Urban heat vulnerability assessment for guiding heat resilience strategies: A case study of Pattaya city, Thailand

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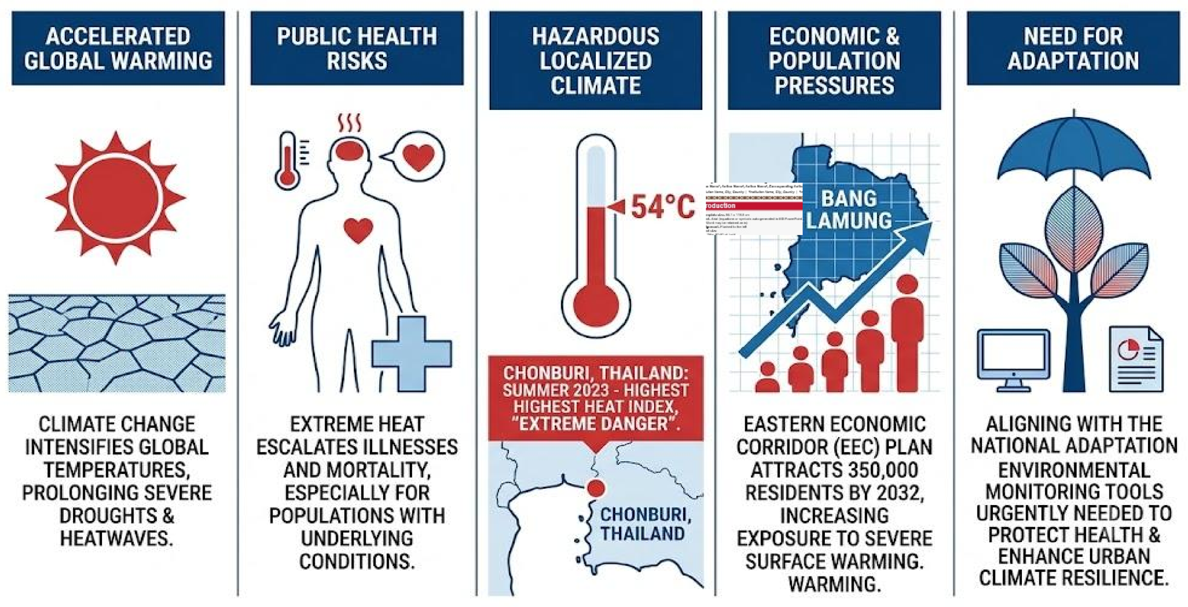
Introduction



Research Background

Accelerated Global Warming: Climate change has intensified global temperatures, prolonging severe droughts and heatwaves.

Public Health Risks: Extreme heat escalates illnesses and mortality, especially for populations with underlying conditions.

Hazardous Localized Climate: In summer 2023, Chonburi recorded Thailand's highest heat index, hitting an "extreme danger" level of 54°C.

Economic & Population Pressures: The Eastern Economic Corridor (EEC) plan will attract 350,000 residents to Bang Lamung by 2032, increasing population exposure to severe surface warming.

Need for Adaptation: Aligning with the National Adaptation Plan (NAP), environmental monitoring tools are urgently needed to protect health and enhance urban climate resilience.

