How Are Current Planners in L.A and Singapore Harnessing Innovations to Mitigate Urban Heat Island? How Might They Need to Adapt in a Warming and Urbanizing World?

By Elisa Kwun, Katie Reeder and Jasmin Senghera

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Introduction

Based on a 2016 UN Habitat Report, 54% of the global population resides in cities. This percentage is only expected to grow[1]. At the same time, anthropogenic climate change is projected to warming the globe beyond a 1.5 degree world - a scenario which seriously threatens the economic, social and ecological sustainability of our cities. The IPCC 'Special Report on 1.5 Degrees' report, released in October 2018, warned that an average temperature warming by more than 1.5°C will exacerbate urban heat islands, a risk which is tied to human death and illness[2]. With urbanization and shifting climates becoming increasingly pressing issues in cities around the world both today and in the future; the urban heat island effect is just one of the many outcomes of this rapid expansion. The urban heat island effect is characterized by higher temperatures in the urban sphere in comparison to rural regions. It is a pressing issue of this day and age as not only does it imply a warming world but it also has major implications for health issues and rising energy usage.

The aim of this report is to explore UHI in the context of L.A and Singapore to investigate current UHI mitigation strategies and to investigate how the current focus may need to shift based on the onslaught of urbanization and climate change. This report will thus answer the questions; how are current urban planners in L.A and Singapore harnessing innovations to mitigate UHI and how might they need to adapt in a warming and urbanizing world? This report will begin by defining UHI and its detrimental impacts. It will then offer a contextualization of UHI in Singapore and L.A, examining current urbanization and climate trends, and then providing an overview of existing UHI mitigation strategies along with their successes. Lastly this report will examine the shortcomings of current UHI mitigation in these areas and how planners will have to adapt based on the urbanization and climatic variability projected for the future to ensure sustainability of these cities.

Los Angeles and Singapore were chosen as focal cities on the basis that both cities are large urban centers with comprehensive plans to mitigate the urban heat island effect. Mitigating UHI is a strong priority for both of these cities given that they are both severely impacted by it. However, there are some drawbacks to their approach. What can be seen is that both Singapore and Los Angeles focus on mitigating UHI with market growth very strongly in mind. Thus, investigating these cities proves to be an informative process.

What is an Urban Heat Island?

Urban heat-islands (UHI) are generally described as urban areas with a temperature comparatively higher than that of non-urbanized (rural) surroundings.[3] While the effect is felt throughout the day, the differences between urban and rural heat are most pronounced at night. Expansive urban sprawl intensifies the effect. Urban heat islands are a product of reduced

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[1] UN Habitat. 2016. World Cities Report 2016. UN Habitat.

[2] IPCC, Summary for Policymakers. In: Global Warming of 1.5°C. 2018, 11

[3] Aflak et al. 2017. Urban heat island mitigation strategies: A state-of-the-art review on kuala lumpur, singapore and hong kong. Cities 62 : 131-45.

evaporative cooling, increased heat storage in dark materials, lowered vegetation cover, an increase in impervious surfaces, and heat produced through anthropogenic activities, such as the combustion of fossil fuels.[4]

Why Is it a Sustainability Issue?

Health

One of the biggest issues of the urban heat island is that it fosters an environment that is only going to increase in temperature. This is problematic for the health of individuals, especially in the summer. Weather events such as heat waves or even prolonged exposure to high temperatures result in increased heat-related mortalities as well as increased respiratory difficulties, heat cramps, heat strokes, and exhaustion[5]. With the prevalence of the UHI in the future, surges in temperature will only serve to increase the risk of these health issues[6]. This risk is exacerbated for vulnerable individuals such as children, elderly and individuals with chronic illnesses, in particular as these temperatures will not decline at night, and they are left unable to find relief[7]. In addition to the aspect of heat-related health problems, there is the aspect of the heightened dispersal of infectious diseases. As UHI's alter surface temperature and humidity levels, this can increase the spread of diseases such as dengue fever. The replication of this virus is found to be aggravated at temperatures greater than 30 °C[8].

Energy Use

Energy use plays a large role in the way that we mitigate and adapt to climate change to offset UHI. There is a heavy reliable on energy as it is incorporated in many aspects of our lives - from lighting and cooling in our home, to transportation, heating, cooking and even water consumption, it is hard to imagine the growth that society has experienced without the use of energy. With climate change, there will likely be an increase in the demand of electricity to cool during the summer to combat the rising temperatures, especially in urban centres. As of 2016, 80% of the world's energy consumption came from fossil fuels and only 5% from renewables.[9] Burning of fossil fuels results in heat and carbon dioxide (CO_2) into the atmosphere, where it can trap and prevent it from escaping into space. With the heat trapped exceeding the heat released, the temperature increases and we feel the "warming" effects. Our current dependence and use of fossil fuels is limiting our success in reducing global warming effects. New innovations and infrastructure will be necessary to meet the increase in demand of energy in a

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[4] Campbell-Lendrum and Corvalán, "Climate Change and Developing-Country Cities: Implications For Environmental Health and Equity"

[5] 1. Government of Canada, *Climate Change and Health. 2010*

[6] Heaviside, Macintyre, and Sotiris Vardoulakis, " The Urban Heat Island: Implications for Health in a Changing Environment." *Current Environment Health Report,* 4 (2017): 296-305.

