Short Communication

The Current Status of Green Space around Elementary Schools: A Case Study of Malang, Indonesia

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ABSTRACT

Green space is important for childhood development, particularly in developing countries. The city of Malang, Indonesia has experienced steady economic and population growth in recent years, but green space area in the urban environment has been declining. In this study, we elucidated the status of green space accessible to children in Malang, and discussed ways of improving green space use. We identified green spaces around 291 elementary schools using satellite remote sensing. A RapidEye satellite image, which covered the study area with a 5-m ground sample distance, was acquired on May 20, 2015. From this image, the area of green spaces within 1 km radius circles of elementary schools were calculated. The total area of green space in the city was 45.439 km², 41.3% of the total city area. Smaller green spaces were located near the city center, whereas larger green spaces were located in the southeastern part of the city. The green space ratio within 1 km of 96 schools was less than 15%, and it was 15–30% around 104 schools. Overall, there were few green spaces within walking distance of schools in Malang. The green space ratio in the city center was also low. Green spaces in the city should be maintained, and additional opportunities should be provided for children to access green spaces.

Keywords: accessibility, childhood, green space, landscape, urbanization

INTRODUCTION

Urban green space provides residents with important environmental services such as water resource management, biodiversity conservation, carbon sequestration, and landscape aesthetics (Arifin and Nakagoshi, 2011; Byomkesh et al., 2012; Coombes et al., 2010; Maas et al., 2006). Urban green space includes public parks, nature conservation areas, sports fields, riparian areas (e.g., stream and river banks), greenways and nature trails, community gardens, roadside trees, green walls, green alleyways, and cemeteries (Roy et al., 2012). Private backyards, communal grounds of apartment buildings, and corporate campuses are also considered private green spaces (Wolch et al., 2014). Green space is important for children living in urban areas (Ioja et al., 2014; Mizuki and Minami, 2003; Richardson et al., 2017), as adult environmental opinions are formed by experiences with nature during childhood (Ewert et al., 2005; Jim and Shan, 2013). Nature-focused kindergartens and schools have provided children with opportunities for inter-

acting with green spaces in Europe and the United States (Elliott and Chancellor, 2014; Fjørtoft and Sageie, 2000; MacEachren, 2013; Schäffer and Kistemann, 2012). Children can explore nature in green spaces in a supervised or unsupervised manner (Jansson et al., 2016). Green spaces not only provide children with opportunities to experience nature (Coolen and Meesters, 2012), but are also places for children to make friends (Seeland et al., 2009). Because of these benefits, Glackin and Jones (2012) suggested that local green spaces should be used for teaching and studying science in south London, United Kingdom. Kweon et al. (2017) and Wu et al. (2014) also showed that children who study in school environments with more trees perform better academically. However, rapid urbanization and population growth have led to changes in land use and cover, resulting in an overall reduction in green space area (Dewan and Yamaguchi, 2009; Kusimi, 2008; Ramdani et al., 2015).

As urbanization and populations increase in developing countries (Dewan and Yamaguchi, 2009; Kusimi, 2008; Ramdani et al., 2015), it is important to understand the status of green space around children in these countries to improve green space access. In 2015, 53.7% of the population in Indonesia lived in urban areas (World Bank, 2016). The urban population is projected to exceed the rural population by 2020. In 2050, 70% of Indonesians are projected to live in urban areas, a higher pro-

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Fig. 1 Location of Malang, Indonesia (gray area). The delineated area is that covered by the satellite image. The 100-m interval contour lines were generated using a digital surface model (DSM) and data obtained from the Advanced Land Observing Satellite (ALOS). The city is surrounded by mountains and mountain ranges.

portion than in other Asian countries (United Nations, 2014). As cities become more urbanized, a smaller proportion of the urban population will experience nature directly (Cox et al., 2017). Thus, children in urban areas in Indonesia may have less access to green space. However, little is known about the status of green space around children in Indonesia. Although studies have been conducted on broad-scale land-cover changes and land management in urban areas (Achmad et al., 2015; Agaton et al., 2016; Ramdani et al., 2015; Wolfersberger et al., 2015), these studies did not focus on green space around children. Malang, the second largest city in East Java, is a typical example of a rapidly urbanizing city in Indonesia. Urbanization in Malang is occurring in an uncontrolled manner (Ramdani et al., 2015), with increasing housing development and a decreasing area of agricultural land and forests. Urban area cover increased from 21% in 2001 to 40% in 2014 (Ramdani et al., 2015). This rapid urbanization has resulted in a steady decrease in green space in Malang.

