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Greenhouse gas emissions keep growing. Global temperatures keep rising. And our planet is fast approaching tipping points that will make climate chaos irreversible. We are on a highway to climate hell with our foot on the accelerator.

– António Guterres, Secretary-General of the United Nations

Authors dedicate this book to the world to assist governments, local authorities, professional architects, urban designers, and planners, as well as experts and researchers in mitigating global climate change and adapting to its severe, destructive, and extreme events through the reduction of urban heat island (UHI) and heatwaves by exploiting and increasing urban green coverage and blue and green infrastructures in addition to substituting grey infrastructure to ultimately achieve livability in urban areas, cities, and regions. Such actions contribute to attaining the United Nations Agenda 2030 and the Sustainable Development Goals (SDGs), primarily SDG 3 – Good Health and Well-being, SDG 11 – Sustainable Cities and Communities, SDG 13 – Climate Action, and SDG 15 – Life on Land.

Authors

Preface

The era of global warming has ended; the era of global boiling has arrived.
– António Guterres, United Nations Secretary-General,
on Thursday, 27 July 2023.

In the past five years, climate change (CC) extreme events globally have exacerbated in an unprecedented rate leaving cities and regions worldwide with devastated impacts and dangerous destruction, but these are coupled with the deadly pandemic COVID-19 that hit the world severely in 2020. Also, the notion for this book emerged in 2020 in view of global warming, CC, severe manifestation, and impacts worldwide causing enormous risks due to extreme events as well as the global boiling in the third quarter of year 2023.

This book is also a continuation of the previous book *Biomimetic Architecture and Its Role in Developing Sustainable, Regenerative, and Livable Cities: Global Perspectives and Approaches in the Age of COVID-19*, which is published by Springer in September 2022, https://link.springer.com/book/10.1007/978-3-031-08292-4, but is a wider perspective.

With the large impact of human activities on natural resources, which are depleted and becoming scarce due to rapid population growth worldwide, especially urban population; this would pose huge pressure on cities and local governments to cope with such population increase. In this context, the share of the world's population living in cities is projected to increase to reach 80% by 2050, compared to the current share of 55% (World Economic Forum – WEF). Such population increase would lead to huge energy consumption in cities in addition to more than double global material consumption to about 89 billion tonnes (the UN International Resource Panel). Another challenge in cities is the rise of air pollution due to human activities, mainly from vehicular transportation, which elevates pollution and deteriorates air quality that impacts health and well-being in urban areas. An additional challenge is the urban heat islands (UHIs) in cities, which affect inhabitants severely in terms of heat stress, morbidity and mortality rate (World Health Organization – WHO), specifically with less public green spaces and urban greening to reduce urban heat islands effect (UHIE). In this context, nearly all of the world's population (99%) breathe air that surpasses the WHO guideline thresholds and holds high

levels of pollutants, with low- and middle-income countries suffering from the highest exposures (WHO data 2023). Since air pollution including smog over cities causes problems to human health; more interventions to increase blue and green infrastructures are required to offset such impacts. Moreover, around 2.4 billion people worldwide are vulnerable to dangerous levels of indoor air pollution as well, hence impacting the health and well-being of people living in cities and urban areas. Additionally, the effect of fine particulate matter in ambient air pollution in both cities and rural areas resulted in strokes, heart diseases, lung cancer, and acute and chronic respiratory diseases (WHO 2023). Furthermore, seven million premature deaths are recorded annually because of outdoor and indoor air pollution (WHO).

All indicated threats and risks highlight the important and significant role of urban greening (UG) and increase of urban green coverage (UGC) through exploiting green infrastructure (GI), such as parks, gardens, trees, green roofs, and living walls; and blue infrastructure (BI), such as water bodies, lakes, wetlands, and fountains in cities and regions. Thus, it is imperative to state that urban greening (UG) have enormous benefits for health and well-being, not to only have large number of urban green spaces (UGSs) in cities and urban areas, but also to enable citizens to visit UGSs and facilitate accessibility to experience less heat stress since UGSs lessen outdoor thermal discomfort during heatwaves – the book highlights all these benefits. Moreover, based on the fact that GI could attain 80% of the SDG 11 – Sustainable Cities and Communities' targets, it is vital to capitalize on transforming gray infrastructure into blue and green infrastructures (BGI) in urban areas exploiting UGC, especially in existing urban areas and cities, through nature-based solutions (NbSs) and ecosystem services-based solutions (ESbSs) in the design, planning, and implementation process.

