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Title:

Technical Research on Heatwaves and Urban Design: An Inventory of literature to identify

a) characteristics of the urban environment that are more susceptible to the effects of heatwaves

b) solutions for fighting against heatwaves as found in urban design

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mathemagenesis

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Methodology

To identify the characteristics of the urban environment that are more susceptible to the effects of heatwaves and to propose solutions for fighting against heatwaves as found in urban design, we conducted an intensive literature research.

As part of the methodology we followed a series of steps for searching and organizing findings concerning the reasons that make an urban environment sensitive to heat waves.

These steps are described below:

1. Keyword selection: “cities AND heatwaves”, “Urban Heat Islands”
2. Search Engine selection: Scopus, Taylor & Francis, Google Scholar.
3. Temporal Scope: The search was limited to items published from 2018 to 2023 inclusive. In one case, regarding open water surfaces, search was extended to the previous five years, because of the relative lack of recent relevant literature.
4. Geographical scope: Although focus is on Europe, certain papers from other regions (China, SE Asia, USA, Australia) were also examined, because research is richer in those zones (as heatwaves constitute a more massive phenomenon) and conclusions appear to have universal validity.
5. Screening Process: Items were classified by relevance. All search engines returned an excessive number of papers, ranging from at least 3,341 (Taylor & Francis) to more than 17,000 (Google Scholar). However, it was impossible to restrict keywords further, because this would be based on arbitrary criteria and exclude material that is relevant. We therefore started from review papers, selecting the ones focusing on factors affecting the intensity of heatwaves in cities or/and policies and measures to mitigate urban heat islands. Then proceeded to certain papers cited in the reviews or covering in more detail aspects pinpointed in the reviews. At some point, conclusions tended to repeat, and research stopped when a fair number of new papers provided no new factors. In the end, **36** papers were selected, according to their title, number of citations, abstract, keywords, structure and conclusions.
6. Data Organization: A spreadsheet was created including these papers: their title, journal of publication, authors, date, category (review, case study, modeling/quantitative analysis, comparative analysis, policies), geographical area of investigation, indicated factors and proposed measures/policies

Analysis and classification of findings

Following the organization of the selected data, findings regarding the two parameters under scrutiny (features affecting the vulnerability of urban areas to heatwaves, proposed solutions) were compared, checked for overlaps, grouped and classified according to a taxonomy that was considered suitable for our objective. Among different terms to describe the same factors or solutions, those were selected that are more comprehensive, without lacking accuracy.

1. Indicated factors contribution to urban heatwave vulnerability:

Factors affecting the intensity of heatwaves in urban areas were classified according to the table:

Indicated factors related to heatwaves in urban areas		References
Urban Structure and Morphology	Urban area/size	Florenzio et al. 2022, Deilami et al. 2018
	Built-up density	Florenzio et al. 2022, et al. 2021, Deilami et al. 2018, He Y. et al. 2018, Yang et al. 2019b
	Building heights	He B-J. et al. 2019, Yang et al. 2019b, Nwakaire et al. 2020
	Aspect Ratio (Height/width) of streets	Merlier et al. 2018
	Frontal Area Density	Yang et al. 2019a, Yang et al. 2019b
	Street pattern	He Y. et al. 2018, He B-J. et al. 2019
	Grid size	Yang et al. 2019a
	Compactness	Deilami et al. 2018, He B-J. et al. 2019
Rate of Urbanization	Urban population	Deilami et al. 2018
	Urban expansion rate	Deilami et al. 2018, Ulpiani 2020
	Urban development intensity	Deilami et al. 2018
Urban Surface and Materials	Sealed urban patches	Florenzio et al. 2022
	Surface composition	Deilami et al. 2018, Nwakaire et al. 2020
	Porosity	Florenzio et al. 2022, Tayyebi & Jenerette 2018, Deilami et al. 2018
	Human-made surfaces albedo	Burbidge et al. 2021, Deilami et al. 2018, Nwakaire et al. 2020
	Soil moisture	Deilami et al. 2018
	Open water surfaces	Deilami et al. 2018, Steeneveld et al. 2014
Vegetation	Vegetation area	Tayyebi & Jenerette 2018, Deilami et al. 2018
	Normalized Difference Vegetation Index	Tayyebi & Jenerette 2018
Climate and Geography	Landscape	Deilami et al. 2018
	Elevation	Deilami et al. 2018, Equere et al. 2021
	Distance from the sea	Tayyebi & Jenerette 2018
	Climate type	Deilami et al. 2018, Nwakaire et al. 2020

