and its Applications in Building Construction: Aseptic Packaging as a Thermal Insulator for Emergency Housing	López-Guerrero, Rafael Eduardo; Nalbandian, Kevork Micael; Caamaño, Leonardo; Beller, Scott; Carpio, Manuel
1348	The Potential Of Wall Thermosyphon To Reduce Heat Generated By Internal Charge Density In Residential Bedrooms	Almeida, Fernando da Silva; Brandalise, Mariane Pinto; Cisterna, Luis Hernán Rodríguez; Mantelli, Marcia Barbosa Henriques; Mizgier, Martin Ordenes
1361	Development of Accessibility Evaluation Checklists for Public Sports Facilities	Baek, Si-Yeon; Bae, Yoong-Ho; Kim, Jin-Cheol; Kim, Sung-Wan; Lee, Kyung-Hoi
1659	The Effects Of An Airtightness Prescriptive Regulation Code In A Developing Country: The Chilean New Housing Airtightness Requirements And Its Effects On The Timber Construction Quality	Victorero, Felipe; Mendez, Daniela
1184	¿Innovation or Effectiveness? Using a Competition as a Teaching Tool	Herrera-Limones, Rafael; LopezDeAsiain, Maria; Borrallo- Jiménez, Milagrosa; Roa-Fernández, Jorge; Hernández-Valencia, Miguel

S34

SESSION 34

page 1057

Sustainable Buildings and Technology (4) | ANDES HALL | Chair Barbara Widera

1615	Photocatalytic Wall Shingles from Recycled High-Density Polyethylene. An Environmental Solution to Remove Atmospheric Gaseous Pollutants in Urban Areas	Carbonnel, Alexandre; Perez, Hugo; Gavilanes, Dayana; Loyola, Mauricio; Moreno, Cristobal; Escobar, Daniel; Jiménez, Maria Paz; Murillo, Herman; Chacón, Carla; Formandoy, Yanara; Masferrer, Roxana
1599	Calculating Algorithm to Estimate the Hygrothermal Performance of Vegetation for Green Screen Façades	Vásquez, Claudio; Da Rocha, Camila; De La Barra, Pedro Pablo
1559	Thermal Insulation Using Sheep Wool: Social, Environmental And Economic Impact Of Large-Scale Use In Social Housing	Nunez Berte, Alejandra Elena; Evans, John Martin; Fernandez Luco, Luis
1158	Analysis and Assessment of the Global Warming Potential of Solid Wood and Timber Frame Construction Based on a Life Cycle Assessment Including Forestry Production and Transport Options	Stanger, Nico Frank; Findeisen, Erik; Steinbach, Sven
1344	Vacuum-glazed Windows: A Review on Recent Projects' Methods, Results, and Conclusions.	Pont, Ulrich; Schober, Peter; Wölzl, Magdalena; Schuss, Matthias; Haberl, Jakob

S35 SESSION 35

page 1087

Challenges for Developing Countries (3) | RAPA NUI HALL | Chair Alessandra Prata

1374	Endogenous Constructions Under Abnormal Conditions: Taking Two New Rammed Earth Constructions In Rural Areas Of Southwest China As Examples	Liu, Xiaoxue; Wan, Li; Chi, Xinan
1129	Ethics of a Brick: Investigating the common wood fired brick in Uganda	Olweny, Mark Raphael Owor; Ndibwami, Alex; Ahimbisibwe, Achilles; Niwamara, Thomas; Mugeme, Patrick; Kirabo, Brenda; Ayebare, Derek
1445	Can Solar Thermal Heating Mitigate Fuel Based Space Heating in the High Mountains of Lebanon?	Geagea, Tony Lichaa; Saleh, Philippe H.
1531	Experimental Construction Site and Student Autonomy: Perspectives of Another Teaching for Equitable Cities	Carvalho, Conrado Goncalves; Silvoso, Marcos Martinez
1552	Streetscapes for São Paulo: Walkability and Ergonomics. An Urban Assessment Methodology for Urban Design Policies	Sato, Andre Eiji; Albala, Paula Lelis Rabelo; Mülfarth, Roberta Consentino Kronka

PLEA SANTIAGO 2022
Will Cities Survive?

Green Infrastructure to reduce cooling loads and heat stress in Mediterranean Climates

A building simulation and machine learning approach

MASSIMO PALME[1] ANNA MANGIATORDI[2] CAROLA CLEMENTE[2] RICCARDO PRIVITERA[3] DANIELE LA ROSA[3] CLAUDIO CARRASCO[1]

[1] Universidad Técnica Federico Santa María, Departamento de Arquitectura
[2] Università di Roma La Sapienza, Dipartimento di Architettura e Progetto
[3] Università di Catania, Dipartimento di Ingegneria Civile e Architettura

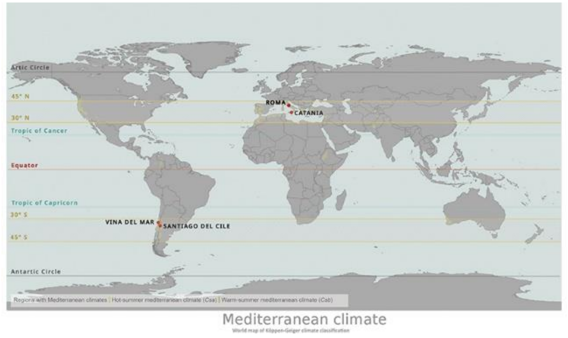
ABSTRACT: Climate change impact on cities and urban warming due to anthropogenic effects are urgent problems to be solved. Among the most beneficious strategies to reduce those impacts we can account the development of green infrastructures in cities, a kind of intervention that assure both mitigation of global warming by reducing greenhouse gases emissions, and adaptation to warmer urban environments. This work presents a building simulation and machine learning methodology to estimate the energy and comfort-related benefits that can be obtained by using a green infrastructure to shadow buildings' façades and roofs. We used previously developed simulation models to test the energy savings provided by different types of trees planted to produce shadows on buildings. Then, we tested different algorithms to predict using a machine learning approach the saving that can be obtained in different buildings-trees contexts for the cities of Catania, Rome, Santiago de Chile and Viña del Mar. Results show that the saving obtained is in the range 5-60%, mainly depending on the number of façade shadowed and on the specie of trees; and the prediction accuracy of machine learning process is over 90% for a binary classification (energy saving > 15% or <15%).

KEYWORDS: Urban Heat Island, Urban Climate, Green Infrastructure, Building Performance Simulation, Machine Learning

1. INTRODUCTION

During the last decades, global warming and land use change have intensified the urban heat stress condition, affecting energy loads of buildings and both indoor and outdoor thermal conditions. The problem is so deep that in 2021 the world experimented the record temperatures of 48.5 Celsius degrees in Canada during the summer and peaks of 29 Celsius degrees in central Chile in the middle of the winter season. Scientific community is agreeing that urgent measures should be taken to mitigate the global warming and the urban heat island (UHI) phenomenon. At the same time, there is an urgent need to develop adaptation strategies to face warmer environments, including nature-based solutions to restore ecological services in cities and reduce the probability of heat stress under heat waves [1]. Green Infrastructure (GI) is a strategy to achieve these goals, and has more benefits such as CO_2 sequestration, reduction of flood damages, visual and acoustical better environment, biodiversity development. Many authors assessed in the past the possible reduction in UHI intensity provided by trees and vegetal surfaces [2-3]. The influence of trees on indoor thermal environment has also been assessed by various studies [4-5]. In previous works, authors established a strategy to simulate not only theoretical solutions, but real configurations of trees-buildings relations, depending on availability of space in case studies sectors placed in Mediterranean climates [6]. Mediterranean climates are normally located between 30 and 45 degrees of latitude in both hemispheres, covering the Mediterranean Sea basin, the South and North America Pacific coasts, and small parts of Australia and South Africa (figure 1) [7].