In articulating this book, authors envisaged the key topics of livability, climate change mitigation and adaptation, UHIs, UG, and livable cities since they are steadfast and laying in the forefront worldwide attention, particularly amid urban climate crisis globally and persisting and mounting challenges facing large- and megacities, especially post COP21 – Paris, France (2015), COP26 Glasgow, UK (2021), and COP27 – Sharm El Sheikh, Egypt (2022). Thus, we developed this book to focus mainly on livability in urban areas and how UHIs mitigation through greening large- and megacities can contribute to climate change adaptation (CCA).

Indeed, the colossal challenges for governments worldwide are immense, in view of the current crises, which the globe is currently witnessing and experiencing between 2020 and 2023, predominately COVID-19, energy prices and supply, climate crisis, food shortages and supply, and above all, the severe heatwaves in 2019, 2021, and the sweltering and unprecedented heat in 2023, and the recent hurricane and devastated that slash Derna city in Libya, where 25% of the city has been destroyed. In fact, more than 11,300 people reported dead plus over 20,000 citizens are missing (the United Nations Office for the Coordination of Humanitarian Affairs – UNOCHA report, September 17, 2023). In addition, more than 38,640 people displaced in the most devasted areas in northeastern Libya (the International Organization for Migration – IOM). In this context, seven catastrophic and destructive floods also hit many countries in the first 10 days of September 2023,

specifically Central Greece, Central and Coastal Spain, northwest Turkey, and southern China, including Hong Kong, as well as southern Brazil and southwestern the United States. Such unprecedented events, in a very short period of time (11 days), raise alarm to the world to act quickly to save the plant from climate change extreme events and risks; otherwise, it would be too late, and more destruction is anticipated.

Therefore, the book highlights "Livability," "Urban Livability and Livable City," "Urban Heat Island Effect," and "Urban Greening" as great sources for knowledge to enhance health and well-being as well as mitigate UHIs in cities to encounter the challenges facing governments and local authorities to create a livable built environments and enhance existing ones.

In fact, livable cities, UG, and BGI are aligned with the United Nations' 2030 Agenda for Sustainable Development and SDGs, particularly, goal 11 – Sustainable Cities and Communities, goal 13 – Climate Action, and goal 15 – Life on Land. Thus, it is essential that international institutions address the advantages and features of UG and BGI in the national strategies, policies, and action plans to counterbalance CC and mitigate extreme UHIs in cities to bring about a livable future for all.

During the development of this book, which took almost 3 years of extensive work, the authors faced many challenges. First, the book proposal was prepared in September 2020, and the book contract was signed in August 2021. All these took place during the deadly pandemic Coronavirus (COVID-19), but due to the governments' confinement policy and lockdown in 2020 and partially in 2021, this resulted in many delays in articulating the book. Second, we encountered another challenge. We initially planned to delve into the comparison between three large cities (Cairo, Egypt and Lagos, Nigeria – the largest cities in Africa, and Rome, Italy), but the types of data that were available from sources in Abuja, the capital of Nigeria, were not exactly the one what we needed for the simulation comparison. Thus, we decided to eliminate the comparison into only two large cities (Cairo and Rome). Third, the process of obtaining the data for the large city of Rome (15 municipalities) in the Lazio region, Italy, to compare with city of Cairo (41 districts) in the Greater Cairo region, Egypt, took more time than that planned due to unforeseen reasons. Fourth, the author received her first baby boy at the end of March 2023. That's why the book was delayed from its original date of publication (November 2022 and April 2023), but it has finally materialized, thanks to all authors and support team who made this book come true.

The main emphasis of this book, under its broad umbrella, is "Livable Cities" and related UHIE, health and well-being of inhabitants, and exploiting UGC. Thus, the book "Livable Cities: Urban Heat Islands Mitigation for Climate Change Adaptation through Urban Greening" is structured into two main parts encompassing a total of seven chapters that concentrate on issues of vital topics: "Livable Cities," "Urban Heat Islands Mitigation," "Urban Green Coverage," "Climate Change Adaptation," "Health and Well-being," and "Regulations and Recommendations of UGC Post COVID-19."

Such topics are currently gaining the world's attention and that of the international organizations amid the unprecedented heatwaves that hit most of Europe, Mediterranean region and North Africa, Japan and West part of the United during July 2023 and the global boiling which risk the attainment of the SDGs. The book furnishes the information needed to understand UHIs and their causes, as well as the parameters affecting heat islands. Also, it highlights the mitigation strategies for UHIE in cities.

