論　文　の　要　旨

題　目　Guidelines for Urban Land Use Planning in the Central Business District of Bangkok from the viewpoint of Urban Heat Island Mitigation
(バンコク CBD における都市ヒートアイランド緩和のための土地利用計画ガイドラインに関する研究)

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Urban Heat Islands (UHIs), characterized by elevated temperatures in densely built areas, pose significant challenges to local climates, particularly in sprawling cities like Bangkok. This study investigates the UHI phenomenon in Bangkok using a two-scale approach: mesoscale (regional and provincial) and microscale (urban district). By integrating field observations, numerical models, and empirical generalizations synthesized from developed urban environmental climate maps (UECMs), this research aims to enhance urban planning by translating complex urban climate phenomena into spatial data, ultimately informing effective policy decisions. While previous research primarily focused on developed countries with temperate climates, this study addresses the gap in tropical Southeast Asia. It examines Bangkok, a megacity facing rapid urbanization, severe UHI effects, lack of urban climate study, situated in a unique plain basin with extensive water networks. Utilizing Thai government observation climate data and clarified spatial data, the study investigated the relationship between spatial variables and urban climate. Further, numerical models were employed to overcome resource limitations and analyze urban ventilation, air temperature, regional climate, and land use. This comprehensive approach aims to inform urban land-use planning and guide policymakers in addressing Bangkok's specific climatic challenges.

Three main objectives guided this research: 1) Apply diverse methodologies and scales of urban climate study to understand urban climate in tropical countries. 2) Clarify the relationship between Bangkok's climate and influencing spatial variables from a UHI mitigation perspective at two urban scales. 3) Identify critical areas affected by the UHI phenomenon at both scales. The study focused on supporting BMA land-use policies at both mesoscale (regional and provincial) and microscale (Central Business Districts, CBDs).

At the mesoscale level, the study extended its scope to the Bangkok Metropolitan Region (BMR) and employed two urban climate methodologies. Firstly, field observations incorporated 2019 climate data from 68 stations along with spatial variables (land cover, distance to coastline, distance to rivers/canals) to analyze the relationship between climate data and its spatial distribution. This revealed correlations between nocturnal air temperature fluctuations and green cover, diurnal variations impacted by distance to coastline, and significant influence of both distance and building coverage on summer wind speed. Consequently, a BMR UECM was constructed based on these three variables, identifying nine distinct zones with critical areas requiring intervention, particularly in central BMA. Secondly, numerical calculations and cluster analysis using Weather Research and Forecasting (WRF) models revealed spatiotemporal temperature and wind speed patterns, dividing BMA into six temperature and six ventilation zones. UECMs of BMA were developed based on these zonal maps and overlaid with high-density building coverage. While both mesoscale climate findings highlighted critical areas, comparing them emphasized the limitations of relying solely on one method in data-scarce environments. Although observation data offers real-world information, its scarcity can lead to inaccuracies. Notably, high-density

coastal areas with strong sea breezes exhibited poor ventilation, underlining the need for diverse data sources. Conversely, inland areas with open spaces displayed potential for high wind speeds, highlighting the influence of local topography.

Microscale Analysis of CBDs, the study investigated ventilation and temperature characteristics of two Bangkok CBDs (Yaowarat and Ratchadamri) using 2022 field measurements, spatial analysis, and computational fluid dynamics (CFD) simulations. The focus was on key factors influencing urban ventilation, particularly wind speed and open space ratio within a 100-meter radius. Comparative analysis revealed distinct ventilation characteristics between the areas due to their unique topography. However, both demonstrated suboptimal ventilation, requiring improvements in wind velocity. Microclimate analysis and UECM development for the Ratchadamri area, based on field measurements, numerical models, and correlation analysis, identified areas with high building coverage and limited greenery as critical for high temperatures (wet bulbed globe temperature) and low wind speed. These variables were used to create a district-scale UECM, dividing the area into six distinct zones based on thermal environment, ventilation, and urban characteristics. Notably, Zone 6 represented a critical area with the highest temperature and lowest wind speed.

The study's findings led to the development of design proposals for mitigating the UHI phenomenon. At the regional scale, a master plan for creating "The Urban Ventilation Corridor in the BMR" – a continuous open space running north-south through collaboration with four provinces – could improve ventilation and mitigate UHIs. Additionally, utilizing the existing water network as an urban humid ventilation corridor was proposed. At the district scale, adapting vernacular architectural characteristics to create horizontal open public spaces and connecting them with existing open areas could improve airflow and mitigate heat and air pollution. Additionally, shaded open spaces adapted to tropical activities and livelihoods were proposed.

This study demonstrates a novel approach to urban climate analysis by integrating diverse methodologies and scales. Applied to a tropical metropolis like Bangkok, it offers valuable insights for shaping governmental policies and urban planning across the BMA at various scales. Moreover, it underscores the critical role of urban climatology in Thailand, fostering stakeholder awareness and highlighting the synergy between field measurements and numerical modeling to inform evidence-based urban planning decisions. Notably, further community engagement through workshops could refine the developed Urban Environmental Climate Maps (UECMs) at both scales, ensuring long-term viability and alignment with local needs. Additionally, expanding the research methods beyond the specific context of summer climate analysis towards encompassing broader environmental issues and seasonal variations holds promise for future investigations.