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Role of green space in urban planning: Outlook towards smart cities

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ABSTRACT

The challenges that urbanisation pose is multi-faceted. Land allocation priorities to urban green cover are usually neglected or readily negotiated in the countries that are in transition. Urbanisation devoid of urban green can cause many social and physical impacts on its residents. Hence, locally suitable Green Index should be devised and incorporated in the urban planning of cities, in spite of the size of the city. This analysis is to showcase the green index for the planning of smart cities. The devised green index is verified in the real-world context of Gulbarga city, India, thereby understanding the practicality of this index. The results show scope for alternative green cover, where ever the green index is low. This technique presents intra-city green cover pattern analysis. Such analysis emphasises to reserve the space for green in urban planning for well-being in totality. The aspect of Land Surface Temperature (LST) analysis and correlating the same with the amount of green cover further enhances the process of promoting green cities. The assessment of per capita green space with the standards of World Health Organisation (WHO) identified the scope of greenery initiatives in various parts of the city.

1. Introduction

More than 50% of the global population currently lives in urban areas (Debnath et al., 2014). This circumstance implies the essentiality to study the urban environment (Pickett et al., 2011). The Urban ecological system is one of the essential element for human survival in cities. People get their services directly or indirectly from ecosystem functions as ecosystem services (Bolund and Hunhammar, 1999). Environmental change in urban areas is the focus for many kinds of research in the last couple of decades. Recent investigations on the environment of urban regions reveal that urban ranges are hotter than their surroundings. Resultant process is the heat island created by the adjacent surface spread and anthropogenic activity (Grimm et al., 2008). Heat stress in urban communities are often more harmful; later on, because of the antagonistic impact of expanding urbanisation results in an extensive temperature alteration, its allied effects are felt on several vulnerable species and human health. Though there are numerous procedures like altering roof material and cool colours to relieve this Urban Heat Island (UHI) effect, none has been meaningfully competent to combat the effect.

Urban Green Infrastructure (UGI) is an indispensable part of urban planning, and their significance is understood exceptionally for keeping up the natural quality and sustainability of the city environment (Gee et al., 2009) (Making our cities attractive How the EU contributes to improving the urban environment, 2010). Bio-parks, parks, gardens, places of recreation, informal green spaces such as aquatic fronts, green spaces surrounding historical sites, railway and road corridors and native vegetation types constitute the Urban Green Spaces (UGS) of a city. Urban habitats such as abandoned industrial sites and overgrown gardens also represent UGS (Tzoulas et al., 2007; Venn and Niemelä, 2004). The system approach to UGI is more quantitative and focused on meeting the societal demands of green space. Greenbelt, Green wedges, artificially created scenic spots, parks and the like that are city-centric are of its kind. The Planning approach towards UGI is more comprehensive and integrated. Such establishments accomplish planning strategies from the provision of new green space and at the same time conserving the existing green space. The UGS provides various advantages to urban occupants. They act as urban lungs retaining contaminations and discharging oxygen (Haq, 2001). They also provide clean air and helps in conserving water and soil and balances city's natural urban environment (Cilliers et al., 2015; Bilgili and Gökyer, 2012). Several types of research demonstrate that UGS help people to recover from physical and mental anxiety, stress and helps in improving human behaviour and traits (Georgi and Dimitriou, 2010; Shackleton et al., 2015).

There exist extensive research and document on the ecosystem of urban green and its interconnected benefits to human well-being. The linkages that exist between urban green spaces and the resultant benefits are brought out by the approaches to UGI (Lafortezza et al., 2013). The investigations on UGI are evident for its contributions to boost economic value of land, social and community benefits, environmental quality and biodiversity, health and well-being and the like (Bell

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et al., 2007) (Sanesi et al., 2015). Due to competition for space in the urban region, the urban forest and urban green are vulnerable for encroachments by the growth of the city. Establishing urban forests in decommissioned industrial areas can achieve compensation to the lost green cover. (Mg. Sanesi et al., 2007). Hence, an alternate approach to urban planning is essential to restore UGI. The Green Surge project (Cvejić et al., 2015) reports varied UGI and their functional linkages to a better urban environment. Versatile implementation of Green Infrastructure policies promotes integrated development of urban infrastructure (Mell, 2013). The relationship between urban impervious surface and the vegetative surface is an important determinant of ecosystem process, and hence the green cover studied in proportion with urban built give more meaningful results (Pauleit and Breuste, 2011). Green Infrastructure extended approaches through spatial planning not only emphasise on ecosystem services but have its positive influence on habitat conservations (Lennon, 2014).

2. Green space, urban planning and smart cities

The concept of smart cities identifies itself on the role of Information and Communication Technologies (ICT) in the functioning of cities (Batty et al., 2012). The concepts and policies of smart cities are promoting smartness to make cities technologically more intelligent. Review of many studies shows advanced technologies have driven the extent of technology use, but have not explained how city become smart by being green and sustainable? Urban planning plays a crucial role in designing the green infrastructure through policies and educating the mass about the importance of green in urban areas (Hostetler et al., 2011). Urban green spaces play a vital role which can be a substantial part of sustainable development of cities. There is an urging need to consider integrative, interdisciplinary approaches to improve green spaces (Haq, 2001).

