GIS-Based Assessment of the Green Space Per Capita in the City of Galle, Sri Lanka

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Abstract

The extent and distribution of Green Space play a vital role in urban planning since it contributes significantly towards enhancing the environment of the city by improving air quality and urban health, reducing urban heat island effect, reducing noise, conserving biodiversity and providing many other socio-economic benefits. The proper distribution of green spaces in urban environments is therefore a necessity for sustainable development and healthy living. Green space is becoming an important measure to judge the ecological sustainability of urban areas. The World Health Organization (WHO) has set a minimum standard for urban green space per capita for healthy living as 9.5m^2/ person. The United Nations (UN) has proposed that the per capita green space should be more than 30m^2/ person. Therefore, this study has assessed the green space per capita in the Galle city with reference to these standards. The available green spaces in the Galle city are extracted using GIS and the extent of prevailing green space is calculated at the Grama Niladhari (GN) divisional level. Then, the population data and the available green space are compared with global standards to reach the final results. The analysis shows that 50% of the Galle city is covered by urban vegetation. Certain areas such as the Kongaha GN division do not meet the WHO standard as it falls short of 1343 sq.m of green space to reach the standard. The Kongaha, Medawalamulla North and Thalapitiya GN divisions fall below the UN standard and it would be necessary to establish green spaces with areas of 37956 sq.m, 64797 sq.m and 66018 sq.m respectively, for these divisions to meet the UN standard. However, the green space per capita for the entire city amounts to 87m^2/ person and this indicates that Galle is a healthy city in terms of the availability of urban green spaces.

Keywords – GIS, Green space per capita, Sustainability, Urban green spaces, Urbanization

Introduction

Urban green space should be treated as an important part of urban planning (Wendela, Zargerb & Mihelcica, 2012) as it is a good indicator of the quality of the city as well as the quality of life of the local community. Green spaces are key elements of the urban landscape and urban sustainability (Kabisch, N., Qureshi, S. & Haase, D., 2015). Scholars have affirmed the value of urban green space in terms of its health (Rojas et al., 2016), economic (Maas, J. et al., 2006), social (Saz Salazar, 2007) and climatic (Smith, T., 1997; Lafortezza, 2009) benefits. With the continued rapid pace of urbanization, it is projected that 90% of the world's population will be living in cities by the end of the 21st century (UN, 2012). Therefore, the presence and extent of green spaces in a city will have a direct bearing on the quality of life of urban residents (Szulczewska et al., 2014).

As Tan (2012) observed in his study, "the high quality of a built environment, made possible through the functional benefits of urban greenery, has therefore emerged as an important goal of urban development to create healthy and livable cities." In 2003, the United Nations Department for Economic and Social Affairs showed that urban greening and urban forests are particularly critical to maintain healthy cities in the developing countries, which contain some of the largest and most overcrowded metropolitan areas.

There are several standards for assessing the sustainability of cities, and they are defined by various organizations. One important measure used in these standards is the per capita green space of a city (Laghai & Bahmanpour, 2012). This measure represents the extent of green areas in square meters (m^2) available for a single citizen. The UN has recommended that the per capita green space should be more than $30m^2$, while the WHO declares it should not be less than 9.5 m^2 per person. Therefore, this study assessed the green space per capita in the Galle city based on these standards.

Problem Identification

With the expansion of industrialization in cities and suburbs, the rate of growth of the urban population has reached dizzying levels around the world. This uncontrolled growth has had a strong negative impact on urban green space (Kong & Nakagoshi, 2005), and obviously this requires immediate attention. Green spaces and urban trees will become increasingly important in developing countries, especially in Asia, as the rate of urbanization is greatest in the smaller main cities of Asia. As urban expansion and urban population growth are continuous phenomena, creating green spaces in accordance with the aforementioned international standards will be a challenging task.

