Abstract

This report examines the thinking regarding the urban environmental infrastructure for measures against the heat island phenomenon. The heat island phenomenon is an environmental issue specific to urban areas caused by the process of urbanization over time. In March 2004, an outline of heat island measures was proposed. As one of the pillars of heat island measures, the outline proposed improvement of urban structures, such as securing a path for wind to pass above green areas and water. In implementing measures to counteract the heat island phenomenon on a citywide scale, it is necessary to improve and enhance the infrastructure for the urban environment, such as green space, water, and wind pathways, with careful planning. In this survey, “urban environmental infrastructure” was recognized as the foundation of the city that will contribute to alleviation of the heat island phenomenon. The definition of “urban environmental infrastructure” was examined.

Key words: urban environmental infrastructure, heat island phenomenon, environmental policy, acceptable environmental capacity

1. Research outline

The heat island phenomenon is an important environmental issue specific to urban areas caused by the process of urbanization. The Japanese Government’s Ministry of the Environment considers this phenomenon to be a form of heat air pollution, and is developing measures to address this issue. With the implementation of the Three-Year Program for Promoting Regulatory Reform (Further Revised), which received government approval in March 2004, the various ministries related to heat island measures have established liaison conferences, and an outline of measures for addressing the heat island phenomenon was proposed in March 2004. Improvement of urban structures, such as securing a path for wind to pass above green areas and water, was proposed as a major measure to deal with this issue. In implementing measures to counteract the heat island phenomenon on a citywide scale, it is necessary to improve and enhance the infrastructure for the urban environment (hereafter, “urban environmental infrastructure”), such as green spaces, water, and wind pathways. This requires careful planning, and therefore detailed investigations are required. The urban environmental infrastructure is the foundation of the city that will make a major contribution to alleviation of the heat island phenomenon. A survey was performed to determine the types of development and improvements should be made to the urban environmental infrastructure in future to address this issue on a metropolitan scale.

Trends in heat island-related measures

December 2001: Urban regeneration project “Regeneration of urban environmental infrastructure in a large city area.”
This measure aims to construct a network of waterways and green spaces by maintaining, creating, and regenerating the natural environment and restoring ecosystems to reduce the heat island phenomenon and expand places where people can come into contact with nature.

January 2002: “Fundamental plan for the environment of Tokyo.”
This measure involves implementation of measures at the city level, those for covering city blocks and buildings, and those to suppress artificial heat emissions to address the heat island phenomenon.

March 2004: As part of the urban regeneration project, “Ground design for infrastructure for the urban environment in the Tokyo Metropolitan Area” was established at a conference attended by relevant government ministries and agencies as well as prefectures and cities.


December 2004: “Urban regeneration project (Phase 8).”
A wide variety of efforts to be a “sustainable city” are being strongly promoted during restructuring of large-scale land use, such as an area to be developed urgently for city regeneration. Model case type efforts are being actively promoted and supported.

April 2006: “Phase three fundamental environment plan.”
To improve the air quality in cities, a number of initiatives are being actively promoted from the viewpoint of space utilization and relationships with waterways and green spaces within the cities themselves to reduce the environmental load.
2. Definition of urban environmental infrastructure and consideration of its implementation

In our search, urban environmental infrastructure was defined as "facilities and spaces that have functions to improve environmental properties, and that are developed, improved, and maintained to contribute to improvement of the environmental property (standard) in the area by sufficiently utilizing area (district)-specific environmental elements and environmental elements of each facility/space." Here, the term "environmental elements" refers to elements that may affect natural ecosystems, air quality, water quality, etc.

3. Examining the concept of urban environmental infrastructure as part of the heat island measures

Here, we discuss recent progress in measures to alleviate the heat island effect as circumstances around the urban environmental infrastructure. Ground design of the urban environmental infrastructure in the area around Tokyo (March 2004 Conference on Overall Check of the Natural Environment (hereafter, "ground design")), the aim of which was to promote urban regeneration utilizing multiple aspects of the natural environment by maintaining large pockets of natural space around Tokyo, as well as to form water and green networks, describes the environmental infrastructure involved in these measures. According to ground design, the urban environmental infrastructure is "the natural and artificial foundation of a city that contributes to improving the urban environment to improve quality of life (QOL) through maintaining and restoring a sustainable ecosystem in large cities from a large-scale perspective, providing a place for people to come into contact with nature, and reduce the heat island phenomenon." Concept of ground design are as follows.