[7] Pearce, Fred, "Urban Heat: Can White Roofs Help Cool World's Warming Cities?" *Yale Environment 360*, March 7, 2018.

[8] Araujo et al., "Sao Paulo Urban Heat Islands Have a Higher Incidence of Dengue Than Other Urban Areas." *The Brazilian Journal of Infectious Diseases* 19, no.2: 146-155.

[9] Shell, "Shell World Energy Model A View to 2100". 2017

clean way. Extreme efforts needs to be put in place to use renewable energy sources to greatly reduce the effects of global warming.

Social Justice

The urban heat island effect is also a concern for social justice and social sustainability. UHI effect lowers outdoor thermal comfort (OTC), which impacts outdoor activities when spaces of community (streets, parks or plazas) are too warm to be tolerated.[10] Urban heat mitigation is also a social justice and 'climate justice' concern, as numerous studies suggest that the poor, elderly, children, and those without access to indoor cooling systems are disproportionately impacted by urban heat stress.[11] Urban heat riskscapes largely overlap with the distribution of low-income neighbourhoods, many of which have poor vegetative cover. In a warming, urbanizing world, questions of thermal equity must be rapidly addressed to ensure climate justice.

Singapore and UHI

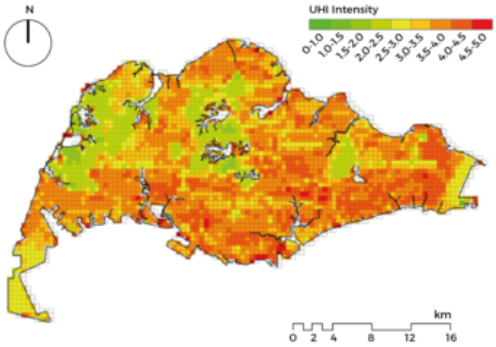

Figure 1. A map indicating the UHI intensity of Singapore[12].

Singapore is an island state located in proximity to the Southern region of Malaysia[13]. It is a region characterized by an equatorial climate resulting in consistently high yearly

[10]Ghaffarianhoseini et al., "Analyzing the Thermal Comfort Conditions of Outdoor Spaces in a University Campus in Kuala Lumpur, Malaysia." The Science of the Total Environment (2019): 1343.
[11] Bruce Coffyn Mitchell and Jayajit Chakraborty, "Exploring the Relationship between Residential Segregation and Thermal Inequity in 20 U.S. Cities." *Local Environment* 23, no. 8 (2018): 796-813.
[12] Reuben Li and Matthias Roth, *Mapping the Urban Thermal Environment in Singapore using a GIS Framework,* 2010.
[13] Matthias Roth and Winston Chow, "A Historical Review and Assessment of Urban Heat Island Research in Singapore." *Singapore Journal of Tropical Geography* 33, no. 3 (2012): 381-397.

temperatures accompanied by high yearly precipitation[14]. This type of climate is not favourable in the current onslaught of climate change given that these high temperatures will be worsened by the urban heat island effect. In addition to its characteristic climate, Singapore has also become well-known for its extensive urban expansion. The regions of built-up areas increased from 28% to 50% between 1955 and 1998, while many natural green areas such as forests and jungles declined in the region surrounding the city.

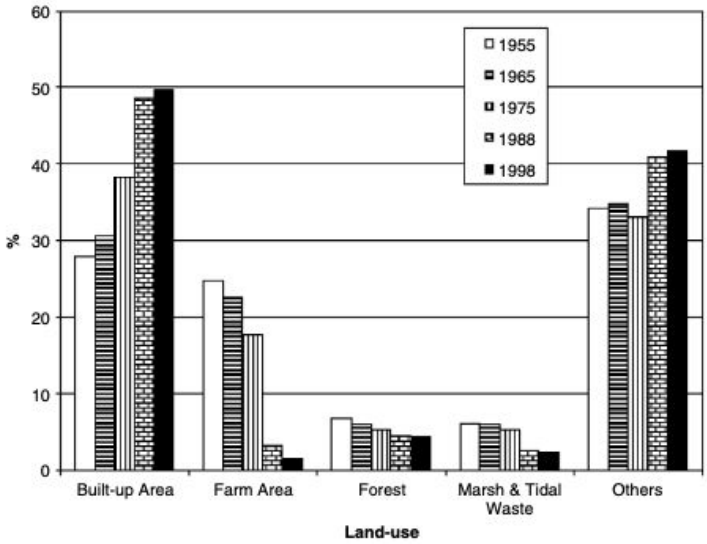

Figure 2. The shifts in land-use in Singapore from 1955 to 1998. In this context, 'Others' refers to open spaces, public gardens, cemeteries, military establishments, and unused land[15].