The book coverage also demonstrates the need for new approaches to attain sustainability, livability in cities, and sustainable development goals (SDGs) by addressing the role of UHI mitigation in built environments. The coverage also presents the livability definitions and livable city index (LCI), as well as the ranking of livable cities worldwide. The book also tackles an important question: "Can urban green spaces and urban green coverage as features of green infrastructure assist in achieving healthier and livable cities and regions? What is the role of urban green coverage in urban design and planning?" In addition, the book illustrates the key role of livability in improving the health and well-being of cities' inhabitants and the relationship between CC, air pollution and UHI, and the urgent need for climate adaptation, as well as the part of UGC role in the crafting of the post-COVID regulations.

As per the aforementioned narrative, all these defy hinder the global effort to attain the United Nations Agenda and the SDGs by 2030. Therefore, UG, increasing UGSs, and doubling the current UGC in cities are a must to curb CC and extreme events manifested worldwide. Moreover, NbSs and ESbSs have many potentials and inspirations for future sustainable living. The green and inclusive recovery of COVID-19 has been focusing largely on CC, but less attention has been paid toward biodiversity and UG. Thus, post-COVID regulations should simultaneously address CC measures and actions on biodiversity loss to create and achieve livable, sustainable, and resilient cities. In any post-COVID regulations, biodiversity loss and climate action should be mutually tackled and addressed as part of wider efforts to attain a green, sustainable, and resilient recovery in order to attain COP26 outcomes, primarily the Glasgow Climate Pact and Climate Neutrality by 2050, and the outcomes of COP27 for climate adaptation measures and funding.

The book also explores the socioeconomic impact of UHIE and its livability on cities and citizens. The seven domains of a livable city are presented. The coverage also includes ways in which GI can foster healthy, livable, and green cities. It is imperative to link concepts such as livability and UHIE to the SDGs to ensure their attainment. In addition, this book demonstrates several examples of how UHIs are manifested worldwide. It also presents the UHI definitions and sheds light on its causes, parameters affecting it, and its impact on cities and residences. It explains the factors influencing UHIs' impact on health including heat exposure, vulnerability, and behavioral exposure. Nevertheless, it portrays that most actions should be directed toward the vulnerable categories of society, such as the very young, elderly, and socioeconomically disadvantaged. The book also explores various strategies for mitigating high temperatures in cities, including the use of reflective materials,

permeable and water-retaining materials, UGC, as well as other effective measures, and presents their cooling effect in different climates.

More and above, the book concentrates on the implementation of UGC as a mitigation strategy by presenting an environmental framework of five steps for UGC application that can aid urban planners in greening implementation. Also, it explains the cooling benefits of various UGC types, such as trees, vertical greening (vegetated façades and living walls), green roofs, and UGSs, by reviewing various studies globally to identify the gap. It also furnishes and provides readers with the needed solutions and recommendations on the key points for the application of various types of UGC. Furthermore, the coverage provides better understanding of the link between UHIs and CC. It also sheds light on global cities' plan to reduce air temperatures by implementing UGC. These plans are manifested in six global cities: Chicago City (the United States of America), Curitiba City (Brazil), Stuttgart City (Germany), Tokyo City (Japan), Melbourne City (Australia), and Johannesburg (South Africa). The book also concentrates on large cities by conducting UHIs' mapping and UGC assessments in two cities (Cairo and Rome). Comparative analysis was conducted between the two cities to enable mapping of hot spots that need intervention.

In addition, the book focuses on applying the environmental framework to mitigate high temperatures and land surface temperature (LST) in cites by implementing UGC, specifically in Cairo and Rome. Heat vulnerability index (HVI) maps were created for these two cities in order to prioritize the hot spots. Also, the cooling benefit of the proposed UGC was simulated to test and assess its role on the urban microclimate. Moreover, the framework was tested in future CC scenarios to determine its effectiveness in mitigating CC.

The book also presents guidelines for healthier UG in the age of post-COVID. Moreover, it depicts the regulations and recommendations to create sustainable, livable, and resilient cities. These include regulations and recommendations for UGC and GI in developing new cities and improving existing ones. Finally, the book closes by delving into global patterns of public green spaces (parks and gardens, nature areas, playgrounds, water bodies, and forests) and presenting the ranking of European Green Cities scores based on the European Environmental Agency.

