

# Chapter 12

## The Strategic Role of Green Spaces: A Case Study of Kalaburagi, Karnataka

Ramesh Anguluri, Priya Narayanan and Krishna Udnoor

**Abstract** Greenhouse gas emission of carbon dioxide (CO<sub>2</sub>) is one of the major factors causing global climate change. Urban green space presumes a key part in controlling the general carbon cycle and reducing climatic CO<sub>2</sub>. To Improve the Environment and control the pollution, Green space has become important to diverse Planning concerns that live in the urban environment, to comprehension the part of urban green space in the urban environment. Remote sensing is a well-known tool due to its ability of monitoring urban vegetation rapidly and continuously. This paper asks how should we plan green space? We contend that planners can improve healthier cities for more people by reconsidering three facts of green space planning: Green Space as infrastructure, Green Space as Spaces of everyday life and Green Space as leisure destinations for recreation. The main objective is to build quality infrastructure and more adaptable space throughout the city.

**Keywords** Green index · Per capita green space · GIS · Smart green city planning

### Acronyms

CO <sub>2</sub>	Carbon dioxide
UHI	Urban heat is land
UNGI	Urban neighbourhood green index
POS	Public open space
QNPC	Quality neighbourhood park criteria
GIS	Geographic information system

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CLC	Classified land cover
NDVI	Normalized difference vegetation index
NIR	Near infrared
m <sup>2</sup>	Square meters
GI	Green index
GD	Green area density
TA	Total area
G	Green space
GMP	Gulbarga Mahanagara Palike
WHO	World Health Organization
HUDCO	Housing and Urban Development Corporation
INUGS	International norms for urban green space

## 12.1 Introduction

Research on urban growth has gained focus due to global change with massive increase of urbanization and more than 50% of the world population currently live in the urban environment—A figure that has been predicted to grow to 70% by the year 2050 (Turner et al. 2014). With this migration and growing urbanization to maintain environments and development of urban vegetated area are among today's challenges of sustainable urban planning (Lang et al. n.d.). Urban Green spaces especially urban trees are vital components of urban ecosystem (Digirolamo 2006; Stamatina Th. Rassia Panos M. Pardalos) and green corridors in urban areas, not only have ecological and climatologic importance for residents but also affect the local recreational quality and public health. The attractiveness of an urban area is significantly influenced by the amount of green which can be directly used and perambulated or visually and aesthetically enjoyed. Particularly the pleasure of even little green areas in various places at certain moments (Lang et al. 2006). However, human settlements are far from natural in status and much more adapted to the special needs of our economic life. There are several factors to mitigate urban green have been proved recently.

Mainly, a rapidly transformed urban setting plays a crucial role to change the green vegetated area of natural habitats. Several researches have been suggesting urban planning to adapt new conditions by urban planning measures. Most of the recommendations are dealing with the increase of greenery in urban area (Fröhlich et al. 2014). Although there are several strategies to mitigate the UHI (Urban Heat Is land) effect, most of the studies focus on the cooling effect of urban parks and gardens (Rotem-mindali et al. 2015). Urban parks may have a cooling effect of up to 1.5–3 °C, depending on the time of day (Fig. 12.1).

Concluded that even small parks of ~0.24 ha could mitigate the adverse effects of UHI and the potential additional effects of global warming in cities. Others



**Fig. 12.1** Park at Veerendrapatil layout colony in Jayanagar Gulbarga. *Source* Author

showed that medium to large size parks (>150 ha) have an even greater thermal effect (Rotem-mindali et al. 2015; De Vries et al. 2003). However, there are several researches and studies that measures and explore green spaces in urban areas. The studies include the development of UNGI (Urban Neighbourhood Green Index) as measurement on green spaces in urban areas, the study on quality and quantity, POS (Public Open Space) the study on the assessment of QNPC (Quality Neighbourhood Park Criteria) as well as a study that scrutinizes the guidelines and Policies of nature conservation include both the restoration of green space deficits in the densely built-up inner cities and an improvement of the connectivity between green spaces (Malek et al. 2015; Jansson and Persson 2010). Reckonable information about green structures and the amount and distribution of green spaces is essential for sustainable planning.

