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Remote sensing technology for disaster mitigation and regional infrastructure planning in urban area: a review

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Abstract

A Very high intensity of regional development is ubiquitous in urban areas. Therefore, urban development requires a proper spatial development strategy in many facets, especially social aspect and disaster potential. The essence of social aspect lies in the prevailing norms and local wisdom that have long existed and become the basis of community life. Inducing various effects on infrastructure development, disaster potential has to be considered as well. Disaster mitigation measures can start with the use of continually developing remote sensing technology, which provides a basis for preparing sustainable development planning. The realization of these measures in urban areas demands specific adjustment to the environmental conditions. This study aimed to examine the capacity of remote sensing data to support disaster mitigation and infrastructure planning based on energy conservation in urban areas. The results indicate that remote sensing technology can be an option for sustainable development planning in urban areas.

Keywords*: disaster, energy conservation, mitigation, remote sensing, urban area*

1. Introduction

Urban area is characterized by the intensive construction of infrastructures. As a developing area, it becomes an indicator of regional growth rate. One of its characteristics is observable in the activities of the community. Most of which, people in urban area rely on the industrial sector [1, 2, 3] and trade [4]. Industrial growth in urban areas has to be followed by proper urban area management. The expected output from this management is sustainable development. Also, elements like local cultural wisdom [5] that have long existed in urban areas have to be appropriately maintained as they are the characteristics and the identity of a region. Sustainable development in urban areas has to pay attention to various elements, such as environment and society [6]. Sustainable development demands by Yan et al., in [7] not only sustainable natural resources and environment but also sustainable human welfare and happiness.

Infrastructure is inseparable from sustainable development. Basic network facilities, is a part of infrastructure development that cannot be separated, in order to fulfill the harmony of human life [8]. For successful implementation, infrastructure development planning has to take social and environmental aspects into account so that potential adversity on human life and the environment can be avoided. A shortcoming in this planning may lead to both natural and social disasters [9]. Disasters occurring in urban areas include fires [10,11], floods [12,13], earthquakes [14,15,16], social conflicts [17, 18,19], and technological failures [20].

Infrastructure development planning can be implemented in either a short or a long term period. It can also cover a narrow or a wide region. The primary supporting factor in development planning is data availability, including quantitative, qualitative, and geospatial data. Geospatial data is crucial point in providing basic information for infrastructure development planning [21, 22] in urban areas [23]. It contains geographic information of objects, either natural or artificial, in a region. The method used to obtain this data is, for instance, remote sensing. It

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produces geospatial data in the forms of aerial photos and satellite images. An aerial photograph can be acquired using Unmanned Aerial Vehicle (UAV), while a satellite image is obtained from the geospatial data providers. The UAV has higher spatial resolution than satellite images. UAV technology is equipped with camera and apply the 2D triangulation principle. If a triangle altitude d and angles α and β are known, the distance e [24] can be calculated. The basic principle of triangulation in a 2D plane shown in Figure 1.

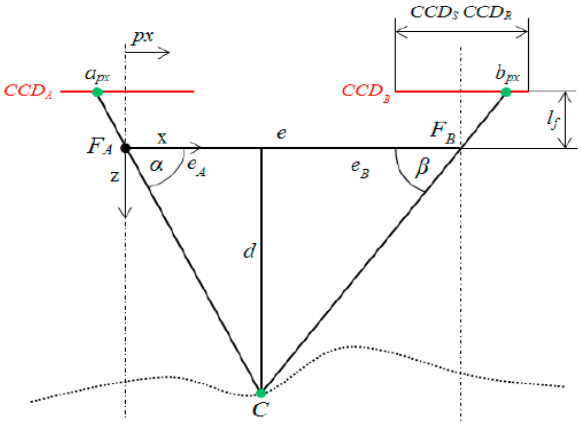

Figure 1. The basic principle of triangulation in a 2D plane [24]

Urban development planning also needs to consider the efforts put into preserving energy resources effectively and efficiently, called energy conservation. Accentuating these measures, an area with sustainable development planning can be created. This research applied remote sensing technology to disaster mitigation and regional infrastructure planning with an emphasis on energy conservation, particularly the electricity in urban areas.