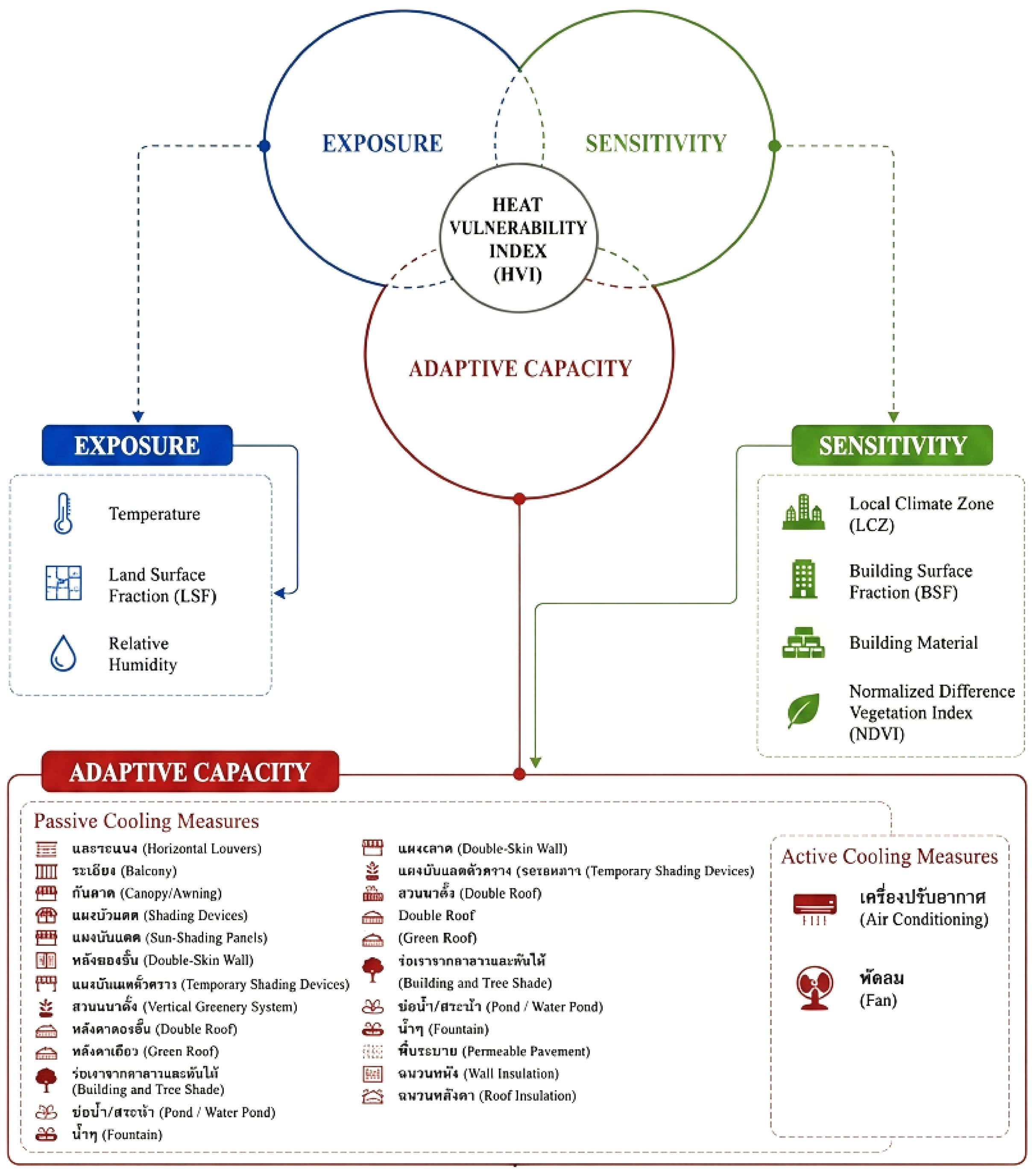
Research Objectives

Assess Urban heat vulnerability assessment e: Quantify heat vulnerability and its health impacts within a prominent regional hotspot.

Map Vulnerability: Utilize normalization and kriging interpolation to create spatial maps identifying subdistricts most vulnerable to heat.

Inform Policy & Early Warning: Provide evidence-based data to support early-warning systems and guide climate-informed planning.

Methodology



Study Sites / Area: Centered on Pattaya City, Thailand, the region's most densely populated area. It targets an urban environment highly vulnerable to heat due to rapid sprawl and dense built-up.

