# Ph.D. Thesis

Urban Green Space for Children: Identifying and Assessing the Green Space for Elementary School Children in Malang, Indonesia（子どものための都市緑地 : インドネシア・マランにおける小学生のための緑地の特定と評価）

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## 1. General introduction

Green space can be subdivided into publicly accessible and private green; or into natural, agricultural and urban green (Klompmaker et al., 2018). Variance in greenness within the surrounding area can also be used as a green space measurement (Pereria et al:, 2013). Urban green space is defined as: public goods that allow free access and represent pockets of nature for all residents and are maintained by public agencies for citizens leisure and recreation (Contesse et al., 2018). In Indonesia, green space is categorized into public and private green space and thus includes: park, forest, green belt (green area full of trees between two different land use, forest, garden, mixed garden, agriculture area), green space between the road, green space for pedestrian walk, green space below the fly-over road and green space for particular use (Indonesian Ministry of Public Works, 2008).

Green spaces are an integral part of any city (Belmeziti, et al., 2018) and are very important because they provide ecosystem services which include supporting services, regulating services and cultural services (MEA- Millennium Ecosystem Assessment, 2005). Urban green space also offers a wide range of other urban services, such as, a space where families and individuals can relax, areas of natural beauty where city dwellers can learn about nature and spaces in which to practice sport (Hofmann, Westermann, Kowarik, & van der Meer, 2012; Lindholst, 2009). Urban green space is considered as ecological elements within cities (Luederitz et al., 2015, p2).

Green space has many benefits for children's physical and mental wellbeing. Exposure to greenness at home and school can improve children's cognitive development (Dadvand et. al., 2015)

and decrease spectacle use for children (Dadvand et. al., 2017). Green space with treed area contributes in increasing children's physical activity (Janssen & Rosu, 2015) and academic performance (Kweon et. al., 2017, Hodson & Sander, 2017). Green space such as park and private garden were important especially for children in low-education household (Richardson et. al., 2017).

Green space in any kind of form, can also provide a place to learn about nature. Green space in form of urban forest can increase children's knowledge about native animals in their environment (Sampaio et.al., 2018), meanwhile green space in form of urban gardening serve as a place for children to learn about science in real world (Fusco, 2001). Green space also serves children as a place for direct experience in nature. Children who have direct experience in nature show more willingness to support conservation effort, whether they live in urban or rural area (Zhang et.al, 2014).

In developing countries, such as Indonesia, city which undergoing rapid urbanization often destroy or degrade the green space for other land uses (Heynen, Perkins, & Roy, 2006). Rapid urbanization also said to prevent children's play experiences in outdoor environments (Kernan, 2010).

The purpose of this study was to identify and assess the green space for elementary school children in Malang, Indonesia. This study was divided to the two following sections.

(1) The current status of green space around elementary schools: a case study of Malang, Indonesia

(2) The actual use of green spaces by children and parents in Malang, Indonesia

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## 2. The current status of green space around elementary schools: a case study of Malang, Indonesia

### 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; Mass 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 interacting 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 proportion 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% 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 southeast 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 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 (McDonalds, 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 Figure 2.

Smaller green spaces were located at 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.

### *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.

***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. Form 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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* English title is tentative translation from original Indonesian title by the authors of this paper.

**Table**

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

| | | Interpretation on Google Earth | | | | | |
|---|---|---|---|---|---|---|---|
| | | Woody vegetation | Non-woody vegetation | Built-up | Bare land | Total | User's accuracy (%) |
| Testing data | Woody vegetation | 39 | 8 | 0 | 3 | 50 | 78.0 |
| | Non-woody vegetation | 5 | 41 | 1 | 3 | 50 | 82.0 |
| | Built-up | 2 | 2 | 44 | 2 | 50 | 88.0 |
| | Bare land | 0 | 10 | 7 | 33 | 50 | 66.0 |
| | Total | 46 | 61 | 52 | 41 | 200 | |
| | Producer’s accuracy (%) | 84.8 | 67.2 | 84.6 | 80.5 | | |

**Figures**

Fig. 1. Location of Malang, Indonesia (gray area).

Fig. 2. Green spaces detected using the maximum-likelihood method to classify the RapidEye satellite image (gray area).

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

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

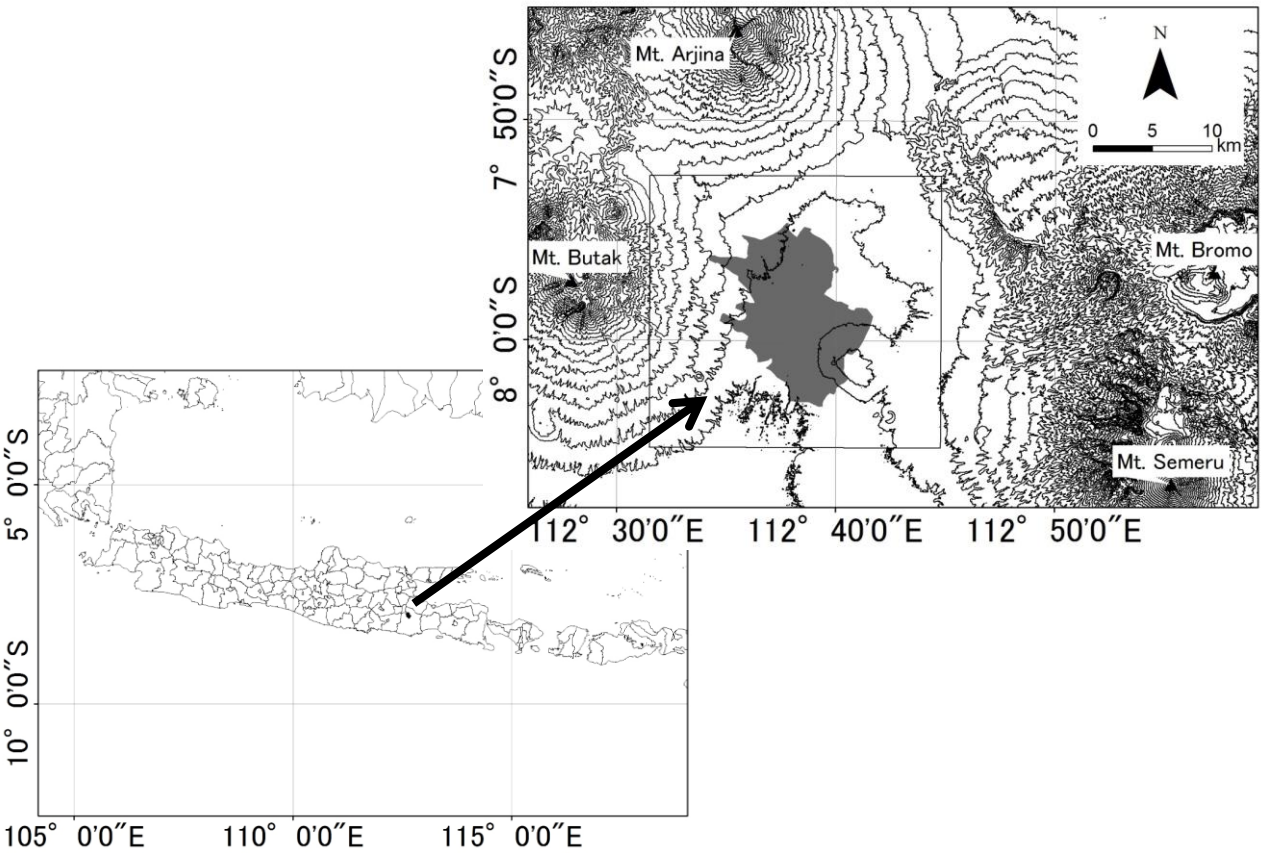


Fig. 1. Location of Malang, Indonesia (gray area). The delineated area is that covered by the satellite image. The 100-m interval contour lines were generated using a digital surface model (DSM) and data obtained from the Advanced Land Observing Satellite (ALOS). The city is surrounded by mountains and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