2. Research Method

The data source in this study included aerial photos and satellite images. The aerial photograph was obtained primarily by taking pictures of the field using Unmanned Aerial Vehicle (UAV). In general, there are two types of UAV, namely wing and rotor. In this research, we used rotor (multi-rotor) UAV with 4 (four) propelers which we know as quadcopter. UAV utilization with a simple mechanical design, now can be used as a commercial and scientific purposes [25]. Multi-rotors usually composed of more than two rotor propellers have various advantages, such as simple structure, high mobility, easy maintenance, vertical take-off and landing, and good safety [26]. Multy-body model of the quadcopter tiltrotor shown in Figure 2.

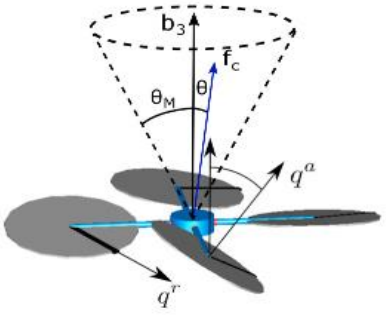

Figure 2. Multi-body model of the quadcopter tiltrotor [25]

Current technology of remote sensing can provide high-resolution satellite imagery [27-34]. Furthermore, the resultant images cover broader areas and some of which are also complemented with spectral and radiometric data. The research data source is presented in Table 1.

Table 1. Geospatial Data

Data (Satelite Imagery/ UAV)	Acquisition Year	Spatial Resolution
UAV	2018	2.5 cm
Bing Satellite Maps	2012	58.7 cm
ArcGIS Online	Multy years	58.6 cm
Google Maps	2017	58.7 cm
Landsat8 (Pan)	2017	15 m

3. Study Area

This research was conducted in urban areas close to the administrative borders of Yogyakarta City and two regencies in the Special Region of Yogyakarta. They included Depok District (in Sleman Regency), Sewon District (in Bantul Regency), and Sayidan (in Yogyakarta City). The first two districts are directly adjacent to Yogyakarta City. In the recent years, they have experienced very rapid development. Sampling location of this research can be observed in Figure 3. Sayidan is a densely populated residential area in Gondomanan District, Yogyakarta City. The settlements are separated by Code River. Based on landscape analysis, they are located in mid-channel bars, river valleys, and natural levees [35]. Depok, Sewon, and Sayidan are urban areas with different characteristics of infrastructure development.

