Development of Urban Green Spaces for Achieving Ecological and Social Benefits of Urban Areas in Sri Lanka

Sri Lanka Journal of Social Sciences and Humanities
Volume 1 Issue 2, August 2021: 161-173
ISSN: 2773 692X (Online), 2773 6911 (Print)

Published by Faculty of Social Sciences and Languages, Sabaragamuwa University of Sri Lanka
Website: https://www.sab.ac.lk/sljssh
DOI: http://doi.org/10.4038/sljssh.v1i2.47
SLJSSH

Wijewardhana, A.M.C.[1,*] and Senevirathna, E.M.T.K.[1]

[1] Department of Geography and Environmental Management, Sabaragamuwa University of Sri Lanka, Belihuloya, 70140, Sri Lanka.

Received: 18 March, 2021, **Revised:** 20 May, 2021, **Accepted:** 27 June, 2021.
How to Cite this Article: Wijewardhana, A.M.C. and Senevirathna, E.M.T.K. (2021). Development of urban green spaces for achieving ecological and social benefits of urban areas in Sri Lanka. Sri Lanka Journal of Social Sciences and Humanities, 1(2), 161-173.

Abstract

Green spaces create a link between human beings and the environment around them to enhance the quality of human life and benefits for both. But the reductions of green spaces in urban areas lead to several environmental and social problems world-wide. This study focused to find the required sites for Urban Green Space (UGS) development to gain ecological and social bene-fits in Rathnapura Municipal Council. Six Grama Niladhari Divisions were selected for the study. Accordingly, digitized Google Earth Pro satellite images in 2019 and population data in 2018 were used for analysing existing UGS. According to that geomet-ric calculation, buffer, near, and weighted sum tools in ArcMap 10.4 were used to analyses data. Green Space Per Capita Index (GSPCI) was calculated to find whether the existing UGS is enough or not for the healthy living of the residents based on rec-ommendation scales of World Health Organization (WHO) and United Nations (UN) as 9m2 and 30m2 green spaces per person respectively. It has been found the study area is exceeding both recommended levels. Whatever the GSPCI, the study has found Mihindugama, Rathnapura Town North and West have required approximately 114624, 8474, and 38617 square meters of addi-tional UGS respectively according to buffer analysis based on GSPCI regard to UN recommendations. Weighted sum analysis has found that approximately 18% of land highly required UGS. Meanwhile, the study has revealed Mihindugama, Kospelawinna, and New Town have a shortage of UGS near the residential areas. Moreover, the study shows there is a potential to develop UGS in the area by approaching existing resources. As consequences of this study will provide ideas for mitigating urban issues and guide to fulfil the additionally required UGS to better development.by the above findings for the benefit of future online learning and to carry out such educational activities without interruption.

Keywords: Existing Green Spaces (EGS), Geographical Information System, Green Space per Capita Index, Urban green space (UGS)

INTRODUCTION

A green environment is a basic need of humans and other animals on Earth because it provides food, water, and fresh air for the healthy living of any animal. Therefore, the value of a green environment is immeasurable. Unfortunately, the lack of awareness of people with regards to this is one of the major reasons for losing the green environment on this planet. With the decline of the green environment, the world lost its aesthetical beauty, water sources, biodiversity, food, fresh air, and climate changes such as extreme temperature, natural disasters. On the other hand, illnesses and uncomfortable living conditions of urban citizens have become severe issues. Consequently, at present, there is a demand for a green environment everywhere around the world to mitigate those issues. Among them, the demand is high in urban areas compared to rural areas. "UGS plays a significant role in shaping towns and cities towards sustainability (White Paper: GS in the City, 2018). It provides a sustainable urban environment in many ways such as purifying air and water, filtering noise, and stabilizing the microclimate (Neema et al, 2013). As examples of benefits of UGS, a study proved the people who are near to the greenest areas have the lowest risks of poor mental and it was proved at a 95% confidence interval. As well, greater than 15% of GS availability causes to minimize the risk of cardiovascular disease. Moreover, the overall physical activity levels are higher in greener neighbourhoods (Richardson et al, 2013). According to Kleerekoper et al, (2012), vegetation has an average cooling effect of 1–4.7 C^0 that spread 100-1000m of an urban area. Another significant study mentioned a single tree can provide about 270 kWh cooling per day, per tree, due to evapotranspiration effects alone and vertical green can reduce interior surface temperature by >20 C^o (Konau, 2016). Further, street trees (one of UGS) contribute to mitigating noise pollution while protecting especially the bird species in the area. One of the study has done by Pena, revealed that the saving of native and canopy tree species along the streets cause to protecting bird diversity in city streets (Pena et al, 2017). To UGS development, there is a concept of vacant lands/ vacant sites. Potential areas for new establishment or redevelopment of UGS are called vacant sites for UGS development. According to WHO, devel-