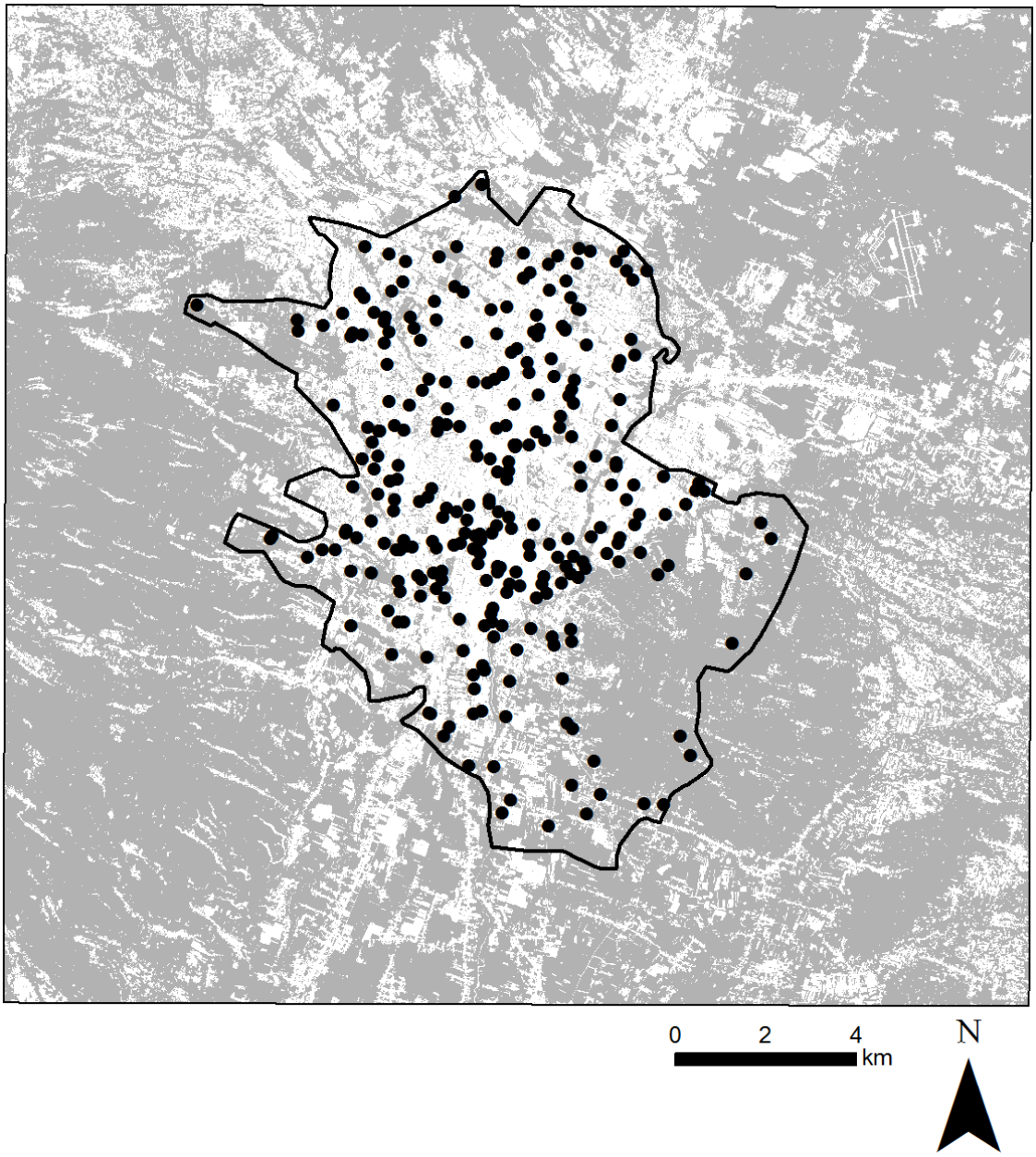


Fig. 2. Green spaces detected using the maximum-likelihood method to classify the RapidEye satellite image (gray area). Points represent the locations of elementary schools.

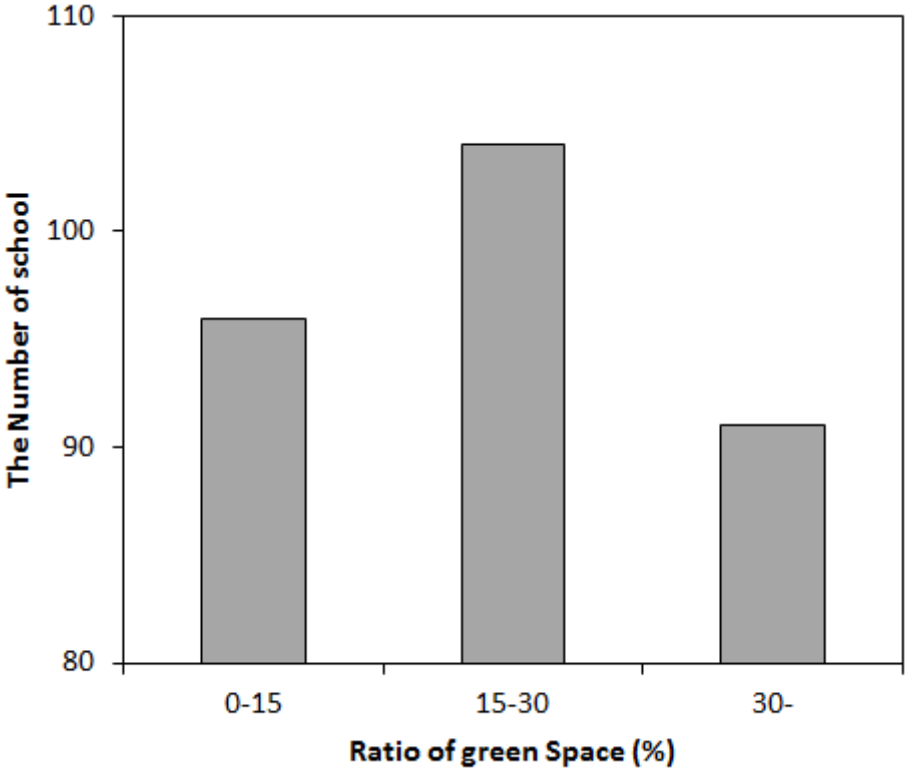


Fig. 3. Distribution of the green space ratio within 1 km radius circles around elementary schools.

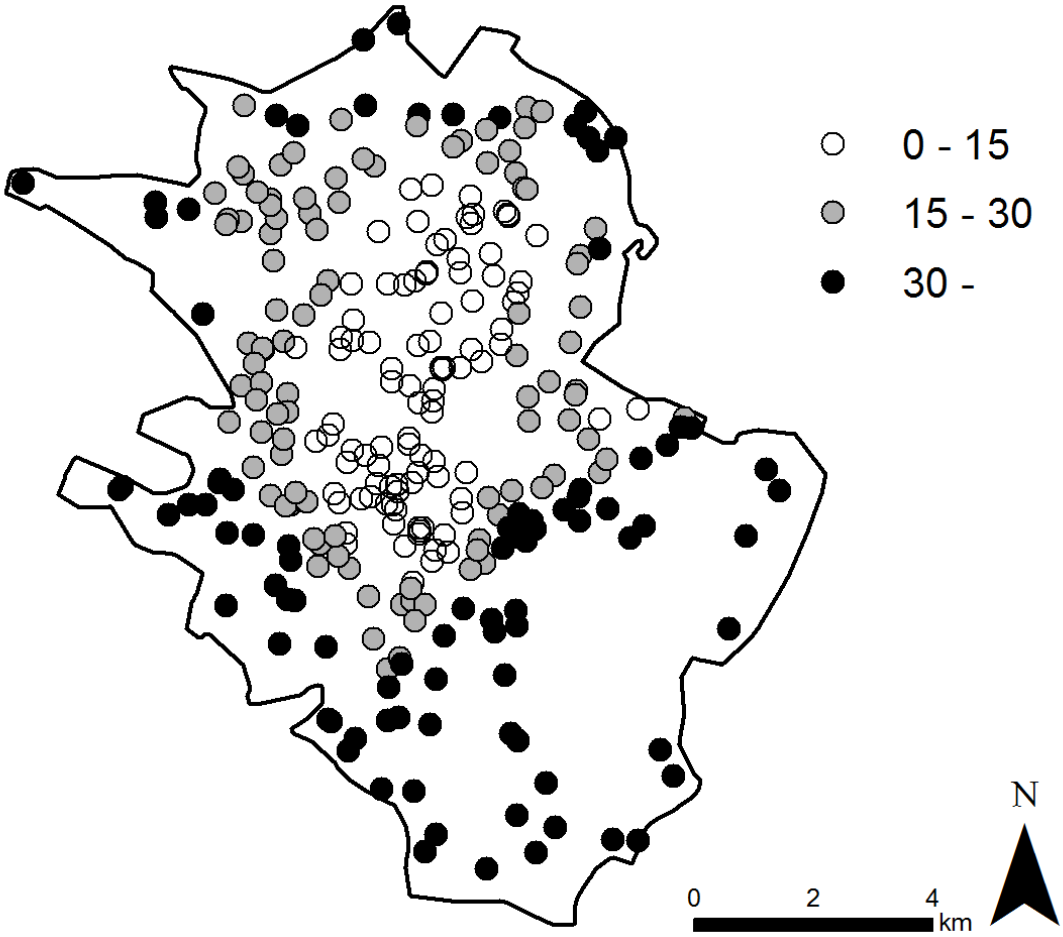


Fig. 4. Green space ratios (%) within 1 km radius circles around each elementary school in Malang.