Concept of ground design
Functions of the natural environment (water and greenery)
1) Function to provide a place for maintaining species diversity
2) Function to provide a place for interaction between people and nature
3) Function to provide pleasant scenery and view
4) Function to adjust the urban environmental load
   4-1 Purification of water sources
   4-2 Function to prevent global warming
   4-3 Reduction of heat island phenomenon
   4-3-1 Improving airflow in cities
   4-3-2 Creating cool spots
   4-4 Function to relieve organic waste
5) Function to prevent disasters

The ground design process considers the desired features of waterways and green networks, focusing on the subsequent effects of such developments. However, as there is insufficient knowledge regarding this topic as a heat island measure, the specific future outlook of waterways and green networks focusing on their urban environmental load regulatory function was not considered.

4. Concept of urban environmental infrastructure as part of the heat island measure

In this section, we discuss the infrastructure of the urban environment that contributes to heat island measures. Here, we define urban environmental infrastructure as basic facilities/spaces and structures comprised of wind/water/green space/soil, as well as renewable energy.

(1) Two approaches to heat island measures
The purpose of the heat island measures is to reduce sensible heat load in urban spaces. The methods to achieve this can be divided into two large categories: those to minimize the emission of sensible heat in order to reduce environmental load and those to deal effectively with the emitted sensible heat based on the acceptable environmental capacity. The expression "contributes to heat island measures" refers to both environmental load reduction measures and those to increase the acceptable environmental capacity. In general, the acceptable environmental capacity refers to the limits of the purifying capability of nature. The urban environmental infrastructure in this study is a special case in that it treats both natural and artificial elements contributing to heat island measures equally. For example, the waste heat disposal system of a city is an example of an artificial element, while the capacity of such artificial elements, in this case treatment capacity of the waste heat disposal system, is considered the acceptable environmental capacity of artificial elements.

In the urban environment, there are areas where localized large load is generated. As it is difficult to make large changes to the urban morphology or land cover over a short period, it is difficult to enforce drastic measures that involve the acceptable environmental capacity of nature. For example, two different approaches can be considered regarding treatment methods for heat emission in major business districts of major cities: to release the heat into air that has sufficient acceptable environmental capacity, or to construct waste heat disposal systems by building trunk lines for cooling water underground. From the viewpoint of acceptable environmental capacity, these two approaches are of equal value. The load generated in the area is treated by combining the acceptable environmental capacity of both natural and artificial elements. When the concept of acceptable
environmental capacity is expanded to artificial elements, natural and artificial elements considered as urban environmental infrastructure can be discussed equally.

(2) Urban environmental infrastructure as part of heat island measures
The concept of urban environmental infrastructure for heat island measures was examined in this study. This concept is based on facilities/spaces (systems) in urban areas comprised of wind, water, green space, and soil (as well as renewable energy), and is used in the development of heat island measures. In a city, facilities and spaces that contribute to either reduction of environmental load or to increasing the acceptable environmental capacity are considered urban environmental infrastructure. These are not necessarily limited to public spaces/facilities; even privately owned land, spaces, and facilities can be considered social infrastructure if they contribute to heat island measures. The expression “comprised of wind, water, green space, and soil” is used because implementing and utilizing the purifying and dilution capabilities of natural elements, such as wind, water, and green space, are among the most important points in both reduction of environmental load and increasing the acceptable environmental capacity. Wind, water, green space, and soil, as well as renewable energy, will be referred to as “natural elements” in our research.

In addition, foundational facility/space structure is considered to involve artificial elements (facilities or utilities) as well as space resources in urban areas that contribute to heat island measures. That is, the urban environmental infrastructure explains the social function of infrastructure that contributes to heat island measures by combining the three keywords: natural elements, artificial elements, and space resources.

The following is not a strict classification, and the groupings may require future discussion, but for the purpose of discussion in this study, the urban environmental infrastructure is classified into the following three types.

I. Natural elements themselves, or combinations of these elements that have significance as urban environmental infrastructure.
II. Artificial elements contributing to heat island measures (facilities or utilities) themselves, or combinations of these elements that have significance as urban environmental infrastructure.
III. The combination of space resources and natural elements from urban areas, or artificial elements (facilities or utilities) contributing to heat island measures is applicable as urban environmental infrastructure.