The city of Galle, the capital of the Southern Province is a famous and highly populated city that is developing rapidly; it is a 1st order town as per the urban hierarchy in the Southern Region. According to the Planning Policy of the Department of National Physical Planning, the Galle city is to be developed further as part of the national development process. Therefore, proper distribution of green spaces will play a vital role in future urban planning projects in Galle to ensure sustainable development. In this endeavor, it will be an essential step to demarcate the urban green spaces according to international standards. There has been no comprehensive study to date to analyze green space per capita in the Galle city. Therefore, this study will prove significant, since this is the first attempt to identify and measure the green space quantitatively and calculate the per capita green space of each Grama Niladhari Division of the Galle MC, and this will be done using the Geographical Information System (GIS). The areas that fall short of the standards set by the UN and the WHO will be identified and marked for future decision making processes.

Research objectives

a). To map the existing urban green spaces of the Galle MC region.

b). To calculate the urban green space per capita of each Grama Niladhari Division in the Galle MC.

c). To identify the GN divisions that fall outside the international standards for urban green space per capita.

d). To calculate the additional extent of green areas required in each division to meet the international standards for urban green space per capita.

Literature review

Urban green spaces

Though the definition of green space has long been argued by scholars, a universally accepted definition is still in the making (Byomkesh et al., 2012). The European Commission (2013) defined green space as a strategically planned network of high quality natural and semi-natural areas with other environmental features, designed and managed to deliver a wide range of ecosystem services and protect biodiversity in both rural and urban settings. In other words, urban green space is land situated in urban areas with open soil surface that may be partly or fully covered by vegetation (Swanwick et al., 2003, p97).

Jim and Chen (2003) defined urban green space as vegetated areas that can be found in urban environments and named as semi-natural areas in a city; this may include parks, forest patches, open spaces, residential gardens or rows of trees along one or both sides of a street.

Green space typology as proposed by Swanwick et al. (2003) is a useful tool to classify a wide range of green spaces across cities on the basis of land use types (Table 1). In this interpretation system, green spaces include four main types namely amenity green spaces, functional green spaces, semi-natural habitats and linear green spaces.

Table 1: Typology of urban green spaces

Amenity green spaces	Recreation Green Spaces	Parks and gardens
		Informal recreation areas
		Outdoor sports areas
		Play areas
	Incidental Green Spaces	Housing green spaces
		Other incidental spaces
	Private Green Spaces	Domestic gardens
Functional Green Spaces	Productive Green Spaces	Remnant farmlands
		City farms
		Allotments
	Burial Grounds	Cemeteries
		Church yards
	Institutional Grounds	School grounds (including school farms and growing areas)
		Other institutional grounds
Semi-natural Habitats	Wetlands	Open/ running water
		Marshes, Fens
	Woodlands	Deciduous woodlands
		Coniferous woodlands
		Mixed woodlands
	Other Habitats	Moor/ heath
		Grasslands
		Disturbed ground

Linear Green Spaces	River and canal banks
	Transport corridors (roads, rails, bicycle paths and walking routes)
	Other linear features (e.g. cliffs)

Green space functions

Urban green spaces are viewed as the green lung of the city, and typically perform important functions, including soaking up rainwater and pollutants, and mitigating urban heat. They can also provide considerable socio-economic benefits, such as space for socializing, rest and recreation (Peschardt et al., 2012; Rahnama & Akbari, 2013), and substantially increase property values (Lin et al., 2013).

Green spaces by lending themselves to a wide range of functions and purposes can play a significant role in benefiting the urban environment and its populace. These benefits can be categorized as applying to the social, environmental, and economic domains as shown in Table 2 (Barber, 2005; Dunnett et al., 2002; Handley et al., 2007; Swanwick et al., 2003).