## 3. The actual use of green spaces by children and parents in Malang, Indonesia

### Introduction

Urban green spaces have provided very important near-natural environments for urban children. Activities in green spaces have positive effects on the physical and psychological health of children (Bell et al. 2008; Barton & Pretty 2010; Almanza et al. 2012; Dadvand et al. 2018). Green spaces are a place for exploration and playing for children whether it was managed or unmanaged (Jansson et al. 2016). Green space also contributes as a place to experience nature (Coolen & Meesters 2012) and for making friends (Seeland et al. 2009). Wu et al. (2014) and Kweon (2017) showed that children who study in school environments with more trees tended to perform better academically.

In developing countries green spaces are often destroyed and degraded for other land uses (Byomkesh et al. 2012; Ramdani et al. 2015; Agaton et al. 2016; Herwirawan et al. 2017). Due to rapid urbanization, Indonesian cities are suffering from a lack of green space. Green spaces in big cities such as Jakarta, Bandung, Surabaya, and Medan have decreased from 35% on average to less than 10% nowadays (Kirmanto et al. 2012). Along with the rapidly growing population, the area of green space per capita is also very low, for example, Jakarta has merely 7.08 m2 GS/capita, compared to Stockholm (80 m2), New York (30 m2), and Paris (15 m2) (Kirmanto et al. 2012). In this case, Indonesian cities could not meet the standard of World Health Organization (WHO) which recommends cities to provide a minimum of 9 m2 of green area/capita (Reyes et al. 2014). With more

than 53.7% of the population already lived in urban areas since 2015 (World Bank 2016) and will rise to 70% in 2050 (United Nations 2014), Indonesia must work very hard to provide green space for the citizen. Within this situation, Indonesian children, especially those in an urban area will lose the benefit provided by green space if the green space continues to decrease.

At the same time, urbanization has been thought to decrease nature related experience for children (Shanahan et al. 2017; Soga et al. 2018). The high proportion of urban areas are made of artificial material and is segregated from a natural system and process (Soga & Gaston, 2016; White et al. 2018). For the children, recent urban expansion and densification have reduced the availability of their neighborhood natural places (Turner et al. 2004; Neunoven et al. 2007; Zhang et al. 2014; Soga et al. 2016). Sedentary activities such as watching TV and playing with toys are more famous for children (Singer et al. 2009), and these activities decreased children's available time to engage with nature (Hoffert 2009; Singer et al. 2009). Children and youth in cities around the world are also increasingly cut off from enjoying their neighborhoods because their parents worried about safety (Gaster 1991; Johnson & Hurley 2002). Open spaces or playground sometimes not located nearby, and children need to cross the main road (Othman & Said 2012), and this is also one reason that increases parent's anxiety about letting their children play in green space.

Despite all the constraints above, children in some countries were found to use and play in green space actively. Previous studies have reported children's use of green space in developed countries. Tandy (1999) reported 23% of children aged between 5 and 12 years in urban Australia

liked to play at parks. In another similar study in Australia, 41% of children aged between 8 and 12 years preferred to play in open areas, natural areas, parks and playgrounds (Cunninghum et al. 1996). As much as 68% of boys' and 50% of girls' activities were in outdoors in the Omaha, USA (Cherney & London 2006). In Helsinki, children chose natural settings as favorite place although they were fewer compared to the sport and residential settings (Korpela et al. 2002), a contrast to Northern New Mexico where children still chose mountains and natural places (such as rivers, rocks, and ditches) as their favorite place (Derr 2002).

Unfortunately, studies about children's use of green space developing country such as Indonesia is very limited. Former research about green space in Malang, Indonesia mostly focused on green space availability and its function for ecosystem services such as providing oxygen (Mbele & Setiawan 2015), reducing CO2 emission (Andriono et al. 2013), improving thermal comfort (Sunaryo 2015), and biodiversity conservation (Nisa et al. 2013). Study about green space around children's environment is very difficult to find. As the increase of urbanization and population continue in Indonesia (Arifin & Nakagoshi 2011; Agaton et al. 2016), it will be very important to understand how children in urban area use green space. We also need to pay attention to parents, who are significantly affected children's use and perception of natural places, including green space (Soga et al. 2018). Thus, in our study, we investigated the actual use of green space by parents and children in Malang, Indonesia. Our study aimed to understand the correlation between available green

space around children's neighborhood (measured by satellite image analysis) and the actual use of green space by children and parents (measured by questionnaires).

## Materials and Methods

### *Study Site*

Malang is the second largest city in East Java (Figure 1), with a total area of 110.06 km2. The city is surrounded by mountains and mountain ranges, including Mt. Bromo, Mt. Butak, Mt. Arjuna, and Mt. Semeru. The southern part of Malang is a large plateau, the northern part is a fertile highland, the eastern part is a plateau with less fertile soil, and the western part is a vast plateau (Pemerintah Kota Malang 2018). The population was 820,243 based on the 2010 Census and had doubled in 40 years. It was estimated to reach 874,890 in 2020 (Badan Pusat Statistik Kota Malang 2015). Economic and population growth have been marked with steady in Malang, and the government has been unable to control the urbanization process and related population growth and urbanization (Ramdani et al. 2015). Urbanization in Malang with increasing of the housing area and decreasing agricultural and forested land is happening in the uncontrolled situation, and urban area cover increased from 21% in 2001 to 40% in 2014 (Ramdani et al. 2015). The rapid urbanization in Malang has resulted in a steady decrease in green space in the city. Our previous study reported that green space ratios around elementary schools in Malang, which was a circle of 1 km radius, were extremely low in the center of the city, which was under 15%. It would be difficult to generate more green spaces because of limited spaces. Therefore, we concluded that it is necessary to provide opportunities for children to spend in green spaces in Malang (Hartatik & Itaya 2016).

***Detection of green space near elementary schools using remote sensing***

As living environments of respondents, land cover distribution near elementary schools were detected using the RapidEye satellite image acquired on 20 May 2015. It was a 5-m ground spatial resolution (Figure 1). After normalized difference vegetation index (NDVI) values were calculated using red (630–680 nm) and near-infrared (760–850 nm) bands, it was combined with red, green (520–590 nm) and blue (440–510 nm) bands. The supervised classification, which was maximum likelihood classifier, was applied for the combined image. The four categories of land covers were set up: woody vegetation, non-woody vegetation, built-up, and bare land. Then, 40 training data for the classification and 200 testing data for accuracy assessment was collected represent the four land covers categories. Training data and testing data were collected by photo visual interpretation on Google Earth Pro and Google Street View. The whole image processing was carried out by ERDAS IMAGINE 2016 (ERDAS) including prior processing such as converting from the digital number values to top-of-atmosphere reflectance. Overall accuracy was 78.5%, and Kappa was 0.71 for the result of classification (Story & Congalton 1983; Congalton 1991).

As the daily living area of children, the areas of green spaces in the 2 km radius zones of five schools were calculated. The reported walking rate of children is 4.3 km $h^{-1}$ (McDonalds 2008), and thus 2 km can be walked in approximately 30 minutes.

***Questionnaire survey for children and their parents***

A questionnaire survey was conducted in November 2016 to understand the actual use of green spaces by children and their parents in Malang. Malang is divided into five administrative sub-districts called kecamatan. One elementary school was chosen randomly from each kecamatan. Questionnaires were given to 30 children in grade five at each of the five elementary schools. Their parents received the questionnaires via their children.