Furthermore, from 1.8 million in 1965, the population increased to 5.1 million in 2011. This means that Singapore is a region of extremely high density with 7126 people/km^2 [16]. This is concerning in the context of a rising population given that the urban heat island effect increases the risk of heat-related mortalities and the spread of vector-borne diseases[17]. Overall, this rampant urbanization will only serve to continue increasing the urban heat island effect and the intensity of climate change.

Based on climate projections for the years 2070-2099 in mid to high climate scenarios (RCP 4.5 and 8.5), temperatures are expected to rise between 1.4°C and 2.6 °C. These temperature rises will amplify in conjunction with the UHI effect and have negative implications for sea level rise, health, biodiversity, and the abundance of water[18]. Given these negative outcomes, Singapore is taking a strong stance to eliminate impacts of the UHI effect. Singapore is often dubbed as the "Garden City" due to its utilization of biophilic design. Examples of this

[14] Chow, Winston TL, and Matthias Roth. "Temporal dynamics of the urban heat island of Singapore." *International Journal of climatology* 26, no. 15 (2006): 2243-2260.
[15] Department of Statistics. Yearbook of Statistics, Singapore. Department of Statistics: Singapore. 1998
[16] Ibid, 13.
[17] Heaviside, Macintyre, and Sotiris Vardoulakis. "The Urban Heat Island: Implications for Health in a Changing Environment. *Current Environment Health Report,* 4 (2017): 296-305.
[18] National Climate Change Secretariat, Impact of Climate Change on Singapore. Singapore. 2018

include vertical gardens, blue spaces, green roofs and walls, and immersive vegetation[19]. These green elements of design serve a purpose greater than just aesthetics, rather they work to increase environmental sustainability by increasing biodiversity, improving air quality, and increasing food security[20]. Another aspect of this design is the ability for these green spaces to reduce temperatures by reflecting more sunlight and acting as sinks for greenhouse gas emissions. Some of the other prevalent UHI mitigation strategies within Singapore besides greenery include cool roofs, vegetation, wind corridors, and cool pavements.

Figure 3. Park Royal Tower in Singapore embodying biophilic design[21].

As mentioned previously, Singapore is utilizing a nature-based approach to counter UHI alongside other climate change related issues. In particular, green roofs are widely implemented throughout Singapore. In fact, these roofs have been implemented as far back as 2006 on rooftops of apartment buildings[22]. This widespread implementation can be attributed to the fact that green vegetation has been found to decrease surface temperatures by more than 1°C during the daytime and even during the nighttime[23].

Creating cool roofs is another way Singapore is working to mitigate the UHI, although these haven't been deployed on a large scale yet. These roofs consist of highly reflective materials that prevent these regions from having higher temperatures during the daytime. However, they don't reduce much of the heat at night[24]. Cool pavements are another strategy that hasn't been implemented on a large scale but has shown success on a small scale in

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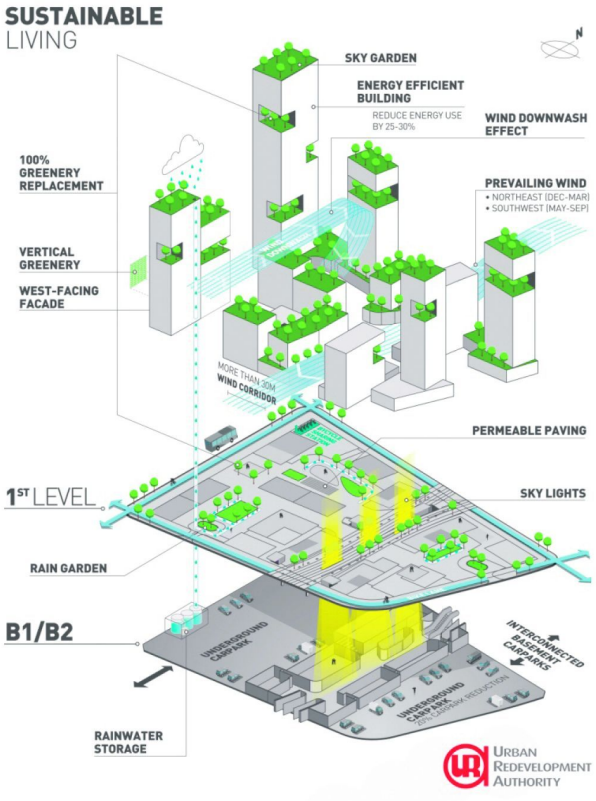
[19]Tan Yen, "Biophilic Design Key to Making Singapore a City in a Garden." *Today.* 2018.
[20] Ibid, 19
[21] Lidija Grozdanic, "Park Royal Tower: WOHA'S Stunning Vertical Garden Tower Opens in Singapore." *Inhabitat.* 2013
[22] Xian-Xiang Li and Leslie Norford, "Evaluation of Cool Roof and Vegetations in Mitigating Urban Heat Island in a Tropical City, Singapore." *Urban Climate*, 16 (2016): 59-74.
[23] Ibid, 59.
[24] Ibid, 66.