Table 2: Functions of urban green spaces

Green Space Functions	*Benefits of Urban Green Spaces*
Social Functions	– Provide a place for quiet contemplation and reflection, relaxation, informal recreation, peace, space and appreciation of nature. − Provide opportunities to improve mental health and physical fitness and take part in a wide range of outdoor sports and activities. − Provide safe areas to meet, talk, play and freely associate with friends and strangers; provide space for interaction between families and between generations. − Provide cultural links with an area's past, and offer a sense of place and identity. − Provide opportunities for community events, voluntary activities and charitable fund raising. − Provide an educational resource- an outdoor classroom for stimulating the exchange of ideas on art, design, the environment and natural science.
Environmental Functions	- Provide habitats for wildlife, aiding biodiversity. − Help to stabilize urban temperatures and humidity. − Absorb pollutants in air and ground water. − Provide opportunities for the recycling of organic materials. − Slow down storm water runoff and reduce the need for big drains. − Provide a sense of the seasons and the links between the natural world and the urban environment.

Economic Functions	– Produce agricultural and horticultural crops. − Promote physical and mental health of people and reduce the cost of social and medical care. − Alleviate environmental problems and curtail environmental spending. − Create job opportunities for managing and maintaining green space. − Add value to the surrounding properties, both commercial and residential, consequently increasing tax yields to maintain public services. − Contribute by attracting more tourists. − Encourage employment and investment. − Increase urban regeneration and neighborhood revival. − Contribute to the local economy by facilitating special events.

Source: Adapted from Barber (2005)

Green space standards

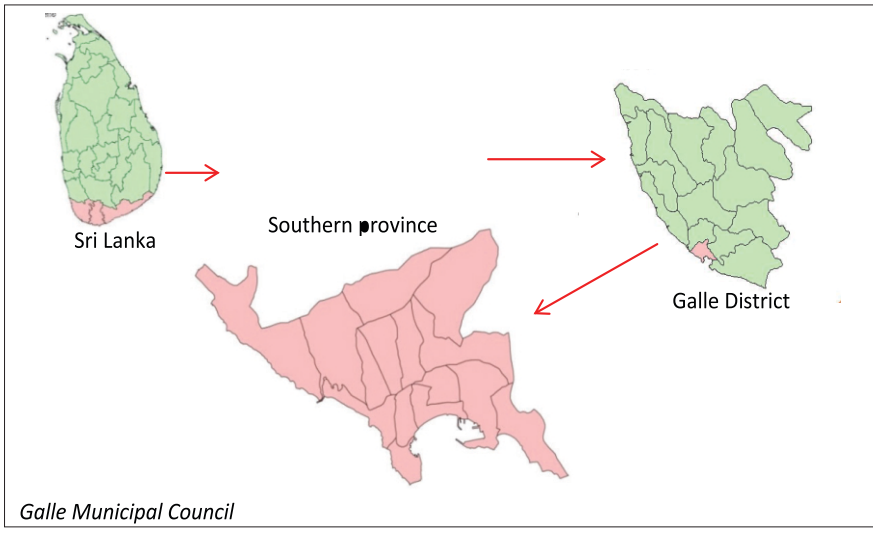
When designing and maintaining sufficient extents of green spaces in an urban area, parameters of the city such as population, environmental conditions, climatic conditions and different cultural behaviors of the permanent residents have to be considered (Arabi et al., 2014; Latifi et al., 2016). The percentage of space that has been allocated for green spaces from the total extent of the urban area can be used to assess the environmental sustainability of a city (Chiesura, 2004). There are several standards in respect of this, which have been drawn up by various organizations, with the aim of guiding town planners to accurately assess the ecological sustainability of cities.

One such standard used to determine the per capita green space extent of a city was prepared by Laghai and Bahmanpour (2012). The value obtained represents the extent of the green area in square meters (m^2) for a single citizen. To calculate the value of the indicator, the total extent of the area covered by green spaces should be divided by the population of that area (Laghai, H. & Bahmanpour, H, 2012). The UN has recommended that the per capita green space should be more than $30m^2$, and cities that can meet this standard are described as sustainable cities; the European Union (EU) has a more relaxed standard with a minimum value of $26m^2$ per person (Khalil, 2014). However, the World Health Organization (WHO) has specified that an area of $9.5m^2$ of green space should be adequate for each person in an urban area to provide a better quality of life (Khalil, 2014). Developed countries often have their own per capita green space values; for example, it is $50m^2$ in the USA, 30 to $60m^2$ in Germany and 50 to $60m^2$ in Switzerland (Hosseini et al., 2015). Major cities too, in developed countries may have their own defined values, such as for example, the $154m^2$ per person prescribed by Los Angeles and $47m^2$ per person by New York (Hosseini et al., 2015).