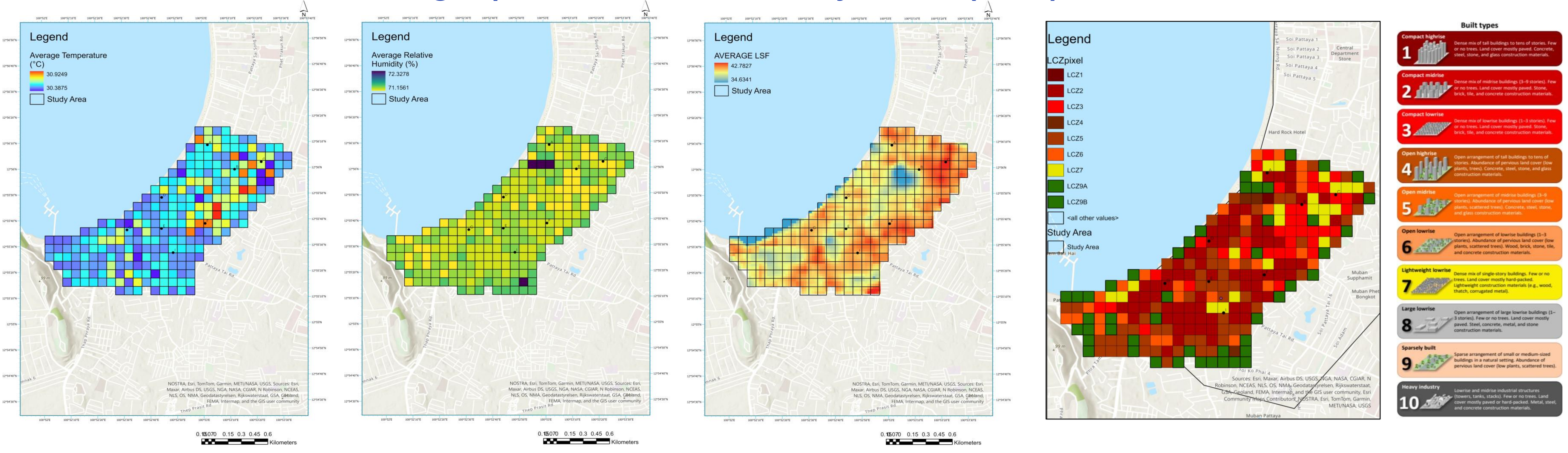
Sampling Strategy: Based on a localized field survey across a high-density urban landscape, evaluating climate risks and structural attributes using individual buildings as the primary unit of analysis.

Data Collection Tools: Exposure was captured via air temperature measurements and satellite land surface data. Sensitivity metrics (built footprints, green spaces) were extracted from satellite imagery, while adaptive capacity was assessed via observations of cooling elements.

Statistical / Modelling Approach: Applying the IPCC framework, the Heat Vulnerability Index (HVI) was developed using min–max normalized variables. It integrated exposure (temperature, LSF, humidity), sensitivity (LCZ, BSF, materials, NDVI), and adaptive capacity (shading, passive, and active cooling).

