Special issue: Urban green infrastructure and the ecological functions

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Sustainable cities in the future will depend on urban green infrastructure and its ecological functions (Mell 2009; Breuste et al. 2015). Green infrastructure is broadly used to describe the multifunctional approach to ecological planning. Various ecological functions, such as regulation of water flows and water purification (Lee et al. 2018), local climate regulation and adaptation (Lehmann et al. 2014), carbon storage and sequestration (Mensah et al. 2016), biodiversity conservation (Watts et al. 2010), accessibility for amenity and recreation, environmental education (Wolsink 2016), and other ecosystem services, can be arranged simultaneously in one green space. This concept of green infrastructure is especially relevant for the urban area, because only limited green spaces are allowed to be conserved or additionally restored in cities. Controversy on whether or not to harmonize the benefits from traditional gray infrastructure and those multiple ecological functions from green infrastructure remain in the planning literature (Tiwarly and Kumar 2014). Therefore, further studies are needed on the structure and functions of the urban green infrastructure, specifically on how to optimize the solutions in a limited urban area. We can divide the challenges in urban green infrastructure into monitoring and assessment issues.

Challenges in monitoring: beyond the LULC map of a city

Land use land cover (LULC) map is the traditional and still useful spatial data set platform especially in tracking the changes from the past to the future. For example, using LULC maps, we can estimate how we have lost ecosystem services during last tens of years or how we can adapt to climate change in the future (Pauleit and Duhme 2000; Kalnay and Ming 2003). Recently, with more frequent updates in LULC data sets, we can analyze spatiotemporal changes in more detail by combining them with other multiple data sources. The heterogeneous urban landscape is frequently affected by multiple disturbances, such as continuous development pressure, intensive use of citizens, invasive species, as well as climate extremes and damage (Su and Fath 2012; Gładalski et al. 2016). To understand the mosaics, dynamics, and the mechanism of urban landscape change, we need to advance monitoring strategy with higher spatial and temporal resolution data (Houborg and McCabe 2018). Observation data sets should not only be from a single source but also from a fusion of different observation data sets (Wang et al. 2015). Furthermore, the updated monitoring techniques can be integrated with three-dimensional spatial data sets to better understand the complex mixture of natural and built environments and the observed functions of the real urban environment.

Challenges in assessment: enhancing urban resilience by an effective functional network

Novel assessment methods for the urban green infrastructure are emerging that depend on the multiple ecological functions (Watts et al. 2010). A single function may be important because it is directly related to the current citizen's life, e.g., mitigation of storm water or heat island—but note that different spatial solutions for different ecological challenges should be efficiently implemented under one integrated planning framework, e.g., an ecological network. An ecological

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network is one of the key concepts to be assessed better in terms of conservation or restoration priority when we are building the urban green infrastructure (Nielsen et al. 2013; Lerman et al. 2014). Traditional ways to understand the ecological network were based on structural connectivity, which largely considered the physical adjacency among green spaces (Kong et al. 2010). This method was useful to apply to planning so far. With the advances in assessment methodology, the traditional ecological network concept should be developed to include structural connectivity. A functional network can be a more convincing framework for integrated multiple functions and can be considered as common infrastructure for providing urban ecosystem services to citizens more efficiently. Furthermore, advancement in the assessment methodology is relevant in terms of monitoring; new data sets support new assessment results and more effective planning implications on the problem faced.

Aims and scope of this special issue

The aim of this special issue is to distinguish the current issues related to the urban green infrastructure and the ecological functions in Korea. In Korea, several policy-driven public technology programs supported by Korea Ministry of Environment on the urban ecosystem resilience are ongoing. These programs are struggling to include topics ranging from monitoring, assessment to the planning strategy, against the urgent challenges in improving citizens' quality of life. The topics in this special issue may not be enough to see the whole picture, but are still useful to provide specific examples.

We invited five articles. Hyeyeong Choe¹ attempted to simulate the city's overall green and open space connectivity in Seoul city by using the open space permeability derived from multiple spatial data sources. The implication for the planning can be considered as an example of the functional ecological network. Hankyul Heo² illustrated that a mobile Lidar-driven three-dimensional laser scanning data set was effective to estimate key parameters of urban trees in an automated way, also showing the potential to use it for monitoring urban green infrastructure at a broader scale. Yingnan Li³ identified the microclimate zone within a large park in Seoul, based on the Lidar-driven three-dimensional spatial information for the ecological structure in the park and

spatial distribution maps of simulated microclimate factors. This approach is expected to lead the way in evidence-based landscape design in urban areas. Wanmo Kang⁴ focused on the challenges facing the management of invasive species; although this is one of the most critical issues in cities of Korea, the responses to the outbreak of invasive species are not often well organized in advance. This article also attempted to identify a priority area of an emerging invasive species, using species distribution models. Byungsun Yang⁵ focused on the potential ability of urban trees to intercept the rainfall in terms of mitigation. On the basis of the three-dimensional structure of individual trees, the authors discussed their ecological function in regulating water flow in urban areas.

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¹ Omnidirectional connectivity of urban open-spaces provides context for local government redevelopment plans.

² Estimating height and diameter at breast height of urban park and street trees using mobile LiDAR.

³ Zonal classification of microclimates and their relationship with landscape design parameters in an urban park.

⁴ Identifying habitats and corridors of an invasive plant, *Ageratina altissima* in an urban forest.

⁵ The effects of tree characteristics on rainfall interception in urban areas.

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