Study area

The city of Galle, capital of the Southern Province, is a famous and highly populated city that is developing rapidly. The Galle town is a 1st order town as per the urban hierarchy in the Southern Region. The Galle Municipal Council area covers an extent of 1742.4 hectares, and consists of 15 wards, which are subdivided into 43 Grama Niladhari Divisions. See Map 1.

Map 1: Location map of the Galle MC

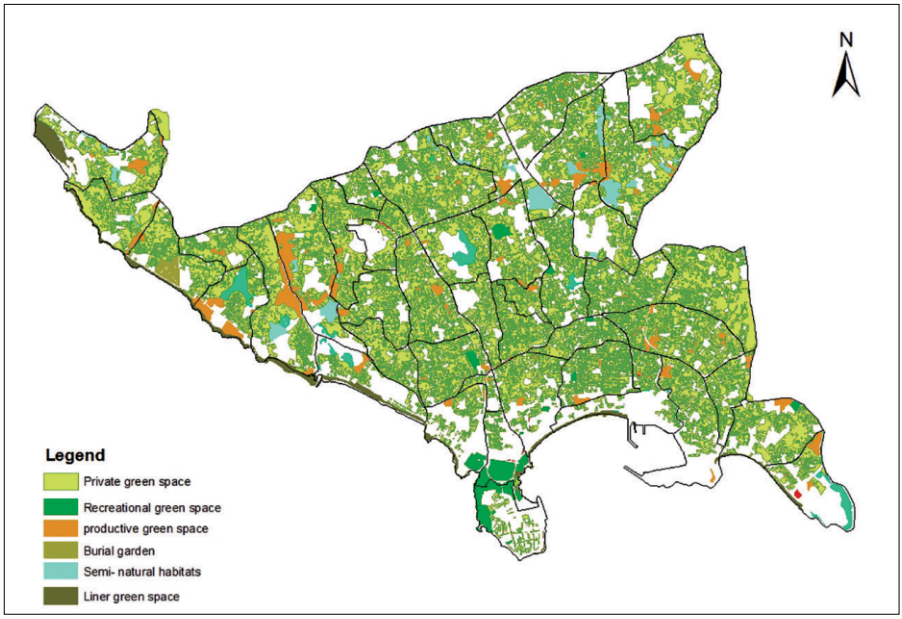


The following types of urban green spaces can be found in the Galle MC region.

Table 3: Types of urban green spaces in the Galle MC

Recreation Green Space	Parks and gardens, Outdoor sports areas, Play areas
Private Green Space	Green spaces within housing plots
Productive Green Space	Paddy, coconut and tea cultivated land
Burial Grounds	Cemeteries and Church yards
Institutional Grounds	School playgrounds, other institutional grounds
Semi-natural Habitats	Marshes, Grasslands, Wetlands
Linear Green Spaces	Canal and river banks