[*] **Corresponding author:** Tel.: +94 (71) 832 4740; Email: hmrupasingha@gmail.com
https://orcid.org/0000-0003-3922-4290

oped countries have more UGS compared to the UGS in developing countries (Bardhan et al, 2016). Most of the cities in developing countries like Sri Lanka have problems such as over-population density and lack of space because more people concentrate on cities for occupations. This issue arises from rural-urban disparity in developing countries causing deforestation in urban areas and a shortage of UGS. But most developed countries have the best strategies and economic strength to establish and maintain the UGS.

Sri Lanka has a history of GS planning since ancient times. 'Wewa' concept of ancient Sri Lanka was evidence to early Sri Lanka has applied the green city concept for its development purposes. As evident in an ancient country, governors consider its environmental protection even when planning cities. Yet, Sri Lanka still has a shortage of UGS in its cities. Colombo is the commercial capital of Sri Lanka and it is a metropolitan region which shows rapid urbanization". One study revealed Colombo city is facing a severe issue due to the shortage of green areas around it. Colombo maintains its green space per capita index as the world's standard until 2011 and presently it became a serious problem (Li and Pussella, 2017) than other areas in the country. Rathnapura Municipal Council (RMC) in Sri Lanka is the owner of the second-largest urban forest with high biodiversity in Sri Lanka which is named as 'Pompekele' urban forest, even though now it is declining due to encroachments for various reasons. For instance, the encroachment of riparian GS along the 'Kalu river' in RMC is destroying rapidly. However, Rathnapura Urban Development Authority expects to develop RMC as a green city to minimize such issues in the area. In that point, it expects to develop green cover by 40% in 2030 and redevelop existing urban green parks according to its plan for 2018-2030. As well as there are some proposed projects of making a greener environment for city decoration. Although, there is no ongoing regular strategy to develop the UGS in the entire RMC.

Urban green space planning is a sub-discipline of land use planning and urban planning as well as land use architecture, various environmental studies including geography, ecology, and botany, etc. Particularly, one of the important points is that GS is a fundamental part of an urban ecosystem. Identification of a suitable location for urban areas in the world is currently a huge issue in urban planning. Further, there are many problems which are related to the accessibility of public green spaces. Hence, the identification of suitable locations for urban green is a very essential part of urban green space planning (Lashari et al, 2017).

OBJECTIVES

Objectives of this study were to identify the existing green spaces of the study area, identify the existing types of urban green spaces and their extent, identify the social and ecological qualities of existing green spaces, analyze which extent of green spaces need for healthy living of the people in the study area, investigate the problems of the study area which can be recovered by urban green spaces establishment, analyse the requiring locations for new green space development in Rathnapura Municipal Council to gain ecological and social benefits while mitigating urban issues in the area. There were few specific objectives as to identify the existing urban green spaces, their extent, and the qualities, to calculate the Green Space per Capita Index for the study area, to the identification of requiring green spaces for healthy living of people in the study area, to identify the necessity of urban green spaces based on problems in RMC, to identify the requiring locations of urban green spaces in the study area.

STATEMENT OF THE PROBLEM

According to the 'Urban development plan of Rathnapura – 2018-2030', the decline of the forest cover causes urban heat in the study area about 31C^0 every December to March. Due to the geographic locational barrier on smooth wind flow, people feel about 35 C^0 heat in the daytime than the actual temperature. For instance, 80% of land affects two to five days from three types of floods; critical flood, major flood, and minor flood. In addition to these specific issues, RMC faces common urban issues such as environmental pollution, unhealthier living conditions of the people, etc. These issues are challenges for the development of RMC. Therefore it is essential to identify the ways of mitigating and overcome these challenges to achieve sustainable development.