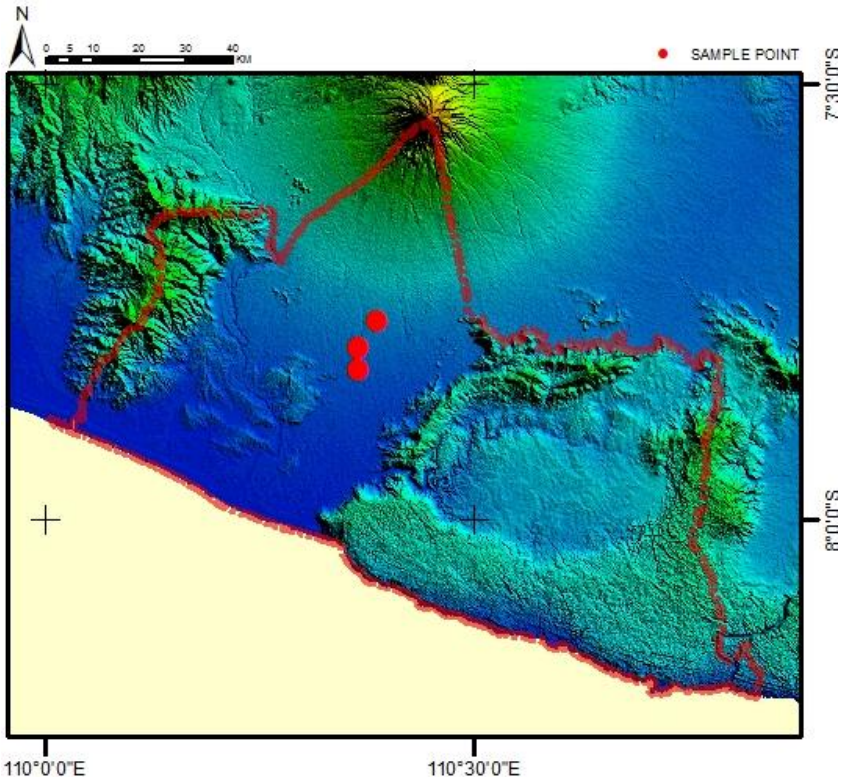

Figure 3. Study area

4. Results and Analysis

In this research, geospatial data was used to show the condition, particularly the infrastructure development, of the study area. It included aerial photos and satellite images with different spatial resolutions. This difference determines the amount of information obtained from the data. The level of spatial data resolution will affect accuracy of the analysis results. The higher the level of spatial data resolution will be directly proportional to the level of accuracy. Figure 4 presents the satellite images of several study sites. The Landsat image was formatted with a scale of 1:500,000, while the satellite images and aerial photos were produced with similar scale (i.e., 1:5,000) in accordance to the need of the research. These geospatial data have different spatial resolutions.