Although the optimal green space area for children is not known, Indonesia has developed several green space indices for city planning. According to government regulations, at least 30% of the city area should be designated as green space, and at least 20% of this green space should be publicly accessible (Ministry of Public Works, 2008). Additionally, the World Health Organization (WHO) recommends that each city inhabitant should have access to at least 9 m² of green space (OECD, 2013). In Japan, the Nishinomiya city government mandated that each residential

area should have a green space ratio, defined as the proportion of vegetation to visible land area, of at least 15% (Susaki and Kubota, 2017).

In this study, we used satellite remote-sensing to elucidate the current status of green space around children in elementary schools in Malang, Indonesia, and discuss ways to improve access to green space.

MATERIALS AND METHODS

Study Site

Our study site was Malang, the second largest city in East Java, Indonesia (Fig. 1). Malang has an area of 110.06 km², and is surrounded by mountains and mountain ranges, including Mt. Bromo, Mt. Butak, Mt. Arjuna, and Mt. Semeru. Malang comprises a large southern plateau, northern fertile highlands, an eastern plateau with less fertile soil, and a vast western plateau (Pemerintah Kota Malang, 2018). The downtown area is located at the center of the city. According to the 2010 census, the population of Malang is 820,243, and widely dispersed throughout the city. The population has doubled over the last 40 years, and is estimated to reach 874,890 in 2020 (Badan Pusat Statistik, 2015). The economy in Malang has been growing steadily, and the local government has been unable to control the urbanization process and related population growth and urbanization (Ramdani et al., 2015). In 2003, the city was composed of 54.48%

Fig. 2 Green spaces detected using the maximum-likelihood method to classify the RapidEye satellite image (gray area). Points represent the locations of elementary schools.

vegetation, 7.25% open land, and 38.27% constricted land (Purwanto et al., 2016). Ten years later, the composition changed to 35.54% vegetation, 2.41% open land, and 62.05% constricted land (Purwanto et al., 2016). During this period, west and south-east Malang started to develop as well.

Location of Elementary Schools

We obtained the names and addresses of 330 elementary schools in Malang (Malang District Board of Education, 2018). Based on these addresses, we conducted a visual assessment of each location using satellite images hosted by Google Earth Pro and Google Street View, and the latitude and longitude of each elementary school was recorded. The locations of 291 Malang

schools were conclusively identified (Fig. 2). The locations of 39 schools could not be determined conclusively.

Detection of Green Spaces around Elementary Schools Using Remote-sensing

Green spaces were detected using a RapidEye satellite image, which was acquired on May 20, 2015, and covered the study area at a spatial resolution of 5 m (Fig. 1). After normalized difference vegetation index (NDVI) values were calculated using red (630–680 nm) and near infrared (760–850 nm) bands, the NDVI layer were combined with red, green (520–590 nm) and blue (440–510 nm) bands. The supervised classification, which was maximum likelihood classifier, was applied for a combined

Table 1 Accuracy of classification of land cover types on the RapidEye satellite image acquired on May 20, 2015

		Interpretation on Google Earth				User's accuracy (%)
		Woody vegetation	Non-woody vegetation	Built-up	Bare land	Total
Testing data	Woody vegetation	39	8	0	3	50
	Non-woody vegetation	5	41	1	3	50
	Built-up	2	2	44	2	50
	Bare land	0	10	7	33	50
	Total	46	61	52	41	200
Producer's accuracy (%)		84.8	67.2	84.6	80.5	

