remote sensing

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Editorial

Editorial for the Special Issue: "Remote Sensing of Urban Ecology and Sustainability"

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Abstract: The remote sensing of urban ecology and sustainability is an emerging topic to understand the human living environment in urban areas from outer space, airplanes, and unmanned aerial vehicles. In this editorial, we provide an overview of the five papers published in this Special Issue and offer suggestions for future research directions in this field, both with respect to the remote sensing platforms and algorithms and the development of new applications.

Keywords: urban ecology and sustainability; urban remote sensing

1. Background

The 21st century population growth in urban areas has led to the proliferation of megacities and the pervasive expansion of peri-urban areas [1]. This global urbanization has profoundly influenced urban ecosystem structures and functions, greatly changed the landscape within and around cities worldwide, and has significantly influenced the living environment of urban residents [2]. While there are great economic and social benefits associated with urbanization, negative ecological consequences, such as urban heat island effects, biological invasion, air and water pollutions, and biodiversity loss and degradation, are happening simultaneously [3–6]. With the goal to mitigate and minimize the environmental consequences of urbanization, it is crucial to better understand how to create a sustainable urban environment that balances the conflict between human activities and environmental responses.

Remotely sensed images and the analytical techniques to extract information from the imagery offer a comprehensive approach to monitor and observe urban ecosystems in real time through high spatial-temporal-spectral-resolution data [7]. After more than 50 years of development, various remote sensing data sources (optical, thermal infrared, microwave (SAR/INSAR), light detection and ranging (LIDAR), and night lights) have been widely applied to understand the urban environment, including urban green infrastructure, urban flooding, the urban heat island, urban economic development, and habitat fragmentation [8–11]. One of the challenges of urban remote sensing is that the sensors (and the subsequent data) were not originally designed to extract information from urban areas. As a result, scholars have used and designed a variety of methods from simple indices (e.g., the Normalized Difference Vegetation Index (NDVI) [12] and the Normalized Difference Built-Up Index (NDBI) [13]) to complex methods (e.g., fuzzy classifiers and expert systems) as a means of analyzing images from urban areas. In addition to remote sensing techniques, methods in spatial analytics, geographic information systems, and urban climatology have been incorporated to understand urban complexity [14,15].

2. Papers in the Special Issue

In this Special Issue (see Table 1), most studies used medium-resolution satellite images, such as Landsat Satellite series and Advanced Land-Observing Satellite (ALOS), to understand how the urbanization process influences urban ecology and urban sustainability. Particularly, the urban heat island [16–18] and urban green space development [19] receive the most attention from the Special Issue contributors. The study area of most studies focuses on a single city due to the heavily satellite image analysis efforts, but the existing cloud-based satellite image analysis platforms, such as Google Earth Engine, can significantly improve the spatial coverage from city level to country level [19]. Due to the limitation of the 3D satellite images, most of the studies explore the urban landscape patterns in 2D. A further extension of 3D urban landscape analysis is significant and necessary, similar to the multidimensional urban form concept proposed by Wentz et al. (2018) [20] and the recent attempt by Handayani et al. (2018) [21] in this Special Issue. Most of the studies incorporated a temporal dimension into the consideration (2–4 time stages) to understand the urban expansion process, except the country scale analysis by Huang et al. (2018) [19]. From the methodology perspective, image analysis such as land use/land cover classification, land surface temperature derivation, and biophysical indicators calculation have been commonly used to extract useful information from the satellite images. Beyond this, 2D landscape metrics derivation, statistical analysis, exploratory spatial data analysis, and spatial regression techniques have also been applied to further understand the research topics.

Table 1. Publication summary in the Special Issue.

Publication	Topic	Data	Spatial Scale and Dimension	Methods
Zhao et al. (2018) [16]	Urban heat island and landscape pattern change	Landsat 5 and 8 in 1996,2006, and 2014	City scale, 2D (Zhengzhou, China)	Image analysis; landscape metrics analysis; correlation analysis
Huang et al. (2018) [19]	Urban form impacts on urban green space	Landsat 7 and 8, in 2015	Country scale, 2D (China)	Image analysis; landscape metrics analysis; boosted regression tree
Handayani et al. (2018) [21]	Multidimensional urban expansion	ALOS; LIDAR in 2010 and 2016	City scale, 2D and 3D (Surabaya, Indonesia)	Image analysis; landscape metrics analysis
Li et al. (2019) [17]	Spatiotemporal patterns of urban heat island	Landsat 5 and 7 in 2000, 2005, 2010, and 2015	City scale, 2D (Hangzhou, China)	Image analysis; exploratory spatial data analysis; geographically weighted regression
Wang et al. (2020) [18]	Urbanization effects on urban warming and cooling	Landsat 5 and 8; NLCD [1] in 2001, 2006, 2011, and 2016	City scale, 2D (Las Vegas, USA)	Image analysis; geographically weighted regression

[1] NLCD: National Land Cover Dataset.

3. Outlook to the Future

The articles published in this special issue contribute to the understanding of urban landscape pattern change, urban expansion, urban green infrastructure, and the urban heat island by using innovative approaches to extract rich spatio-temporal information from satellite images. Several future research directions are also presented. First, a global level remote sensing-based analysis of urban expansion and shrinkage will reveal more interesting patterns and disclose underlying questions from the rapidly global urbanization process. Further, 3D landscape features and metrics need to be further developed to understand the vertical expansion and shrinkage of the urban areas. Additionally, the new advancement of remote sensing data sources, such as Planet Dove (high spatio-temporal resolution multispectral imagery), Global Ecosystem Dynamics Investigation (GEDI, global satellite-based light detection and ranging (LIDAR) imagery), and JL1-3B (high spatial resolution night light imagery), can be used to further understand the existing and new urban ecology and sustainability questions [22–24]. Lastly, advanced techniques (deep learning, artificial intelligence, urban climate modelling, and advanced spatial statistics) and cloud-based computational platforms (e.g., Google Earth Engine) will need be central in future research methodology toolkits.

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