In recent years, remote sensing and in GIS (Geographic Information System) software advances provide cheaper computing power, have made it progressively easier to measure precisely urban land cover and in green spaces. Most recent studies tend to rely either on CLC (Classified Land Cover) Images or on NDVI (Normalized Difference Vegetation Index) data derived from satellite imagery to measure the different types of land use (Li et al. 2015). High resolution imagery has been used to generate CLC data and estimate the percentages of tree canopy and of grassy areas with reasonable accuracy.

## 12.2 Kalaburagi as a Study Area

Kalaburagi city has a long history from the Bahamani Sultans who formed this city as their capital in fourteenth century, came into control of the sultanate of Delhi. From the year 1724 to the year 1948, Kalaburagi was a part of Hyderabad state ruled by the famous Nizams. Kalaburagi was known as ‘Kalburgi’, means “rose petals” in poetic Persian. Kalaburagi district is located in the northern part of the Karnataka state and lies between latitude 17° 10' and 17° 45'N and longitude 76° 10' and 77° 45'E. Kalaburagi is the biggest district in Karnataka State covering 8.49% of the area and 5.9% of State's population. It is bounded by Bijapur district of Karnataka) and

Sholapur district (of Maharashtra), in the west by Bidar district of Karnataka) and Osmanabad district of Maharashtra) on the north and Raichur district of Karnataka in the south. It is one of the three districts that were transferred from Hyderabad State to Karnataka state at the time of re-organization of the state in 1956. Kalaburagi is an agriculture-dominated District with crops such as Tur, Jowar, Bajra, Paddy, Sugarcane and Cotton. District receives an annual rainfall of 839 mm. Kalaburagi with an area 83 km<sup>2</sup> region is considered for the analysis. The City has 55 Wards with Population of 5.3 lakhs (Census 2001) and is governed by Kalaburagi Mahanagara Palike.

## 12.3 Methodology

To derive the various parameters to measure quality of neighbourhood green, Indian Remote Sensing satellite data IRS P6 LISS IV data has been used as base data for quantifying the amount of vegetation and broadly classified vegetation as, very high vegetated area, highly vegetated area, moderate vegetated area, low vegetated area vegetation, very low vegetated area. LISS-IV is a multispectral high resolution sensor with a spatial resolution of 5.8 m. Due to imaging in multispectral domain, i.e. green, red and Near-Infrared (NIR band) region; it is useful in vegetation identification and characterization.

### 12.3.1 Green Space Extraction

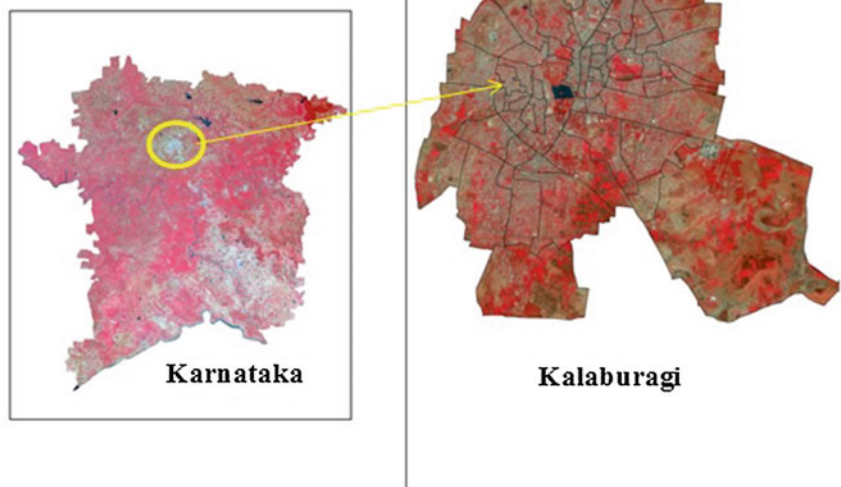
NDVI stands for the Normalized Difference Vegetation Index is the most widely used vegetation Index. It can enhance the difference between vegetated and non-vegetated areas, due to the fact that vegetation displays high reflectance in the near-infrared band but has low reflectance and high absorption in the red band. NDVI is calculated as

$$\text{NDVI} = \frac{\text{NIR} - \text{IR}}{\text{NIR} + \text{IR}}$$

Vegetated areas have a relatively high near-IR (Infrared) reflectance and low visible reflectance. Due to this property, various mathematical combinations of the NIR and the Red band have been found to be sensitive indicators of the presence and condition of green vegetation these mathematical quantities are thus referred to as vegetation indices.