	Winds	He B-J. et al. 2019
	Heatwaves (intensity, frequency, seasonal variation)	Deilami et al. 2018, Nwakaire et al. 2020
Local infra-urban Conditions	Local climate zones	Yang et al. 2019b, Yang et al. 2020
	Proximity to the city centre	Kyriakopoulos et al. 2022
	Distance to coast	Kyriakopoulos et al. 2022
	Street orientation	Jamei Rajagopalan 2018
	Building geometry	Merlier et al. 2018
Social and Economic Conditions	Land uses	Deilami et al. 2018, Nwakaire et al. 2020
	Transportation	Deilami et al. 2018, Nwakaire et al. 2020
	Urban Metabolism	Nwakaire et al. 2020
	Waste Heat	Burbidge et al. 2021, Nwakaire et al. 2020
	Pollution	Ulpiani 2020
	Policies and Strategies	Szpak 2020

2. **Proposed solutions:**

Measures and urban policies to address heatwaves were selected were classified according to the table:

Proposed measures and policies		References
Urban Design	Road network design	He Y. et al. 2018, Balany et al. 2020
	Aspect Ratio (Height/width) of streets	Balany et al. 2020
	Urban voids	Roggema 2018
	Lift-up design	Du et al. 2017
	Natural Ventilation based Urban/Architectural Design	Song et al. 2018, Deilami et al. 2018, He B-J. et al. 2019
Green Infrastructure	Urban Parks	Burbidge et al. 2021, Deilami et al. 2018, Hintz et al. 2018, Balany et al. 2020, Degirmenci et al. 2021, Kong et al. 2021, Nwakaire et al. 2020
	Street Trees and Shrubs	Deilami et al. 2018, Hintz et al. 2018, Balany et al. 2020, Kong et al. 2021, Nwakaire et al. 2020
	Private Gardens	Deilami et al. 2018
	Green Roofs and Facades	Clar & Steurer 2021, Meerow & Keith 2021, Deilami et al. 2018, Hintz et al. 2018, Balany et al. 2020, Mihalakakou et al.

		2023, Kong et al. 2021, Nwakaire et al. 2020
	Appropriate Planting Design and Species	Daniel et al. 2018, Rahman et al. 2018
Blue Infrastructure	Waterbodies	Meerow & Keith 2021, Deilami et al. 2018, Hintz et al. 2018, Degirmenci et al. 2021
	Irrigation	Kong et al. 2021
	Public Water Supply	Hintz et al. 2018
	Pavement Watering	Hintz et al. 2018, Daniel et al. 2018
Grey Infrastructure	Cool and super cool materials	Pour et al. 2019, Deilami et al. 2018, Wang et al. 2021, Hintz et al. 2018, Santamouris & Yun 2020, Degirmenci et al. 2021, Kong et al. 2021, Nwakaire et al. 2020
	Manmade Shade	Meerow & Keith 2021
	Insulation	Hintz et al. 2018
	Mechanical Ventilation	Hintz et al. 2018
	Renovation of Old Buildings	Hintz et al. 2018
	Reflective or Shading windows	Hintz et al. 2018
Urban Planning and Policies	Land Use Regulations	Meerow & Keith 2021, Parsaee et al. 2019
	Population Distribution	Yang et al. 2019
	Transport Modal Split	Nwakaire et al. 2020
	Construction Regulations	Hatvani-Kovacsa et al. 2018
	Waste Heat control	Meerow & Keith 2021
	Heating, Ventilation, and Air Conditioning Regulations	Hatvani-Kovacsa et al. 2018
	Public Participation and Self-management	Burbidge et al. 2021, Parsaee et al. 2019
	Education/awareness	Hintz et al. 2018, Parsaee et al. 2019
Management strategies	Warning Systems	Meerow & Keith 2021
	Emergency Plans	Meerow & Keith 2021
	Public Health Services	Hatvani-Kovacsa et al. 2018
	Energy Consumption Control	Hintz et al. 2018
	Cooling Centers	Meerow & Keith 2021
	Drinking Fountains	Meerow & Keith 2021
Methodology	Holistic Approach	Wang 2022
	Models and Simulations	Luo et al. 2022
	Adaptation to Climate Zones	Yang et al. 2019b