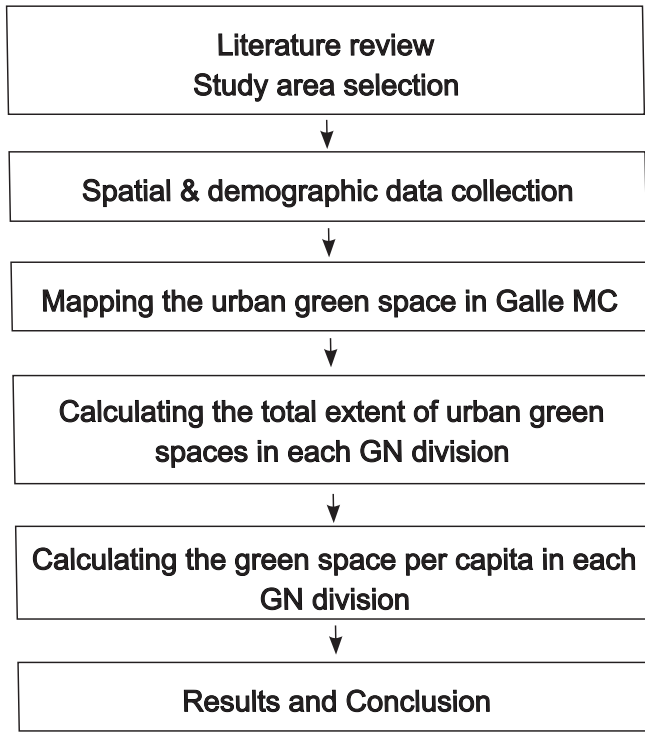
Map 2: The types of urban green spaces in each GN division of the Galle MC.



Methodology

The steps of the methodology applied to the study can be seen in Fig. 1.

Figure 1. Methodology



The population data of each GN division were collected from the Department of Census & Statistics. Existing green spaces were identified and extracted using GIS. The green space per capita in each GN division was calculated (Equation 1).

$$GSPC_{(GN)} = EGS_{(GN)} / P_{(GN)}$$

Where,

$GSPC_{(GN)}$ ***: green space per capita of GN Division***

$EGS_{(GN)}$ ***: existing green spaces of the GN Division***

$P_{(GN)}$ ***: population of the GN Division***

The area of green space required for healthy living in a GN division was calculated according to the population of each GN division (by assuming an equal distribution of population within a GN division) as per the standard value recommended by WHO (Equation 2).

$$TGS_{(GN)} = P_{(GN)} \times GSPCS_{(WHO)\ or\ (UN)}$$

Where,

$TGS_{(GN)}$: Total green space area required for healthy living in the GN division according to the selected standards

$P_{(GN)}$: population of the GN Division

GSPCS: Green space area per capita standard value recommended by WHO (9.5m2/person) or UN (30m2/person)

By subtracting the existing green space area from the ideal green space area required for the population in each GN division (as per the WHO or UN standards), the shortfall in the amount of green space required can be calculated (Equation 3).

$$AGS_{(GN)} = EGS_{(GN)} - TGC_{(GN)}$$

Where,

$RGS_{(GN)}$: Additional green spaces needed to be established in the GN division

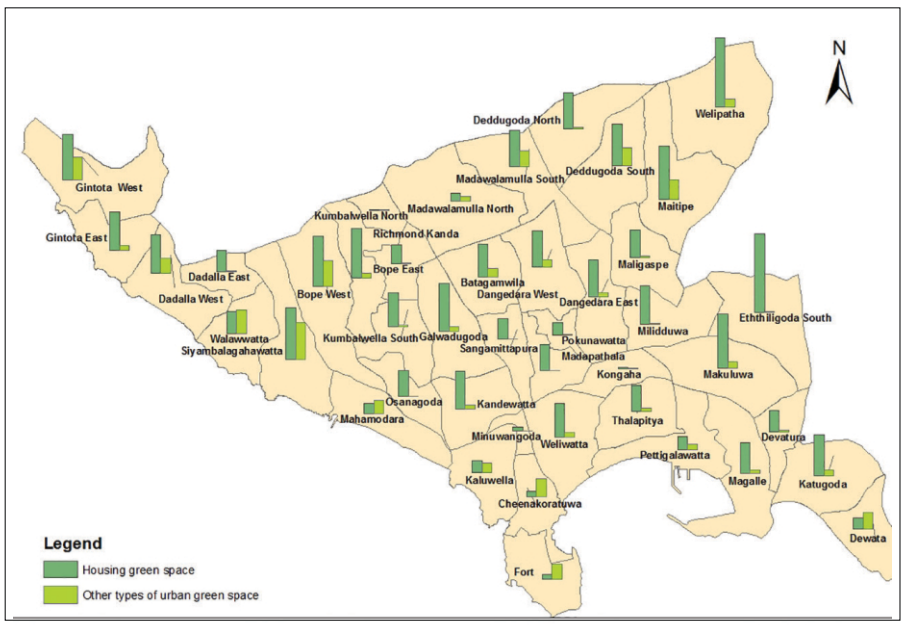
$EGS_{(GN)}$: Existing green spaces in the GN Division

