기본연구보고서 2022-7

폭염대응을 위한 도시 가로녹지계획 연구

Green Street Strategy on Urban Heat Wave

김영지 Kim, Youngji
박유나 Park, Yuna
오성훈 Oh, Sunghoon

Summary

Kim, Youngji
Park, Yuna
Oh, Sunghoon

Chapter 1 Introduction

Due to climate change, heat waves have been witnessed repeatedly in recent years. As this trend is likely to intensify in the future, it is urgent to prepare city policies to respond to heat waves. Prevalent heat waves threaten urban residents' health and reduce their daily activities, which may develop a vicious cycle that further increases urban energy consumption and aggravates climate change. Therefore, a pleasant microclimate environment is critical to facilitate walking and outdoor activities and create a virtuous cycle by reducing the use of passenger cars and building energy to devise a sustainable city that responds to the climate crisis. In this context, spatial response plans are needed.

In street spaces experienced by citizens in their everyday lives, green streets can offer a solution to alleviate the heat stress of users. Although green streets should be considered significant to mitigate heat waves in the street space, the current green street plan under development primarily focuses on the physical conditions, such as the width of the road for installing green streets. In order to adapt to the foreseen climate crisis in the future, it is necessary to analyze street thermal environment and, based on this, establish a green street plan for heat mitigation of the street spaces.

This study aims to prepare a green street planning strategy considering green street's urban temperature reduction function and contribute to efficiently alleviating urban

heat stress. To this end, it intends to prepare the basis for a more efficient plan by deriving the surrounding factors that affect the street thermal environment. In addition, this study analyzes the limitations of the current green street planning system and derives the institutional basis for the green streets plan by examining related policy cases and the perception survey on pedestrians, which is the primary purpose of responding to heat waves in order to propose green street policy alternatives to respond to heat waves.

Chapter 2 Current Legal Systems and Plans Related to Green Streets in Korea

This study seeks to present a green streets plan from a heat wave response perspective and provide an institutional basis for efficiently realizing such a green streets plan. Accordingly, this chapter reviews laws and systems related to green streets and examines the planning system for trees most closely related to street space. The major laws and systems related to green streets include the 「Creation And Management Of Urban Forest Act」 for street trees (green area belts), 「Act On Urban Parks And Green Area s」 for facility green areas, 「Building」 for landscaping and public notice Act", which succeeding decrees and rules shall be discussed together with local municipal ordinances. Also, for street tree planning systems, the detailed master plans for Seoul, Daegu, Ulsan, and Songpa-gu, Seoul, built autonomously for street trees, were analyzed in depth together with 43 cases of Municipal Ordinance on the Creation and Management of Street Trees and 160 cases of Municipal Ordinance on Creation and Management of Urban Forests, etc.

Examining green street-related laws and legal plans showed that the current green streets plan is being established to create a green network and improve the city's aesthetics. Although the 「Urban Forest Act」, which stipulates street trees (green area belts) among green streets, specifies the purpose of heat wave mitigation, the master plan accordingly shows that green streets are planned as an ecological network connecting urban forests.

In addition, as a result of examining the details of the green streets plan, the

consideration of the integrated context of the street space in the green streets plan was insufficient. Legal facilities of green streets, such as green area belts, facility green spaces, open spaces, and landscaping on the site, are not integrated into the planning, creation, and management stages. Also, no linkage was hardly found with various physical elements constituting the street space. In most cases, only minimal physical conditions, such as the width of sidewalks for installing green streets, are being considered. Even more refined cases merely present plans dividing residential and commercial areas. These results revealed that the physical environment constituting the street and making a difference in the street thermal environment had not been taken into account and suggest that it is necessary to consider the context of these street spaces in an integrated way to create a more pleasant and cooler street space.

As a result of examining the criteria for planting areas, planting locations, and layouts of green streets, it was difficult to find specific construction and management standards considering the temperature reduction function of green streets. Among the main facilities of green streets, only comprehensive standards were presented for facility green spaces, open spaces, and landscaping. Concerning street trees, more specific regulations are provided. Still, most suggest planting sizes based on the width of the sidewalk. Only the standards at the time of planting are presented, indicating that the management target standards are insufficient. In addition, in the planning and management stage of green streets, emphasis is placed on growth and efficient management rather than the function of reducing the temperature of green streets. Therefore, when establishing a green streets plan to respond to heat waves, it is necessary to specify a specific layout strategy, growth target, and shade size to increase the heat reduction effect.