STUDY AREA

RMC is the study area which locates in Sabaragamuwa province in Sri Lanka (Figure 1) and it is away approximately 100km from Colombo. There are 63,493 of population living in the study area (Resource Profile – Rathnapura, 2018). RMC has 13 Grama Niladari Divisions (GND) and there are other 5 GND that belong to both RMC and Rathnapura Pradeshiya Sabha. (Resource profile - Rathnapura DSD, 2018). Altogether there are 18 GND in the study area (Figure 1). Accordingly, six GNDs, namely New town, Kospelawinna, Mihindugama, Rathnapura town, Rathnapura town west and north selected out of them for this study. Since 1981, RMC is developing as a duel city both old town and new town. RMC extends 22.2km^2 of land. According to the "Disaster Risk Reduction and Preparedness Plan" of the Rathnapura city, its undeveloped land is 38.7%. But 21.1% can be used to develop while other areas cannot be used due to environmental conditions. Eleva-tion of RMC varies from 18m to 305m. The topographical characteristics of the study area caused to face landslides and flood hazards every year. Location within 'Kalu river valley', surrounded highlands and rapid urbanization cause that.

LITERATURE REVIEW

Rakhshandehroo et al, (2017) defined an urban space as the region surrounding a city. Brilhante et al, (2018) mentioned that "Green city concept and a method to measure green city performance over time applied to fifty cities globally: Influence of GDP, population size and energy efficiency" explained both green and greening terms are used similarly to emphasize the sustainability and eco-friendliness of an organization, a location or a commodity or anything in the world (green economy, green tourism, etc). According to the United States Environmental Protection Agency (EPA), green space is a kind of open space. Accordingly, "green space is a land that partly or completely covered with grass, trees, shrubs, or other vegetation". Cilliers et al, (2013) "Approaching value-added planning in the green environment," said that the green spaces differ from open spaces. Open space is any type of open land or isolated parcel of open land which has known value or not. While green space is pre-planned and preserved, open land is an interconnected system with cultural, ecological, development, and agricultural aspects. WHO, "Urban green spaces: a brief for action" mentioned that urban green space is a very important component of green infrastructures to enhance the social well-being in a city. Hence, urban green spaces must be easy to access for