A short synopsis on the findings

Most relevant research is focused on the urban **structure** or morphology, urban materials and natural elements in the cities.

Urban structure and morphology factors are mostly related to ventilation and shading. Among them, certain ones have a clear contribution to the intensity of heatwaves (eg large urban areas combined with high densities, uninterrupted frontal areas, too complicated street patterns), while others seem to have contradictory effects: for example, too high buildings may inhibit proper ventilation, but too low buildings may have a negative effect on shading. On the macro level, urban dynamics, such as the rate of urban expansion, is also considered to contribute to heatwave vulnerability.

Urban materials are mostly related to the thermal capacity of surfaces. It is evident that two particular attributes are positively correlated with the mitigation of heatwave effects: high albedo (i.e. solar reflectivity) of surfaces and building envelopes, and high porosity of ground-surface materials.

Vegetation is largely considered to have a positive effect to the mitigation of urban heat islands, but this also depends on the correct planning, species and health of trees, shrubs and grass (as measured by the Normalized Difference Vegetation Index). Open water surfaces are also found to play a positive role, as the evaporation of water absorbs heat and increases air humidity (which, combined with ventilation, can enhance the sense of coolness), although deep waterbodies can also have a contradictory effect due to their high thermal capacity, that can delay cooling in the night.

Studies correlating urban heat islands with geographic or climatic characteristics are rather limited, because those factors are mainly subject to physical rather than urban geography.

Another series of studies is focused on the infra-urban level, i.e. on the differentiation of conditions within the urban fabric: for example, proximity to the sea is largely acknowledged as a factor mitigating heatwaves, whereas the opposite applies to the proximity to the city center. The orientation of streets affects both ventilation (according to the local prevailing wind direction) and shading (with W-E streets being more exposed to the sunlight than N-S ones).

Finally, there are certain approaches that focus on factors related to human activity in cities. This might concern life in the cities (with factors such as high industrial activity, pollution or a high percentage of private transports clearly deteriorating urban heat conditions) or urban policies to address climate change and heatwaves, in particular.

Proposed solutions, obviously, correspond to the indicated factors. In general, they are divided into two large categories: means to address the causes of urban heat islands, and strategies to manage their effects. In the last instance, literature is more relevant to crisis management rather than urban studies or architecture, although in the case of allocating cooling centers or providing public drinking fountains, for example, the two fields overlap.

In the first instance, urban and architectural design standards are essential, because they can hardly affect the already built-up environment and they are mostly intended for future urban expansion or, at most, local renewal projects. On the other hand, urban planning, in the most general sense, including regulations and urban policies, land uses, transportation etc, is supposed to be essential both for existing urban areas and for future

expansions. Certain researchers underline the role of education, which falls into the particular interest of our project.