Figure 1:
Mediterranean climates and cities considered in this study



Machine learning (ML), a branch of artificial intelligence that learn from a set of data to do a prediction or a classification of new configurations performance, has been used to predict the energy loads reduction in summer and the indoor heat stress probability, with the objective to help urban planners in deciding where to place the GI considering the global cost-benefits results [8].

In this work, the methodology developed in previous works is applied to the cases of Rome, Catania, Santiago de Chile and Viña del Mar, evaluating the capability of GI to reduce cooling loads and indoor heat stress as well as the accuracy of ML process to predict the results for new cases.

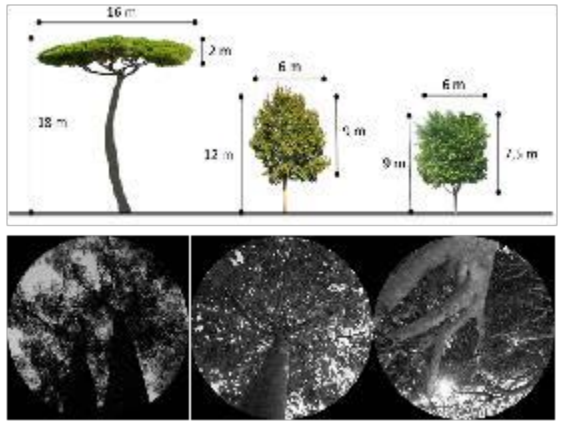
2. METHODOLOGY

To establish the capability of a GI to reduce cooling loads and heat stress probability, we followed a three steps methodology. Firstly, some real case studies has been considered (Catania, Roma, Santiago de Chile, and Viña del Mar) and a classification of effective building-trees configurations has been obtained. This process includes the identification of typical urban morphologies and buildings' shapes and design of linear GI configurations to be placed to an appropriate distance from the building's façades.

Secondly, the interaction building-trees has been modelled by using shadow masks in TRNSYS Studio version 17. The trees are represented as simplified solar shadow elements with a permeability to sunlight obtained by field assessment using fish-eye images and Gap Light Analyzer (GLA) software to process the radiation data [9]. Finally, a set of simulations was run out to obtain the base case (without trees) and the configuration performance. Buildings were modelled in TRANSBUILD type of TRNSYS and simulation was run with TRNSYS Studio.

Once obtained the simulation results, a ML technique was developed to predict the cooling load and the probability of heat stress occurrence for new configurations. We tested different algorithms to obtain two different classifications: one with a single value (15% energy saving and heat stress probability reduction) and the other with a five categories strategy to indicate the estimated amount of reduction obtained with the GI.

Figure 2:
Trees' morphology and solar permeability



Simulations were done in Mediterranean climates, characterized by slightly different behaviour determined by latitude and coast distance: Catania (Mediterranean semi-arid, on the Mediterranean Sea), Rome (Mediterranean, at 20 km from the Mediterranean Sea), Santiago de Chile (Mediterranean-continental, at 100 km from the Pacific Ocean), and Valparaiso-Viña del Mar (Mediterranean semi-arid, on the Pacific Ocean).

Weather files for selected locations have been obtained from the webpage climate.onebuilding.org [10,11] and modified by using Urban Weather Generator (UWG) tool to consider the urban heat island effect of the sectors. UWG tool was developed by Bueno et al. [12] and updated several times to improve accuracy of the prediction [13,14]. It was tested in different climates [15,16,17] locations and permits to realize parametric studies on the influence of urban form on microclimate.

UWG needs for many inputs for running. Most important are: inputs on urban morphology (as built up area, façade to site ratio, average building height, green areas, albedo values for all surfaces, anthropogenic heat production in the urban sector). Here we focused on morphological parameters to generate the representative urban weather file. Anthropogenic heat and albedo values have been left as a fixed value across the cases.

Urban heat island intensity has been found to be higher in Santiago than in the other cases. The phenomenon is positive at night and slightly negative during the day. Table 1 resumes the parameters values used for UWG simulations and table 2 shows the max and min values of UHI intensity for all locations.

Table 1:
Parameters used in UWG simulation

Location	Built Area	Fac. ratio	H (m)	Green Area
Tor Bella Monaca	0.11	2.64	24	0.25
Casale Caletto	0.12	0.62	15	0.08
Trimesteri Etneo	0.19	0.88	12	0.05
Les Condes	0.15	0.73	15	0.27
Benidorm	0.07	0.36	12	0.24

Table 2:
UHI intensity for locations studied

Location	Max UHI	Min UHI
Tor Bella Monaca	3.7	-1.0
Casale Caletto	2.4	0.6
Trimesteri Etneo	2.8	-1.1
Les Condes	6.1	-1.5
Benidorm	2.0	-0.4

2.1 Selection of urban compounds

Urban compounds to be studied were selected among urban development sectors since the ’60 decade until today in Rome (Tor Bella Monaca and Casale Caletto), Catania (Tremesteri Etneo), Santiago de Chile (Las Condes) and Viña del Mar (Benidorm). The analysis conducted on the sectors leaded to the selection of 40 specific configurations, considering the availability of space to plant trees, the building morphology and the green areas already present in the sector (figures 3-7).