Singapore. These cool pavements work with the use of infrared reflective paints that lower the albedo of the previous asphalt or concrete surface[25]. An experiment utilizing this method in Singapore revealed that this cool pavement lowered the surface temperature around 5 K in comparison to the concrete pavement[26].

A slightly different approach to UHI mitigation is the manipulation of urban form through wind corridors. Singapore has this characteristic of buildings large in size and height. This is problematic as the orientation of these buildings can alter the wind environment which disallows natural ventilation that can be used in cooling buildings[27]. It can be seen that the orientation of these large buildings decreases wind speed and lowers air circulation. Thus, Singapore is working to combat this through wind corridors where they are orienting buildings in such a way to allow for natural wind[28]. This strategy has actively been pursued in Singapore's Marina South housing where buildings of different heights and openings within buildings have been utilized to allow for natural ventilation and thus reduce the impact of the UHI effect[29].



[25] M. Santamouris, "Using Cool Pavements as a Mitigation Strategy to Fight Urban Heat Island - A Review of the Actual Developments." *Renewable and Sustainable Energy Reviews,* 26 (2013): 224-240.
[26] Ibid, 27.
[27] Dan Zhu. "Study on Facade Openings Design Method Responding to Urban Ventilation Issue in High Density Cities." *Procedia Engineering* 169, (2016): 133-141.
[28] Audrey Tan. "Cooling Singapore Project Comes Up With 86 Ways to Help Island Beat The Heat." *The Straits Times*. 2018.
[29] Urban Redevelopment Authority, *Urban Design Plan for Sustainable Living in The Marina South Precinct,* 2013.

Figure 4. Singapore's design plan for the Marina South residential buildings[30].

With these strategies implemented, it appears that Singapore is definitely actively working towards mitigating UHI. The many initiatives underway in Singapore such as "Cooling Singapore" and "Singapore's Climate Action Plan" also exemplify this universal goal to prevent future warming. Yet, ultimately urban expansion will continue, thus Singapore will have to expand some of these strategies on a large scale.

Los Angeles and UHI

The Los Angeles County is home to 3.9 million people, and population estimates suggest that the county will have an additional 1.2–3.1 million residents by 2060.[31] Urbanization and widespread urban sprawl have exacerbated the heat island effect by depleting green cover. The extensively built-up and sparsely vegetated county already has the most intense UHI rating in California, and 5-10% of the current energy demand in Los Angeles goes towards cooling buildings to compensate for the UHI increase since 1940 (about 0.5-3°C).[32] In mid to high climate change scenarios (RCP 4.5 and 8.5), the baseline temperature of Los Angeles will increase by 1–4 °C (2–7 °F) in the region.[33] In addition to aggravating urban heat, changes to global climate could increase the number of extreme heat waves by 150%–840%.[34]

[30] Woo Boon. "Wind Corridors for Future Marina South Residents." *Today*, December 25th, 2013.
[31] Bruce C. Mitchell and Jayajit Chakraborty, "Landscapes of thermal inequity: disproportionate exposure to urban heat in the three largest US cities.". 2015
[32] Vahmani et al., "Investigating the climate impacts of urbanization and the potential for cool roofs to counter future climate change in Southern California", *Environmental Research Letters,* vol. 11, no. 12, pp. 124027. 2016
[33] Burillo et al., "Forecasting Peak Electricity Demand for Los Angeles Considering Higher Air Temperatures due to Climate Change." Applied Energy 236, (2019): 1.
[34] Stephanie Pincetl, Mikhail Chester, and David Eisenman. "Urban Heat Stress Vulnerability in the U.S. Southwest: The Role of Sociotechnical Systems." *Sustainability* 8, no. 9 (2016). doi:http://dx.doi.org/10.3390/su8090842. Page 842.