On a lower scale, research focuses on what is referred to as green, blue and grey infrastructures. Green infrastructure is about vegetation, blue infrastructure regards waterbodies and watering, while grey infrastructure concerns artificial materials to mitigate the effects of heat outdoors (pavements, manmade shade) or indoors (insulation and ventilation of buildings, windows etc). Cool and super-cool surface materials, including a large spectrum of high-tech innovations, occupy a large part of the literature in this category. Compared to urban design or planning, policies of green, blue or grey infrastructure have the advantage of direct applicability, although they must be reasonably expected to have less universal effects than a radical process of urban redesign.

Finally, a smaller number of papers deals with issues of methodology.

Critical remarks on the findings

Despite all interest findings and conclusions, research regarding characteristics of the urban environment related with heatwaves and possible solutions to urban heatwaves seem to lack a holistic view. Different factors seem to be examined autonomously, with only limited concern to combine them or compare their impact. Best case scenario, a variety of factors is simply listed. This renders it difficult to evaluate the relative weight of different parameters.

Moreover, the relevant research and literature is often restricted to a technical discussion, avoiding a critical approach. This can lead to disregarding the contradictory effects that certain factors or solutions might lead two, by not taking account of both direct and indirect consequences: for example, compactness of the urban fabric is generally considered to increase urban heat, however a compact city might at the same time mean less uncontrolled urban sprawl, which might in turn entail higher quality peri-urban vegetations and environmental standards, with beneficial effects for the urban core too. Most importantly, technical approaches often fail to integrate economic, social and political factors that are crucial for understanding urban structures and functions, urban heat islands as well as climate change in general. Therefore, a more holistic, combined and critical approach to address the issue would be probably needed.

Code	Journal	Paper title	Writer	Date	Category	Geographical Area	Indicated factors	Proposed policies
1	Building Research & Information 46 (8)	Natural ventilation in cities: the implications of fluid mechanics	Jiyun Song, S. Fan, W. Lin, L. Mottet, H. Woodward, M. Davies Wykes, R. Arcucci, D. Xiao.-E. Debay, H. ApSimon, E. Aristodemou, D. Birch, M. Carpentieri, F. Fang, M. Herzog, G. R. Hunt,R. L. Jones, C.	28 Jun 2018	Research paper	London	Ventilation, Urban form	
2	Journal of Environmental Planning and Management	The role of urban planning in climate adaptation: an empirical analysis of UHI in European	N. Florenzio, G. Guastell, F. Magni, S. Pareglio & F. Musco	26 May 2022	Comparative analysis		Urban morphology (size, sealed urban patches, built-up density, porosity)	
3	European Planning Studies 29 (3)	Climate change adaptation plans in Polish cities – comparative	Agnieszka Szpak	31 Mar 2020	Comparative analysis	Warsaw/ Krakow/ Poznan	climate change strategies	

4	International Journal of Sustainable Energy 41(11)	Characteristics of the urban heat island effect in the coastal Mediterranean city of	Panagiotis Kyriakopoulos, Yannis G. Caouris, Manolis Souliotis & Mattheos	30 Aug 2022	Case study	Kalamata	Proximity to the city centre, Distance from the sea	
5	European Journal of Remote Sensing 52	Airborne thermal remote sensing: the case of the city of Olomouc, CzechRepublic	Tomáš Pour, Jakub Miřijovský & Tomáš Purket	08 Jan 2019	Case study	Olomouc		Natural materials
6	Journal of Building Performance Simulation	A data schema for exchanging information between urban building energymodels and urban microclimate models in coupled	Na Luo,Xuan Luo, Mohammad Mortezazadeh, Maher Albettar, Wanni Zhang, Dongxue Zhan,Liangzh	09 Nov 2022	Modelling /quantitative analysis			Coupled simulation: urban building energy models and urban microclimate models
7	Architectural Science Review 61	Design with voids: how inverted urbanism can increase urban resilience	Rob Roggema	27 Jul 2018	Policies	Almere, Sydney		Urban voids, Inverted urbanism