Chapter 3 Analysis of the Impact of Green Streets on the Urban Thermal Environment

This chapter constructed variables by reviewing precedent studies and examined the influence relationship between each variable and the street surface temperature through correlation analysis and multiple regression analysis to understand the factors affecting

the thermal environment of street space. To this end, this study performed the preceding work to build temperature data suitable for the microscopic spatial scale and constructed variables using location point data of street trees as an analysis unit to examine the influence relationship based on the standard and arrangement of street trees, rather than the mere presence of street trees. Each variable was analyzed by dividing it into spatial and green street characteristics. In addition, by synthesizing factors affecting the thermal environment, focusing on the areas derived as hot spots as a result of thermal environment analysis, street types were classified, and the actual conditions of each street type were investigated. Temperature data was collected to intuitively see the impact of green streets on pedestrians' thermal comfort, and then statistical analysis results were verified.

The analysis result confirmed the difference in the thermal environment depending on the built environment characteristics constituting the street. The surface temperature and building height had a negative (−) correlation, and the road width had a positive (+) correlation, which showed that the higher the building height and the narrower the road width, the lower the temperature. In addition, the street thermal environment varies according to the use of the surrounding buildings. The average temperature was higher when the surrounding streets were densely populated with industrial facilities, single−family houses, or low−rise residential areas such as multi−family and row houses. The average temperature distribution varied according to the direction of the road; the temperature value was highest when the road direction was east−west, which suggests that it is appropriate to adopt different strategies for each road direction when planning green streets in the future.

In addition, according to the results of correlation analysis on green streets and street thermal environments, the measurements and planting intervals of currently established street trees were ineffective for the optimal temperature reduction effect. As a result of the correlation analysis between the ratio of the crow width to the height of street trees and the surface temperature, a negative (−) correlation was evident when the ratio was about 0.6 or more. This result suggests that the crown width needs to maintain above a certain level to maximize the temperature reduction effect of street trees. Also, as a result of examining the ratio of planting interval to crown width of street trees, the temperature value was the lowest when the ratio was around 1.1. This result suggests that the current crown width of street trees should be increased or the planting interval

should be narrowed, considering that the current ratios of planting interval to crown width are distributed at 1.5 to 2 on average.

In addition, as a result of measuring the surface temperature of pedestrians using a thermal imaging camera, the presence of shade directly affected the thermal stress of pedestrians. In particular, green spaces other than street trees, such as green streets, parks, and apartment landscaping facilities, provided continuous shade and further reduced heat stress on pedestrians. In addition, the surrounding on-street parking space generated radiant heat from the vehicles, raising the ambient temperature. As a result, various green street facilities should be designed in connection with surrounding facilities, such as parks, to alleviate street space heat more effectively, and the establishment of green street plans should consider street usage behavior.

Chapter 4 Analysis of Perceptions for Improvement of Green Streets from the Perspective of Response to Heat

This study collected the opinions of 1,000 ordinary people about the benefits of green streets and the direction of improvement of green streets in the future through a pedestrian perception survey on green streets. The survey items of this study mainly comprise the current status of green streets, the perception of the necessity of green streets, the perception of the future improvement direction of green streets, and the characteristics of the respondents. The survey subjects were selected through regional and gender allocation and were conducted mainly in metropolitan cities and Gyeonggi-do, where relatively similar urban environments were distributed.

As a result of perception analysis, citizens selected shade as the most important among the different functions of green streets. As the main reason for the need for green streets in everyday life, 60.1% of respondents chose the availability of shades, suggesting that shades are considered essential regardless of the surrounding environment. In addition, for reasons of selecting necessary items for the improvement of green streets, 25.6% of

the respondents chose "Temperature can be lowered in hot weather," which was ranked second. Furthermore, 82.8% of respondents were willing to pay taxes to improve green streets. Thus, people desire temperature reduction by providing shades as the top priority among the various functions of green streets and are favorable in paying taxes for improving the green streets.

Recognition of these green streets showed different results depending on the type of residence; in particular, there was a difference in satisfaction with green streets. For respondents living in high-rise building clusters, the percentage of positive responses to the satisfaction or sufficiency of green streets was 53.3% and 51.3%, respectively, significantly different from 39.3% and 32.7%, the counterpart figures for residents of low-rise building clusters. This result suggests that it is necessary to consider the characteristics of the surrounding built environment when establishing a green streets plan in the future and particularly focus on low-rise building clusters when improving green streets.