$TGS_{(GN)}$: Total green space area required for healthy living in the GN division according to the selected standard.

Results and analysis

According to the results of the analysis as given in Table 4 (annexure), it is evident that 50% of the Galle city is covered with urban green spaces. Housing green spaces represent the highest extent of urban green spaces within the Galle MC (Map 3).

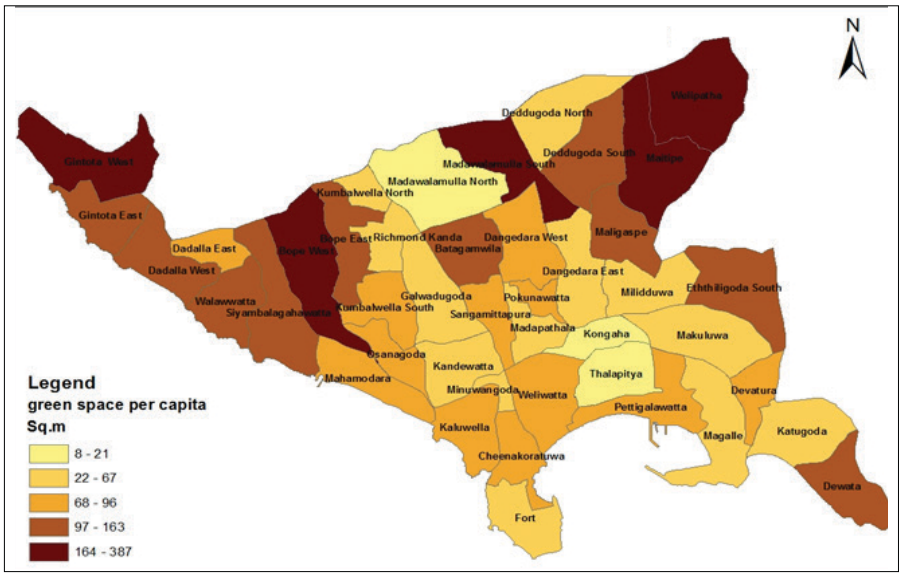
Map 3: Types of green spaces in each GN division of Galle MC



Housing green spaces are important as they provide residents with immediate access to urban green spaces. They also play a significant role in contributing to the overall vegetation cover in the Galle city. According to Map 3, householders in Ethiligoda South, Welipatha and Dedugoda GN divisions are maintaining a significant extent of residential gardens.

Map 4 shows the green space per capita by GN division in the study area. Green space per capita in Gintota West, Bope West, Medawalamulla South, Maitipe and Welipatha GN divisions exceed the standards while Kongaha, Medawalamulla North and Thalapitiya GN divisions fall below the level specified by the standard.

Map 4: Green spaces per capita of Galle MC



Data in Table 4 (annexure) revealed that the Kongaha GN division would not meet the WHO standard since urban green space per capita value is 8.7% and according to the calculation an additional 1343 sq.m of green space would be required to reach the WHO standard. The other GN divisions meet the WHO standards and presently the highest green space availability in the Galle city is in the Medawalamulla South GN division (220.5 m^2/ person).