NDVI gives a measure of the vegetative cover on the land surface over wide areas. Dense vegetation shows up very strongly in the imagery, and areas with little or no vegetation are also clearly identified. Therefore vegetation produce high

### Study Area Map of Kalaburagi



**Fig. 12.2** Location map of study area: Kalaburagi, Karnataka State, India. *Source* Prepared in ARCGIS10.1 by the authors as a part of analysis

values in NDVI image and non-vegetated area have low values (Tsutsumida et al. 2013; Lang et al. 2004). The vegetation area derived by a pixel-based classification method usually has a large number of ‘pepper and salt’ points (Taylor et al. 2014). Based on empirical knowledge and field work, which provides the ability to delineate isolated vegetated area and a row of trees in a dense urban area (Fig. 12.2).

### 12.3.2 Calculation of Proximity Green Index

Finally green space has been classified in the following types as very low green space, low green space, moderate green space, high green space and very high weighted green index (GI) have been determined based on the percentage of green area with respect to the population with in the area.

Multispectral imagery LISS IV data were used for the classification of vegetation and settlements. A global threshold was chosen manually for vegetation extraction. Similarly, a global threshold was also selected to extract the buildings and generate (Taylor et al. 2014).

### 12.3.2.1 Spatial Proximity Distribution of Green space and Population

The growth rate of population is generally related to the urban growth, population growth forces the built-up areas to expand when the urban growth expansion gives pressure directly proportional to green space of urban or agriculture area. Green space identified hypothetically by careful examination of built-up area and population growth rate as per capita according to international norms. The NDVI image was used to calculate the density of green space in the study area. As it did not take into account the open space without vegetation and agriculture area in the same manner ward boundary overlaid on the vegetated layer to calculate percentage of vegetation area in each ward (58 wards)

$$\Delta GD = (ga) - (ta)$$

where  $G$  = Green space minus total area,  $GD$  = green area density,  $ga$  = green area,  $ta$  = total area

Green space density has been calculated as percentage of green space to the total area of the city. However, this process of calculating index is useful for the intra-city analysis of green area and its relative compactness as a pattern. The proportion of population and proportion of green space have been calculated by dividing the population and green space of the respective zone by the total population and total green space of GMP (Gulbarga Mahanagara Palike), respectively

$$Gi = Xi / \sum_{i=1}^n Xi$$

where  $Gi$  is the proportion of a phenomenon (Green Index) occurring in the  $i$ th zone,  $Xi$  is the observed value of the phenomenon in the  $i$ th zone and  $n$  is the total number of population (Kim and Wentz 2006; Bhatta 2012; Guobin et al. 2003).

Therefore, in this study, the Proximity of GI is classified here as four types of vegetated areas like very high vegetated area, highly vegetated area, moderate vegetated area, low vegetated area and very low vegetated area such ratio is essential to plan the sustainable planning purpose.

