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GIS based analysis for assessing the accessibility at hierarchical levels of urban green spaces

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ABSTRACT

The accessibility to hierarchy (defined based on function and size) of Urban Green Spaces (UGS) is essential for frequent and optimal use of UGS as it promotes social interaction and physical activity among city population. The issue of accessibility to UGS is one of the crucial aspects of sustainable urban planning and it is linked to growing concern over the wellbeing of urban population particularly children and lower socioeconomic groups. The following study presents use of GIS based network analysis to assess the accessibility of UGS at hierarchical levels by applying different network distance to each hierarchy of UGS in a dense and complex urban setting in a developing region. Results show that there is poor accessibility to UGS at all hierarchical levels particularly at lower hierarchy of UGS which is meant for early age children. The large variability in accessibility at all hierarchical levels is also indicative of highly varying and skewed development patterns in the study area. The studies carried out in these regions and approach applied in this study may provide useful tools to planners to identify the deficient areas for future development of UGS for balanced and sustainable planning.

1. Introduction

Urban areas consist of more than half of the world's population and it is projected that by 2030, it may grow up to 60%. However, urban areas are generally characterized by degraded environment, increasing pollution, higher temperatures and decreasing amount of Urban Green Spaces (UGS). UGS are very crucial in improving the quality of life in cities, balancing heat budget and providing thermal comfort (Giannopoulou, 2012; Oliveira et al., 2014; Cetin, 2015) and helping individuals to recuperate from physical and mental stress of our day to day life (Fuller et al., 2007; Grahn and Stigsdotter, 2010; Lee and Maheswaran 2010). Urban green spaces are important or improving the living conditions in urban areas through improving air quality and aesthetics, increasing property values and reducing energy consumption for cooling. UGS can be used as a comprehensive tool for sustainable development of urban areas. (Haq, 2011; Galeeva et al., 2014). UGS also provide much needed spaces for children's to play which is important for their physical, social and cognitive development (Bird, 2009; Amoly et al., 2014).

Different hierarchical levels of UGS are defined by many planning authorities as hierarchy of UGS (Table 1) for social use (Anon., 2010) as they are designed to provide specific functions to particular user group. For example, a totlot (Master Plan of Delhi defines totlot as the smallest unit of UGS for very young children to play), a play space at the doorstep fulfils daily needs of the early age children and quite essential for their overall development. At early age, a beneficial association have been found by researchers between exposure to green space and cognitive development (Dadvand et al., 2015). Similarly, a neighbourhood park and community park allows the people to have multiple activities with family members and a city level park or countryside provides an opportunity for weekend recreation for the entire family (Van Herzele and Wiedemann, 2003). Hence, all hierarchical levels of UGS are necessary and compliments each other.

Accessibility is one of the major factors influencing the frequent use of UGS and improving the wellbeing among its users (Coles and Caserio, 2001; Buff City status report, 2003; Neuvonen et al., 2007; Schipperijn et al., 2010; Stahle, 2010). Hence, it is important that all the residential areas have accessible and approachable UGS at various hierarchical levels for enhancing urban quality of life (Van Herzele and Wiedemann, 2003). Lowest unit of the hierarchy of UGS such as residential green or totlots needs to be located at a distance in the nearest vicinity of a residential unit so as to encourage its

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Table 1
Hierarchical Level and Urban Green Space standards in different regions.

Classification of Parks in America (Jia, 2001)			
Class	Area	Serving population	Service Radius
Children's park	200–400 m2	500–2500	Neighborhood (300–400 m)
Small Pleasance	200–400 m2	500–2500	Neighborhood (300–400 m)
Neighboring Park	2–8 ha.	2000–10000	400-800m
District Park	8–40–Ha	10000–50000	800-5000m
Large Urban Park	>40 ha	>50000	Riding distance within an hour (by Car)
Regional Park	>100 Ha	Serving a larger region	Riding distance within an hour (by Car)
Specific Facility	Including avenues, Seashore, square, historic relic, flood plain, small park, lawn, forestry land etc.		
Classification of Parks in Greater London Plan			
Parks Smaller than 20 Ha in Size	–	–	400 m
Korean Urban Green Space System (Oh and Jeong, 2007)			
Parks	Area		Catchment Distance
Children' Park	Over 1500	–	Less than 250 m
Neighborhood Park	Over 10, 000	–	Less than 500 m
Walkable area parks	Over 30,000	–	Less than 1000 m
Local Parks	Over 1,00,000		No Limit
City Level Parks	Over 1,000,000		No Limit
Urban Natural Parks	Over 100,000		No Limit
Cemetery Parks	Over 100,000		No Limit
Sports Complex Parks	Over 10, 000	–	No Limit
Minimum standards for urban green spaces for Flanders, Belgium (Van Herzele and Wiedemann, 2003)			
Functional level	Min. surface (ha)		Max. Dist. From home (m)
Residential green	–		150
Neighborhood green	1		400
Quarter green	10		800
District green	30		1600
City green	60		3200
Urban forest	>200		5000