Thus, the book "Livable Cities: Urban Heat Islands Mitigation for Climate Change Adaptation Through Urban Greening" is organized into two main parts: Part I delves into some of the key issues related to UHIE in urban areas and cities. It reveals the threat to the world's rapidly growing urban population and cities resulting from extreme heat exposure from both CC severe events and the UHIE. It also highlights a theoretical approach of UHIE, its causes, and the factors influencing its impact on human health as well as how urban development resulted in massive loss of vegetation to the global UHIE. In addition, it portrays the factors influencing the severity of UHI and the strategies for mitigating high temperatures in cities, besides the cooling effect of mitigation strategies in different climatic zones. This volume also furnishes a full comprehension of UHIE and its impacts and suggests ways to surmount such effects in urban areas and cities alike. While it shows the significant role of implementing UGC to mitigate UHIE and CC in cities.

It sheds light on a broad review of the UHIE and how implementing UGC can cool cities and significantly reduce high temperatures in cities. Moreover, this part depicts the environmental framework for applying UGC to mitigate UHIE through many steps, mainly neighborhood scale and street scale, and to identify specific UGC, which fits best at certain locations in the street. Additionally, it illustrates factors influencing the cooling effect of UGC types as well as the lessons learned about the cooling benefits of UGC types.

Part I is outlined into three chapters: Chap. 1 "Livability: The Direction to Mitigating Urban Heat Islands' Effect, Achieving Healthy, Sustainable, and Resilient Cities, and the Coverage," while Chap. 2 "Understanding Urban Heat Islands Effect: Causes, Impacts, Factors, and Strategies for Better Livability and Climate Change Mitigation and Adaptation," and Chap. 3 "Urban Green Coverage as a Strategy for Mitigating High Temperatures in Cities."

Part II encompasses four chapters dedicated mainly toward the global plans to mitigate UHIE through the exploitation of UGC. It also highlights the assessment of UHIs and UGC in megacities, specifically in Greater Cairo, Egypt and Rome, Italy. This part also illustrates an overview of UGC plans of six global cities, and it divulges on UHI and extreme high temperature (EHT) in cities, while it presents the answers to an important question: "Can blue and green infrastructures assist in lowering surface temperatures and mitigate UHIE yet create healthier and livable cities?" In addition to authors' thoughts, it raises a question: "Can green-blue infrastructures substitute grey infrastructure to reduce the impact of intensified UHIs in urban areas and cities?" Moreover, it addresses nature-based solutions (NbSs) as a significant strategy to achieve livable and resilient cities' and followed by elucidating UGC and its role in post COVID-19 regulations and recommendations for better future. Part II is outlined into four chapters: Chap. 4 is entitled: "Global Cities' Plans to Mitigate Urban Heat Islands Effect Exploiting Urban Green Coverage," while Chap. 5 "Assessment of Urban Heat Island in conjunction with Green Coverage in Large Cities: Cairo, Egypt, and Rome, Italy", and Chap. 6 "Environmental Framework for Mitigating High Temperatures in Global Cities Exploiting Urban Greening: Two Case Studies: Cairo, Egypt, and Rome, Italy," finally Chap. 7 "Urban Green Coverage and Its Role in Post-COVID-19 Regulations and Recommendations."

At the end of this book, an important question is highlighted: "Can blue and green infrastructures and city innovation assist in mitigating UHIE and creating livable, sustainable and resilient cities?" The answers have been narrated in this book.

With the contributions from the lead author (an international and national expert who has more than 37 years of experience in higher education, government, senior management, and consultancy in strategy and policy related to sustainable urban development, sustainable energy policies, and CC mitigation and adaptation), as well as other three authors' qualifications and wide experiences; this book portrays indispensable and in-depth knowledge on the topic "Livable Cities: Urban Heat Islands Mitigation for Climate Change Adaptation Through Urban Greening."

The authors strongly believe that the book is a useful source of learning and knowledge, which would support policymakers, governments and local authorities. The book also provides knowledge to professionals, research centers, libraries, and academicians, as well as researchers, and students who are involved in this field. In addition, this book would assist industry's stakeholders involved in the development of cities to attain livability, CCA, and the SDGs by 2030.

Transforming gray infrastructure and maximizing the exploitation of NbSs, ESbSs, and BGIs in large cities and regions are also vital, not only to mitigate and counterbalance CC risks but also increase cities' livability and resilience.