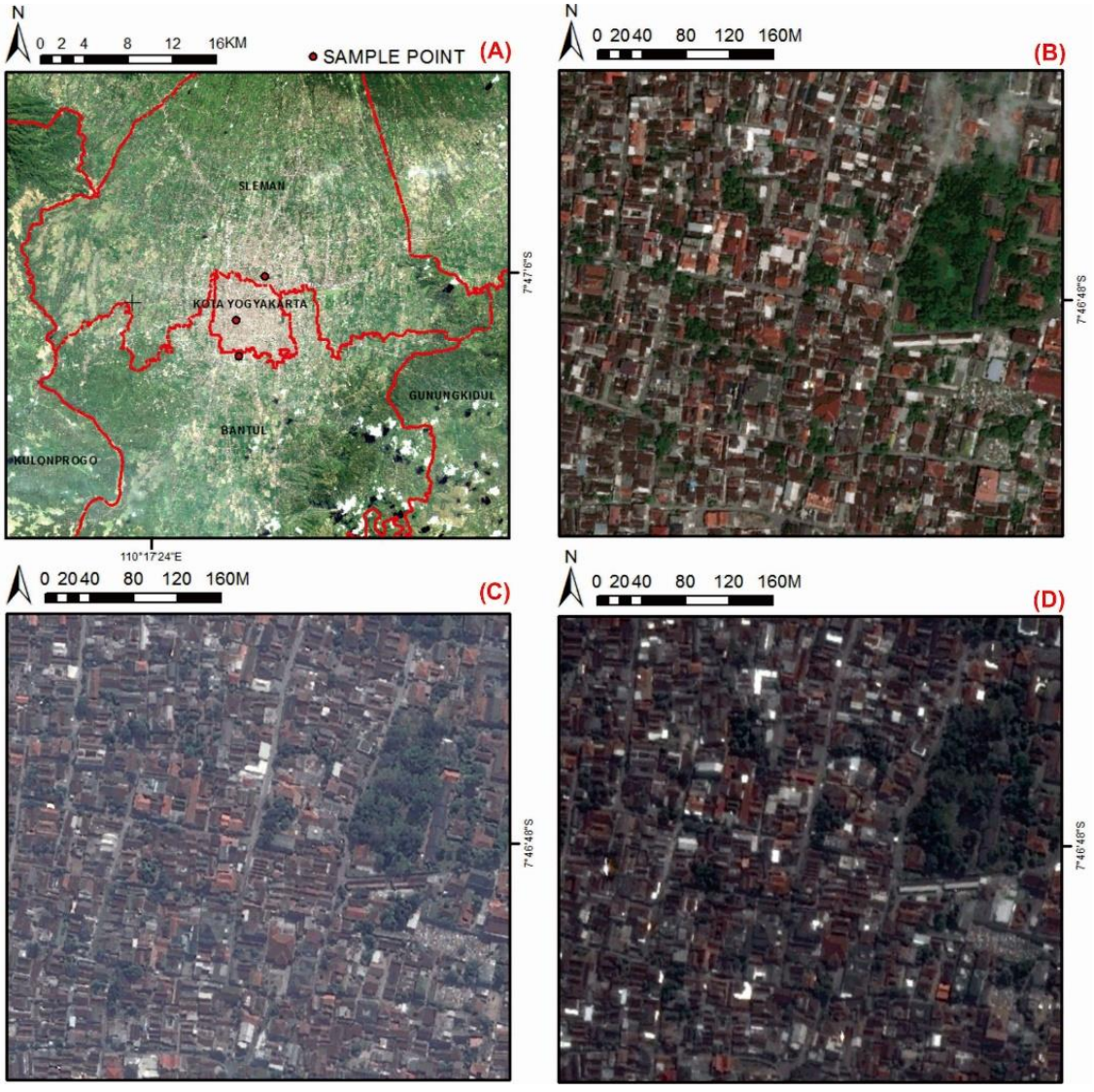

Figure 4. Satelite imagery, geospatial data

Landsat-8 image (A) has a low resolution. It is suitable for a preliminary study in regional planning because it is equipped with several bands that represent specific wavelengths. In this research, the preliminary assessment included land use estimation and natural resource inventory (e.g., water bodies, soil and rocks). Landsat-8 imagery is periodically available and relatively complete. However, the data obtained from it cannot be used in large scale mapping.

ArcGIS Online Imagery (B), Bing Maps Imagery (C), and Google Maps (D) have a similar spatial resolution. These data can be used for land use inventory as a further study. Their relatively high spatial resolution helps to identify objects such as buildings and public facilities. Among the geospatial data used in this research, UAV-derived photographs in Figure 5 (E) have the highest resolution. They perform the condition of the latest land cover and land use in detail. The accuracy level of the inventory of buildings and public facilities is relatively high. Therefore, an error in object classification can be avoided.