The children were asked, their gender, whether they like to play outside, green spaces where they usually play, and green spaces where they like to visit. Their parents were asked, places where they recognized as green spaces, green spaces near their home, and green space where they visit with their children. They were also asked about their home address (sub-district and village name), their socioeconomic background including their age, education level, and income.

In this study, the actual use of green space by children and parents were understood through questionnaires, and then the strategy for increasing green space and opportunity to use green space were discussed

## Results and Discussion

### *General information on the respondents*

Figure 2 and Figure 3 show land cover types around five elementary schools in Malang. They share certain similarities in that composition of built-up and bare land except for school A. The area of built-up and bare land in the 2 km zone around school B, C, D, and E were more than 75%, meanwhile the area of woody vegetation and non-woody vegetation that is considered as green spaces around school A was close to 70%. Children in school A were surrounded by richer green spaces than other schools.

Table 1 shows the number of questionnaires collected and the general information of the respondents. A total of 147 (98.0%) questionnaires were received from the children and 145 (96.7%) from their parents. More girls replied than boys, because of the gender distribution. The average age of the parents ranged from 39.2±7.67 to 41.0±5.62 years for the five schools. Many parents of the children in schools A and E had relatively high income and education levels compared with schools B, C, and D (Figures 4 and 5).

### *The actual use of green spaces by children and their parents*

Almost all of the children liked to play outside (86.7–100%). After school, they usually played in parks (65.5–100%) and open fields (51.7–96.7%). In school A, they stayed in gardens (86.7%) as well (multiple answers, solid lines in Figure 6). Children chose multiple types of green spaces for

playing (2.2–4.2 on average). Children in school A chose significantly more places than school C and D (Steel-Dwass test, $p < 0.01$). Children in school E chose significantly more places than school D (Steel-Dwass test, $p < 0.05$). There was no significant difference between schools B, C, and D and between A and E (Steel-Dwass test, $p > 0.05$). Many children preferred to play in parks (51.7–90.0%) and open fields (41.4–80.0%). They usually played in places where they like. In school A, they liked to play in gardens as well (multiple answers, broken lines in Figure 6). Children chose multiple types of green spaces as favorite places (1.6–3.0 in average). Children in school A chose significantly more places than school B, C, and D (Steel-Dwass test, $p < 0.01$, 0.05). Children in school E chose significantly more places than school D (Steel-Dwass test, $p < 0.05$). There was no significant difference between schools B, C, and D and between A and E (Steel-Dwass test, $p > 0.05$).

Many parents recognized parks (70.0–93.9%) and forest (37.9–86.7%) as green spaces (multiple answers, Figure 7). In school A, paddy fields/agriculture (70.0%) and garden (70.0%) were recognized by parents as well. Parents chose multiple types of green spaces as green spaces (2.6-4.5 in average). Parents in school A chose significantly more places than school C and D (Steel-Dwass test, $p < 0.05$). There was no significant difference between schools B, C, and D and between A and E (Steel-Dwass test, $p > 0.05$). Parks (57.7–93.2%), forests (38.5–79.3%) and garden (72.4%) were more identified as the green spaces near their homes (multiple answers, solid lines in Figure8). Parents in school A and E identified forests more than other schools. Parents chose multiple types of green spaces near their homes (2.2–4.8 in average). Parents in school A chose significantly more

places than school B, C, and D (Steel-Dwass test, $p < 0.05$), and parents in school E chose significantly more places than school D (Steel-Dwass test, $p < 0.01$). There was no significant difference between schools B, C, and D and between A and E (Steel-Dwass test, $p > 0.05$). Many parents visited parks (64.0–89.7%), forests (34.0–72.4%) and gardens (55.2%) with their children (multiple answers, broken lines in Figure 8). Parents who chose open fields were fewer than children. Parents in school A and E visited forests more than other schools. Paddy fields/agriculture (65.5%) and open field (62.1%) were more chosen by parents in school A. Parents chose multiple types of green spaces (1.8-3.9 in average). Parents in school A chose significantly more places than school B, C and D (Steel-Dwass test, $p < 0.01$, 0.05), and parents in school E chose significantly more places than school C and D (Steel-Dwass test, $p < 0.05$). There was no significant difference between schools B, C, and D and between A and E (Steel-Dwass test, $p > 0.05$).

Some study reported that accessibility to green spaces is often highly stratified based on income, ethnic-racial characteristics, age, gender, ability, and other axes of difference (Byrne et al. 2009; McConnachie & Shackleton 2010). In our study, the parents of children in schools A and E had higher income and education levels, while there was less green space near school E compared with school A. Schools B, C, and D, where the parents' income and education levels were moderate, and there were small green spaces around them. These backgrounds might affect the number of choice for questions with multiple answers. Children and their parents in school A and B chose more options

for each question than other schools. The higher income and education levels might make extend choice variety.

While there were few green spaces around schools in Malang, especially in the center of the city, fortunately, children liked to play in the outside more than other studies (Cunninghum et al. 1996; Derr 2002; Tandy 1999; Cherney & London 2006). However, children preferred to spend their time in well-maintained or level areas, such as parks and open fields. In Indonesia, outdoor sports such as football are very popular among children and adults. Therefore, children might prefer open spaces regardless of vegetation quantity. Parents also preferred to spend their time with their children in parks. Although their parents had also visited forests with children, it might be not frequent enough for children. Refshauge et al. (2012) reported that the variety of facilities in parks is an important factor motivating parents to bring their children. Lin et al. (2014) suggested that it is important that measures to increase people's connection to nature to encourage park visitation. Experiences with nature during childhood influence environmental views in their life (Ewert et al. 2005; Jim & Shan 2013). Natural kindergartens and forest schools have provided such opportunities in Europe and the United States (MacEachren 2013; Elliott & Chancellor 2014). Glackin and Jones (2012) suggested that local green spaces should be used for teaching and learning science through the study in south London. The essential qualities of children's favorite places were accessibility and a location within the route from home to other destinations (such as a friend's house or school) (Prakoso 2018). It might be important to provide parks with enough vegetation and attractive program within their living area

in order to make them use green spaces. Recently, the cooperation with companies as CSR program for maintains urban parks have been progressed in Malang (Kurniawati et al. 2017). Developing environmental education programs cooperating with these companies might be possible. Since parents' income and educational levels influenced the variety of choices for green spaces, the developed program should be opened to everyone. It should be noted that urban planner should develop parks based on children preference because children have a different view from adults about their outdoor environment (Oloumi et al. 2012).

Based on the results of our study, it was clearly understood that the distribution of green space around elementary schools in Malang is not equal (Figure 2, Figure 3). Due to this unequal green space distribution, children also might have unequal access to green space. Strategies to tackle this issue are the management of private green space by local government through social marketing and incentive programs (Shanahan et al. 2014). Malang has private green space around 1,383 ha, which include: parks in resident and housing area, parks around office, and commercial building (institutional parks) (Peraturan Daerah Kota Malang 2011), and these private green spaces are also potential as children’s play spaces.

In this study, we also revealed that parents were more actively used urban forest compared to children (Figure 6, Figure 7). This result may be related to children's preference for the outdoor environment. The urban forest is lacking amenities and facilities for children's play, and challenging play equipment is an important factor that attracts children to play outdoors (Aziz & Said 2012).

Parental concern about safety in the urban forest may prevent children to use it because parent's attitude about the natural environment was said to have a significant impact on children's attitude (Soga et al. 2018). In this situation, parents in Malang should show a more positive attitude towards the urban forest, for example by taking their children to visit the urban forest. They can also suggest their children go with peers because children are much more likely to play outdoors if they have friends or other children of the same age to play with (Aziz & Said 2012).

Schools also must play an important role in encouraging children to use green space around them. Schools can cooperate with green space manager or local government to use public land near schools (such as park and urban forest) and those existing green space maybe revitalized through a school-based program (Johnson & Hurley 2002). For study purpose, local green space can be used for teaching and learning science (Glackin & Jones 2012). If a school has lack of school green area or has small school green area, they can redirect their green curricula project towards public green space, especially if the green space is located near the school (Ioja et al. 2014).