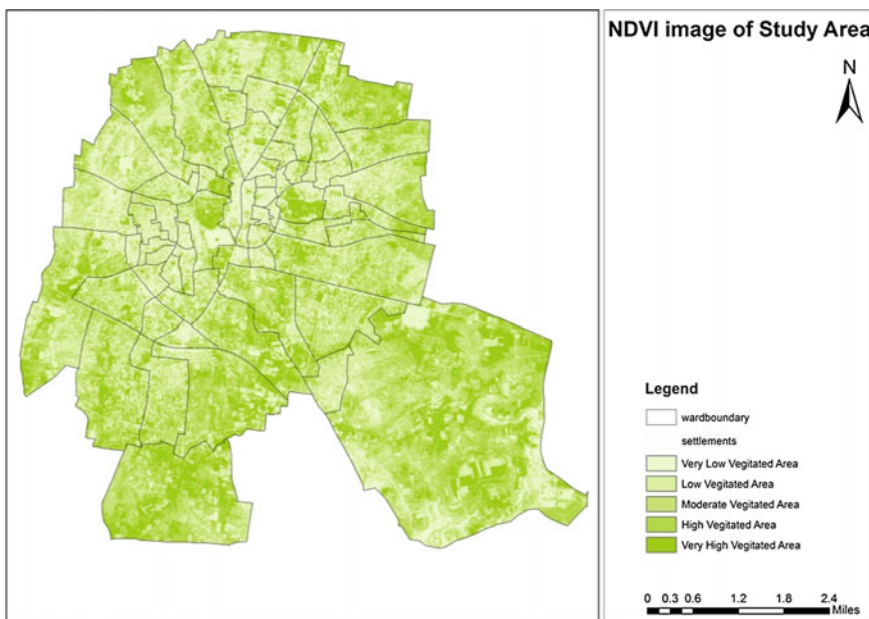
## 12.4 Results

The issue of required open green spaces per capita in urban systems has remained controversial. In twentieth century, experts in Germany, Japan and other countries proposed a standard of 40 m<sup>2</sup> urban green space in high quality or 140 m<sup>2</sup> suburb forest area per capita for reaching a balance between carbon dioxide and oxygen, to meet the ecological balance of human well-being. The World Health Organization (WHO) suggests to ensure at least a minimum availability of 9 m<sup>2</sup> green open space

per city dweller. There is yet another yardstick, which refers to London but has relevance to any city. Abercrombie prepared a plan in 1943–1944 suggesting that 1.62 ha (four acres) open space per 1000 population was a reasonable figure to adopt for London (Singh n.d.; Kim and Wentz 2006; Li et al. 2005). Based on this study the distribution of green space at GMP can be seen in Fig. 12.3. After derivation of the vegetation to each ward in the study area, the results can be seen in Fig. 12.3 showing that most zones present a negative, unbalanced rating. According to the pattern of green space availability, each ward can be classified into 5 zones.

The Green Index (GI), i.e. percentage of green in each cell, is based on binary classification (green and non-green classes) of NDVI measurements. The NDVI image was generated using IRSP6 LISS IV data of study area. The negative values of NDVI measurement were classified as built-up area and positive values were classified as green class. The ward boundary was overlaid over the binary image and percentage of green in each cell ward is calculated (Schöpfer et al. 2004; Ruangrit and Sokhi 2004).

Based on the percentage, each ward had been classified in four green quality classes' i.e. low, moderate, high and very high green quality (Table 12.1) based on the population divide by green space of the particular ward according to the WHO. The categorization of all values in four equal intervals/classes was done for the sake



**Fig. 12.3** NDVI map showing the vegetative area city at ward level. *Source* Prepared in ARCGIS10.1 by the authors as a part of analysis

**Table 12.1** Showing percentage vegetation and as well as population at local level (ward level) according to WHO and categorization

W. no	Vegetation (m <sup>2</sup> )	TA	Population	GI	GS	Required
1	1.17	2.53	12,621	1.13	High	0.04
2	0.8	1.39	12,634	1.13	Moderate	-0.33
3	0.25	0.73	7971	0.71	Low	-0.46
4	0.36	0.79	14,468	1.30	Low	-0.94
5	0.24	0.6	7592	0.68	Low	-0.44
6	1.22	2.41	6613	0.59	Very high	0.63
7	0.18	0.5	8047	0.72	Low	-0.54
8	0.24	0.82	7249	0.65	Low	-0.41
9	0.08	0.27	3097	0.27	Very low	-0.19
10	0.07	0.18	5202	0.46	Very low	-0.39
11	0.09	0.36	10,278	0.92	Very low	-0.83
12	0.91	1.92	6946	0.62	Moderate	0.29
13	0.34	0.71	17,133	1.54	Very low	-1.2
14	0.47	0.72	14,145	1.27	Very low	-0.8
15	0.03	0.13	7982	0.71	Very low	-0.14
16	0.05	0.2	5318	0.47	Very low	-0.42
17	0.18	0.56	7061	0.63	Very low	-0.45
18	1.37	2.25	13,365	1.20	High	0.17
19	0.57	1.83	8039	0.72	Moderate	-0.15
20	0.41	1.56	16,355	1.47	Very low	-1.06
21	0.11	0.4	10,589	0.95	Low	-0.84
22	0.2	0.59	15,446	1.39	Very low	-1.19
23	0.18	0.3	19,993	1.79	Very low	-1.61
24	0.08	0.36	10,075	0.90	Very low	-8.92
25	0.02	0.11	9333	0.83	Very low	-82.98
26	0.03	0.17	5708	0.51	Very low	-0.48
27	0.02	0.11	6544	0.58	Very low	-0.56
28	0.27	0.59	9636	0.86	Low	-0.59
29	0.31	0.6	13,918	1.25	Moderate	-0.94
30	1.87	3.42	12,596	1.13	Very high	0.74
31	0.03	0.14	5048	0.45	Very low	-0.42
32	1.87	2.54	11,095	0.99	Very high	0.88
33	0.56	1.19	8027	0.72	Moderate	-0.16
34	0.03	0.16	5006	0.45	Very low	-0.42
35	0.12	0.41	8445	0.76	Very low	-0.64
36	0.05	0.19	11,703	1.05	Very low	-1
37	0.05	0.2	7531	0.67	Very low	-0.62
38	2.22	4.08	16,218	1.45	High	0.77
39	0.1	0.32	7164	0.64	Low	-0.54