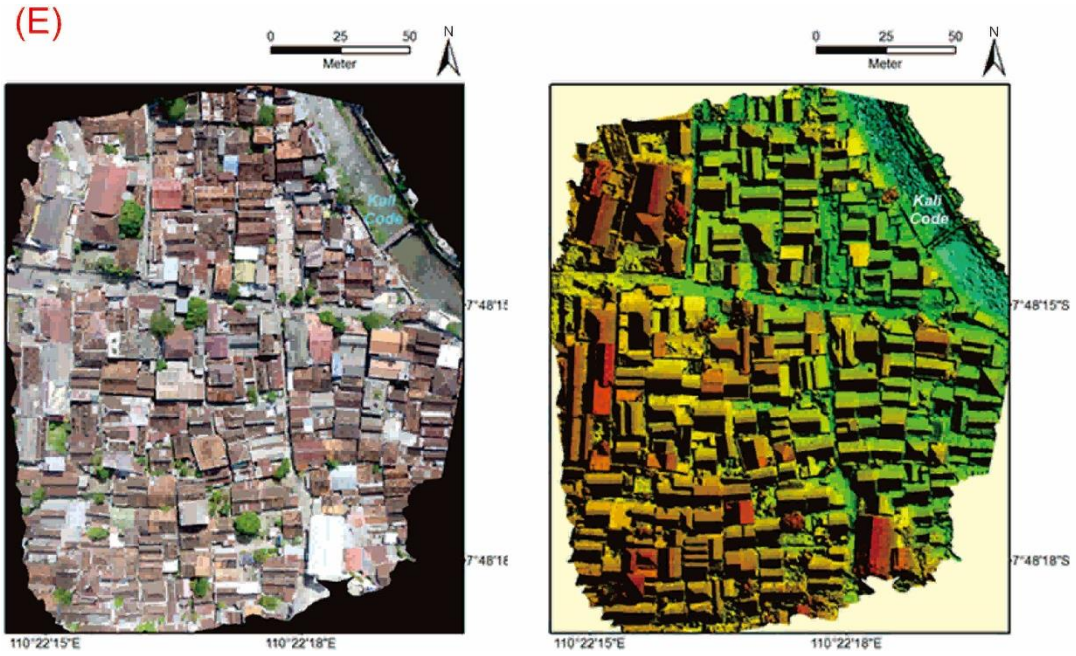

Figure 5. UAV data and DEM part of Sayidan [35]

In connection with disaster mitigation measures in urban areas, geospatial data in the form of satellite imagery and aerial photograph provide many benefits. Satellite imagery can be used in disaster analysis or monitoring [36, 37] in extensive areas. For example, Landsat-8 satellite imagery is equipped with multiple bands, and when complemented with COSMO-SkyMed radar imagery, it can identify inundation [36]. Aerial photographs can be used in disaster monitoring or mapping analysis, for instance, in the events of fires [38], floods [39], earthquakes [40, 41] and infectious diseases [42]. Figure 5 shows aerial photos with different spatial resolutions. The aerial photography produced a 2.1cm spatial resolution, which is categorically very high. It enables land use identification on a more detailed scale. Regarding disaster mitigation, an aerial photograph can be used to identify damages in the affected areas.