In general, strategy for increasing urban green space can include (Ministry of Public Work 2016): 1) enforcing the regulation about land use change, existing green space must not be changed to other land use, 2) acquisition of land for new green space by local government, 3) developing green space corridor which can act as parks connector, green space corridor can be made by planting more trees along waterways, road, and pedestrian, 4) acquisition of private green space and make it into public green space, 5) developing green wall/green roof for area with limited green space, 6) creating

new regulation that supports for green city development, and 7) creating green community by encouraging local people for more actively engage in urban green space. Previous study by Haaland and Bosch (2015) also suggested similar strategies for provision of urban green space in compact cities, including: 1) preserving green space, 2) enhancing quality of existing green space, 3) providing green space on redeveloped sites, 4) greening difficult sites lacking green space (narrow streets), and 5) smart allocation to increase visibility and visual quality.

## Conclusion

The actual use of green spaces by children and their parents were found through questionnaires for them in five elementary schools in Malang, Indonesia. While children liked to play outside, their children preferred to spend their time in well-maintained or level areas, such as parks and open fields. Parents also preferred to spend their time with their children in parks. It might be important to provide parks with enough vegetation and attractive program within their living area in order to make them use green spaces. The cooperation with companies as corporate social responsibility program for developing environmental education programs might be effective.

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**Table**

Table 1 Attributes of the respondents from each school

| Schools | Children | | | | Parents | |
|---|---|---|---|---|---|---|
| | Number of answers | Boy | Girl | Unknown | Number of answers | Average age (s.d.) |
| A | 30 | 11 | 19 | | 30 | 39.4 ( 5.47 ) |
| B | 29 | 11 | 17 | 1 | 29 | 40.7 ( 6.56 ) |
| C | 29 | 15 | 14 | | 27 | 39.5 ( 6.43 ) |
| D | 29 | 7 | 22 | | 29 | 39.2 ( 7.67 ) |
| E | 30 | 15 | 15 | | 30 | 41.0 ( 5.62 ) |
| Total | 147 | 59 | 87 | 1 | 145 | 40.0 ( 6.44 ) |

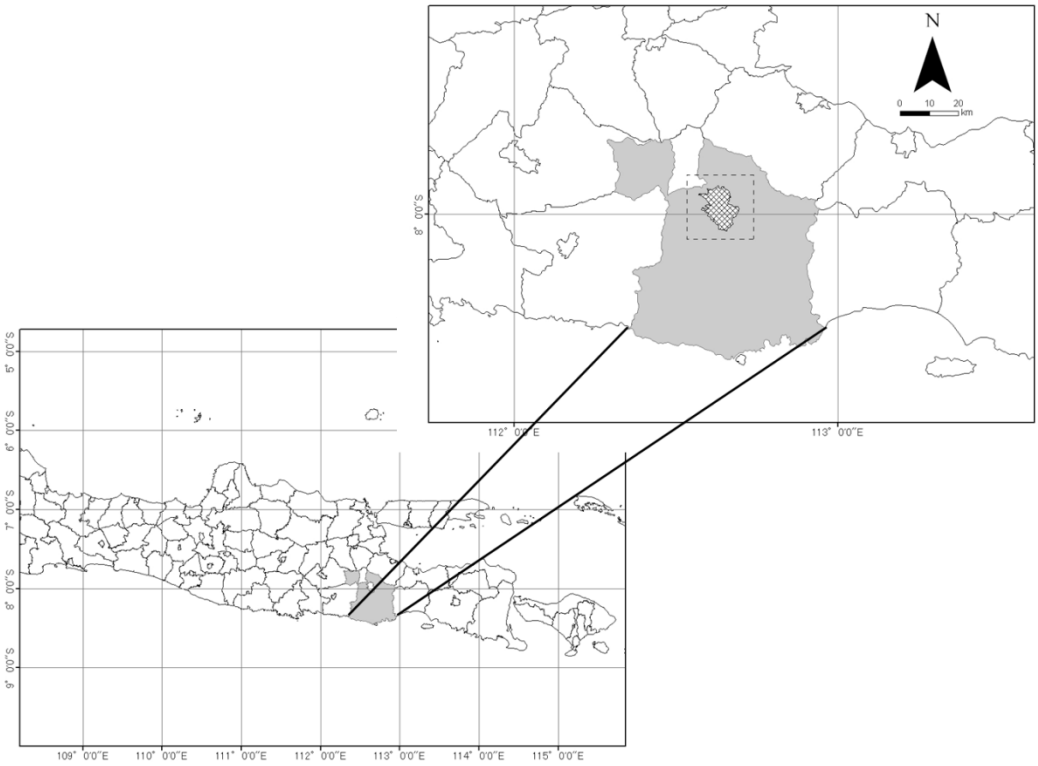


Fig. 1. Location of the study site. Malang (hatched line) is located in the northern part of the Malang Regency (gray area). The area surrounded by the broken line is the area pictured in the satellite image.

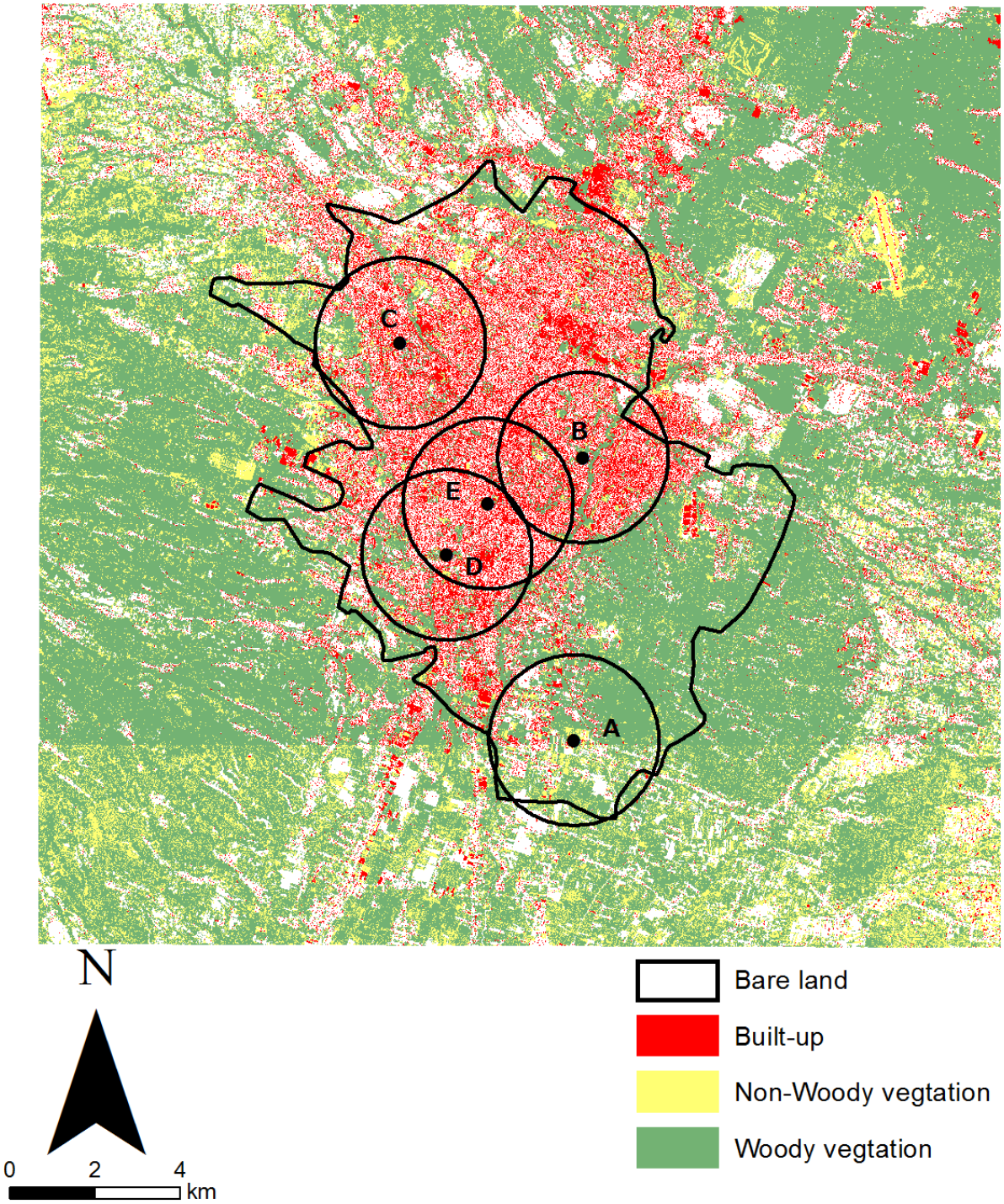


Fig. 2. Land cover types in Malang detected using a satellite image. A to E are the school locations. The circles are the two km zones around the schools. The boundary line shows the boundary of the city.