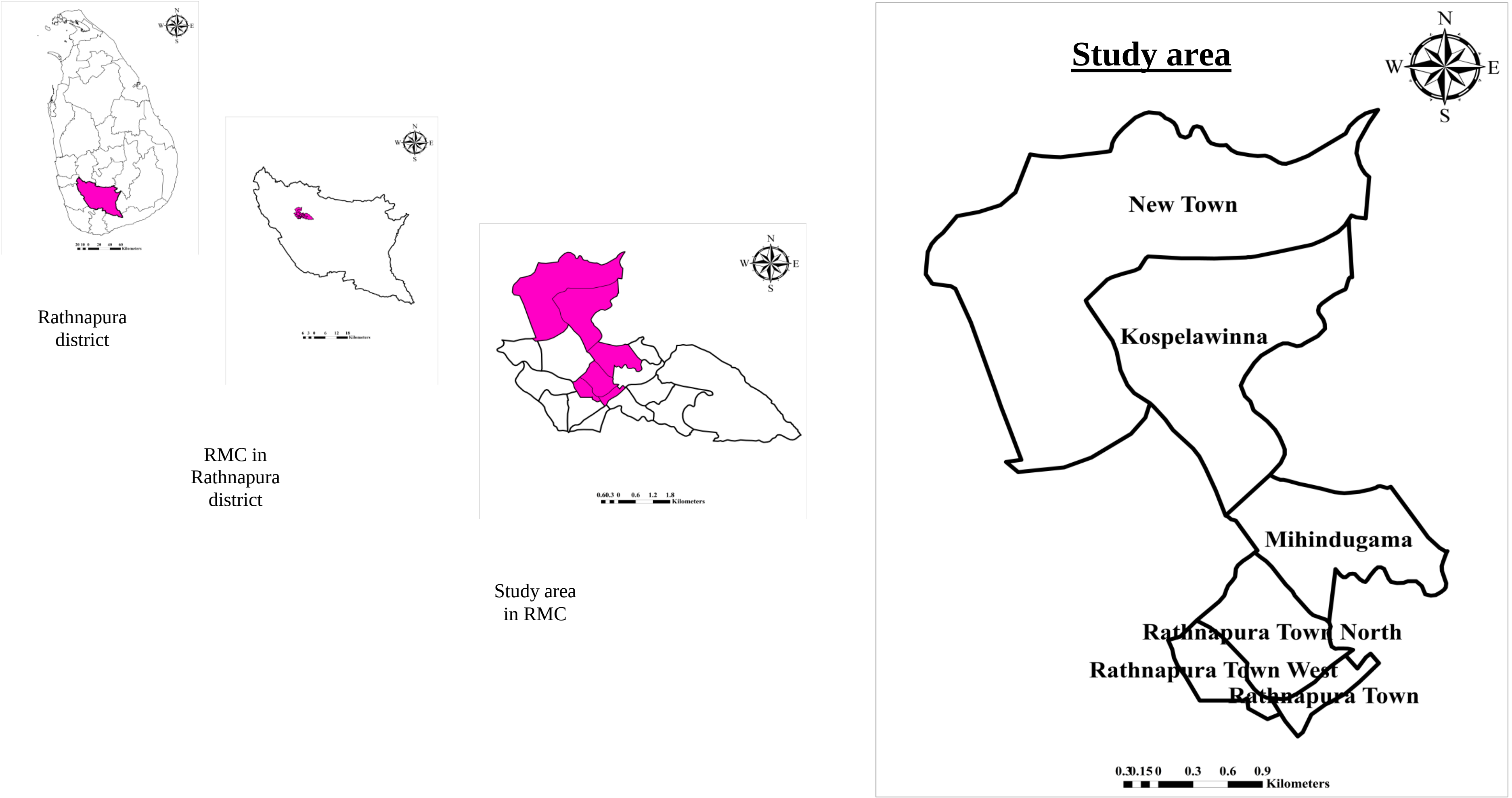


Figure 1: Location of the study area

Data source: UDA in Rathnapura, Survey Department of Sri Lanka, 1996 each person in the city and they must be simultaneously distributed in the entire city. In addition to that WHO indicated eight urban green spaces that can be established in a city; roadside greenery and vegetation barriers along streets or rail tracks, small urban green spaces such as gardens or pocket parks and playgrounds, green roofs and facades, parks, and urban meadows, greenways and corridors coastal, riverside or lakeside trails, linking green with blue spaces, recreational and urban gardening facilities and facilitated access to urban woodlands, forests and natural wildlife areas. Moreover, WHO indicated specific guidelines to be considered before the urban green spaces planning; what type and size of urban green space are being planned? what are its main functions to be? which population groups are expected to make use of it? who is responsible for its maintenance and management? might the planned urban green space be a way to upgrade a deprived area?. Dickinson, (2018) defined "urban green spaces are often among the few places where city dwellers can interact with nature and are known to provide multiple benefits to human well-being". According to this definition, accessibility is the most important criterion in urban green space planning because it determines the interaction between people and nature. Arvanitidis et al, (2009), "Economic aspects of urban green space: a survey of perceptions and attitudes," noticed the value of green spaces acknowledged since the end of the 19th century. This study indicated that the urban green spaces have economic value too. Accordingly, it can be divided into three basic categories; (I) the direct economic value of urban green spaces –: Recreation, paying for sports facilities, (II) indirect or spill-over benefits -: For health, crime or business activity, (III) non-use or values that do not leave any behavioural trail (symbolic values). Gupta et al, (2012) explained that urban green spaces act as the lungs of a city that absorb pollutants and release oxygen to provide clean air, soil, and water and to balance the natural environment. Further, it revealed urban green spaces function as visual screens and act as a noise barrier and avoid too much spatial uniformity and also releasing mental stress and continue the physical health of man. Manlun, (2003) "Suitability analysis of urban green space system based on GIS" developed a model for urban green space planning for Dongguang municipality in China. At the beginning of this study, it was based on existing green spaces and their problems in the area. Then analysed data on stakeholders which was collected through an interview and selected the suitability factors; air quality, landscape quality, surface water quality, historic cultural value, water system influence, noise influence, and existing land use to achieve the target by considering data availability. Each factor was divided into three suitability classes; high, moderate, and not suitable through a description for each suitable level. Then assigned scores for each class as 3, 2, and 1 for high, moderate, and not suitable respectively. For example, the air quality factor was assigned high suitability when it is an area with low air quality. According to that classification, a study has created suitability maps for each factor. Moreover, the study identified factors except for air quality, surface water quality, and noise influence as certain factors to reduce the errors of the final result and calculated the certainty factor of those factors. Thereafter, got the composite certainty factors of those factors and built up the suitability maps for those four factors. Then two weighting methods were applied to the study to assign weights for these factors. Using the method of integration, this study weighted stakeholders' opinions regarding all suitability factors according to their importance. According to Manlun, the method of integration is an 'expert assess' and 'hierarchic analysis of nine degrees used to assign weights for each factor. It assesses the importance of each factor as a percentage of the opinions. Finally, the normalized weights were calculated using a statistical formula. This study used several techniques; 'expert assess', 'hierarchic analysis of nine degrees', weighting to built-up a method for the identification of the suitable places for urban green spaces in the study area. For instance, the created model can be applied to any city in the world with or without improvements. M'Ikiugu et al, (2012) 'Urban green space analysis and identification of its potential expansion areas' used landscape metrics and suitability checklist and proximity buffering within GIS application for identification of potential sites to expand the urban green spaces to Central Nairobi city. Digitized maps and the structured interviews of field experts were the basic data collection methods in this study. Using a landscape matrix, the research compared, analysed, and found urban green space per capita and distribution pattern of the urban green spaces. Using pair-wise comparison and Analytical Hierarchy Process, the research developed an urban green space suitability checklist including eight variables; areas within 100m proximity of existing