Overall accuracy = 78.5%, Kappa = 0.71

image. Land cover was grouped into four categories: Woody vegetation, Non-woody vegetation, Built-up and Bare land. In our dataset, 40 polygons were used for classification training, and 200 points were used to assess classification accuracy. Training and testing data were manually annotated by visually interpreting photographs obtained from Google Earth Pro and Google Street View. A confusion matrix was constructed by comparing test data with predicted values to quantify overall accuracy and the kappa coefficient (Congalton, 1991; Forestry and Forest Products Research Institute, 2012; Story and Congalton, 1983). We defined woody vegetation and non-woody vegetation as green spaces. Image processing and pre-processing, such as converting digital numbers to top-of-atmosphere reflectance, were carried out using ERDAS IMAGINE 2016 (Hexagon Geospatial).

We generated a circle with a radius of 1 km from the center of each school, and the green space area within these circles was calculated using ArcGIS 10.0 (ESRI). The reported walking rate of children is 4.3 km/hr (McDonald, 2008); thus, distances of 1 km can be covered by children within approximately 15 minutes.

RESULTS AND DISCUSSION

Detection of Green Spaces Using a Satellite Image

The overall accuracy was 78.5%, and the kappa coefficient was 0.71 (Table 1). The accuracy of detecting green spaces improved to 86.3% when woody vegetation and non-woody vegetation were combined as green space in urban areas. The green space detected on our map is displayed in Fig. 2.

Smaller green spaces were located in the city center, whereas larger green spaces were located in the southeastern part of the city. Total green space area in Malang was 45.43 km² and the overall green space ratio was 41.3%. The per capita green space area was 55.38 m². The green space area in Malang is larger than the area guidelines proposed by WHO and the city of Nishinomiya (Susaki and Kubota, 2017). In contrast, the capital of Indonesia, Jakarta, which is also the largest city in Indonesia, has 7.08 m² of green space per inhabitant (Kirmanto et al., 2012) and far fewer green spaces than Malang.

Fig. 3 Distribution of the green space ratio within 1 km radius circles around elementary schools.

Status of Green Space around Children in Malang

The average green space ratio within 1 km radius circles around each school was 26.7% (0.84 km²). Although the governments of Indonesia (Ministry of Public Works, 2008) and the city of Nishinomiya (Susaki and Kubota, 2017) did not specify the optimal green space area for children in their regulations, we may be able to use their recommendations as guidelines for Malang. Thus, we categorized green space area into three grades based on 15% increments in the green space ratio within 1 km of each school (Fig. 3). The green space ratio was <15% around 96 schools, and 15–30% around 104 schools. Our results suggest that nearly 70% of the elementary school children in Malang have little access to green space, even though experiences in nature during childhood are important for forming adult environmental opinions (Ewert et al., 2005; Jim and Shan, 2013). Because schools near the city center tended to have lower green space ratios (Fig. 4), children living near the city center may have less daily access to nature.

Fig. 4 Green space ratios (%) within 1 km radius circles around each elementary school in Malang.

Recommendations for Improving the Green Space around Children in Malang

Green space is important for childhood development (Coolen and Meesters, 2012; Glackin and Jones, 2012; Ioja et al., 2014; Jansson et al., 2016; Kweon et al., 2017; Mizuki and Minami, 2003; Richardson et al., 2017; Seeland et al., 2009; Wu et al., 2014). Although elementary schools near the city center had less green space surrounding them, the green space ratio within 1 km of each school was more than 30% for schools located on the periphery of the city. Because Malang is highly urbanized, there is little open land left, and these green spaces should be conserved. To do this, the city's residents could lead conservation efforts (Sesanti et al., 2011) in cooperation with private companies. For example, some urban parks in Malang are maintained in partnership with private companies as part of their program of corporate social responsibility (Kurniawati et al., 2017). It is necessary to provide opportunities to stay in green spaces also should be considered. According to the 2016 Malang Regional Policy, 81 green spaces have been designated as urban parks, and 7 green spaces are described as urban forests (Malang City, 2016). These 88 parks and forests can complement the green space available on the periphery of the city to provide children with greater access to green space. The use of these green spaces should be more promoted. From this point we might go on to an even more detailed examination of the usage of green spaces in our future research.

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