Urban Green Infrastructure is an inter-linked network of green spaces that together renders ecosystem befits to the society (Lafortezza et al., 2013). The interconnected UGI operates at different levels. The investigations of UGI in neighbourhood level result in several local effects. The regional-scale study of the same can be analysed as city-region and its surroundings by community involvement (Davies et al., 2015). Urban green spaces range from large urban parks, urban woodlands, green fields, street trees/parks to private green spaces such as gardens, roof gardens, wall creeper greens and domestic greens. Urban green spaces do not necessarily include only green, also include the blue areas like riparian zones and lakes that support the growth of greenery (Cvejić et al., 2015). Often, the ecosystem services of these green that are unconsciously enjoyed by an urban area go unrecognised. Services like cleaning of air, reduction of temperature, ambience, and psychological effects are values that cannot quantify in any measures (Weber et al., 2006; Costanza et al., 1997). In the context of global climate change urban ecosystems are mostly not represented.

The implementation of UGI follows different stages. At first, a predetermined space in planning and policy making of urban spaces find the virtual space for green in urban areas. Converting the UGI to reality without compromising for different social, cultural and political pressure realises the implementation of the plan. Once the green space comes to reality, their regular maintenance needs public and community involvement. Such UGI can reduce ambient air temperature that can further reduce power consumption to regulate indoor temperature (Georgi and Dimitriou, 2010). The lack of understanding of multiple benefits of open green spaces in urban areas results for countries in transition to ignore green spaces (Govindarajulu, 2014). Uncontrolled expansion of the cities and their infrastructure have made green spaces vulnerable to the need of space (Gomes and Moretto, 2011) (Derkzen, 2012). The broad range of resources involving stakeholders in planning, support and implementation makes the UGI programme challenging for the countries in transition (Lindley, 2013).

The values and standards of human have changed the world. The change concerning urban sprawl has adversely affected the natural ecosystem due to massive land transformations. In this process, a change of green to a mass of concrete creates a continued increase in impervious surface. This rapid urbanisation created unnatural environments. This research provides a comprehensive and practical framework for benchmarking cities towards UGI. Without a proper conceptual framework and planning for the smart green city, it is hard to determine sustainability (Debnath et al., 2014). The study would allow benchmark model for UGI and accurate indicators of smartness for allocation of green space to the planners. Such comprehensive studies are essential to move towards making cities smarter.

3. Study area

Gulbarga city, recently renamed as Kalaburagi, is the largest urban centre in North Karnataka, India. The geographic coordinates of the city are 17.33^0 latitude North and 76.83^0 longitude East. The city is known for hot climate ranging from 22 °C to 40 °C in summers, and cool and dry winters with temperature ranging from 15 °C to 33 °C. The average annual rainfall of the city is 777 mm (Indian Metrological Division). The average number of rainy days is 46, (the year 1971–2000) (Narayanan, 2012). The city gets most of its rainfall from the Southwest monsoon ranging up to 186.6 mm. Convectional rainfall and thunderstorms are quite common phenomena in the month of April-May. The population of Gulbarga city is 543,147 according to 2011 Census. There are 102,830 households. Administratively, the division of Gulbarga into fifty-five wards and three outgrowths makes together fifty-eight local administrative units. Gulbarga city covers a spatial spread of 81 km^2. After the implementation of article 371-j aimed to bring all round development through special constitutional provisions to Hyderabad – Karnataka region in the Indian constitution, there is a lot of thrusts given to Gulbarga's development and reformation policy (Constitution of India 118th Amendment Bill, 2012). Such amendment impacted in fast expanding of the city and its vertical rise. Recently, Gulbarga is identified and funded by the state government to develop it as a smart city. The primary goals are to ensure round the clock potable water supply, to keep the city clean with better and efficient solid waste and sewage management, rejuvenating and developing the civic amenity sites into parks and the like. In this background, urban planning becomes the essential part of development, to plan the sustenance of a liveable city with more lung space.

4. Analysis and methodology

Research on green space quantifies green area based on Normalised Differential Vegetation Index (NDVI) performed on a satellite imagery of a region. NDVI is a technique in satellite image processing for characterising vegetation in an area through satellite images. Though such techniques are used in many analyses of urban greenery, UGS do not consider all the green cover in the city. Hence, traditional classification method would not suit this context. This research is unique to employ object-oriented semi-automated extraction technique used to extract the avenue tree grooves from satellite imagery of very high spatial resolution. Nevertheless, researchers paid attention towards intra-city disparity in green to guide precisely its residents and administrators to improve green in a particular geographic location within a city. Moreover, there seldom exist any scientific reasons for backing policy decisions to introduce new green spaces. Analysis of green space by per-capita green available for each inhabitant of the city is first of its kind.

The Proportional Green Index would explain the intra-city variation in the distribution of dedicated green cover. However, there are methodologies which indirectly measures environmental indicators through lichen distribution and tobacco plant's response to environment quality (Nali et al., 2007) (Lorenzini et al., 2003). Alternatively, Land surface temperature that was extracted from the MODIS (Moder-