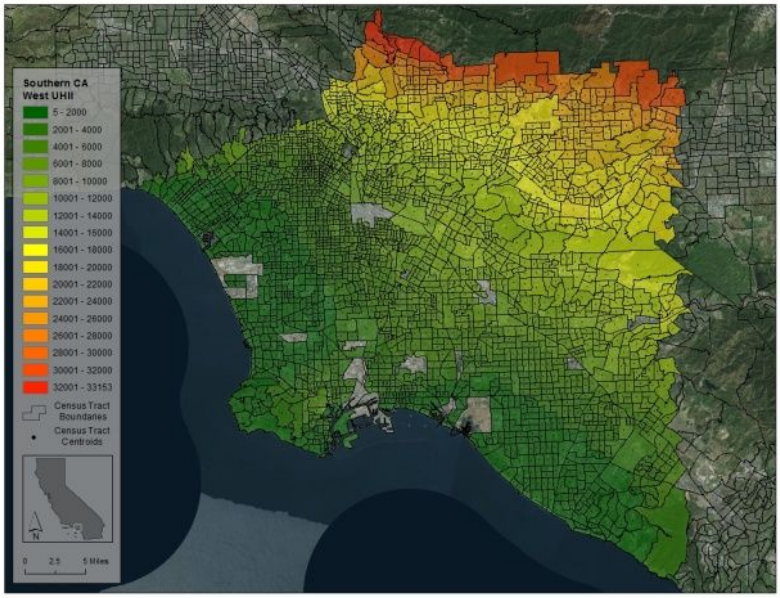


Figure 5. Urban Heat Island Temperatures in the Greater Los Angeles Area.[35]

As a warming and urbanizing city, Los Angeles is increasingly incorporating matters of livability, sustainability, energy, and climate adaptation into their urban plans. The impacts of urban form, building materials and nature-based solutions in the context of Los Angeles have been researched extensively.[3637] In 2016, L.A pursued a comprehensive route to addressing urban heat with the "Urban Heat Island Reduction Plan", an interdepartmental initiative which bakes UHI mitigation into their regional master planning process.[38] The UHI committee focused on four main strategy areas: expanding and maintaining the urban forest; promoting cool roofs, increasing urban green space, and promoting cool and permeable pavements.[39] Los Angeles was the first county in the United States to pass a cool roofs ordinance.[40] As the city offers subsidies and rebates for cool roofs, while levying a tax on roofs with low albedo,'cool roofs' are often cheaper than those made of traditional materials.[41]

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[35] California Environmental Protection Agency, "Urban Heat Island Index for California", (2019). Accessed April 1, 2019 at https://calepa.ca.gov/climate/urban-heat-island-index-for-california/

[36]Haider Taha et. al.,"Air-Temperature Response to Neighborhood-Scale Variations in Albedo and Canopy Cover in the Real World: Fine-Resolution Meteorological Modeling and Mobile Temperature Observations in the Los Angeles Climate Archipelago." *Climate* 6, no. 2 (2018): 53.

[37]Zhang et al., "Systematic Comparison of the Influence of Cool Wall Versus Cool Roof Adoption on Urban Climate in the Los Angeles Basin." *Environmental Science & Technology* 52, no. 19 (2018): 11188-11197.

[38]Governor's Office of Planning and Research California, "Los Angeles County Department of Public Health: Urban Heat Island Reduction Plan". 2016.

[39] Governor's Office of Planning and Research California, "Los Angeles County Department of Public Health: Urban Heat Island Reduction Plan", 2

[40]Ibid, 39

[41]Virginia Hewitt and Eric Mackres, "Cool Policies for Cool Cities: Best Practices for Mitigating Urban Heat Islands in North American Cities", American Council for an Energy-Efficient Economy, Global Cool Cities Alliance, 2014. Page 26.

Like Singapore, Los Angeles has pursued nature-based solutions to urban heat. In 2001, the city launched a free tree planting program called City Plants. In partnership with the Department of Water and Power, the program delivers free trees to the doorstep of any resident in partnership with several nonprofits. The program prioritizes planting in low canopy neighborhoods as a way to increase energy efficiency as well as thermal comfort.[42] To address the extensive greyscape of L.A., cool pavements have been tested as an alternative to mineralized surfaces in a number of neighbourhoods.[43] Results from the pilot programs indicated that on warm summer afternoons, coated areas were "10 degrees cooler than untreated black asphalt" across test sites.[44] The city is also considering the concept of using cool pavement coating on bike or pedestrian paths as it could improve surface smoothness for cyclists while reducing surface heat for pets.[45] While these initiatives offer a promising start, there are a number of issues that future planners will need to address.

What is the Current UHI Discussion Lacking?

Los Angeles and Singapore are implementing measures with colliding benefits at the city scale. However, to remain sustainable in the future these cities will also need to counter market-driven planning and issues of social inequality to create livable, vibrant, and sustainable urban environments.