(continued)



**Table 12.1** (continued)

W. no	Vegetation (m <sup>2</sup> )	TA	Population	GI	GS	Required
40	0.04	0.16	9275	0.83	Very low	-0.79
41	0.08	0.25	6964	0.62	Very low	-61.92
42	0.1	0.32	8180	0.73	Low	-0.63
43	0.19	0.35	4870	0.43	Moderate	-0.24
44	0.07	0.21	7703	0.69	Very low	-0.62
45	0.07	0.23	12,339	1.11	Very low	-1.04
46	1.24	2.31	10,393	0.93	High	0.31
47	1.36	2.11	5989	0.53	Very high	0.83
48	1.51	2.16	4847	0.43	Very high	1.08
49	0.38	0.76	6808	0.61	Moderate	-0.23
50	0.67	1.26	12,175	1.09	High	-0.42
51	0.22	0.49	4268	0.38	Moderate	-0.16
52	0.15	0.41	8695	0.78	Very low	-0.63
53	2.52	3.47	10,736	0.96	Very high	1.56
54	1.04	1.83	16,820	1.51	Moderate	-0.47
55	2.1	3.36	17,334	1.56	Very high	0.59
56	11.24	19.01	635	0.057	Very high	11.18
57	0.17	0.82	2020	0.18	Moderate	-0.01
58	4.17	5.54	2864	0.25	Very high	3.92

of simplicity as this index provides the relative value for comparative evaluation between different neighbourhoods rather than any absolute value.

#### ***12.4.1 The Analytical Results Thus Obtained from Wards***

**Zone 1 (Very High Vegetated Area):** This zone is having highly vegetated area and in this zone 9 wards are lying which are ward nos 58, 55, 53, 48, 47, 32, 6 and 30 is varying green space in between 1.22 and 11.24 m<sup>2</sup> occupied in the outer part of the city, ward 56 is the southern part of the kalaburagi found highest value is 11.24 m<sup>2</sup>. The best meet the needs of green areas for the city of kalaburagi according to the WHO and UNGI values. Total area of green space, 56 was the best and most balanced and zone 55 was good but not as balanced as above ward 56.

**Zones 2 (High Vegetated Area):** In this zone 5 wards are lying, i.e. ward no 1, 18, 38, 46 and 50 present values that are generally high and balanced in terms of population according the international standards.

**Zone 3 (Moderate Vegetated Area):** Follows the same trend as previous areas but zone 3 is somewhat quite less vegetated area. It shows the unbalanced of green space and in this zone totally 10 wards are lying, i.e. ward no 2, 12, 19, 29, 33, 43,

49, 51, 54 and 57 ranges in between 0.8 and 1.04 m<sup>2</sup> of green space according to WHO these are quite unbalanced according to population.

**Zones 4 and 5 (Low and very low vegetated Area):** zones 4 and 5 are very highly deficient vegetated areas in this zone which lies in the middle part of the city and it covers totally 9 wards in the zone 4 ranging from 0.1 to 0.36 m<sup>2</sup> and zone 5 almost 25 wards are lying and these wards are highly deficient vegetated areas ranging from 0.3 to 0.15 m<sup>2</sup> and vegetated area is having unbalanced and low vegetated areas among the whole city and highly populated areas (Fig. 12.4; Table 12.2).

In the study area there are 34 wards of acute shortage of green areas with high building density and 10 areas with moderate vegetated areas and 14 wards having very good green space among the all 58 wards. This kind of study indicates the pattern of green space in relation to population provides a useful and practical tool to establish a proper distribution of green space, referencing the urban fabric. The ranges of the classification can be a clear reference of green areas that should exist in a city (Gonzalez-duque 2012).