The Kongaha, Medawalamulla North and Thalapitiya GN divisions fall below the UN standard. For these three divisions to meet the UN standard it would be necessary to establish green spaces with areas of 37956 sq.m, 64797 sq.m and 66018 sq.m respectively, within those divisions. Presently, green spaces per capita of the GN divisions are 8.7%, 15.1% and 21%.

The average green space per capita in the whole city is approximately 87.5m^2, which is well above the WHO & the UN recommended values. Compared with other South Asian cities such as Mumbai and Chennai where the green space per capita is less than 1m^2/ person, and the Colombo city where the green space availability is 9.53m^2/ person (Kuchelmeister, 1998), the Galle city is far ahead. Therefore, the total area presently covered by green spaces in the Galle city is large enough to accommodate the needs of the city's population.

Conclusion

This study was carried out to assess the existing green spaces in the Galle city of Sri Lanka quantitatively and to identify the GN divisions that were below the recommended standard values of the WHO and the UN for green spaces.

The green space per capita figure for the entire city is 87m^2/ person and that shows that Galle is an environmentally sustainable city. The present extent of housing green spaces within the MC area makes a significant contribution to this. Therefore, it can be seen that private land accounts for a large proportion of urban green spaces in the city of Galle.

The important point is that there is a surplus of green spaces in most of the GN divisions and the amounts of green space in 40 GN divisions are well above international standards. According to the findings of the study, it can be concluded that Galle is a sustainable city at present with a very good value for the per capita green space. Green spaces are uniformly distributed throughout the city area, and the total area occupied by green spaces in the city is large enough to accommodate the needs of the population.

The methodology adopted in this study can be utilized effectively in other urban centres as well to calculate the green space per capita as that would be helpful to enhance the environmental quality of the location in accordance with the WHO and the UN standards.

Table 4: Comparing existing green space with available standards and assessing the shortage and surplus

No	GN Division	Total Land extent (sq.m)	Existing green area (sq.m)	% Green area	Population	Green space per capita	Total green space required for healthy living according to the WHO standard	Shortage or surplus (Based on WHO standard)	Total green space required for healthy living according to the UN standard	Shortage or surplus (Based on UN standard)
1	Batagan-wila	377,823	217,989	58	1,563	139.5	14849	+203141	46890	+171099
2	Bope East	373,355	287,850	77	2,220	129.7	21090	+266760	66600	+221250
3	Bope West	653,546	400,902	61	1,036	387.0	9842	+391060	31080	+369822
4	Cheenakor atuwa	276,023	119,717	43	1,304	91.8	12388	+107329	39120	+80597
5	Dadella East	196,321	121,660	62	1,684	72.2	15998	+105662	50520	+71140
6	Dadella West	404,953	278,420	69	2,073	134.3	19694	+258727	62190	+216230
7	Dangedara East	425,595	210,855	50	3,884	54.3	36898	+173957	116520	+94335
8	Dangedara West	436,534	225,905	52	2,331	96.9	22145	+203761	69930	+155975

No	GN Division	Total Land extent (sq.m)	Existing green area (sq.m)	% Green area	Population	Green space per capita	Total green space required for healthy living according to the WHO standard	Shortage or surplus (Based on WHO standard)	Total green space required for healthy living according to the UN standard	Shortage or surplus (Based on UN standard)
9	Deddugoda North	466,625	199,440	43	3,012	66.2	28614	+170826	90360	+109080
10	Deddugoda South	522,416	314,774	60	2,510	125.4	23845	+290929	75300	+239474
11	Devetura	220,683	116,078	53	1,437	80.8	13652	+102427	43110	+72968
12	Dewata	395,011	145,587	37	1,273	114.4	12094	+133494	38190	+107397
13	Ethiligoda South	588,834	415,251	71	3,176	130.7	30172	+385079	95280	+319971
14	Fort	349,884	103,743	30	1,613	64.3	15324	+88420	48390	+55353
15	Galwadu-goda	459,565	275,561	60	5,240	52.6	49780	+225781	157200	+118361
16	Gintota West	631,215	358,403	57	1,370	261.6	13015	+345388	41100	+317303
17	Gintota East	341,788	227,586	67	1,391	163.6	13215	+214372	41730	+185856
18	Kaluella	376,195	111,450	30	1,382	80.6	13129	+98321	41460	+69990
19	Kandewat-ta	369,940	216,796	59	3,694	58.7	35093	+181703	110820	+105976
20	Katugoda	474,691	243,349	51	3,777	64.4	35882	+207468	113310	+130039