8	Local Environment 27	Don’t blame it on the sunshine! An exploration of the spatialdistribution of heat injustice across	Manon Burbidge, T. Smith Larsen, S. Feder & S. Yan	23 Nov 2021	Case study	Antwerp	Solar reflectivity of human-made surfaces, Waste heat energy generated by high building densities	Resident managed parks
9	Journal of Urban Affairs 45	Climate change adaptation with green roofs: Instrument choice and facilitating	Christoph Clar & Reinhard Steurer	08 Mar 2021	Policies	Copenhagen, Hamburg, Vienna		Suitable green roof policies

10	Journal of the American Planning Association 88	Planning for Extreme Heat, A National Survey of U.S. Planners	Sara Meerow & Ladd Keith	08 Dec 2021	Comparative analysis	US cities		Heat mitigation strategies (Land use regulations, Urban design, Urban greening, Manmade shade, Water features, Green roofs, Appropriate building materials, waste heat management), Management strategies (Emergency response, Warning systerms, Drinking Fountains, Utility assistance, Info & awareness, Cooling centres, Vulnerability assessments, Staff)
11	International Journal of Remote Sensing 39	Assessing diel urban climate dynamics using a land surface temperature harmonization model	Amin Tayyebi & G. Darrel Jenerette	7 Feb 2018	Modelling /Quantitative analysis	California	Distance to coast, NDVI, Vegetation, Impervious surface	

12	Architectural Science Review 62	Effect of street design on pedestrian thermal comfort	Elmira Jamei & Priyadarsini Rajagopalan	15 Nov 2018	Case study	Melbourne	Street orientation	
13	International Journal of Applied Earth Observation and Geoinformation 67	Urban heat island effect: A systematic review of spatio-temporal factors,data, methods, and mitigation measures	Kaveh Deilami, Md. Kamruzzaman & Yan Liu	May 2018	Review		Area/percentage of vegetation, UHI seasonal variation, Urban area, UHI day/night variation, Population, Proportion of waterbody, Percentage of road/pavement, Biophysical components, Impervious surface, ground surface albedo, Social and economic valiables, Landscape metric/ecology, Density of buildings, Bare soil, Soil moisture, Normalized multi-band drought index, Elevation, Urban expansion rate, Urban compactness ration, Area of forest, Agricultural area, Porosity, Precipitation/humidity, Fallow land, Number of private/public vehicles, 3D characteristics of cities, Urban development intensity, Residential area, Industrial area, Surface energy flux	High-albedo materials, Green strategies (urban forests/parks, street trees, private green in gardens, green roofs or facades), Improving urban ventilation, Waterbodies

14	Renewable and Sustainable Energy Reviews 146	Cool pavements for urban heat island mitigation: A synthetic review	Chenghao Wang, Zhi-Hua Wang, Kamil E. Kaloush & Joseph Shacat	Aug 2021	Review			Cool pavements: reflective, permeable, innovative
15	Sustainable Cities and Society 36	Derivation of generic typologies for microscale urban airflow studies	Lucie Merlier, Frédéric Kuznik, Gilles Rusaouën & Serge Salat	Jan 2018	Review		Urban forms: urban roughness (canopy heterogeneity, relative dimentions), urban permeability (connectedness, geometry)	
16	Building and Environment 117	Effects of lift-up design on pedestrian level wind comfort in different building configurations under three wind directions	Yaxing Du, Cheuk Ming Mak, Jianlin Liu, Qian Xia, Jianlei Niu & K.C.S. Kwok	May 2017	Quantitative analysis	Hong Kong		Lift-up design