urban green spaces, wetlands, riparian areas, bare soil or open grounds, demand areas, transportation, and or infrastructure corridors, friendly land use planning, and those with unfriendly land use planning. According to the experts' opinion these all variables were weighted. Each space of the land use map was included this weight in a new field of its attribute table. Finally, the map symbolized these data as their summations and through a colour gradient, the map shows High, Mid, and Low Potential of those spaces to urban green spaces expansion. Then researcher followed the identification of potential expansion areas of urban green spaces for the same study area to minimize the bias. It was buffering the existing urban green spaces, rivers and streams, wetlands, transportation, and infrastructure. As an example, they buffered transportation networks as highway 60m, main road 30m, feeder roads 15m, and railway 50m buffer zone. Generated two maps; potential map after urban green space checklist application and potential map after proximity buffers were overlaid. In the normalization process, the checklist application map assigns 10,20, and 30 as low, mid, and high potential respectively, and the proximity buffer overlay map assigns 5,10, and 15 as low, mid, and high potential respectively. Then, both normalized maps were overlaid together based on the single normalized score that indicates where they overlapped, and where they did not overlap for getting the final composite potential map for urban green space expansion in the study area. Chang et al, (2012) 'A GIS-based green infrastructure planning for sustainable urban land use and spatial development' aimed to plan green infrastructures in Longgang district of Shenzhen city in China considering ecological connectivity of green spaces to conserve and develop future land in the city. They explained, "A series of land use maps are the foundation of green infrastructure planning". Hence, the study used land use maps for achieved their target. "Patch-Corridor-Matrix Model" was used for the entire landscape pattern analysis. The study focused on ecological principles and selected four major components to analysis landscape patterns such as a few large patches of natural vegetation, major stream or river corridors, connectivity with corridors and stepping stones between large patches, and heterogeneous bits of nature across the matrix. Then, the study analysed the spectrum of the patch size of each land use type; agro-lands, transportation lands, low-density built-up lands, water reservoirs, and unused lands using land use map of the study area and this patch size spectrum of each land use type was divided as the area larger than 50hm2, 10hm2 -50hm2, and smaller than 10hm2. Then, the landscape pattern was divided into an eco-land matrix, the built-up and eco-land patches, and the traffic and river corridors by the statistical distribution of the land-use polygon sizes. Ecological Connectivity Assessment (ECI) method used to identify where the connectivity between larger patches. The ecological cost-distance calculation is the first step of ECI. This study used a cost-distance model in GIS and other elements to use the ECI are an impedance surface from artificial land units and barrier effect value sets were calculated using formula. Finally, based on the guideline of a nature reserve's establishment pattern in the Regulations of the People's Republic of China on Nature Reserves, the ecological connectivity pattern of the study area were divided into four types based on the ECI value by natural breaks classification method in GIS: the core, the buffer, the transitional zone, and the no or low connectivity area. To sum up, the study created an ecological connectivity index distribution map for the study area. The hubs and links of the green infrastructure network were generated by overlaying the results of the Patch-Corridor-Matrix pattern and the core buffer-transition zone in the study area. Senanayake et al, (2013) "Assessment of green space requirement and site analysis in Colombo, Sri Lanka: A Remote Sensing and GIS approach" was a study about green capacity analysis of Colombo city. This study used Normalize Difference Vegetation Index to calculate the existing green spaces of the city. For that, the study used Visible Red (0.62- 0.69 µm) and Near Infrared (0.77-0.90 µm) bands of Thailand Earth Observation System (THEOS) satellite imagery. Next extracted green space areas were then converted into polygon feature class and intersected with the GN divisions' layer of Colombo city. The area calculation of existing green spaces was calculated by GIS software and to calculate green space per capita, 2011 population data was used. Then study calculated green space per capita and required green spaces for healthy living of the urban citizens. Further, the study needed to identify where should be establish required green spaces in each GND in Colombo city and they used the buffering technique of GIS. The standard minimal green space area per capita value recommended by WHO and population densities of each GN division was used in the calculation of the required buffer radius using the following method. Since GN divisions are the smallest administrative areas in the country, the population within a GN division has been assumed to be equally distributed in this analysis (land area of Kurunduwatta, the