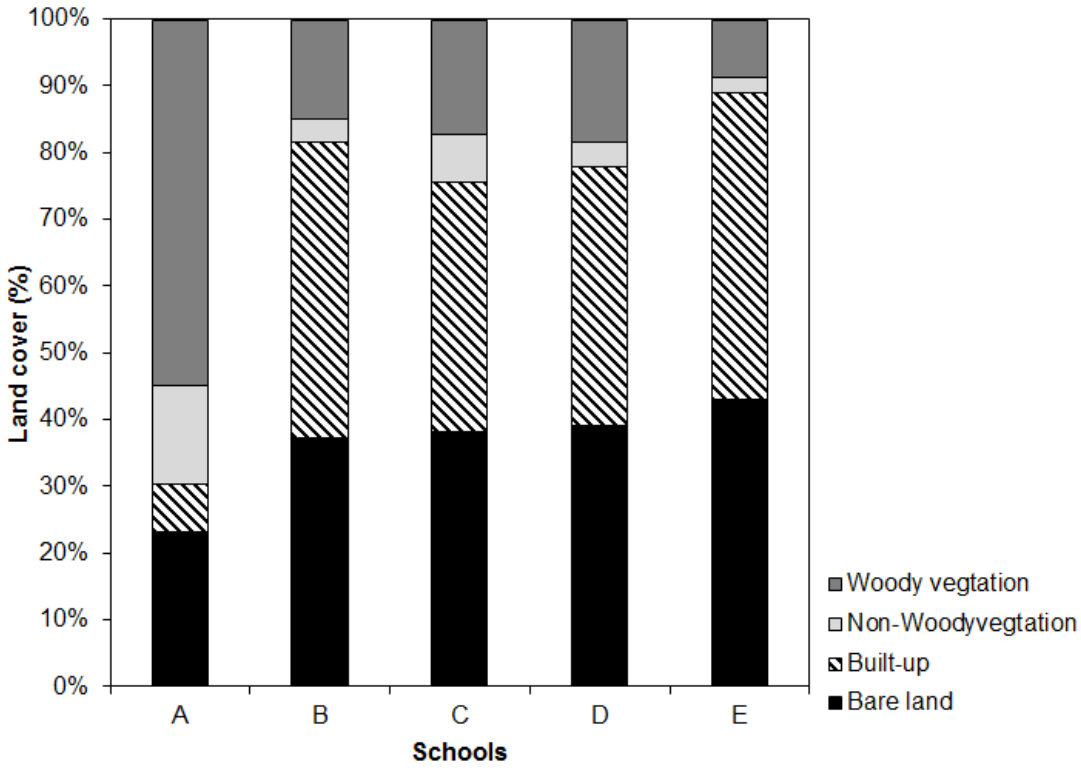


Fig. 3. Land cover types in the two km zones around the schools. There were very few green spaces around the schools, except for school A.

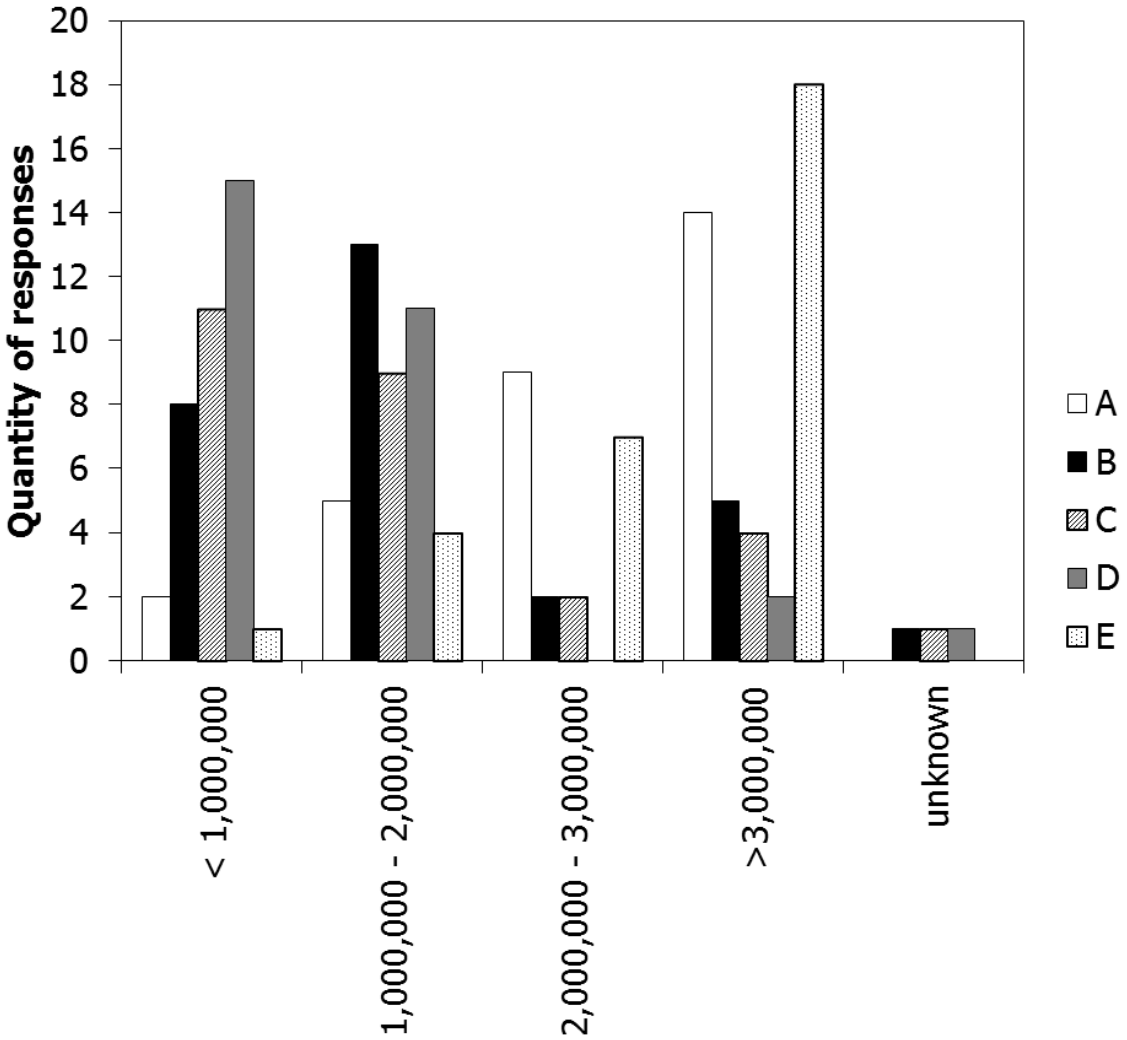


Fig. 4. Distribution of the income levels of the parent respondents. Schools A and E had many parents with relatively high incomes, while schools B, C, and D had parents with moderate incomes.