Figure 3:
Casale Caletto compound and configurations analysed

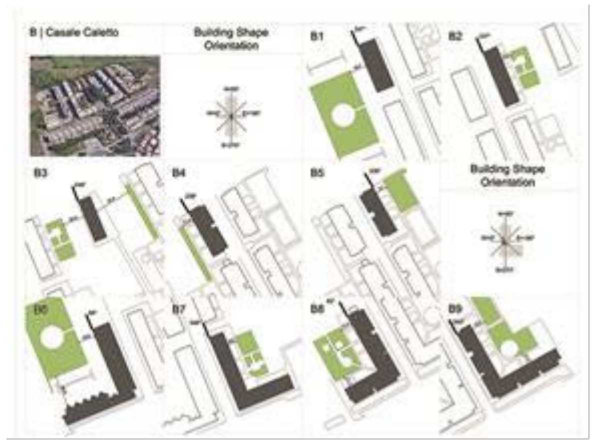


Figure 4:
Benidorm compound and configurations analysed

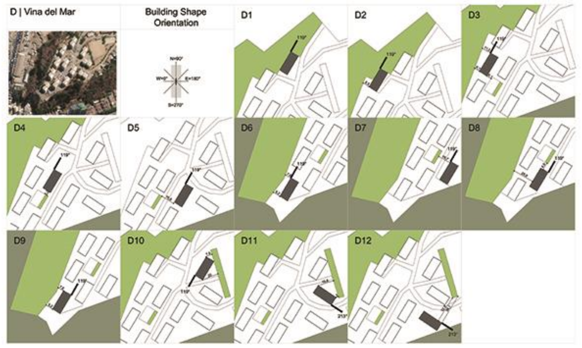


Figure 5:
Las Condes compound and configurations analysed

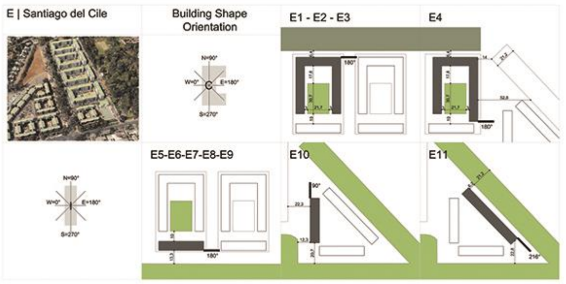


Figure 6:
Tor Bella Monaca compound and configurations analysed

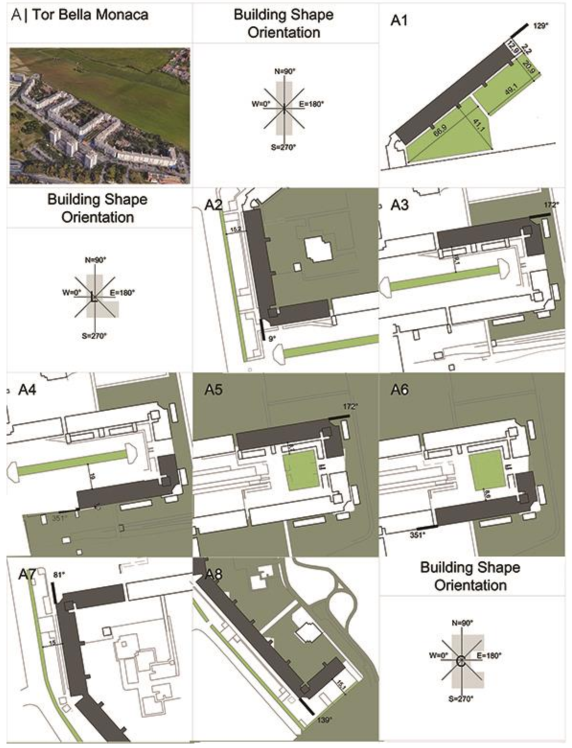
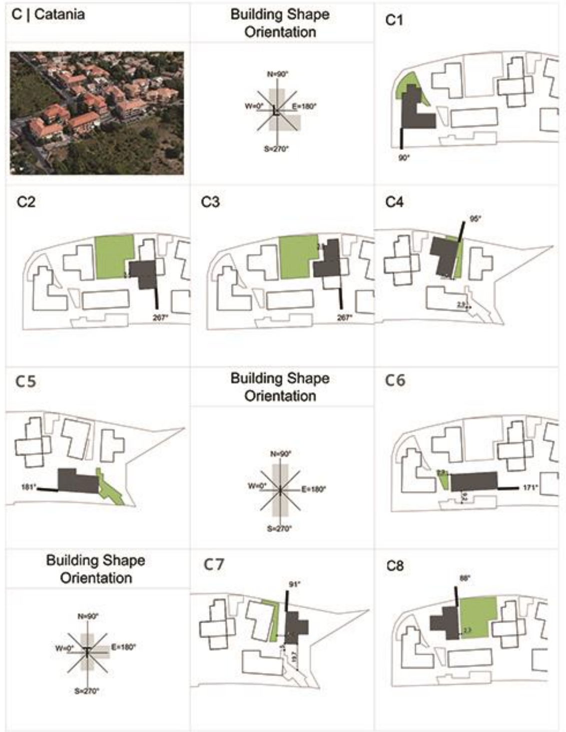


Figure 7:
Trimesteri Etneo compound and configurations analysed



2.2 Simulations of cooling loads

To simulate the cooling loads, buildings of selected compounds were firstly grouped in standard types by plan shape. We used “T”, “C”, “L” and “I” typical shapes. Each shape has its standardized dimensions and internal distributions. Figure 8 shows the plan shape of typical buildings.

Figure 8:
Standard building shapes considered in this study

Simulations consider standard materials used in Mediterranean climates, with solar absorptions and thermal transmittances for walls and roofs resumed in table 3. Windows to wall ratio depends on the building form, as shown in table 4. For all cases, radiation control was considered to simulate the use of blinds or other internal system. Table 5 shows operational settings used.

Table 3:
Envelope values for all buildings

Element	Construction	Thermal transmittance (W/m^{2}K)	Solar absorption or g-value windows
Walls	Bricks - XPS	0.56	0.60
Flat roofs	Conc. - XPS	0.32	0.60
Windows	Alum. single	5.80	0.86

Table 4:
Windows to wall ratios for building tyipes

Shape	Floor surface	Window/wall ratio main fac	Window/wall ratio other
I	480 m^2	20%	7%
C	800 m^2	20%	20%
T	400 m^2	20%	15%
L	528 m^2	20%	20%

Table 5:
Operational settings used in the study

Description	Schedule or control	Value
Light gains	18-22 h	5 W/m^2
Cooling set point	0-24 h	26 ˚C
People	0-24 h	1 met
Occupancy	0-24 h	50 m^2/p
Solar shading open	120 W/m^2	1.0
Solar shading closed	140 W/m^2	0.4

In TRNSYS, shadows are simulated as geometrical masks obtained by projecting the inclination angle for minimum and maximum solar incidence on each floor. The point to see the sky or the tree was set into the middle of the façade (figure 9). Equations (1)-(6) show the calculation procedure to obtain the inclination angles.

$$\alpha_{min} = arctan\frac{a_{min}}{b} \quad (1)$$

$$\alpha_{max} = arctan\frac{a_{max}}{c} \quad (2)$$

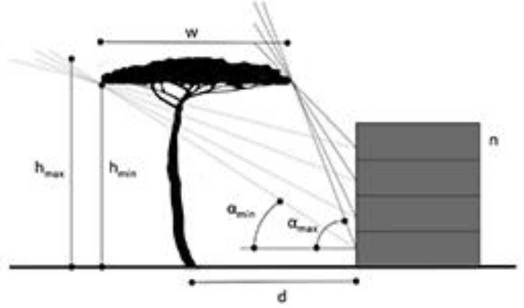
$$a_{\min\,(n)} = h_{min} - [1.5 + 3 \times (n-1)] \quad (3)$$

$$a_{\max\,(n)} = h_{max} - [1.5 + 3 \times (n-1)] \quad (4)$$

$$b = d + \frac{w}{2} \quad (5)$$

$$c = d - \frac{w}{2} \quad (6)$$

Figure 9:
Shadow mask calculation



2.3 Machine Learning

Once obtained simulation results, a machine learning strategy was developed to predict, based on certain numbers of predictors, the final cooling load reduction that can be reached by planning trees in a determined configuration. As a continuous prediction of cooling load is difficult to be obtained, we developed a classification method to divide the configurations in categories. In a first attempt, we used a 15% of reduction in cooling load as the threshold value to be used. In a more interesting attempt, we established five ranges: very low saving (0-5%), low saving (5-15%), medium saving (15-25%), high saving (25-35%) and very high saving (more than 35%). We used different algorithms to predict the results: Loess, Random Forst, KNN, GLM and a combination (ensemble) of all them. Respect to predictors, we used: climate classification, type of urban environment, altitude, latitude, sea distance, number of floors, number of façades on shadow, plan shape, orientation, distance, and tree species.

3. RESULTS

Simulation results show that the energy savings that can be reached in summertime are in a range 2-60%. Figure 9 resumes the values for 120 simulations (40 representative configurations, 3 species of trees). Figure 10 shows the average savings obtained by location, divided by tree species.