Singapore

Singapore is doing a lot to mitigate the urban heat island effect as well as other climate change related issues. the prevalence of deforestation within Singapore counterproductive to these initiatives. There are policies in effect such as the Natural Reserves Ordinance and the Parks and Trees Act to protect these forested regions, but deforestation has continued on from as far back to the 1800's to present day[46]. This is concerning as only 3% of Singapore is forested[47].

Currently, in the Mandai region of Singapore, an eco-tourism hub has been proposed. It's expected to be completed in 2023 with a bird park, a rainforest park, and a resort to facilitate an immersive interaction with nature.[48] While this may seem like a great initiative, as it implies strengthening biodiversity, greenery and environmental education through Singapore, the park is not entirely environmentally sustainable. To make way for this resort, two large forests are being cleared[49]. Given that forests aid in reducing surface temperatures by acting as CO_2 sinks and reflecting sunlight, the proposal undermines UHI mitigation initiatives. In a similar vein, the

[42]City Plants LA, "Our Story" 2019
[43]Environmental Protection Agency, "Cool Fixes for Hot Cities Part 2: Los Angeles". 2018
[44]Environmental Protection Agency, "Cool Fixes for Hot Cities Part 2: Los Angeles", 6.
[45]Environmental Protection Agency, "Cool Fixes for Hot Cities Part 2: Los Angeles", 19
[46] Goh Kim,"When Tigers Used to Roam: Nature & Environment in Singapore." *Biblioasia.* 2018
[47] CIA World Factbook. Singapore. MongaBay.
[48] Agence France-Presse, "Singapore Wants to Build a Green Tourism Hub But Environmentalists Say The Plan Will Ruin Natural Habitats." *South China Morning Post,* 2019.
[49] BBC, "Singapore's Mandai Eco-Resort: Paving Paradise to Put Up An Eco-Resort." *BBC News,* 2018.

original forest town of Tengah has been planned to be deforested to make way for residential buildings[50].

Deforestation only serves to increase the urban heat island effect, as trees release CO_2 upon being logged. This results in a rise of greenhouse gases in the atmosphere compounds existing trends of global warming.[51] Furthermore, by removing forests Singapore is also increasing the intensity of UHI as these forests have a relatively high albedo to reflect incoming sunlight, deforestation diminishes this effect. Although Singapore has made considerable efforts to mitigate UHI, market-driven deforestation needs to be reconsidered given the various cooling services provided by forested areas. As planners continue to grapple with issues of land-use in Singapore, considering developments for housing or the desire to promote ecotourism, they will need to counter the market-driven developments by valuing the benefits provided by preserving the natural environment.

Los Angeles

While urban heat island effect is a public health issue, mitigating thermal stress is also a matter of social justice. In the 2014, the U.S. Department of Agriculture recommended that the Los Angeles County Regional Planning suggested that areas with greater population density were of "greater the priority for tree planting".[52] However, density alone is an insufficient metric when identifying areas for climate adaptation- density must be examined alongside socioeconomic data to identify and prioritize most socioeconomically vulnerable areas of the city for climate adaptation. Several studies in the U.S and abroad have revealed a link between lower socioeconomic status and greater exposure to heat stress.[53] A geographic survey of Urban Heat Island vulnerability in Los Angeles found that racial/ethnic and socioeconomic inequalities are positively linked to greater heat exposure.[54] Across the county, an unequal proportion of racial/ethnic minorities (Hispanics and Non Hispanic African Americans) as well as residents with disabilities were significantly and positively related to heat exposure. In the lower income neighborhoods of Los Angeles, there are fewer green spaces. Additionally, many buildings in these neighbourhoods are poorly insulated and often lack air conditioning, reducing thermal comfort for residents.[55] Such findings reinforce the need to integrate social data in analyses of risk for urban heat to ensure that UHI mitigation initiatives benefit populations with the lowest adaptive capacity.

As future planners work towards a 'climate just' city, it will be necessary to consider more factors than the biomass, albedo, and urban form of a region. Countering the socioeconomic

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[50] Cheryl Teh, "Parliament: Decisions to Clear Land and Forest Cover Not Taken Lightly Says Desmond Lee." *Straits Times,* 2019.
[51] Mitchell Vale, "Deforestation and Its Extreme Effect on Global Warming." *Scientific American*. 2015
[52] Nowak et al., "Assessing urban forest effects and values, Los Angeles' urban forest." Resour. Bull. NRS-47. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 30 p. 2011
[53]Christopher K. Uejio et. al., "Intra-Urban Societal Vulnerability to Extreme Heat: The Role of Heat Exposure and the Built Environment, Socioeconomics, and Neighborhood Stability." *Health and Place* 17, no. 2 (2011): 499.
[54]Ibid, 31
[55]Ibid, 34

inequalities of market-driven cities requires planners issues of environmental justice, ensuring that heat in the city is reduced, but that issues of thermal inequity are examined and addressed.