17	Urban Climate 24	Effects of non-uniform and orthogonal breezeway networks on pedestrian ventilation in Singapore's high-density urban environments	Yueyang He, AbelTablada & Nyuk Hien Wong	Jun 2018	Case study	Singapore	Breezeways (density, morphology)	Appropriate road network design
18	Sustainable Cities and Society 47	Enhancing urban ventilation performance through the development of precinct ventilation zones: A case study based on the Greater Sydney, Australia	Bao-Jie He, Lan Ding & Deo Prasad	May 2019	Case study	Sydney	Urban typology (building heights, street pattern, compactness), external meteorological conditions (synoptic wing, katabatic/anabatic wind, breeze, wind speed, wind direction)	Ventilation performance-based planning

19	Urban Climate 24	Facing the heat: A systematic literature review exploring the transferability of solutions to cope with urban heat waves	Marie Josefine Hintz, Christopher Luederitz, Daniel J. Langa & Henrik von Wehrden	Jun 2018	Review			Green and Blue infrastructure (Greenery and shade, water bodies, green roofs, mapping of urban vegetation, public water supply), grey infrastructure (insulation, renovation of old houses, cooling-roofs, high albedo material, lower peak electricity power, natural and mechanical ventilation of buildings, reflective or shading windows, pavement watering), behaviour of inhabitants

20	Water 12 (12)	Green Infrastructure as an Urban Heat Island Mitigation Strategy—A Review	Fatma Balany, Anne WM Ng, Nitin Muttil, Shobha Muthukumaran & Man Sing Wong	20 Dec 2020	Review			Green infrustructure (trees, grass, shrubs, green roofs, green walls, park), Urban materials, Aspect Ratio (Hight/width of streets), Street Orientation

21	Renewable and Sustainable Energy Reviews 180	Green roofs as a nature-based solution for improving urban sustainability: Progress and perspectives	Giouli Mihalakakou, Manolis Souliotis, Maria Papadaki, Penelope Menounou, Panayotis Dimopoulos, Dionysia Kolokotsa, John A. Paravantis, Aris Tsangrassoulis, Giorgos Panaras, Evangelos Giannakopoulos & Spiros Papaefthimiou	Jul 2023	Review			Green roofs

22	Sustainable Cities and Society 47	Local climate zone ventilation and urban land surface temperatures: Towards a performance-based and wind-sensitive planning proposal in megacities	Jun Yanga, Shanhe Jin, Xiangming Xiao, Cui Jin, Jianhong (Cecilia) Xia, Xueming Lia & Shijun Wang	May 2019	Case study	Shanghai	Urban architectural patterns (High-density high-rise buildings, Frontal Area Density) correlated with different climate zones	Adaptation of urban planning and regulations to different climate zones
23	Science of the Total Environment 751	On the linkage between urban heat island and urban pollution island: Three-decade literature review towards a conceptual framework	Giulia Ulpiani	10 Jan 2021	Review		Pollution and factors affecting it: Temperature-dependent chemistry and daytime-nighttime variability (climate type and source of pollution), Urban geomorphic types, Urban forms, urban growth and inter-urban connection	

24	Journal of Cleaner Production 275	Optimizing local climate zones to mitigate urban heat island effect in human settlements	Jun Yang, Yichen Wang, Chunliang Xiu, Xiangming Xiao, Jianhong Xia (Cecilia) & Cui Jin	Dec 2020	Quantitative analysis	Dalian	Local climate zones	Optimum population distribution within the city
25	Urban Climate 25	Policy recommendations to increase urban heat stress resilience	Gertrud Hatvani-Kovacsa, Judy Bush, Ehsan Sharifi & John Boland	Sep 2018	Policies	Australia		Policy measures: public health services, building and construction industry (regulations on building energy-efficiency and heat stress resistance), urban planning, infestructure, services & utilities

26	Renewable Energy 161	Recent development and research priorities on cool and super cool materials to mitigate urban heat island	M. Santamouris & Geun Young Yun	Dec 2020				Cool and super cool materials (natural and conventional, white coatings of higher reflectance, coloured coatings reflecting in the IR spectrum, IR reflecting surfaces doped wit phase changr materials, temperature induced colour changing materials, fluoriscent materials, innovative radiative cooling structures, other)
27	Landscape and Urban Planning 121	Refreshing the role of open water surfaces on mitigating the maximum urban heat island effect	G.J. Steeneveld, S. Koopmans, B.G. Heusinkveld & N.E. Theeuwes	Jan 2014	Quantitative analysis	Netherlands	Open water surfaces	