Regarding energy conservation measures, geospatial data can be applied using several approaches. Satellite images equipped with a radiometric sensor can be utilized for small scale. For instance, the satellite images from the National Ocean and Atmospheric Administration (NOAA) are suitable for analyzing the impact of light pollution [43] caused by electricity consumption. Meanwhile, high resolution satellite images on spatial data can be applied to create large-scale maps. The primary concept in utilizing satellite image is visual-spatial analysis. The term 'visual' means performing inventory and identification directly on an aerial photograph or a high-resolution satellite image. For example, there are several variables considered in electricity consumption, namely building, road, and the geographical factor of a location. Buildings with specific form are assumed to use a particular amount of electricity. Meanwhile, roads describe the access in the study area. Different types of roads are considered to represent different electrification channels. As for the geographical factors, they can give an overview of the priority areas for development.

5. Conclusion

Nowadays, geospatial data generated from remote sensing technology has a high resolution. Therefore, it can be applied to disaster mitigation and urban infrastructure planning. Urban development also has to pay attention to energy consumption, especially electricity. Excessive use of electricity has a negative impact, such as light pollution. Remote sensing technology grows rapidly, as evidenced by the scope of the resultant data that can be used widely in different fields. It produces geospatial data, which are especially suitable for disaster mitigation and infrastructure development based on energy conservation, all of which are the contributing factors of sustainable development planning.

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References

[1] Wang N. The role of the construction industry in China's sustainable urban development. *Journal of Habitat International*. 2014; 44: 442-450.
[2] Fujii M, Fujita T, Dong L, Lu C, Geng Y, Behera SK, Park HS, Chiu ASF. Possibility of developing low-carbon industries through urban symbiosis in Asian cities. *Journal of Cleaner Production*. 2016; 114: 376-386.
[3] Tarigan AKM, Samsura DAA, Sagala S, Wimbardana R. Balikpapan: Urban planning and development in anticipation of the post-oil industry era. *Cities*. 2017; 60: 246–259.
[4] Allen J, Piecyk M, Piotrowska M, McLeod F, Cherrett T, Ghali K, Nguyen T, Bektas T, Bates O, Friday A, Wise S, Austwick M. Understanding the impact of e-commerce on last-mile light goods vehicle activity in urban areas: The case of London. *Journal of Transportation Research Part D: Transport and Environment*. 2017; 61: 325-338.
[5] Kagan S, Hauerwaas A, Holz V, Wedler P. Culture in sustainable urban development: Practices and policies for spaces of possibility and institutional innovations. *City, Culture and Society*. 2018; 13: 32-45.
[6] Pandit A, Minné EA, Li F, Brown H, Jeong H, James JAC, Newel JP, Weissburg M, Chang ME, Xu M, Yang P, Wang R, Thomas VM, Yu X, Lu Z, Crittenden JC. Infrastructure ecology: an evolving paradigm for sustainable urban Development. *Journal of Cleaner Production*. 2017; 163: S19-S27.
[7] Yan Y, Wang C, Quan Y, Wu G, Zhao J. Urban sustainable development efficiency towards the balance between nature and human well-being: Connotation, measurement, and assessment. *Journal of Cleaner Production*. 2018; 178: 67-75.
[8] Soyinka O, Siu KW, Lawanson T, Adeniji O. Assessing smart infrastructure for sustainable urban development in the Lagos metropolis. *Journal of Urban Management*. 2016; 5(2): 52–64.
[9] Ferrer AL, Thomé AMT, Scavarda AJ. Sustainable urban infrastructure: A review. *Resources, Conservation and Recycling*. 2018; 128: 360–372.
[10] Gernay T, Selamet A, Tondini N, Khorasani NE. Urban Infrastructure Resilience to Fire Disaster: An Overview. *Procedia Engineering*. 2016; 161: 1801-1805.
[11] Waheeda MAA. Approach to Fire-Related Disaster Management in High Density Urban-Area. *Procedia Engineering.* 2014; 77: 61-69.
[12] Yamashita S, Watanabe R, Shimatani Y. Smart adaptation activities and measures against urban Flood disasters. *Journal of Sustainable Cities and Society*. 2016; 27: 175–184
[13] Wang RQ, Mao H, Wang Y, Rae C, Shaw W. Hyper-resolution monitoring of urban flooding with social media and crowdsourcing data. *Journal of Computers and Geosciences*. 2018; 111:139–147.
[14] Mili RR, Hosseini KA, Izadkhah YO. Developing a holistic model for earthquake risk assessment and disaster management interventions in urban fabrics. *International Journal of Disaster Risk Reduction*. 2018; 27: 355–365.
[15] Ubaura M, Miyakawa M, Nieda J. Land Use Change after Large Scale Disasters a Case Study of Urban Area of Ishinomaki City after the Great East Japan Earthquake. *Procedia Engineering*. 2016; 161: 2209-2216.
[16] Fujita K, Ichimura T, Hori M, Wijerathne MLL, Tanaka S. A quick earthquake disaster estimation system with fast urban earthquake simulation and interactive visualization. *Procedia Computer Science*. 2014; 29: 866–876.