Figure 9:
Base case and improved case (with trees) cooling loads

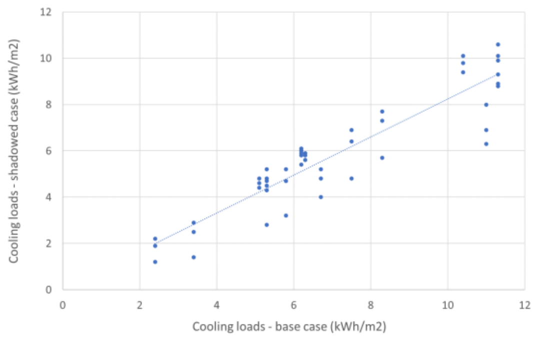
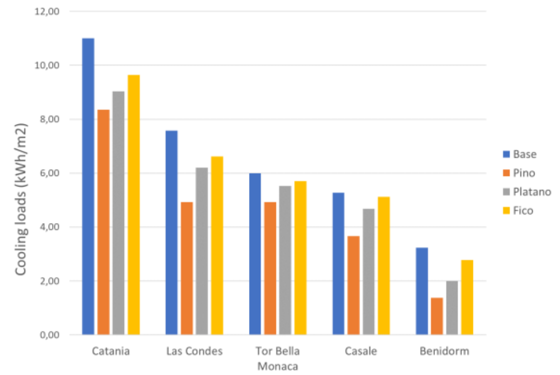


Figure 10:
Average cooling loads by location and tree specie



Looking at figure 10, it is immediate to notice that Benidorm has a summertime energy demand quite lower than other cases, around 2-3 kWh/m^2. In the sectors of Rome, cooling loads of the base case are around 5-6 kWh/m^2 year, while in Santiago loads are around 6-8 kWh/m^2 year. The hottest location is Catania, with summer cooling loads of 10-11 kWh/m^2. Influence of Pacific Ocean's breeze and latitude are the most relevant factors for this.

If the savings over 45% belongs to the case of Benidorm, where cooling loads are low even without shading, the range 2-45% apply to all studied cases. There is a big difference among 2% or 45% of cooling load reduction. So, it is interesting to understand which are the most influencing factors that explain these results.

Among the cases studied, Tor Bella Monaca is clearly the case more difficult to be shadowed. This is obvious because of the number of floors (8) of buildings in this sector, compared with the others (5-4 floors). West façades are confirmed as important façades to be shadowed, and "I" buildings are detected as easier to be shadowed respect other shapes buildings. The case of Santiago is particularly interesting because of the UHI intensity of the sector.

Green infrastructure can be used as a mitigation/adaptation strategy to reduce the impact of urban heat in the city. Table 6 resumes the number of cases analysed and the performance achieved in a 5-categories classification.

Table 6:
Classification of cooling reduction in 5 categories

Location	Very low	Low	Medium	High	Very high
Bella Monaca	3	7	1	0	1
Casale	2	14	8	0	6
Trimesteri	1	5	3	1	2
Les Condes	0	11	5	9	5
Benidorm	0	2	12	10	12
TOTAL CASES	6	39	29	20	26

More than the half of cases have a result higher than 15% reduction in cooling loads, confirming the findings of previous studies [18]. More than one third of the cases present a saving higher than 25% of cooling loads reduction. This allows stakeholders to invest in green infrastructure projects, whit a return of investment guaranteed in a relatively short time lapse.

Machine learning resulted to be quite accurate, achieving the extraordinary result of a 96% of accuracy in a binary categorization process. While a 5-categories classification is required, the accuracy is quite lower but still acceptable for the ensemble of algorithms (75%).

Among algorithms, best results are achieved by the ensemble and by random forest procedure. Random forest is particularly interesting because the output information includes the priority of predictors, putting in evidence that the number of façades on shadow is the key factor to predict the performance. This result is perfectly in accordance with previous studies [19] and with our interpretation of simulation results. The algorithm used the predictor "number of façades on shadow" in the first places of the decision tree, followed by "tree specie", "distance from the sea", "altitude", and "distance from the façade".

4. CONCLUSION

This paper showed how the development of a green infrastructure can help to prevent overheating in buildings and to reduce energy use for cooling during summertime in Mediterranean climates. This benefit must be accounted in a general analysis to establish the convenience to plant trees in urban environments. Green areas has certainly some costs, due to maintenance, water consumption and the process of planting, however the benefits in terms of several ecosystem services provided to the inhabitants shows that the development of a green infrastructure is almost always convenient.

Building performance simulation can be used as a part of the cost-benefit accounting in establishing where to place a green intervention. Machine learning processes can be useful to reduce time to be spent in simulations, allowing technicians to quickly obtain a first assessment of the convenience of the trees under an energy use point of view.

Future works will regard the simulation of different macroclimatic locations, where other factors take more importance: seasonality, heating loads increase, water needs for trees, among others.

ACKNOWLEDGEMENTS

This work was done with the support of Fondecyt Project 1200275 awarded in Chile by ANID, and of the Visiting Research founding awarded by University of Rome La Sapienza.

REFERENCES

1. Stone, B. (2012). The city and the coming climate. Climate change in the places we live. Cambridge University Press.
2. Tiwari, A., Kumar, P., Kalaiarasan, G., Ottosen, T.B. (2021). The impacts of existing and hypothetical green infrastructure scenarios on urban heat island formation. Environmental Pollution 274, 115898.
3. Santamouris, M. (2020). Recent progress on urban overheating and heat island research. Integrated Assessment of the energy, environmental, vulnerability, and heath impact. Synergies with the global climate change, Energy and Buildings 207, 109482.
4. Calcerano, F., Martinelli, L. (2016). Numerical optimization through dynamic simulation of the position of trees around a stand-alone building to reduce cooling energy consumption, Energy and Buildings 112, 234–243.
5. Balogun, A., Morakinyo, T.E., Adegun, O.B. (2014). Effect of tree-shading on energy demand of two similar buildings, Energy and Buildings 81, 305–315
6. Palme, M., Privitera, R., La Rosa, D., Chiesa, G. (2019). Evaluating the potential energy savings of an urban green infrastructure through environmental simulation. Proceedings of the Building Simulation Conference, Rome, 2-4 September 2019
7. Peel, M. C., Finlayson, B. L., McMahon, T. A. (2007). Updated world map of the Köppen-Geiger climate classification. Hydrology and Earth Systems Sciences 4, 439-473
8. Palme, M., Privitera, R., La Rosa, D., Carrasco, C. (2021). Building Performance Simulation to support tree planting for cooling need reduction: a machine learning approach. Proceedings of the Building Simulation Conference, Bruges, 1-3 September 2021
9. Frazer, G.W., Canham, C.D., and Lertzman, K.P. 1999. Gap Light Analyzer (GLA): Imaging software to extract canopy structure and gap light transmission indices from true-colour fisheye photographs, users manual and program documentation. Simon Fraser University, Burnaby, British Columbia, and the Institute of Ecosystem Studies, Millbrook, New York.
10. Climate.onebuilding project (2015). Available on line: https://climate.onebuilding.org (last accessed on march 2022)
11. Crawley, D., Lawrie, L. (2019). Should We Be Using Just "Typical" Weather Data in Building Performance Simulation? Proceedings of the Building Simulation Conference, Rome, 2-4 September 2019.
12. Bueno, B., Norford, L., Hidalgo, J., Pigeon, G. (2012). The urban weather generator. Journal of Building Performance Simulation 6 (4), 1-13
13. Nakano, A., Bueno, B., Norford, L,.Reinhart, C. (2015). Urban Weather Generator – A novel workflow for integrating urban heat island effect within urban design process. Proceedings of the Building Simulation Conference, Hyderabad, 7-9 December 2015
14. Mao, J., Yang, J., Afshari, A., Norford, L. (2017). Global sensitivity analysis of an urban microclimate system under uncertainty: Design and case study. Building and Environment 124, 153-170
15. Mao, J. and Norford, L. (2021). Urban weather generator: physics-based, microclimate simulation for performance-oriented urban planning. In: Urban Microclimate Modelling for Comfort and Energy Studies, Springer
16. Salvati, A., Palme, M., Chiesa, G., Kolokotroni, M. (2020). Built form, urban climate and building energy modelling: case studies in Rome and Antofagasta. Journal of Building Performance Simulation 13 (2), 209-225
17. Palme, M., Inostroza, L., Villacreses, G., Lobato, A., Carrasco, C. (2017). From urban climate to energy consumption: Enhancing building performance simulation by including the urban heat island effect. Energy and Buildings 145 (5), 107-120
18. Tzoulas, K., Korpela, K., Venn, S., Yli-Pelkonen, V., Kazmierczak, A., Niemela, J., James, P. (2007). Promoting ecosystem and human health using green infrastructure: A literature review. Landscape and Urban Planning 81, 167-178
19. Palme, M., Privitera, R., La Rosa, D. (2020). The shading effects of Green Infrastructure in private residential areas: Building Performance Simulation to support urban planning. Energy and Buildings 229, 110531