frequent use by children. A neighbourhood park or community park may be little farther at 10–15 min walking distance and a city level park may be accessed by motorized vehicles with a driving distance of about one hour. A survey carried out by the authors in the study area also emphasizes the same fact that preference for walking time changes with hierarchical levels for the frequent use of UGS. Totlots and housing area users (lowest hierarchies of UGS) prefer walking for 0–5 min, neighbourhood park users do not mind walking upto 10 min and community park users may walk upto 15 min or more (Luthra and Gupta, 2012).

There are a number of studies that deal with the accessibility and assessment of urban green spaces (Stahle 2010; Comber et al., 2008; Sotoudehnia and Comber, 2011) in the developed countries like cities in Europe, United States and Australia. However, there is very little information available on cities in developing countries like Asia, Latin America and Africa on UGS. According to world urbanization prospects by UN-DESA, Asia, despite its lower level of urbanization, is home to 53 per cent of the world's urban population, followed by Europe with 14 per cent and Latin America and the Caribbean with 13 percent (Anon., 2014). Besides, much of the expected future urban growth will take place in countries of the developing regions, particularly Africa. The high pressure of urbanization and continuous migration from rural to urban areas in these regions puts a tremendous pressure on already scarce resources (Mensah, 2014). Higher than global average urban densities leads to a very dense and complex urban structures. The per capita UGS are decreasing in most of the cities in these regions (Chaudhry et al., 2011). Moreover, the intercity and intra-city variations in access to UGS is mostly governed by income structures, castes and other axes of differences. The most neglected UGS are at lower hierarchies as its optimal distribution sometimes leads to the displacement of the vary population for that it is meant for (Wolch et al., 2014). Hence, the early age children specifically belonging to the lower income communities are left to play on streets in an unsafe environment.

Geographic Information System (GIS) is a powerful tool to estimate the accessibility of UGS for the urban population as it provides abilities to map, analyse and create rules for spatial analysis (Kong and Nakagoshi, 2006; Oh and Jeong, 2007; Liao et al., 2009). Simple buffering methods in GIS have been used to estimate accessibility by many researchers using linear distance to generate serviceable areas around facilities (Ahn et al., 1991; Onder et al., 2011). However, since linear buffering does not take into account the actual routes and walking distances to UGS by the user, it provides a somewhat exaggerated picture of the availability of UGS in a particular area. To overcome this, network analysis in GIS environment has been found to provide more accurate measure of accessibility of UGS (Sotoudehnia and Comber, 2011; Comber et al., 2008; Pham and Nakagoshi, 2007; Koohsari, 2011). Van Herzele and Wiedemann (2003) analyzed the accessibility for urban parks greater than 10 ha in raster GIS. Oh and Jeong (2007) and La Rosa (2014) have analysed pedestrian accessibility to UGS by applying a uniform network distance to all hierarchies of parks. However, all hierarchical level of UGS are important as they cater different user groups at every level of hierarchy and should be assessed by employing the different walking distances at each hierarchy. With this point of view, in this study, a GIS based buffer and network analysis were employed to assess the accessibility at hierarchical levels of UGS especially at lower hierarchies.

2. Hierarchical levels and accessibility standards for urban green spaces

Varying hierarchical levels and standards for accessibility to UGS have been adopted by different city councils in different countries with different terminology (Table 1). For example, American system defines accessibility in terms of service radius, Greater London plan in terms of maximum walking distance, Korean system in terms of catchment distance and in Flanders Belgium in terms of max distance from home. This is the distance which people are prepared to walk for using UGS at different hierarchical levels and nearly 90% of the frequent users of UGS resides with in this distance (Luthra and Gupta, 2012). In American and Korean system, the distance at lowest hierarchy of parks is identified as 300–400 m and 250 m respectively (Table 1). However, it has been argued that a