Conclusion

As more people move to cities to inhabit, it is of high concern to mitigate the effects of the “urban heat island” (UHI). To mitigate urban heat, future urban planners will need to respond to social inequalities created by the market as well as buffer development-oriented market forces. Singapore has made considerable efforts to mitigate UHI through many unique green elements such as vertical gardens, blue spaces, green roofs and walls, and immersive vegetation. However, market-driven deforestation needs to be reconsidered given the various cooling services provided by forested areas and preserve the natural environment. In Los Angeles, initiatives are being pushed towards a greener city by proposing nature-based solutions to combat the heat. Programs like City Plants, where they work with the Department of Water and Power, deliver free trees to residents to aid with cooling of pavement in the hot summers. It is important though to integrate social data in analyses of risk for urban heat to ensure that UHI mitigation initiatives benefit populations that experience more wealth inequality. Planners will have to adapt based on the urbanization and climatic variability projected for the future to ensure sustainability of these cities especially in regards to UHI.

Bibliography

Aflaki, Ardalan, Mahsan Mirnezhad, Ali Ghaffarianhoseini, Amirhosein Ghaffarianhoseini, Hossein Omrany, Zhi-Hua Wang, and Hashem Akbari. 2017. Urban heat island mitigation strategies: A state-of-the-art review on kuala lumpur, singapore and hong kong. Cities 62.

Araujo, Ricardo Vieira, Marcos Roberto Albertini, André Luis Costa-da-Silva, Lincoln Suesdek, Nathália Cristina Soares Franceschi, Nancy Marçal Bastos, Gizelda Katz et al. 2015. "São Paulo urban heat islands have a higher incidence of dengue than other urban areas." *The Brazilian Journal of Infectious Diseases* 19, no. 2

BBC. 2018. “Singapore’s Mandai Eco-Resort: Paving Paradise to Put Up An Eco-Resort.” *BBC News*

Boon, Woo. 2013. “Wind Corridors for Future Marina South Residents.” *Today*

Burillo, Daniel, Mikhail V. Chester, Stephanie Pincetl, Eric D. Fournier, and Janet Reyna. 2019 "Forecasting peak electricity demand for Los Angeles considering higher air temperatures due to climate change." *Applied energy 236*

California Environmental Protection Agency, ”Urban Heat Island Index for California”, (2019). Accessed April 1, 2019 at https://calepa.ca.gov/climate/urban-heat-island-index-for-california/

Campbell-Lendrum, Diarmid, and Carlos Corvalán. 2007. "Climate change and developing-country cities: implications for environmental health and equity." Journal of Urban Health 84, no. 1

Chow, Winston TL, and Matthias Roth. 2006. "Temporal dynamics of the urban heat island of Singapore." *International Journal of climatology* 26, no. 15

CIA World Factbook. Singapore. MongaBay.

City Plants LA. 2019. “Our Story”. Accessed April 05, 2019. https://www.cityplants.org/our-story/.

Department of Statistics. 1998. Yearbook of Statistics, Singapore. Department of Statistics: Singapore

Environmental Protection Agency. 2018. “Cool Fixes for Hot Cities Part 2: Los Angeles”

France-Presse, Agence. 2019. “Singapore Wants to Build a Green Tourism Hub But Environmentalists Say The Plan Will Ruin Natural Habitats.” *South China Morning Post*

Ghaffarianhoseini, Amirhosein, Umberto Berardi, Ali Ghaffarianhoseini, and Karam Al-Obaidi. 2019 "Analyzing the thermal comfort conditions of outdoor spaces in a university campus in Kuala Lumpur, Malaysia." *Science of The Total Environment*

Government of Canada. Climate Change and Health. 1. 2010, https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/climate-change-health/climate-change-health-adaptation-bulletin-number-1-november-2009-revised-december-2010-health-canada-2009.html

Governor's Office of Planning and Research California. 2016. “Los Angeles County Department of Public Health: Urban Heat Island Reduction Plan”.

Grozdanic, Lidija. 2013. “Park Royal Tower: WOHA’S Stunning Vertical Garden Tower Opens in Singapore.” *Inhabitat.*

Heaviside, Macintyre, and Sotiris Vardoulakis. 2017. “The Urban Heat Island: Implications for Health in a Changing Environment.” *Current Environment Health Report,* 4
Hewitt, Virginia and Eric Mackres. 2014. “Cool Policies for Cool Cities: Best Practices for Mitigating Urban Heat Islands in North American Cities”, American Council for an Energy-Efficient Economy, Global Cool Cities Alliance, page 26.