Comparative analysis of Viçosa's weather files

Simulation adequacy for urban microclimate

CAIO DE CARVALHO LUCARELLI[1] MATHEUS MENEZES OLIVEIRA[1] JOYCE CORRENA CARLO[1]

[1] Universidade Federal de Viçosa, Viçosa, Minas Gerais, Brazil

ABSTRACT: A microclimate denotes the distinctive climatic conditions within a few meters of a given point. The anthropogenic heat, ground cover, surrounding vegetation, shading, and &c. contribute to thermal comfort level variations within buildings and present prospects and obstacles analogized to the macro and mesoclimatic scales. In this sense, it is essential to determine the fittest weather file for building simulations to reduce propagating errors. Therefore, this study's scope was to appraise four different weather files (TMY3 and Multiyear datasets), relying on indoor and outdoor surveyed and simulated dry-bulb temperature (DBT) and relative humidity (RH) for two institutional buildings in Viçosa, Brazil (20.75° S, 42.88° W), microclimate-affected and not. We pre-selected the best datasets collecting EnergyPlus' Site Outdoor Air DBT and RH outputs and comparing them with outdoor surveyed DBT and RH, later adopting the most representative weather files for indoor simulations. We concluded that the TMY3 file conveyed the best overall results and the lowest Root-Mean-Square Error (RMSE) for RH in microclimate conditions. At the same time, the Multi3Y-High showed better temperature results for the anthropogenic-affected building. Therefore, if pre-testing a weather file is not an option, we indicated TMY3 as the best dataset.

KEYWORDS: On-site survey, Building Simulation, Root-Mean-Square Error, Weather File.

1. INTRODUCTION

A microclimate is a local set of atmospheric conditions that differ from its surrounding area in outdoor air temperature variations, surface temperatures, humidity, wind speed, and wind direction [1], [2]. Anthropogenic heat, evaporation, evapotranspiration, trees shading, and ground cover can modify latent heat exchange between buildings and the outdoors in urban areas, heavily influencing thermal comfort levels inside buildings.

The outdoor climate directly relates to indoor air quality and thermal comfort. Analyzing its relationship with building thermal environmental performance, solar access, and ventilation is a primary research goal on microclimate that will reproduce miscalculations when overlooked [3].

Access to accurate weather data denotes a barrier to more assertive analyzes of the local climate. Meteorological conditions in simulations rely upon data from weather stations, which are typically secluded. Moreover, this data is usually averaged over several years, masking the effect of the urban surroundings and possible site-specific characteristics [2].

Building simulation is a leading method for predicting interactions between indoors and outdoors. Few studies established generic models based on field surveys and statistical analyses, preventing oversimplification. For instance, Scheller et al. [3] compared three different weather files using dry-bulb and dew-point temperature and global and diffuse horizontal irradiance for 15 Brazilian cities, concluding that most analyzed weather files were precise but not.

Toparlar et al. [1] performed building energy analysis in Antwerp for microclimate simulation and characterization. Results showed higher average air temperatures at urban sites away from the park, with 13.9% less cooling demand near the park.

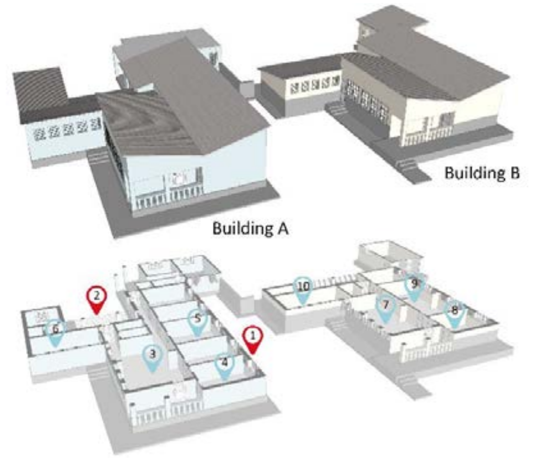
Hence, this study appraised the application of four different weather files (TMY3, Multi3Year-Low, Medium, and High) [4] through surveyed indoor and outdoor data for two similar adjacent institutional buildings in Viçosa, Brazil (20.75° S, 42.88° W), with differing surrounding conditions and microclimates. Our main goal was to pre-select the fittest weather file for microclimate assessment, analyzing its suitability when comparing collected dry-bulb temperature (DBT) and relative humidity (RH) with weather file data and later simulating and comparing indoor DBT and RH with surveyed indoor information.

2. MATERIALS AND METHODS

According to the Köppen classification, Viçosa is warm and temperate (Cwa) with hot and humid summers and cool to mild winters. Both elected buildings (Fig. 01) are part of *Universidade Federal de Viçosa's* Psychosocial Division (20.75° S, 42.88° W).

The buildings were originally designed as housing complexes for university educators and later converted into office spaces and psychological and psychiatric care. Both buildings are one-story, butterfly-roofed, and naturally ventilated. Building A is 155m², and building B is 129m². Building A presents an explicit microclimate caused by a mass of vegetation that provides shading and evapotranspiration, wind exposure, and surrounding lawn (lower ground temperatures and albedo, and constant irrigation). Conversely, building B is secluded, in-between constructions, and anthropogenic-influenced (higher surrounding surface temperatures and albedo).

Figure 1:
Building configuration and data logger's placement. Source: The Authors.



Note: red markers represent outdoor loggers, while blue represents indoor surveyed points.

We scrutinized indoor/outdoor walls, partitions, and roofing materials during the cataloging and field survey stage, adopting Weber et al.'s [5] equivalent reference models and construction layers and NBR 15.220-2's [6] material properties.

Table 1 shows the adopted building layers, thicknesses (Thk), transmittances (Ut), and thermal capacities (Ct). The material layers appear from the exterior to the interior, following EnergyPlus construction inputs. We also considered outdoor thermal absorptance of 0.40 for building A and 0.30 for building B (light blue and yellow) [6].

We collected indoor and outdoor DBT and RH in the Southern summer period from February 26th to March 12th, 2020, using HOBO data loggers (HOBO/ONSET U12 Temp/RH/Light) recording every minute. However, we only considered data between March 8th and March 12th due to the uncommon intense precipitation until March 7th. We also surveyed daily occupation patterns, users, electromechanical equipment, and natural conditioning tactics and modeled 10 thermal zones for building A and 8 compatible zones for building B since building A has an additional office space and aisle. The building calibration applied the uncertainty analysis procedure [7], considering varying occupancy and equipment loads.

We selected four comparable spaces (Fig. 01) to place the data loggers (points 3 and 7 are receptions; 4, 5, 8, and 9 are office spaces; 6 and 10 are cook-rooms) and two outdoor locations (point 1 and 2), one microclimate-affected (point 2) and one not (point 1). Point 1 is in-between buildings and presents higher neighboring surface temperatures and albedo, while point 2 is wind-exposed and vegetation-affected.