The readers of the book are most welcome to contact the lead author through his e-mail address: maboulnaga@eng.cu.edu.eg to share their thoughts and comments, which will be addressed in due course.

Giza, Greater Cairo, Egypt Mohsen Aboulnaga

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Last but not least, thanks are extended to all who made the book concluded and materialized.

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Contents

Abbreviations

AARP	American Association of Retired Persons
AC	Adapted case
ACLI	Australian cities livability index
ACT	Australian Capital Territory
AfDB	African Development Bank
AIVEP	Associazione Italiana Verde Pensile "Italian Green Roof Association"
APGSs	Accessibility of public green spaces
APHRC	African Population and Health Research Centre
AQG	Air Quality Guidelines
AV	Albedo value
BC	Baseline case
BGI	Blue-green infrastructure
BH	Buildings' height
BI	Blue infrastructure
BL	Bare land
BMZ	Ministry of Economic Cooperation and Development, German Federal Ministry for Economic Cooperation and Development
CC	Climate change
CCA	Climate change adaptation
CCBA	Cairo Cleanness and Beautification Agency
CCM	Climate change mitigation
CCMP	Climate change model predictions
CCSs	Climate change scenarios
CE	Cooling effect
CEs	Cooling effects
CEG	Community Evaluation Guideline
CFD	Computational fluid dynamics
CLAC	Central Laboratory of Agriculture Climate of Egypt
CGSs	Community green spaces
CLC	Centre for Livability Cities

CLHI	Canopy Layer Heat Island
CN	Climate neutrality
CO	Carbon monoxide
CO_2	Carbon dioxide
CP	Cool pavement
CP	City planning
CPR	Cities Policy Responses
CR	Cool roof
CRs	Cool roofs
CUF	City urban fabric
CUR	Centre of Urban Research
DFFE	Department of Forestry, Fisheries and the Environment of South Africa
DNSH	Do no significant harm
DoHUD	US Department of Housing and Urban Development
DoT	US Department of Transportation
EBM	Energy balance model
EC	European Commission
EC-JRC	European Commission's Joint Research Centre
EEA	European Environmental Agency
EGD	European Green Deal
EGRs	Extensive green roofs
EHI	Extreme heat islands
EHT	Extreme high temperature
EIU	Economist Intelligence Unit
ENVI-met	Microscale 3-dimensional software model to simulate complex urban environments
EPA	US Environmental Protection Agency
EPW	Weather file
ES	Environmental sustainability
ESA	European Space Agency
ESbSs	Ecosystem services-based solutions
ESI	Environmental sustainability index
ESs	Ecosystem services
ESSAT	Eco-system service assessment tool
EU	European Union
EUROSTAT	The Statistical Office of the European Union
FAO	Food and Agriculture Organization
FGSP	Future Greenspace Skills Program
GCC	Global climate change
GAs	Green areas
GBI	Green and blue infrastructures
GCFL	Greener City Fund of London
GCHA	Global Climate and Health Alliance
GCI	Green city index

GCR	Greater Cairo Region
GDP	Gross Domestic Product
GEs	Green elements
GHG	Greenhouse gases
GI	Green infrastructure
GIS	Geographic Information System
GLI	Global livability index 2023
GOPP	General Authority for Urban Planning of Egypt
GR	Green roof
GRs	Green roofs
GS	Green surface
GSCR	Green Space Commission Report
GSs	Green spaces
GWSs	Green wall systems
H	Height
H/W	Height-to-width ratio
HadCM3	Hadley Centre Coupled Model, version 3
HAM	High albedo materials
HC	Healthy city
HERI	Heat-related elderly risk level
Hg	Mercury
HI	High impervious density
HIA	Health Impact Assessment
HIE	Heat island effect
HRA	Heat risk assessment
HVI	Heat vulnerability index
ICSC	International Centre for Sustainable Cities
IGRs	Intensive green roofs
IMP	Imperviousness
IPCC	Intergovernmental Panel on Climate Change
IS	Impervious surface
ISPRA	Italian Institute for Environmental Protection and Research
ISs	Impervious surfaces
ISTAT	Italian National Institute of Statistics
IUCN	International Union for Conservation of Nature
IWM	Integrated water management
JCP	Johannesburg City Parks
LAI	Leaf area index
LAV	Lower albedo values
LC	Livable city
LCC	Local climate change
LCL	Leaf color lightness
LCo	Land cover
LCs	Livable cities
LGWs	Living green walls