IPCC, 2018: Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, Maycock, M. Tignor, and T. Waterfield (eds.)]. World Meteorological Organization, Geneva, Switzerland, 32 pp.

Kim, Goh. 2018. “When Tigers Used to Roam: Nature & Environment in Singapore.” *Biblioasia.*

Li, Reuben and Matthias Roth. 2010. *Mapping the Urban Thermal Environment in Singapore using a GIS Framework*

Li, Xian-Xiang, and Leslie K. Norford. 2016. "Evaluation of cool roof and vegetations in mitigating urban heat island in a tropical city, Singapore." *Urban Climate* 16

Mitchell, Bruce C., and Jayajit Chakraborty. 2015. "Landscapes of thermal inequity: disproportionate exposure to urban heat in the three largest US cities." *Environmental Research Letters* 10, no. 11: 115005.

Mitchell, Bruce Coffyn and Jayajit Chakraborty. 2018. "Exploring the Relationship between Residential Segregation and Thermal Inequity in 20 U.S. Cities." *Local Environment* 23, no. 8

Mitchell, Bruce C., and Jayajit Chakraborty. 2015 "Landscapes of thermal inequity: disproportionate exposure to urban heat in the three largest US cities." *Environmental Research Letters* 10, no. 11

National Climate Change Secretariat. 2018 Impact of Climate Change on Singapore. Singapore. 2018

Nowak, David J.; Hoehn, Robert E. III; Crane, Daniel E.; Weller, Lorraine; Davila, Antonio. 2011. “Assessing urban forest effects and values, Los Angeles’ urban forest.” Resour. Bull. NRS-47. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 30 p.

Pearce, Fred. 2018. “Urban Heat: Can White Roofs Help Cool World’s Warming Cities?” *Yale Environment 360*

Pincetl, Stephanie, Mikhail Chester, and David Eisenman. 2016. "Urban Heat Stress Vulnerability in the U.S. Southwest: The Role of Sociotechnical Systems." *Sustainability* 8, no. 9. doi:http://dx.doi.org/10.3390/su8090842.

Roth, Matthias, and Winston TL Chow. 2012. "A historical review and assessment of urban heat island research in Singapore." *Singapore Journal of Tropical Geography* 33, no. 3

Santamouris, M. 2013. "Using cool pavements as a mitigation strategy to fight urban heat island—A review of the actual developments." *Renewable and Sustainable Energy Reviews* 26

Shell International BV. 2017. “Shell World Energy Model A View to 2100”.

Taha, Haider, Ronnen Levinson, Arash Mohegh, Haley Gilbert, George Ban-Weiss, and Sharon Chen. 2018 "Air-temperature response to neighborhood-scale variations in albedo and canopy cover in the real world: Fine-resolution meteorological modeling and mobile temperature observations in the Los Angeles climate archipelago." *Climate* 6, no. 2

Tan, Audrey. 2018 “Cooling Singapore Project Comes Up With 86 Ways to Help Island Beat The Heat.” *The Straits Times.*

Teh, Cheryl. 2019. “Parliament: Decisions to Clear Land and Forest Cover Not Taken Lightly Says Desmond Lee.” *Straits Times*

Uejio, Christopher K., Olga V. Wilhelmi, Jay S. Golden, David M. Mills, Sam P. Gulino, and Jason P. Samenow. 2011. "Intra-Urban Societal Vulnerability to Extreme Heat: The Role of Heat Exposure and the Built Environment, Socioeconomics, and Neighborhood Stability." *Health and Place* 17, no. 2

UN Habitat. 2016. World Cities Report 2016. UN Habitat.

Urban Redevelopment Authority. 2013. *Urban Design Plan for Sustainable Living in The Marina South Precinct*

Vahmani, P., F. Sun, A. Hall, and G. Ban-Weiss. "Investigating the climate impacts of urbanization and the potential for cool roofs to counter future climate change in Southern California." *Environmental Research Letters* 11, no. 12 (2016): 124027.

Vale, Mitchell. 2015. “Deforestation and Its Extreme Effect on Global Warming.” *Scientific American*.

Yen, Tan. 2018. “Biophilic Design Key to Making Singapore a City in a Garden.” *Today.*

Zhang, Jiachen, Arash Mohegh, Yun Li, Ronnen Levinson, and George Ban-Weiss. "Systematic Comparison of the Influence of Cool Wall versus Cool Roof Adoption on Urban Climate in the Los Angeles Basin." *Environmental science & technology* 52, no. 19 (2018): 11188-11197.

Zhu, Dan. 2016. "Study on Facade Openings Design Method Responding to Urban Ventilation Issue in High Density Cities." *Procedia Engineering 169*