We divided the methodology into two branches. Section one concerns outdoor surveyed DBT and RH comparison with four standard weather files: TMY3, Multi3Year-Low, Medium, and High [4][1]; i.e., TMY3 (Typical Meteorological Year) is similar to a TRY (Test Reference Year) weather file that summarizes monthly data from different years to compile an artificial climate year [4]; the Multi3Year method presents a year with low temperature and radiation values (Multi3Y-Low), a year with high values (Multi3Y-High), and an average year (Multi3Y-Medium). Normally, simulations applying Multiyear files run several times, according to compiled data. However, we use the Multi3Y-Low, Medium, and High separately to reduce computational demand.

Section one applies EnergyPlus's Site Outdoor Air DBT and RH outputs for comparing simulated and surveyed data.

Table 1:
Building components for walls and roof. Source: The Authors.

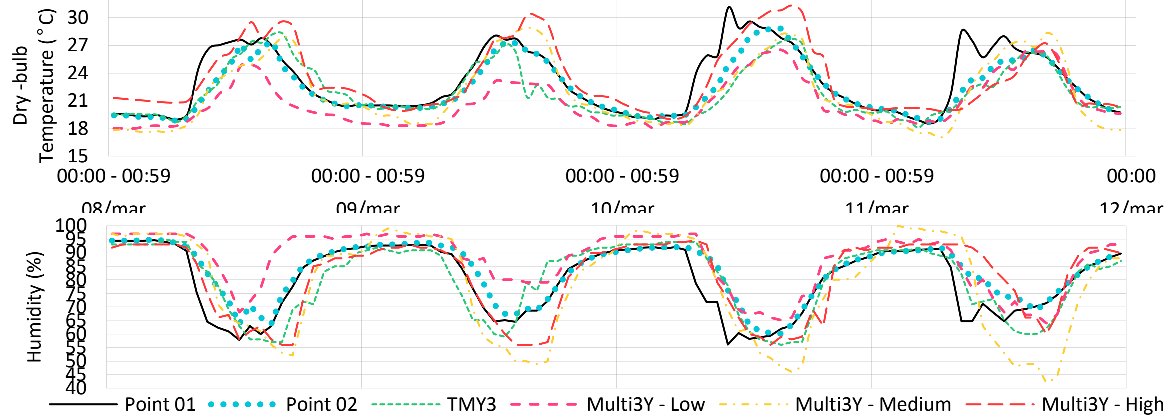
indoor/outdoor walls and partitions					roof				
9-hole hollow brick block 14x19x19 cm	material	Thk *cm*	Ut *W/m²°C*	Ct *KJ/m²°C*	solid concrete slab	material	Thk *cm*	Ut *W/m²°C*	Ct *KJ/m²°C*
	outdoor plaster	0.25	1.83	11		fiber cement sheet	0.80	2.06	233
	ceramic	1.65							
	air chamber	10.70				air chamber	0.25		
	ceramic	1.65				concrete	10.00		
	indoor plaster	0.25							

---

[1] Guimarães [4] created all four files using climatic data from UFV's automatic weather station, assembled by INMET [7]. Also, the *Laboratório de Tecnologias em Conforto Ambiental e Eficiência Energética - LATECAE/UFV* provides said files.

Figure 2:

DBT and RH on Point 01, Point 02, TMY3, Multi3Y-Low, Medium, and High from March 8th to 12th. Source: The Authors.



We selected TMY3 and Multi3Year files considering that the Multi3Year offers the most reliable simulation results for Viçosa, Brazil [4] but presents high computational costs, while TMY3 shows promising results with a single simulation.

$$\mathrm{RMSE} = \sqrt{\frac{\sum_{i=1}^{N}(\mathrm{simulated}_i - \mathrm{surveyed}_i)^2}{N}} \qquad (1)$$

where: *RMSE - Root-Mean-Square Error*
$\mathit{simulated}_i$ - predicted/simulation values
$\mathit{surveyed}_i$ - surveyed data
N - total number of observations

For comparing the outdoor measured data, we adapted a methodology that assesses the highest overall variable (DBT or RH), the daily highest, the overall mean, the daily lowest, and the overall low, over a defined period (5 days) assembled into a boxplot graph [3]. We also applied the Root-Mean-Square Error (RMSE) "Equation (1)" to select the weather file representing the outdoor DBT and RH best.

Section two comprised the simulation process for both buildings using the best weather files selected in section one for each situation. We adopted EnergyPlus' Zone Air Temperature and Relative Humidity and compared the simulation results with indoor surveyed data for points 3 to 6 (building A) and 7 to 10 (building B). We reassessed the methodology adopted in section one, calculating the RMSE and presenting results as boxplot graphs.

3. RESULTS

Fig. 2 shows the DBT and RH for the surveyed data (points 1 and 2) and weather files TMY3, Multi3Y-Low, Medium, and High from March 8th to 12th. For point 1, we observe that the highest discrepancy occurs with Multi3Y-Low with an overall RMSE of 3.05 for the temperature plot (Table2) due to the closeness with sun-exposed walls, concrete slabs, and other human-made materials. Higher surface temperatures influence immediate air temperatures, and consequently, weather files with lower temperatures should show higher dissimilarities.

Table 2:

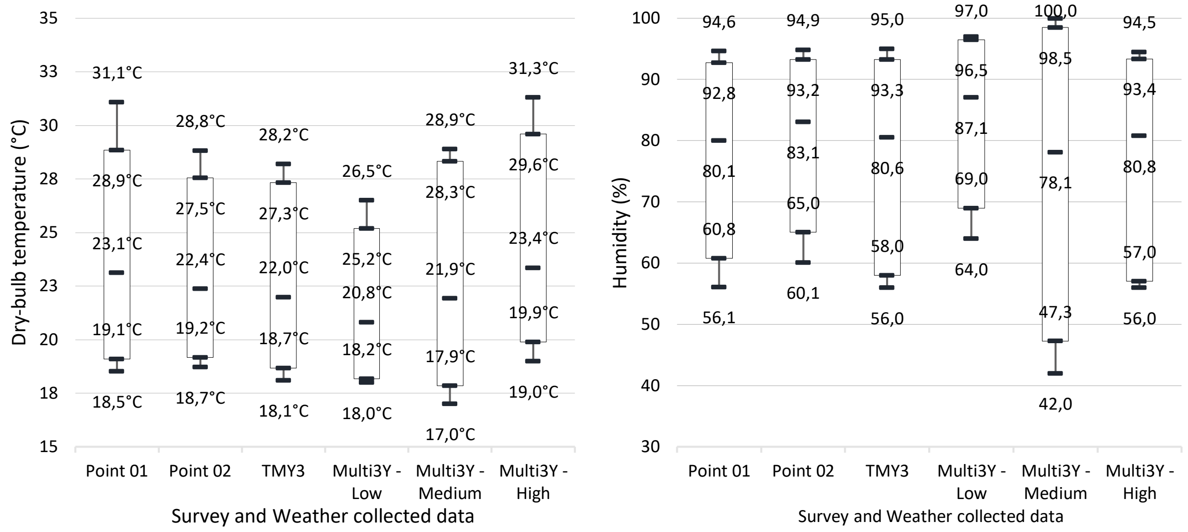
DBT (first section) and RH (second section) percent divergencies for survey data and weather files. Source: The Authors.