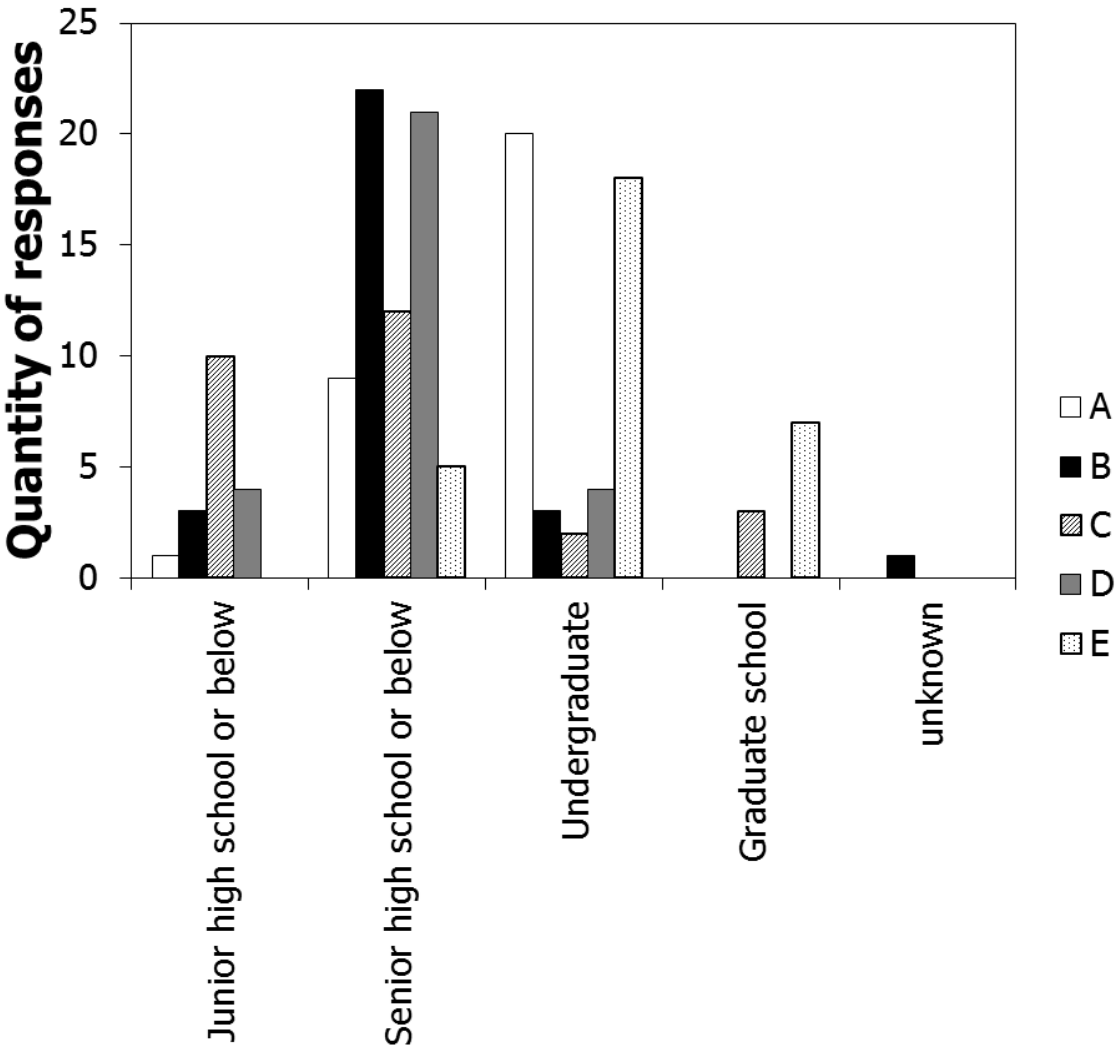


Fig. 5. Distribution of the education levels of the parent respondents. Schools A and E had many parents with relatively high education, while schools B, C, and D had parents with moderate education.

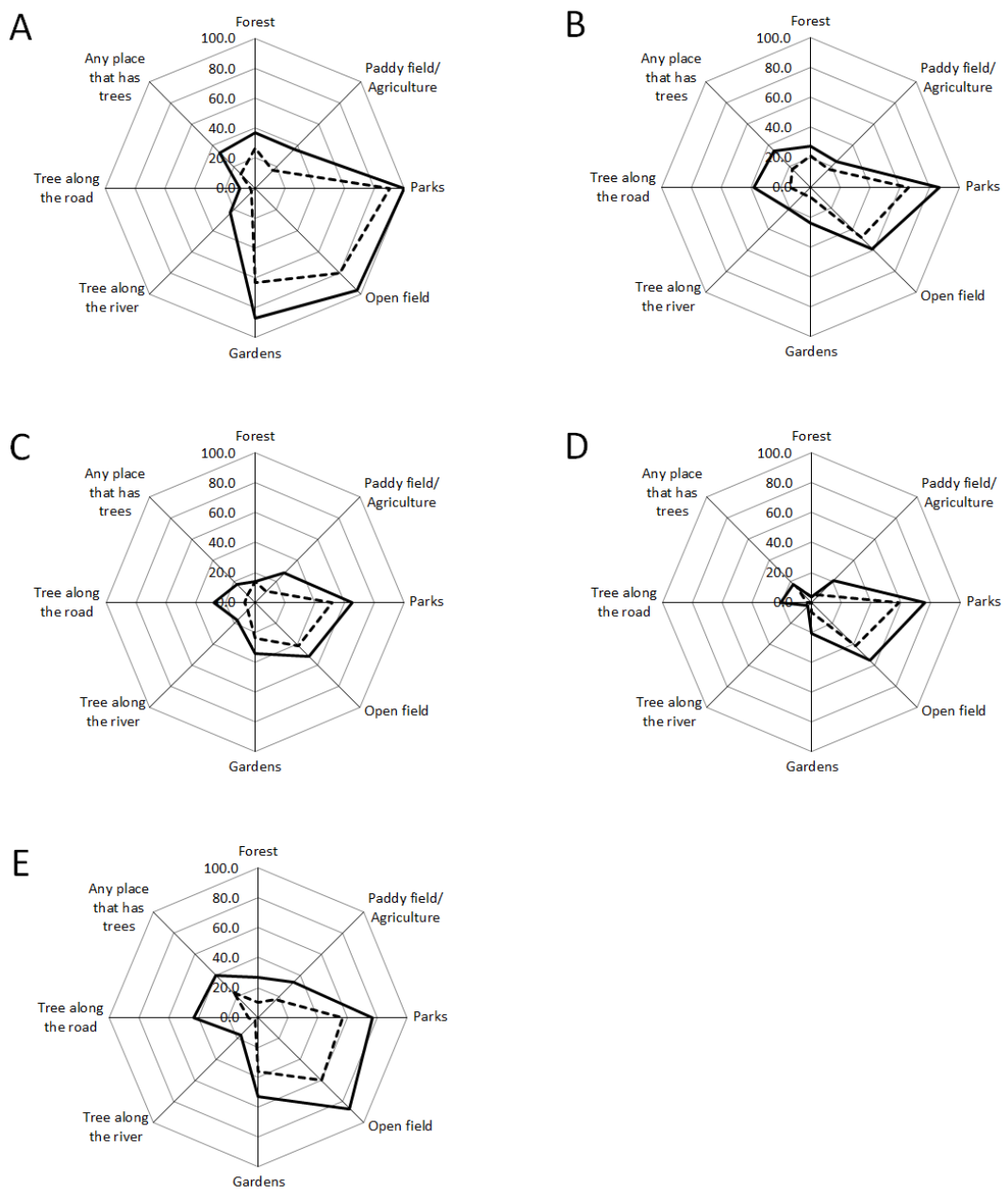


Fig. 6. Answers from children for green spaces where they usually play (solid line, multiple answers) and green spaces where they like to visit (broken line, multiple answers).