28	Urban Climate 23	Role of watering practices in large-scale urban planning strategies to face the heat-wave risk in future climate	M. Daniel, A.Lemonsu & V.Viguié	Mar 2018	Modelling /Quantitative analysis	Paris		Appropriate vegetation and pavement watering
29	Urban Climate 28	Spatial differentiation of urban wind and thermal environment in different grid sizes	Jun Yanga, Yichen Wang, Xiangming Xiao, Cui Jin, Jianhong (Cecilia) Xia & Xueming Li	Jun 2019	Quantitative analysis	China	Grid size, Frontal area Index	
30	Building and Environment 170	Traits of trees for cooling urban heat islands: A meta-analysis	Mohammad A. Rahman, Laura M.F. Stratopoulos, Astrid Moser-Reischl, Teresa Zölch, Karl-Heinz Häberle, Thomas Rötzer, Hans Pretzsch & Stephan Pauleit	Mar 2020	Review			Appropriate planting design and tree species

31	Sustainable Cities and Society 70	Understanding policy and technology responses in mitigating urban heat islands: A literature review and directions for future research	Kenan Degirmenci, Kevin C. Desouza, Walter Fieuw, Richard T. Watson & Tan Yigitcanlar	Jul 2021	Review			Policy responses (Landscape & Urban Form, Green & Blue area ratio, Albedo enhancement policies, Transport modal split, Public Health & Participation), Technology responces (Green Building Envelopes, Cool Surfaces, Sustainable Transport, Energy consumption, HVAC & waste Heat)
32	Sustainability 13 (19)	Urban Heat Island and Its Interaction with Heatwaves: A Review of Studies on Mesoscale	Jing Kong, Yongling Zhao, Jan Carmeliet & Chengwang Lei	30 Sep 2021	Review			High Albedo, High Vegetation Coverage, Irrigation

33	Sustainable Cities and Society 63	Urban Heat Island Studies with emphasis on urban pavements: A review	Chidozie Maduabuchukwu Nwakaire, Chiu Chuen Onn, Soon Poh Yap, Choon Wah Yuen & Peter Dinwoke Onodagu	Dec 2020	Review		Antropocentric Sources (Metabolism, Heating, Air conditioning, Manufacturing, Transportation), Structural Sources (Surface composition, Pavements, Buildings, Urban Canyon), Climatic Sources (Precipitation, Heat waves)	Vegetative Covers and wetlands, Cool Roofs, Public Transport, Sustainable Materials (Innovative pavements)
34	Environmental Technology & Innovation 14	Urban heat island, urban climate maps and urban development policies and action plans	Mojtaba Parsaee, Mahmood Mastani Joybari, Parham A. Mirzaei & Fariborz Haghighat	May 2019	Review			Active involvement in Urban Development Policioes/Action Plans, Urban managerial as well as governmental actions, Public engagement and participation.

35	Sustainable Cities and Society 69	Integration of topological aspect of city terrains to predict the spatial distribution of urban heat island using GIS and ANN	Victor Equere, Parham A. Mirzaei, Saffa Riffat & Yilin Wang	Jun 2021	Modelling /Quantitative analysis	Illinois	Land surface elevation, Other morphological parameters	
36	Sustainable Cities and Society 77	Reconceptualizing urban heat island: Beyond the urban-rural dichotomy	Zhi-Hua Wang	Feb 2022	Policy			The embedment of thermal condition in more holistic urban environmental indicators, Putting planners of local cities into broader contexts informed by the development of decision-making processes historically and spatially, Avoiding one-sidedness of urban planning in segregated departments