	Point 1 x TMY3	Point 1 x Multi3Y-L	Point 1 x Multi3Y-M	Point 1 x Multi3Y-H	Point 2 x TMY3	Point 2 x Multi3Y-L	Point 2 x Multi3Y-M	Point 2 x Multi3Y-H
Min. DBT	2.27%	2.81%	8.21%	2.58%	3.26%	3.79%	9.13%	1.56%
Mean Min. DBT	2.18%	4.80%	6.50%	4.23%	2.62%	5.22%	6.92%	3.77%
Mean DBT	4.88%	9.93%	5.10%	1.06%	1.73%	6.94%	1.96%	4.41%
Mean Max. DBT	5.29%	12.66%	1.83%	2.59%	0.81%	8.52%	2.82%	7.45%
Max. DBT	9.28%	14.75%	7.02%	0.70%	2.14%	8.04%	0.29%	8.62%
Min. RH	0.17%	14.10%	25.12%	0.17%	6.86%	6.44%	30.15%	5.86%
Mean Min. RH	4.54%	13.56%	22.24%	6.19%	10.78%	6.14%	27.32%	12.32%
Mean RH	0.62%	8.76%	2.39%	0.92%	3.03%	4.81%	5.93%	2.74%
Mean Max. DBT	0.52%	4.02%	6.18%	0.66%	0.01%	3.49%	5.64%	0.14%
Max. DBT	0.39%	2.50%	5.67%	0.14%	0.14%	2.25%	5.41%	0.38%

Note: Colors represent deviation between the selected points and weather data. Colors closer to saturated green have smaller deviations, while the opposite is true for red. Comparisons between same DBT and RH (same line) classifications work best.

Figure 3:

Overall max, daily highs, overall means, daily lows, and overall low DBT and RH comparison. Source: The Authors.



Note: Information is according to headline, from top to bottom (overall max, daily highs, overall means, daily lows, and overall low).

The disparity happens due to a difference in the max temperatures of about 14.75%, which corresponds to almost 5°C dissonance (Table 2 and Fig. 3). For the RH analysis, the highest differences occur with Multi3Y-Medium, with humidity values 25% lower and an RMSE of 11.59.

Still, for point 1, the best results indicate Multi3Y-High as the fittest weather file for DBT and TMY3 for RH, primarily due to the immediacy of human-made materials. However, RH in the Multi3Y-High is also very representative, with only a few divergencies compared to the TMY3. Fig. 3 shows the parallelism between point 1 and Multi3Y-High with maximum differences of 0.8°C.

For point 2, the highest DBT divergencies also occur with the Multi3Y-Low, but with an RMSE of 1.80. Daily highs differ at 3.7°C, which corresponds to an 8.52% incongruency that is still very representative, surpassing some point 1 survey/weather data percentages. For the RH analysis, the discrepancy also occurs with Multi3Y-Medium, with RH values 30.1% lower and an RMSE of 11.31 (still lower than the RMSE for RH in point 1, which can correlate to the surrounding vegetation, evapotranspiration, shading, and irrigation).

The highest Point 2 similarities for DBT are with TMY3, with an RMSE of 2.21. Daily highs differ only 0.2°C, and the highest variance is between the minimums with 0.6°C (Table 2 and Fig. 3). TMY3, Multi3Y-Low, and Multi3Y-High are comparable for RH, with a 4% humidity discrepancy at maximum. However, Multi3Y-Low should not apply due to the DBT divergence discussed above.

Highlighting, according to França, Silva, and Carlo [9], and Guimarães [4], simulations with TMY3 already presented lower statistical deviations, while Multi3Y-Low had higher RMSE.

We employed the TMY3 and the Multi3Y-High (single simulation with no Medium and Low data) as weather files for both buildings based on the abovementioned results. Since building A is microclimate-affected (and therefore closer to point 2 results), we hypothesize that TMY3 would perform better, while Multi3Y-High (most similar to point 1 result, susceptible to building shading, surrounding impermeable paving, and wind- sheltered) would be the fittest for building B.

Table 3 shows the RMSE for the selected thermal zones in both buildings. For building A, all RMSEs (DBT and RH) are lower for the TMY3 file.

Table 3:

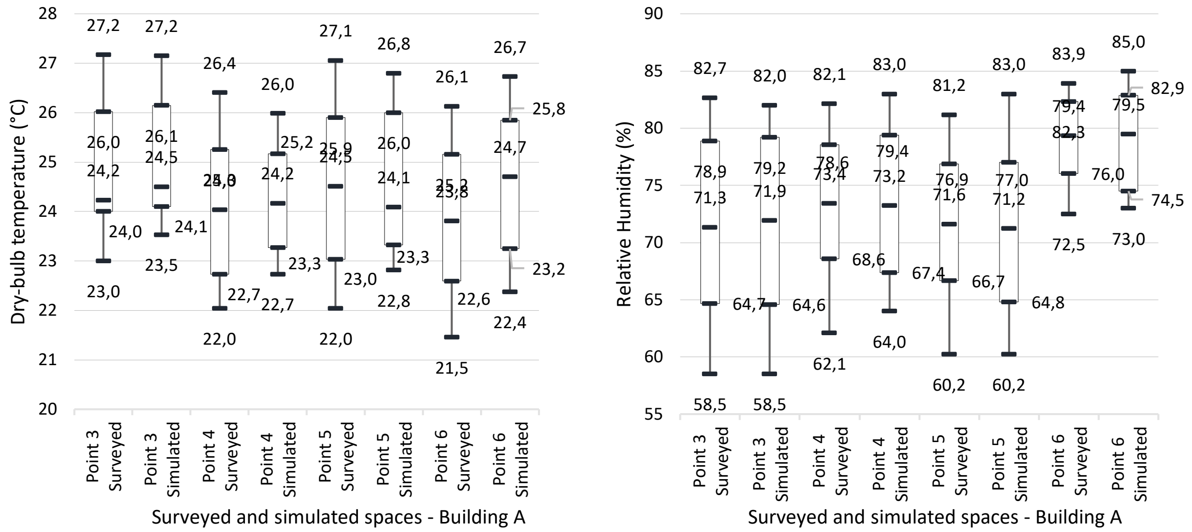
Indoor DBT and RH RMSE for each survey/simulation point. Source: The Authors.

		RMSE for DBT				RMSE for RH			
Build. A	File	Point 3	Point 4	Point 5	Point 6	Point 3	Point 4	Point 5	Point 6
	TMY3	1.41	1.56	1.38	3.23	1.79	1.51	2.39	1.02
	Multi3Y-High	2.15	2.51	2.00	4.33	5.91	7.76	6.20	21.29
Build. B	File	Point 7	Point 8	Point 9	Point 10	Point 7	Point 8	Point 9	Point 10
	TMY3	1.27	1.21	1.47	2.38	7.84	8.04	11.08	12.71
	Multi3Y-High	0.80	0.93	1.37	2.37	7.14	7.48	9.91	11.84

Note: abbreviations stand for: (Build.) building. The lowest RMSEs are highlighted in green.

Figure 4:

Indoor overall max, daily highs, overall means, daily lows, and overall low DBT and RH for Building A. Source: The Authors.



The highest discrepancy for DBT is in point 6, the cook-room, which we consider a possible modeling issue due to the surrounding vegetation evapotranspiration (not included in EnergyPlus modeling file). For the best-represented space (point 5), the temperature differed 0.3°C at most; for point 6, temperatures differed 0.9°C.

Even though the Multi3Y-High performed worse than the former, RMSE is not among the worst results (up to a 9.0 RMSE for other weather files).

For the same building, the RH simulation using the TMY3 showed the best congruency in all results; principally considering the proximity of the survey dates to a cold front and the lack of evapotranspiration simulation. The most divergent space is point 5, with an RMSE of 2.39 and RH values 1.9% lower (Fig. 4).

As we anticipated, the Multi3Y-High presents the best results for building B. The DBT RMSE is the best amongst all simulations with the highest deviation on point 10 (also representing a cook-room in the same orientation as point 6). Due to the low RMSE, air temperatures only vary between 0.2 and 0.4°C (Fig. 5).

However, the RH analysis shows high RMSE for the file mentioned above and even higher deviations for the TMY3. We deduce that, even though the weather file represents accurate air temperatures, surface temperatures, wind speed, and wind direction, it does not account for the foliage specificities and anthropogenic irrigation of the selected sites.