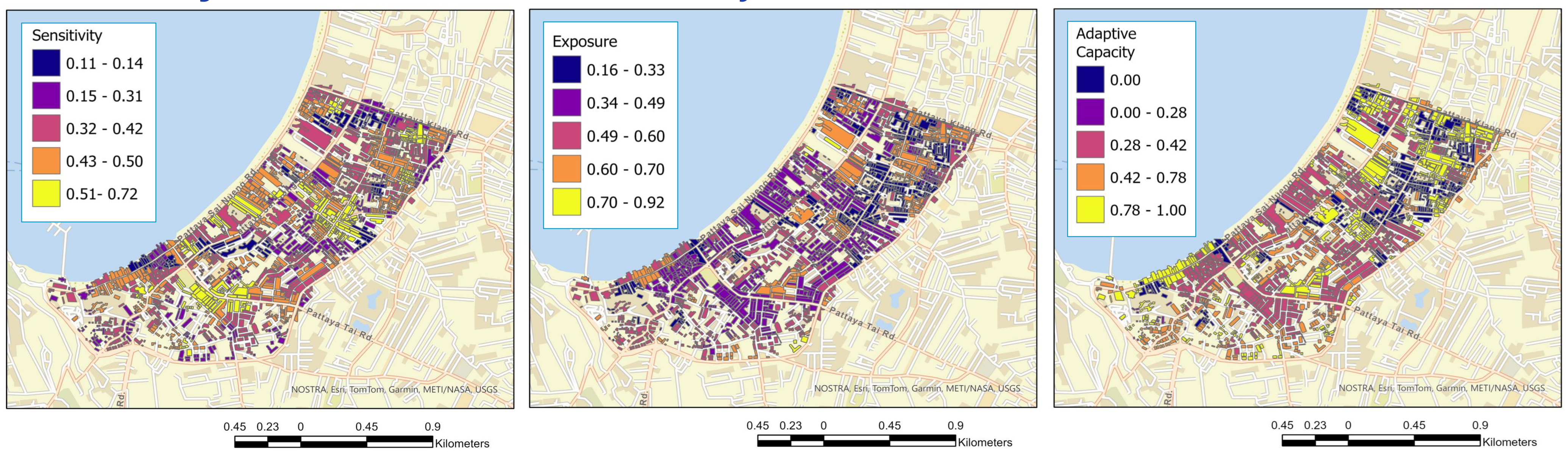
Results

Data collection: Geographic Information System (GIS) Data



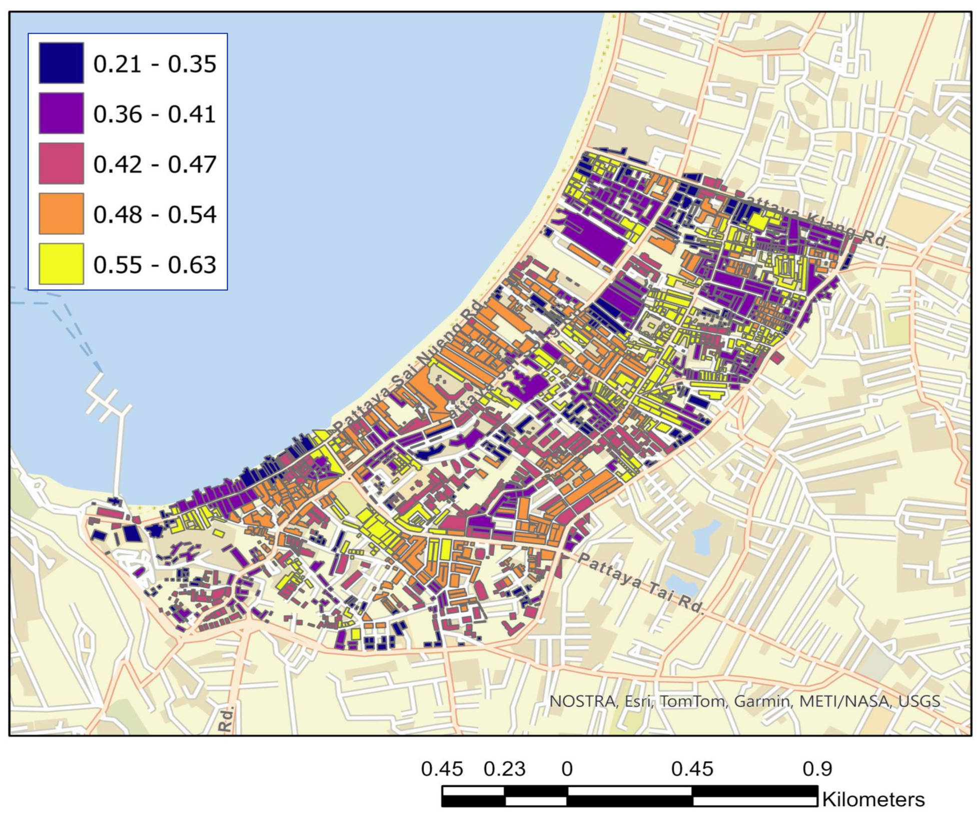
Air temperature | Relative humidity | Land surface temperature | Local climate zone (LCZ)

Data analysis: Urban heat vulnerability assessment



Sensitivity analysis | Exposure analysis | Adaptive capacity analysis

Results: Urban heat index



Key Findings

Vulnerability Hotspots: High heat vulnerability is in central commercial corridors and dense coastal areas, where high exposure and sensitivity intersect with low adaptive capacity.