largest GN division in Colombo city is 3.57 km2 only). To calculate the radius of buffer zone they used the following formula; Where, b = Buffer area around an existing green space, g = Area of the existing green, s = Standard minimal green space per capita recommended by WHO, P= Population density of GND. Then, using another formula calculated the approximate radius of the buffer zone and finally identified where the places required green spaces in Colombo city. Jayasinghe et al, (2017-2018) "GIS-based assessment of the green space per capita in the city of Galle" focused on calculating green space per capita for Galle Municipal Council (MC) in Sri Lanka according to the World Health Organization (WHO) and United Nations (UN) standards. Green space per capita is 9.5m2 /person and 30m2 /person according to WHO and UN respectively. This study used population data and a green space distribution map in the study area. Firstly, the study has created a map to represent existing green spaces in Galle MC using GIS techniques and identify different types of existing green spaces. Then, the total extends of green spaces of each Grama Niladari Division (GND) in Galle MC were calculated. Further, green space per capita was calculated for each GND and both required and shortage/surplus green space extent was calculated as WHO and UN standards. Those green space per capita calculations of each GND were entered into the GIS software and show the spatial distribution of green space per capita in Gall MC. According to the results, three GNDs were not felt into UN standards but they felt into WHO standards. From this method, the study can be applied to find the required green spaces for a place as numerically in the urban green space planning concept. Through that, easy to understand the needed extent of green space for a place additionally or not needed. In addition to green space per capita index calculation, some studies used 'accessibility' criteria to urban green capacity analysis. Here, allocation of the time and distance to reach any urban green space by a person is calculated. This indicator is also useful to estimate the capacity of green spaces to full fill social needs in an urban area. Gantiva et al, (2018) "Methodological proposal for measuring and predicting urban green space per capita in a land-use cover change model: A case study in Bogota" considered which purposed to highlight the location of green space problems in Bogota. This study measured green space per capita and predict its future conditions using the Ordinary Least Square method and Geographic Weighted Regression Model (GWR) using GIS techniques. Megayanti et al, (2020) "Participatory Rural Appraisal implementation in identifying public open space" study focused on the identification of potential sites for public open spaces with the help of villagers in the study area. The study area is Nagrikaler, Purwakarta Regency in Indonesia. Participatory Rural Appraisal (PRA) method is used to achieve the objective of the study. PRA method is successful in rural land use planning even urban planning because it is a community-based research method. For that, field walks, participatory mapping, and focus group discussion were used as data collection methods. PRA was done through five stages; preparation, identification of open spaces and problems, design ideas development, ranking and monitoring, and evaluation. In the identification stage, the researchers met the community to prepare the schedule for the PRA. In the second stage, field walks and participatory mapping were done for the identification of potential spaces. Next, group discussion and neighbourhood mapping sketch were done as the third stage of the PRA. Then with the support of the focus community, the plan was created, and finally, through a community meeting, the plan is evaluated. This study showed the absence of public vacant lands but there are private vacant lands. When considering the background of the study, urban green space planning is derived from concepts of sustainability, green, eco-friendly, and green infrastructures. This field emerged to overcome the ecological and social issues of rapid urbanization. To obtain proper answers to these problems a proper plan should be needed. For that theoretical background proved different standards of urban green space must be considered when planning according to easier usage and benefits of humans. According to the background of the study, urban green space planning studies mainly considered areas lacking green spaces, how to create connections among green patches, and what types of green spaces are most suitable. For that purpose, there is a wide range of techniques for urban green space planning. Modern techniques as Geographic Information System (GIS) and remote sensing techniques, stakeholders participating techniques such as PRA, and different statistical techniques are using in this field. GIS and RS techniques have the wide capability to planning and develop urban green spaces in an area. Especially GIS can develop a bulk of methods for urban green space planning. Hence, this study also used both techniques to achieve the objectives. In addition, most of the previous studies consider common problems in cities when planning urban green spaces. But this research considers problems that specific to the study area through a structured interview with experts.