[17] Shan L, Ann TW, Wu Y. Strategies for risk management in urban-rural conflict: Two case studies of land acquisition in urbanising China. *Journal of Habitat International*. 2017; 59: 90-100.
[18] Yu T, Shen GQ, Shi Q, Lai X, Li CZ, Xu K. Managing social risks at the housing demolition stage of urban redevelopment projects: A stakeholder-oriented study using social network analysis. *International Journal of Project Management.* 2017; 35(6): 925–941.
[19] Dinnie E, Brown KM, Morris S. 2013. Community, cooperation and conflict: Negotiating the Social well-being benefits of urban greenspace experiences. *Landscape and Urban Planning*. 2013; 118: 103–111.
[20] Kai Y, Shuran L, Jiancun G, Lei P. Research on the coupling degree measurement model of urban gas pipeline leakage disaster system. *International Journal of Disaster Risk Reduction*. 2017; 22: 238–245.
[21] Alhamwi A, Medjroubi W, Vogt T, Agert C. Open Street Map data in modelling the urban energy infrastructure: afirst assessment and analysis. *Energy Procedia*. 2017; 142: 1968–1976.
[22] Feltynowski M, Kronenberg J, Bergier T, Kabisch N, Łaszkiewicz E, Strohbach MW. Challenges of urban green space management in the face of using inadequate data. *Journal of Urban Forestry and Urban Greening*. 2018; 31: 56-66.
[23] Lin FY, Lin TP, Hwang RL. Using geospatial information and Building energy simulation to construct urban residential energy use map with high resolution for Taiwan cities. *Energy and Buildings*. 2017; 157: 166–175.
[24] Gabrlik P. The Use of Direct Georeferencing in Aerial Photogrammetry with Micro UAV. *IFAC-PapersOnLine*. 2015; 48(4): 380–385.
[25] Invernizzi D, Lovera M. Geometric tracking control of a quadcopter tiltrotor UAV. *IFAC Papers Online*. 2017; 50(1): 11565-11570.
[26] Zhang T, Liao Y. Attitude measure system based on extended Kalman filter for multi-rotors. *Computers and Electronics in Agriculture*. 2017; 134: 19–26.
[27] Liu H, Fu Z, Han J, Shao L, Liu H. Single satellite imagery simultaneous super-resolution and colorization using multi-task deep neural networks. *Journal of Visual Communication and Image Representation*. 2018; 53: 20–30.
[28] Huang X, Chen H, Gong J. Angular difference feature extraction for urban scene classification using ZY-3 multi-angle high-resolution satellite imagery. *ISPRS Journal of Photogrammetry and Remote Sensing*. 2018; 135: 127–141.
[29] McCharty MJ, Radabaugh KR, Moyer RP, Muller-Karger FE. Enabling efficient, large-scale high-spatial resolution wetland mapping using satellites. *Remote Sensing of Environment*. 2018; 208: 189–201.
[30] Wu B, Tang S, Zhu Q, Tong KY, Hu H, Li G. Geometric integration of high resolution satellite imagery and airborne LiDAR data for improved geopositioning accuracy in metropolitan areas. *ISPRS Journal of Photogrammetry and Remote Sensing*. 2015; 109: 139–151.
[31] Baldwin D, Tschudi M, Pacifi F, Liu Y. Validation of Suomi-NPP VIIRS sea ice concentration with very high-resolution satellite and airborne camera imagery. *ISPRS Journal of Photogrammetry and Remote Sensing*. 2017; 130: 122–138.
[32] Pelta R, Chudnovsky AA. Spatiotemporal estimation of air temperature patterns at the street level using high resolution satellite imagery. *Science of the Total Environment*. 2017; 579: 675–684.
[33] Fisher A, Danaher T, Gill T. Mapping trees in high resolution imagery across large areas using locally variable thresholds guided by medium resolution tree maps. *International Journal of Applied Earth Observation and Geoinformation*. 2017; 58: 86–96.
[34] Morehart CT, Millhauser JK. Monitoring cultural landscapes from space: Evaluating archaeological sites in the Basin of Mexico using very high resolution satellite imagery. *Journal of Archaeological Science: Reports*. 2016; 10: 363–376.
[35] Putra AS, Maulana E, Rahmadana AD, Wulan TR, Mahendra IWWY, Putra MD. *Accuration Test of UAV's Aerial Photo in Densely Populated Areas (Case Study: Sayidan, Special Province of Yogyakarta) (in Indonesia: Uji Akurasi Foto Udara dengan Menggunakan Data UAV pada Kawasan Padat Pemukiman Penduduk (Studi Kasus: Kawasan Padat Sayidan, Daerah Istimewa Yogyakarta))*. Seminar Nasional Pengindraan Jauh. 2016: 278.
[36] Tong X, Luo X, Liu S, Xie H, Chao W, Liu S, Makhinov AN, Makhinova AF, Jiang Y. An approach for flood monitoring by the combined use of Landsat 8 optical imagery and COSMO-SkyMed radar imagery. *ISPRS Journal of Photogrammetry and Remote Sensing*. 2018; 136: 144–153.
[37] Sivanpillai R, Jones BK, Lamb RM. Accessing satellite imagery for disaster response through the International Charter: Lessons learned from the 2011 US Midwestern Floods. *Journal of Space Policy*. 2017; 42: 54–61.
[38] Karma S, Zorba E, Pallis GC, Statheropoulos G, Balta I, Mikedi K, Vamvakari J, Pappa A, Chalaris M, Xanthopoulos G, Statheropoulos M. Use of unmanned vehicles in search and rescue operations in forest fires: Advantages and limitations observed in a field trial. *International Journal of Disaster Risk Reduction*. 2015; 13: 307–312.

[39] de Oliveira Silva L, de Mello Bandeira RA, Barcellos V, Campos G. The use of UAV and geographic information systems for facility location in a post-disaster scenario. *Transportation Research Procedia*. 2017; 27: 1137–1145.
[40] Chang KT, Wan S, Lei TC. Development of a spatial decision support system for monitoring earthquake-induced landslides based on aerial photographs and the finite element method. *International Journal of Applied Earth Observation and Geoinformation*. 2010; 12: 448–456.
[41] Xu Z, Yang J, Peng C, Wu Y, Jiang X, Li R, Zheng Y, Gao Y, Liu S, Tian B. Development of an UAS for post-earthquake disaster surveying and its application in Ms7.0 Lushan Earthquake, Sichuan, China. *Journal of Computers & Geosciences*. 2014; 68: 22–30.
[42] Fornance KM, Drakeley CJ, William T, Erpino F, Cox J. Mapping infectious disease landscapes: unmanned aerial vehicles and epidemiology. *Trends in Parasitology*. 2014; 30(11): 514-519.
[43] Votsi NEP, Kallimanis AS, Pantis ID. An environmental index of noise and light pollution at EU by spatial correlation of quiet and unlit areas. *Journal of Environmental Pollution*. 2017; 221: 459-469.