54.0% of respondents who are reasonably satisfied with green streets still expressed that green streets should be improved, which was more than the majority. Also, respondents expected that if green streets were improved, their average walking time would increase by 12.2 minutes from 25.7 to 37.9 minutes, which indicates that improvement of green streets can induce an increase in walking or outdoor activities. In addition, dense green streets were considered more important than the number of wide lanes regardless of the residential area. This result suggests that future green street plans should be linked with street improvement projects such as road diet to expand green streets.

Chapter 5 Urban Green Street Plans and Policy Alternatives for Response to Heat Waves

This study attempts to find optimal strategies to reduce street heat by maximizing the temperature reduction of green streets and ultimately to formulate policy alternatives to create a city that responds to heat waves. Thus, it analyzed the legal system and plans for green streets, factors affecting the street thermal environment, and the perception of

green streets from the viewpoint of responding to heat waves throughout Chapters 2, 3, and 4. The analysis summarizes the issues related to the current green street plans into six categories: 1) Quantity-oriented green street planning; 2) Current management standards biased to management efficiency rather than policy goals; 3) Lack of consideration for the temperature reduction function of green streets; 4) Lack of linkage between different types of green spaces; 5) Green streets plan from a supplier's point of view without consideration of usage behavior; 6) Approaches lacking an integrated context of the entire street space. In addition, this study presents the following three green street planning strategies to cope with heat waves based on the issues related to the current green street planning: Form-based Strategy, Contextual Strategy, and Tree Shape-based Strategy.

First, the Form-based Strategy suggests green street planning for each street type according to the built environment constituting the street space by breaking away from existing practices of planning based on the width of sidewalks and managing the average value for each road route and leading to the need for more strategic planning for green streets. This study proposes a method to classify street types according to the road direction and building height based on the results above. Second, the Contextual Strategy implies that green street plans should be established by comprehensively considering various elements of street space, green streets, and street usage behaviors, which are recognized in an integrated way from the user's point of view. Lastly, the Tree Shape-based Strategy signifies that a target shape that can maximize the temperature reduction function of green streets should be assumed together with determining mid-to-long-term management goals. Based on these strategies, the temperature reduction impact of the green streets strategy was simulated for the streets of Uijeongbu City, the study site. As a result, PET (physiological equivalent temperature), the human thermal environment index, significantly decreased, confirming the strategy's effectiveness.

Various policy alternatives were presented to the green streets planning strategy: 1) Preparation of street type-specific plans and management systems from heat wave response perspectives; 2) System establishment for creating linkages with green areas that affect the street thermal environment; 3) Determination of mid-to-long-term management goals considering heat wave responses; 4) Implementation of pilot projects to establish heat wave response strategies in units of streets.

First, concerning the "1) Preparation of street type-specific plans and management systems from heat wave response perspectives," the phrase, "Response to the climate crisis," needs to be specified in the purpose of green streets-related laws. Accordingly, corresponding amendments to related laws have been proposed. In addition, green street planning suitable for thermal environments was promoted by including the analysis of the heat wave vulnerable space in the unit of streets as a survey item.

In "2) System establishment for creating linkages with green areas that affect the street thermal environment", the necessity of establishing an integrated plan incorporating all green streets, such as facility green spaces, nearby landscaping, and public spaces, was suggested, evolving from the existing green streets plan centered on street trees. In addition, it was clarified that conditions should be formulated for creating vibrant green streets through street space reorganization. To this end, it was proposed to establish an anti-heat governance system enabling various stakeholders, such as relevant departments of local governments, experts, and citizens, to assemble alternatives at the spatial level beyond individual departments.

In "3) Determination of mid-to-long-term management goals considering heat wave responses", management goals such as target shape and temperature reduction rate were determined considering the temperature reduction function of green streets. Then, a diagnosis system was suggested based on these goals. Accordingly, a platform was proposed to construct an information system on individual trees and link this information with the existing GIS information system related to urban planning, advancing from the current street tree management system for each road route.

Lastly, in "4) Implementation of pilot projects to establish heat wave response strategies in units of streets", an integrated improvement and pilot projects seem necessary for a series of spaces such as sidewalks, roads, and planting and surrounding areas around green streets due to limitations of attaining urban heat mitigation only with green streets. In this process, along with creating green streets, the feasibility of applying various factors such as space width, pavement method, improvement of street facilities, heat wave reduction facilities, and introduction of low-impact development techniques was suggested.

Keywords
heat mitigation, green street plan, street thermal environment, climate change adaptation