MATERIALS AND METHODS

The study mainly focused to calculate the Green Space per capita Index, analyze the Existing Green Spaces (EGS), the requirement of UGS and investigate the potentiality to develop UGS in the study area. For those purposes, the study collected the following data; Satellite image 2019, population data in 2018, experts' opinions, and the literatures. Google EarthPro satellite image in 2019 (Imagery date is February 2019) was used to digitize the existing green spaces and other land use types in the study area to identify various types of existing green spaces in the study area using a digitized image. KML tool of ArcMap 10.4 was used to digitize the satellite image and additionally hydrology and road shapefiles data in 1996 collected from Survey Department in Sri Lanka for buffer analysis. This study has identified the existing green spaces and determined the required green spaces for the healthy living of the urban citizens in the study area using digitized satellite images in 2019 and the population data in 2018 of the area. Moreover, the study has done an area calculation of existing green spaces by using 'geometric calculation' of ArcMap 10.4 software. For determining green space per capita, research was applied World Health Organization (WHO) and United Nations (UN) recommended standard of green space per capita index for healthy living of people for the study area. WHO and UN have recognized the need for $9m^2$ and $30m^2$ of GS per person for healthy living. Geometric calculations of existing green spaces were used to find those indexes. The next step of the study was the identification of the required sites for developing urban green spaces. The required sites of urban green spaces were determined based on the green space per capita index, ecological and s ocial benefits of the urban green spaces to the study area. It is essential to find where the locations that need additional green spaces. For that buffering, and symmetrical difference tools in ArcMap 10.4 were used. Then the study found where the places are not within buffer zones. For that purpose, the study found the symmetrical difference of each buffer zone map layer for the relevant GND layer. 'Symmetrical difference' tool in ArcMap 10.4 has been used for that. As mentioned GSPCI was calculated by assuming people spread as equally in the area. But the identification of residential areas near to the different types of EGS in the area is essential to identify the required sites of UGS in the study area. Accordingly, the building layer and EGS layer were used as the data to analyse that criteria. 'Near' tool of ArcMap 10.4 was used to analyse it. Then the study has created a map of residential areas near each main type of EGS. This study wanted to identify required sites for urban green space planning by considering ecological and social benefits as well. The study considered a flood, noise pollution, and residential areas (buildings) as criteria to identify required sites for UGS based on ecological and social benefits. Those types of criteria correspond to the study area were taken from expert's opinions through structured interviews. For that hydrology map, buildings map, terrain map, and road map were created using ArcMap 10.4 software. Then creating buffer zones for each map using multiple buffering tools. This study assumed flood events are very high in 50m, high in 100m, moderately high in 150m, and moderate in 200m from streams. In addition, the study assumed noise pollution and air pollution are very high in 50m, high in 100m, moderate in 150m, and low in 200m from roads. Then opened attribute tables of both buffer zone layers separately and added a new field to assign weights 1,2,3,4 as lowest to highest value respectively for buffer distances. The field that assigned weights for the road buffer layer was named W3 and in hydrology, the buffer was named as W1. Additionally, there were assigned 4 weights for all buildings, because buildings mean the residential areas. Therefore when finding the required sites for UGS, the study considered all the built-up areas as equally important. The weighted field of built-up areas was named W3. Thereafter, both buffer layers and building layers were created as one layer using 'union tool' and EGS layer joint to the union layer by using the 'join and relate' method in ArcMap 10.4. Then, open the attribute table of the union layer to assigned weights for EGS following the previous method. Accordingly, 3 weights were assigned to high dense green areas and riverine forests, 2 weights were assigned to moderate dense areas, 1 weight was assigned low dense green areas. Finally, using the 'field calculator' of ArcMap 10.4, calculated the ‘weighted sum' of W1, W2, and W3 fields of union layer and substitute the value of the W4 field using a formula. The reason for substituting W4 was that is unnecessary to applying additional GS for EGS locations. But it is not a success if all the EGS are accepting or all are not acceptable for this analysis because there are more benefits from high dense green spaces rather than the low dense green spaces and it is necessary to pay more attention to low dense green areas rather than the high dense green areas when finding the required sites of UGS for the area. In that case, the study decided to give low chance to places that had high dense green areas and riverine forests, a moderate chance for moderate dense green areas, and a big chance for low dense green areas. That was the reason behind the meaning of assigning the different weights for each type of EGS. At last, the study has created a map for the required sites of UGS in the study area. For that classified the above union layer according to the values of field calculation. To that, the map was classified into five categories.