We also point out that we only considered vegetation as shading geometry, not accounting for evapotranspiration, which could increase RH values.

Figure 5:

Indoor overall max, daily highs, overall means, daily lows, and overall low DBT and RH comparison for Building B. Source: The Authors.

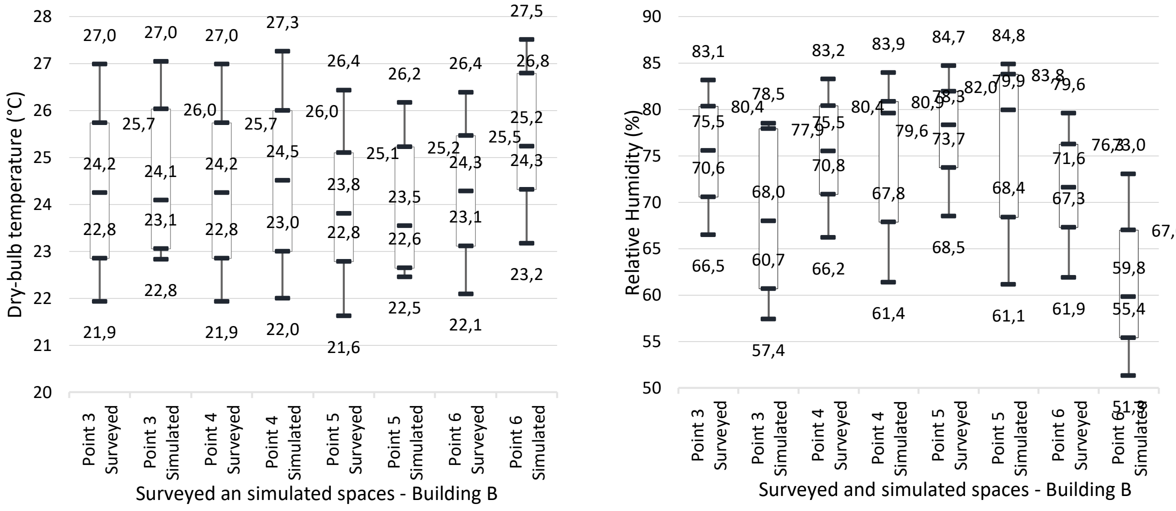


Fig. 4 and 5 show simulated results as lower than surveyed data, corroborating our analysis for both RH simulation values.

Persistently, point 10 (cook-room) showed higher deviations with an RMSE of 11.84 for building B, corresponding to 9% to 12% lower RH values, which could be due to the surveyed dates being right after a cold front with a high precipitation rate.

Since the TMY3 simulations showed the best overall results, we appoint the file as a standard selection for urban spaces, microclimate-affected or not, in Viçosa, Brazil. Even though a traditional Multiyear approach would perform one simulation for each file, we consider Multi3Y-High a possible selection for buildings in urban spaces, especially when away from vegetation (since humidity values are even lower than the TMY3), wind-sheltered spaces, and impermeable ground cover. We also point out that building A showed the best overall results because its surroundings were similar to Viçosa's weather station (approximately 1.5 km from the selected buildings and distant from anthropogenic interventions), which culminates in weather data more suitable for microclimate-affected spaces.

4. CONCLUSIONS

This paper presented a process for selecting, analyzing, and adopting a correct weather file (among TMY3, Multi3Y-Low, Medium, and High) for microclimate and anthropogenic-influenced buildings and urban sites considering single simulation procedures for saving computational time and demand.

We selected two institutional office buildings in Viçosa, Brazil, with similar floorplans but distinct surrounding conditions for surface temperatures, humidity through evapotranspiration and irrigation, and wind exposure.

We performed indoor and outdoor on-site DBT and RH surveys, adopting the outdoor data for the weather file analysis and pre-selection. After conducting the RMSE calculations, we pre-elected the TMY3 and the Multi3Y-High as the fittest datasets.

The TMY3 presented the best overall results and the lowest RMSEs for humidity in microclimate conditions. The Multi3Y-High showed better temperature results for the building with less surrounding vegetation but failed to represent the surveyed RH with an RMSE from 7.14 to 11.84, a 12% discrepancy between surveyed and simulated data.

Prevailing, building A had better results due to the Viçosa's weather station's location, heavily vegetated, near water bodies, and away from anthropogenic interventions, influencing the weather datasets and creating biased weather files that best represent microclimate-affected spaces.

Therefore, we demonstrate that the TMY3 and the Multi3Y-High present good results for both cases among the four weather files. The former best-representing RH for microclimate-affected spaces and the latter DBT for urban spaces. Finally, if pre-testing a weather file is not an option or computational demand is a limitation, we favor TMY3 as the most promising dataset since it does not require multiple simulations and presents the all-around lowest divergences.

ACKNOWLEDGEMENTS

This study was financed by the *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES)* – Finance Code 001 and by *Fundação de Amparo à Pesquisa de Minas Gerais (FAPEMIG)*, financing notice N° 001/2021 Universal Demand - under process code APQ-00266-21.

REFERENCES

1. Toparlar, Y., Blocken, B., Maiheu, B. and van Heijst, G. J. F., (2018). Impact of urban microclimate on summertime building cooling demand: A parametric analysis for Antwerp, Belgium. *Applied Energy,* 228: p. 852-872.
2. Mosteiro-Romero, M., Maiullari, D. Pijpers-van Esch, M. and Schlueter, A., (2020). An Integrated Microclimate-Energy Demand Simulation Method for the Assessment of Urban Districts. *Frontiers of Built Environment,* 6: p. 1-18.
3. Scheller, C., Melo, A. P., Sorgato, M. and Lamberts, R., (2015). Análise de arquivos climáticos para a simulação do desempenho energético de edificações. *Report, LabEEE.*
4. Guimarães, Í. B. Análises de incertezas e sensibilidade de arquivos climáticos e seus impactos em simulações computacionais termo energéticas. (2016). *Master Thesis, Departamento de Arquitetura e Urbanismo,* Universidade Federal de Viçosa, Viçosa.
5. Weber, F., Melo, A., Marinoski, D., Guths, S., Lamberts, R. (2017) Desenvolvimento de um modelo equivalente de avaliação de propriedades térmicas para a elaboração de uma biblioteca de componentes construtivos brasileiros para o uso no programa EnergyPlus. *Report, LabEEE.*
6. ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. ABNT NBR 15.220-2. (2005) Desempenho térmico de edificações Parte 2: Métodos de cálculo da transmitância térmica, da capacidade térmica, do atraso térmico e do fator solar de elementos e componentes de edificações. Rio de Janeiro.
7. Westphal, F. S. Análise de incertezas e de sensibilidade aplicadas à simulação de desempenho energético de edificações comerciais. (2007). *Master Thesis, Departamento de Engenharia Civil*, Universidade Federal de Santa Catarina, Florianópolis, 2007.
8. INSTITUTO NACIONAL DE METEOROLOGIA, NORMALIZAÇÃO E QUALIDADE INDUSTRIAL – INMETRO. *Dados Meteorológicos: Estações Automáticas*. Available in: http://www.inmet.gov.br. Access: June, 2022.
9. França, T. N., Silva, M. A. and Carlo, J. C., (2020). Análise De Sensibilidade Do Poc Em Edificações Naturalmente Ventiladas. *Brazilian Journal of Development,* 6: p. 91120–91135.

WILL CITIES SURVIVE?

PLEA
STGO
2022

November 22 - 25, 2022

WILL CITIES SURVIVE?

The future of sustainable buildings and urbanism in the age of emergency.