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学位論文の要旨（論文の内容の要旨）
Summary of the Dissertation (Summary of Dissertation Contents)

論　文　題　目
Dissertation title

Urban Climate Challenges in Growing Cities of Southeast Asia: Urban Heat Island and Global Warming

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The main objective of this study is to investigate the impact of urban warming on the future challenges of the urban climates in the growing cities of Southeast Asia. Currently, the small- and medium-sized cities in Southeast Asia have been growing rapidly, and they plan to increase their population further. The growing cities of Southeast Asia are expected to encounter particular problems related to urban climate in the future, which is attributed to the urban heat islands (UHIs) and global warming effects.

The literature review is presented in Chapter 2. The review revealed that very few studies on UHI were conducted in the developing countries to project the urban climates after the implementation of the master plans. Moreover, studies have not been conducted in growing cities to project the effect of global warming on the urban climates under the future master plans via direct dynamical downscaling with an RCM. The review also shows that UHI mitigation measures have been widely studied and developed. Nevertheless, given the fact that the anthropogenic heat emissions have an important role in deteriorating or ameliorating the urban climates, few works were carried out to investigate the impacts of the future possible changes in the anthropogenic heat emission derived from plausible scenarios on mitigating the UHIs.

Chapter 3 discusses the methodology used in this study. A numerical simulation model, Weather Research and Forecasting (WRF), was mainly used for urban climate simulations while a building simulation program, TRNSYS, was used to investigate the impacts of the warmed urban temperature on thermal comfort and cooling load in buildings.

Chapter 4 investigates the impact of land use changes on urban climates. Two case study cities were selected, which are Hanoi City in Vietnam and Johor Bahru City in Malaysia. The urban climate simulation was conducted under two land use conditions, i.e. current condition and master plan condition for each case study, respectively. The results of numerical simulations show that the daytime peak air temperature is projected to remain at almost the same level as the current condition even after the implementation of the master plan in Hanoi and JB, respectively. Nevertheless, the high air temperature areas would expand widely over the planned built-up areas.

Chapter 5 takes into account the future weather conditions of the 2030s in Hanoi into the numerical simulation. The future weather data were produced via direct dynamical downscaling with WRF under RCP4.5 and RCP8.5 scenarios. The simulation results with global warming effects show that the urban air temperature is expected to increase along with global warming. The global warming effect contributes, at most, 71% of the temperature increase in existing urban areas of Hanoi City in the 2030s. The increase in air temperature for the near future (i.e. the 2030s) will likely offset the cooling effects from any UHI mitigation measures. The development of UHI mitigation measures must take into account the influence of future global warming, even for the short-term future such as by 2030.

Chapter 6 investigates the cooling effect of the proposed green spaces in the Hanoi Master Plan 2030. In addition to the proposed green spaces, three new configurations of green spaces were proposed, and the resulting impacts on the reduction of air temperature were analyzed. Further, the additional urban greening to achieve more distributed green space by increasing the green coverage ratio (GCR) was also assessed. The result shows that the proposed green spaces are not necessarily effective to cool the entire urban areas. On the other hand, when the same amount of the proposed green spaces were distributed equally in the city, this strategy resulted in a reduction of urban air temperature, especially at night. The increased GCR results in the reduction of the number of hotspots with peak air temperature, particularly in new urban areas throughout the day.

Chapter 7 discusses the impact of the Low Carbon Society (LCS) Blueprint on the reduction of air temperature in Johor Bahru City. It is found that the added sensible heat from anthropogenic activities to the urban environment largely increases the air temperature at night. A significant reduction of urban air temperature under the master plan condition was achievable when the anthropogenic emission scenario of the LCS blueprint was implemented. The estimated reduction in air temperature under the LCS scenario was up to 0.84°C if compared to the Business as Usual (BaU) scenario.

Chapter 8 investigates the impact of the warmed urban temperature on the indoor thermal comfort and cooling load in a residential building in Hanoi. Six energy saving techniques (i.e. cool roof, roof insulation, external insulation, internal insulation, external shading, and window glazing) and natural ventilation techniques (i.e. full day, night-time, and daytime ventilations) were assessed by using TRNSYS and the resulting impacts on the indoor thermal comfort on the thermal comfort and cooling load were analyzed. The results show that among the energy-saving techniques considered in this study, the improvement of the glazing for windows and insulation layers were the most influential techniques to reduce the cooling load under the future weather conditions in the 2030s.

Chapter 9 provides the recommendations to counter the impact of urban warming for the growing cities of Southeast Asia. Considering that the 71% of the increased temperature in the future is attributed to the global warming, we suggest that the growing cities of Southeast Asia should take a serious consideration to the global warming mitigation measures. The key concept of mitigating urban warming is to reduce the sensible heat as much as possible, while also trying to maintain or increase the transformed energy into the latent heat. One of the effective measures is the countermeasures through the reduction in the anthropogenic heat emissions. This strategy has co-benefits. First, the reductions in anthropogenic heat emissions contributed to the reduction of GHG emissions to the atmosphere. Second, the emission reduction also benefits the local climate, such as in the reduction of the air temperature at night.

Finally, Chapter 10 summarizes the main findings of this study and recommends areas for the future studies based on the limitations and findings of this thesis.