LMIC	Low-medium-income country
LST	Land surface temperatures
LT	Low tree cover density
LULC	Land use and land cover
MASL	Meters above sea level
MC	Metropolitan core
MENA	Middle East and North Africa
MODIS	Moderate resolution imaging spectroradiometer
NAS	Nigerian Academy of Science
NbSs	Nature-based solutions
NC	North Carolina
NDVI	Normalized difference vegetation index
NEAP	National Environmental Action Plan
NIHHIS	National Integrated Heat Health Information System
NO_2	Nitrogen oxide
NOUH	National Organization for Urban Harmony of Egypt
NPSs	Natural public spaces
NPV	Net present value
NRF	National Research Foundation
NRRPs	National recovery and resilience plans
NTs	New towns
NUA	New urban agenda
NY	New York
OECD	Organization for Economic Co-operation and Development
PCA	Park's cooling area
PGSs	Public green spaces
PHWP	Public Health and Well-being Plan
PINQuA	Italian National Innovative Program for Housing Quality
PM	Particulate matter
PMV	Predicted mean vote
PNRR	Italian national recovery and resilience plan
POSs	Public open spaces
PPI	Public Policy Institute
PPP	Public-private partnership
PPPs	Public-private partnerships
PSC	Partnership for sustainable communities
PSs	Public spaces
PUGS	Public urban green space
PWR	Permeable and water retaining
QoL	Quality of life
R2	Regression value
SCESF	Environmental Science and Forestry
SCI	Sustainable Cities Initiative
SD	Sustainable development
SDGs	Sustainable development goals

SEP	Socio-economic position
SERG	Sustainable Energy Research Group
SHI	Surface heat islands
SIGRs	Semi-intensive green roofs
SO_2	Sulphur dioxide
SRC	Stockholm Resilience Centre
STs	Street trees
SUD	Sustainable urban development
SUHI	Surface urban heat island
SVF	Sky-view factor
SWMM	Stormwater management model
SWMS	Stormwater management system
T	Mean temperature
Ta	Air temperature
TLS	Tree-lined street
TCI	Thermal comfort index
TAR	Third Assessment Report
Tmax	Maximum temperature
TMG	Tokyo Metropolitan Government
Tmin	Minimum temperature
Tmrt	Mean radiant temperature
Tr	Temperature in rural area
Tu	Temperature in urban area
ΔTu-r	Temperature difference between the urban and rural areas
Ts	Surface temperature
TSG	Trees, shrubs, and grass
UA	Urban agriculture
UBL	Urban boundary layer
UCL	Urban canopy layer
UCC	Urban climate change
UE	Urban ecology
UESs	Urban ecosystem services
UF	Urban fabric
UFo	Urban forestry
UFP	Urban forestry program
UFS	Urban forestry strategy
UFAM	Urban futures assessment method
UG	Urban greening
UGC	Urban green coverage
UGCP	Urban green coverage planning
UGIN	Urban green infrastructure network
UGSs	Urban green spaces
UGOSs	Urban green open spaces
UGSE	Urban green space equity
UHIE	Urban heat islands effect

UHIs	Urban heat islands
UHM	Urban heat mitigation
UIWB	Urban inland water bodies
UK	United Kingdom
UL	Urban livability
ULI	Urban livability index
UN-DESA	United Nations Department of Economic and Social Affairs
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention for Climate Change
UNI	Italian National standards
UPD	Urban development planning
UPs	Urban parks
UPSs	Urban public spaces
US$	US dollars
USGS	US Geological Survey
USLAND	Urban surface landscape
UST	Urban surface temperature
UTC	Coordinated Universal Time
UTE	Urban thermal environment
UV	Ultraviolet
VGS	Vertical greening system
VGSs	Vertical greening systems
Victorian-DHHS	Victorian Department of Health and Human Services
VLC	Vegetated land coverage
VOCs	Volatile organic compounds
W	Width
WB	Water bodies
WBG	World Bank Group
WCCF	World Cities Culture Forum
WEF	World Economic Forum
WHO	World Health Organization
WI	Walkability index
WMO	World Meteorological Organization
WSU	West Sydney University
WSUD	Water sensitive urban design
WUF-VWG	World Urban Forum 2006, Vancouver Working Group

List of Figures