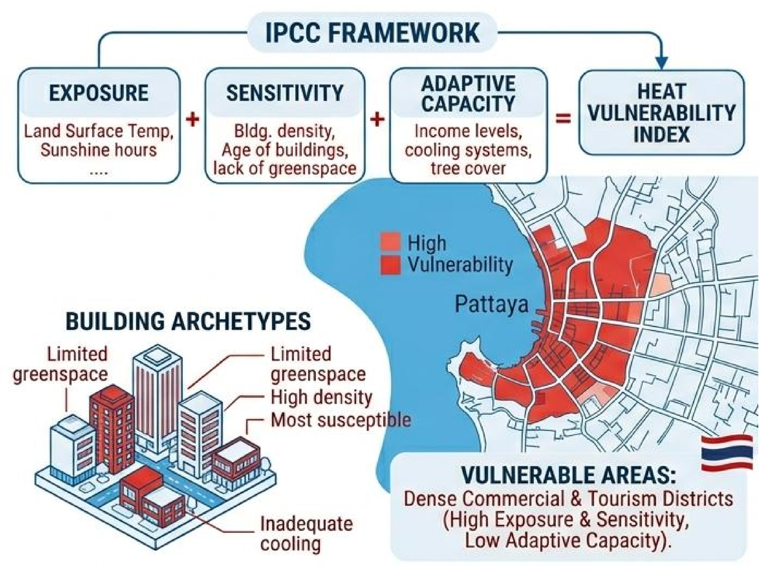
Exposure & Sensitivity Drivers: Extreme exposure occurs in highly urbanized zones. Sensitivity peaks in compact, built-up areas that feature minimal vegetation cover.

Adaptive Capacity: Resilience varies significantly across buildings. Higher capacity is driven by shading devices, passive cooling measures, and active cooling systems, while structures lacking these features remain susceptible.

Cooling Power of Greenery: Increased vegetation directly correlates with lower sensitivity levels, underscoring the role urban greening plays in mitigating localized heat risks.

Strategic Planning: To build resilience and support Thailand's National Adaptation Plan (NAP), municipal frameworks must prioritize building-level cooling, expanded urban greenery, and heat-responsive design strategies.

Conclusion



Key Conclusions

Areas with high heat vulnerability were primarily concentrated in dense commercial and tourism districts, where high levels of exposure and sensitivity coincided with relatively low adaptive capacity.

Buildings characterized by limited green space, high development density, and inadequate cooling measures were found to be susceptible to heat.

The findings emphasize the importance of urban greening, climate-responsive building design, and heat adaptation measures in enhancing urban resilience to heat-related impact, with implementation of Thailand's National Adaptation Plan (NAP) and the climate-resilient urban planning.

Policy Recommendations

National Alignment: Heat risk assessments must be integrated into municipal frameworks to support the strategic goals in Thailand's NAP.

Control Urban Sprawl: City planning agencies should enforce zoning regulations that curb unchecked urban sprawl, shifting toward climate-responsive geometric forms that prevent localized surface warming.

Climate-Informed Building Design: Future urban design guidelines must mandate the restructuring of building clusters and forms to actively integrate shading elements and structural cooling infrastructure.

Green Infrastructure: Local governments should prioritize greening policies that maximize the cooling potential of vegetation and greenspace placement.

Target Vulnerable Zones: Policy interventions should prioritize high-density urban areas that are identified as lacking sufficient cooling infrastructure.

Early-Warning Warning Systems: Evidence-based microclimate data should be leveraged by municipal planning agencies to build robust heat-health early-warning systems and community warning networks.

Reference

[1] Paddison L. (2023). *This month is the planet's hottest on record by far – and hottest in around 120,000 years, scientists say*. Retrieved 18 August 2023, from https://edition.cnn.com/2023/07/27/world/july-hottest-month-record-climate/index.html

[2] Herring, D. & Linsey, R. (2020). *How will global warming harm human health and well- being?*. Retrieved 18 August 2023, from https://www.climate.gov/news-features/climate-qa/how-will-global-warming-harm-human-health-and-well-being

[3] Shi, H., Xian, G., Auch, R., Gallo, K., & Zhou, Q. (2021). Urban Heat Island and Its Regional Impacts Using Remotely Sensed Thermal Data—A Review of Recent Developments and Methodology. *Land, 10*(8), 867. doi:10.3390/land10080867

[4] Philipp, C H. Chow, W.T.L. (2020) Urban Heat Vulnerability Analysis for Singapore D 2.4 – Vulnerability Map. doi:10.3929/ethz-b-000419689

[5] Soytong, P., Janchidfa, K., Phengphit, N., & Chayhard, S. (2018). Monitoring urban heat island in the Eastern region of Thailand and its mitigating through greening city and urban agriculture. *International Journal of Agricultural Technology, 13*(7.2), 1737-1760. Retrieved from http://www.ijat-aatsea.com

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