**Fig. 12.4** Showing high density vegetative area and low density vegetated area. *Source* Prepared in ARCGIS10.1 by the authors as a part of analysis

**Table 12.2** Showing the amount of green space at zone level

Estimation of green index relation to population according to(INUGS) international norms for urban green space				
	Vegetated area (m <sup>2</sup> )	Population	GI required	Surplus GI required
Zone 1	27.86	72,709	6.49	21.37
Zone 2	6.67	64,772	5.8	0.87
Zone 3	5.15	84,350	7.55	-2.4
Zone 4	1.85	80,896	7.24	-5.39
Zone 5	2.94	236,379	21.15	-18.21

*Source* Author

## 12.5 Discussion

Our result shows that the proportions of green space showed significantly high in particularly zones 1 and 2 with combination of agriculture. The amount of high vegetated area close to the urban edge could be due to less proportions of settlement area and quantity of agriculture is high (Ehrenfeucht and Loukaitou-Sideris 2010; Matthies et al. 2015). Due to increasing density of settlements, vegetated area covers very less space. The relationship would have been expected between green space and the number of population is proportionally not equally covered. This study created evidence on the distribution of green space in Kalaburagi city. This may help to design better way for smart city planning. It would help to maximize social and environmental benefits and a more equitable distribution of green area. The establishment of green space promotes the public interest in cities to encourage the participants for recreation and as well as green environment. These evolutionary studies are intended to help improve planning of Green Index to meet the needs of the urban population. Green area (plants) in the cities is not only benefits of social and environmental.

This kind of studies provides the basic indicators to the policy makers in local regulations and also information about GI of the city is also helpful to the planners and managers how to implement GI approaches with an emphasis on linkage of environmental and as well as social services.

## 12.6 Conclusion

Green space are urban infrastructures that should also accommodate daily life activities and leisure, planners must focus on all the areas around the city. Collaborating with public works departments, planners should strive to provide better green space throughout the city. They should also make more incidental spaces available for walkers, citizens and other people. In commercial strips intended to support leisure consumption, planners should ensure that these destinations remain open to all potential users. This section will discuss possible planning inventions for each facet of green space.

During the past century, planning diverged from those professions engaged in infrastructure provision. Although planner's pre-professional roots were in facilitating better health through sanitation and street paving, planners increasingly addressed the systematic dimensions of citizens without engaging with the mundane aspects of paving choice and others specifics of any given street segment (Li et al. 2015; Ehrenfeucht and Loukaitou-Sideris 2010; Dole 1989). Green space design reflects the priorities of municipal engineers and later operations. The links between infrastructure and city planning may be described as numerous but non-strategic and non-comprehensive even as the bond between infrastructure and cities remain tight because planners have left infrastructure provision to others professionals (Li et al. 2015; Ellaway et al. 2005)

By getting involved in the mundane aspects of infrastructure provision and envisioning green space or parks as a continuous and distinct urban space, planners can improve how city green space functions. Basic priorities might include fixing green space development, and to allow all people comfortable access planting and maintaining street trees. The effective use of design elements can better articulate the way building relates to the street edge and the relationship between road sides and adjoining spaces in order to integrate incidental spaces into the larger urban structure. By focusing on holistic provision, planners can incrementally facilitate more sustainable improvements (Ignatieva et al. 2010). To make this happen planner must work at different levels. They should be able to see the whole picture where and how many trees are needed and what type of place is available. Planners have traditionally had influence during new projects review and in this process, they can pay attention to how a building relates to the other building relates to the green space the articulation of its ground floor uses the relationship between the façade and the green space and the location number of trees. They also contribute to plans meant to guide future projects.

However, planners have been less engaged in working collaboratively to add details and smaller improvements to regular maintenance projects and securing the additional funding necessary to make such improvements. Planner's day to day interactions with public works officials can create opportunities to place elements such as benches and street trees along road side during a street make project not only on the main roads including internal small roads of the cities, layout planning for housing and gated community projects, trees increase projects costs they do so marginally, if undertaken at the same time as other street improvements. Such small row plants improvements can lead to larger citywide benefits. For example such a way, i.e. if planner plan to plant the trees along the all roads inside the city roughly we can plant tree 200 trees with in 1 km, if city follows this kind of planning then the city would become a smart sustainable green city.

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