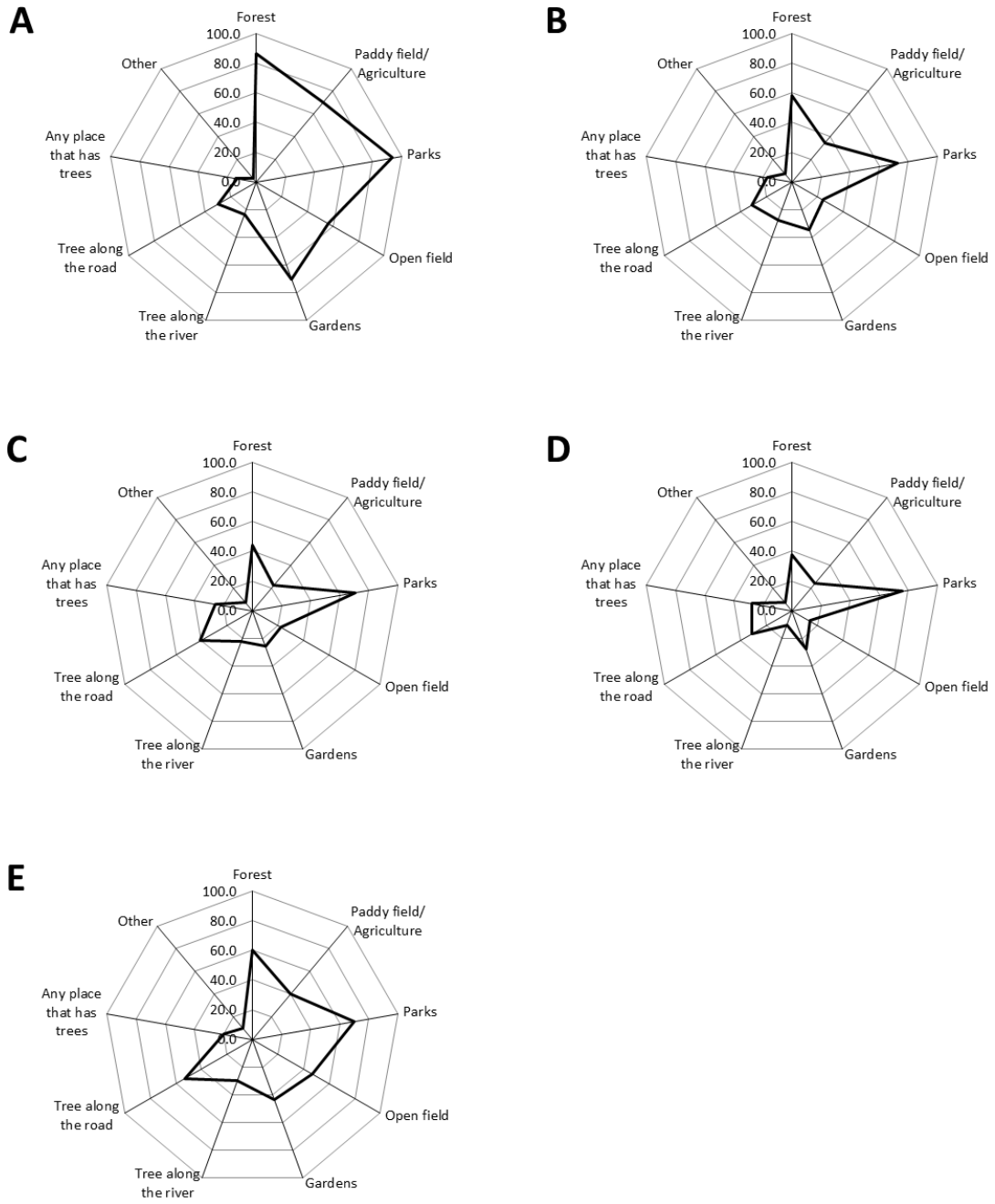


Fig. 7. Answers from parents for places where they recognized as green spaces (multiple answers).

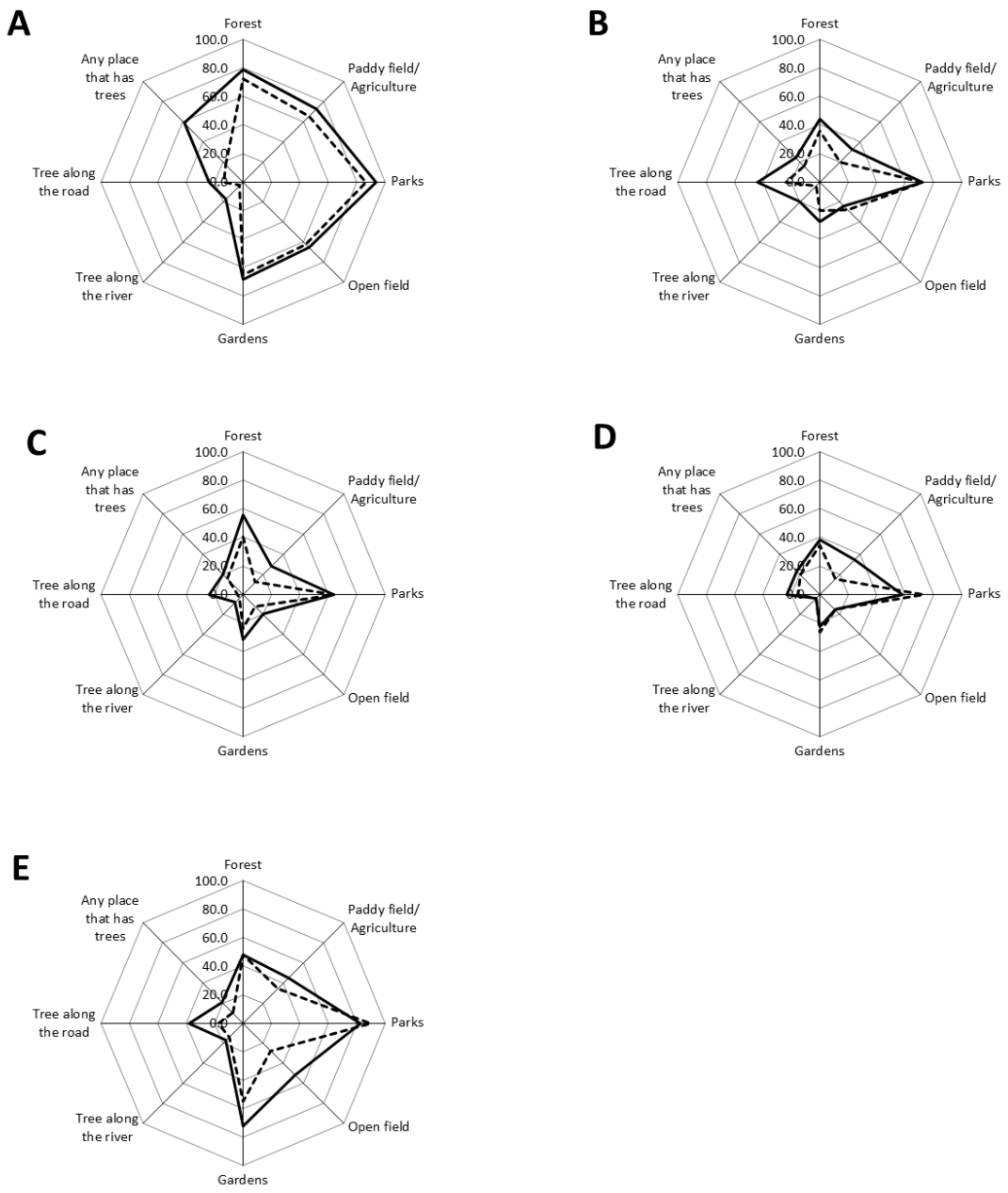


Fig. 8. Answers from parents for the green spaces near their home (solid line, multiple answers) and the green space where they visit with their children (broken line, multiple answers).

## 4. Conclusions

This study provides information for green space management and planning in the future. From this study, we identified and assessed green space around children in Malang, Indonesia. We found the following results from this study.

(1) The current status of green space around elementary schools: a case study of Malang, Indonesia

Total green space area in Malang was 45.43 km2 and the overall green space ratio was 41.3%. Smaller green spaces were located at the city center, whereas larger green spaces were located at the southeastern part of the city. The average green space ratio within 1 km radius circles around each school was 26.7% (0.84 km2). 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. Schools near the city center tended to have lower green space ratios and children living near the city center may have less daily access to nature

Since Malang is highly urbanized and there is little open land left, the green spaces should be conserved. Local government should cooperate with other stakeholders for the provision and management of green space to provide children with more opportunities and access to those green space.

(2) The actual use of green space by children and parents in Malang, Indonesia

From this study we found that almost all the children liked to play outside (86.7–100%). After school, they usually played in parks (65.5–100%) and open fields (51.7–96.7%). Many parents recognized parks (70.0–93.9%) and forest (37.9–86.7%) as green spaces. While there were few green spaces around schools in Malang, especially in the center of the city, fortunately, children liked to play in the outside. However, children preferred to spend their time in well-maintained or level areas, such as parks and open fields.

Based on the results of our study, it was clearly understood that the distribution of green space around elementary schools in Malang is not equal. Due to this unequal green space distribution, children also might have unequal access to green space. Local government must tackle this issue by implementing strategies for managing and maintaining the green space.

**Acknowledgments**

Our deepest appreciation goes to Prof. Ishikawa who provided carefully considered feedback and valuable comments. We are also indebted to Mr. Samsudin of the Board of Education in Malang City whose meticulous comments were an enormous help to us. Finally, we would like to acknowledge the Ministry of Education for the double-degree program between Mie University and Padjadjaran University for a scholarship grant that made it possible to complete this study.