In this study, “environmental facilities,” “environmental spaces,” “environmental utilities,” “environmentalized spaces” are assumed in considering the development of measures or business development regarding urban environmental infrastructure. “Environmental facilities” are mainly combinations of natural elements and public spaces, and are thus classified as either III or I. Such facilities include foundational urban facilities involving waterways and green spaces, such as rivers, canals, water channels, large-scale public water surfaces, large-scale green spaces, parks, and renewable energy supply facilities. “Environmental spaces” are mainly combinations of natural elements and private land, and are thus classified as either III or I. These include private water surfaces (including rice paddies), private forests, private green spaces, communalized open space networks, underground water sources (groundwater), and main lines of wind pathways.

“Environmental utilities” are classified as either II or I, and include waste heat, sprinkler, and renewable energy systems. “Environmentalized spaces” are mainly combinations of natural elements and private land, similar to “environmental spaces” and are classified as either III or I; these include large-scale cooling facilities, city blocks with an area-wide cooling effect, shaded roads, and shaded spaces.

Large-scale cooling facilities and city blocks with an area-wide cooling effect, which could be elements of the load as sources of heat emission when no measures are taken, can contribute to increasing the area’s acceptable environmental capacity by enforcing measures as urban environmental infrastructure. Shaded roads and spaces
contribute to the health and comfort of people living in urban areas, and create shaded areas that are effective as measures to prevent heat stroke. “Environmental facilities,” “environmental spaces,” and “environmental utilities” are considered the basic elements of urban environmental infrastructure, which in broader terms will include “environmentalized spaces.” The facilities and spaces for each type of urban environmental infrastructure will be described in the presentation.

(3) Natural elements contributing to heat island measures
As mentioned above, natural elements contributing to heat island measures refer mainly to the following:
- Water
- Green (green space)
- Wind
- Earth (soil)
- Renewable energy

(4) Artificial elements (facilities and utilities) that could become urban environmental infrastructure
The following is a list of facilities that contribute to heat island measures:
- Energy facilities, e.g., district heating and cooling facilities and natural energy utilizing systems.
- Water sprinkling facilities, fountain facilities.
- Groundwater utilization systems.
- Paving materials, such as water absorbent pavement.
- Building equipment.
- Building exterior finishing materials/building materials, etc.

(5) Space resources that could become urban environmental infrastructure
Space resources, mainly public space and public facility that could become urban environmental infrastructure are listed below.

<table>
<thead>
<tr>
<th>Public Spaces</th>
<th>Private Land</th>
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<tbody>
<tr>
<td>· Roads</td>
<td>· Railways</td>
</tr>
<tr>
<td>· Schools</td>
<td>· Large-scale railway station buildings</td>
</tr>
<tr>
<td>· Other public facilities</td>
<td>· Large-scale parking lots (especially single-level parking lots)</td>
</tr>
<tr>
<td>· Parks in city blocks</td>
<td>· Facilities with large-scale paved areas</td>
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<tr>
<td>· Rivers, area-wide water channels</td>
<td>· Areas to be redeveloped</td>
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<tr>
<td>· Moats</td>
<td>· Underdeveloped land</td>
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<tr>
<td>· Canals</td>
<td>· Abandoned cropland</td>
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<tr>
<td>· Large-scale balancing reservoirs</td>
<td>· Residential areas, etc.</td>
</tr>
<tr>
<td>· Farm ponds</td>
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<tr>
<td>· Underground spaces</td>
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</table>

Here, the basic concept is that even if a space is not public and is instead private land, if it becomes a space that can contribute to heat island measures of a certain magnitude, it will have a social function, and can thus be positioned as urban environmental infrastructure. In addition, although measures for buildings are enforced individually, when such measures accumulate to show a linear and area-wide expansion above a certain magnitude, they can be positioned as environmental infrastructure.

5. Subjects for future investigation

The concept of urban environmental infrastructure to address the heat island phenomenon was examined in our study. Evidence indicating the effectiveness of urban environmental infrastructure as social infrastructure, social accountability, and to understand the distribution, abundance, and utilizable quantities of such elements are necessary for further discussion. Planning, project concept, and implementation (development) measures (in relation to city planning, where it is placed on the budget summary, project subsidiary, incentive, and regulation), future measures development, and business development must be discussed from the viewpoint of urban environmental infrastructure.

References