No	GN Division	Total Land extent (sq.m)	Existing green area (sq.m)	% Green area	Population	Green space per capita	Total green space required for healthy living according to the WHO standard	Shortage or surplus (Based on WHO standard)	Total green space required for healthy living according to the UN standard	Shortage or surplus (Based on UN standard)
21	Kongaha	213,027	15,624	7	1,786	8.7	16967	-1343	53580	-37956
22	Kumbalwe-la North	131,403	60,820	46	904	67.3	8588	+52232	27120	+33700
23	Kumbalwe-la South	321,945	187,658	58	2,447	76.7	23247	+164412	73410	+114248
24	Madapatha	231,233	136,212	59	2,843	47.9	27009	+109204	85290	+50922
25	Medawala-mulla North	748,718	66,003	9	4,360	15.1	41420	+24583	130800	-64797
26	Medawal-amulla South	501,552	275,602	55	1,250	220.5	11875	+263727	37500	+238102
27	Magalle	540,044	180,379	33	2,705	66.7	25698	+154682	81150	+99229
28	Maha-modara	370,275	122,798	33	1,604	76.6	15238	+107560	48120	+74678
29	Maitipe	644,845	380,582	59	1,832	207.7	17404	+363178	54960	+325622

No	GN Division	Total Land extent (sq.m)	Existing green area (sq.m)	% Green area	Population	Green space per capita	Total green space required for healthy living according to the WHO standard	Shortage or surplus (Based on WHO standard)	Total green space required for healthy living according to the UN standard	Shortage or surplus (Based on UN standard)
30	Makuluwa	563,512	319,579	57	4,932	64.8	46854	+272725	147960	+171619
31	Maligaspe	377,342	149,731	40	1,036	144.5	9842	+139889	31080	+118651
32	Miliduwa	395,445	202,875	51	3,933	51.6	37364	+165512	117990	+84885
33	Minuwan-goda	67,651	23,544	35	432	54.5	4104	+19440	12960	+10584
34	Osanagoda	232,318	135,928	59	1,902	71.5	18069	+117859	57060	+78868
35	Pettigala-watta	416,637	99,687	24	1,356	73.5	12882	+86805	40680	+59007
36	Pokunuwita	112,203	70,894	63	911	77.8	8655	+62240	27330	+43564
37	Richmond Kanda	226,839	103,279	46	1,525	67.7	14488	+88792	45750	+57529
38	Sangamith-thapura	236,477	107,869	46	1,209	89.2	11486	+96384	36270	+71599
39	Sangai-yambala-gaswatta	577,761	465,442	81	2,978	156.3	28291	+437151	89340	+376102

No	GN Division	Total Land extent (sq.m)	Existing green area (sq.m)	% Green area	Population	Green space per capita	Total green space required for healthy living according to the WHO standard	Shortage or surplus (Based on WHO standard)	Total green space required for healthy living according to the UN standard	Shortage or surplus (Based on UN standard)
40	Thalapitiya	360,986	152,892	42	7,297	21.0	69322	+83571	218910	-66018
41	Walaw-watta	368,207	237,660	65	1,734	137.1	16473	+221187	52020	+185640
42	Welipatha	760,036	398,819	52	1,916	208.2	18202	+380617	57480	+341339
43	Weliwatta	476,519	197,409	41	2,336	84.5	22192	+175217	70080	+127329
	Total	17,215,972	8,682,602	50	99,198	87.5	942381	7740221	2975940	5706662

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