RESULTS AND DISCUSSION

The digitized land use map of the study area has categorized the types of EGS as high dense green areas, moderate dense green areas, low dense green areas, and riverine forest areas. The total area of EGS is approximately $5,787,101m^2$/ $5.78km^2$. It is about around 46% out of the total land area. Accordingly, all sub-divisions (GNDs) of the study area have EGS. New Town shows the highest spread of EGS among the others. It is about $2,952,345m^2$. The second place belongs to Kospelawinna GND from other GNDs. The lowest EGS is recorded by Rathnapura Town. The reason is the low extent of the land area of Rathnapura Town rather than the high building concentration. However comparing the extent of each GND Rathnapura Town, Rathnapura Town- North, Rathnapura Town West, Mihindugama, Kospelawinna, and

New Town have 0.25, 0.77, 0.58, 1.18, 3.59, and 6.15 square kilometers of land area respectively. According to that, there are approximately 40.5%, 56.9%, 24.02%, 41.2%, 46.5%, and 48% of EGS out of the total land area of Rathnapura Town, Rathnapura Town- North, Rathnapura Town West, Mihindugama, Kospelawinna, and New Town respectively. Among them, New Town and Kospelawinna recorded a lower percentage value of EGS out of its total land area than Rathnapura Town although these both have recorded the highest area of EGS out of the total land of the study area. The reason for that is the extent of land area. Additionally, the fifth-largest GND of the study area is Rathnapura Town-West which has the lowest percentage of EGS out of total land. That percentage value is lower than the percentage value in the smallest GND of the study area (Rathnapura Town) accordingly. The reason for this is the majority of Rathnapura Town-West belongs to built-up areas out of total land than the Rathnapura Town area. Rathnapura Town North is the owner of the fourth large total area of EGS from the study area. When going through the study area, Ratnapura Town North has a high concentration of built-up areas in the lower part of the map. Although the Rathnapura Town-North locates nearest to the city center, this has a large area of EGS about approximately 438,638m^2 as well as approximately 56.9% of EGS out of the total land area (This value is the highest value among all GNDs in the study area) of GND. The location of Pompekele Urban forest reserve and the extent of the total land area of GND is caused to this situation. Consequently, these facts indicate the changes in the extent of EGS among GNDs in the study area have been caused by several factors such as the extent of land area, the concentration of built-up areas, and the location of urban forest reserve.

According to the EGS analysis based on UN and WHO recommended scales, Table 1 shows the GSPCI of each GND in the study area.

Table 1: Calculation of Green Space per Capita Index for the study area

GND Name	EGS (m^2)	EGS (Hectares)	Number of population in 2018	GSPC
Rathnapura Town West	139,332	13.9332	1,832	76.0545852
Rathnapura Town North	438,638	43.8638	4,467	98.1952762
Rathnapura Town	101,135	10.1135	1,766	57.2678369
Mihindugama	485,691	48.5691	8,050	60.3342857
New Town	2,952,345	295.2345	7,064	417.942384
Kospelawinna	1,669,960	166.996	5,134	325.27464

Data source: EGS data from 2019/02 imagery of Google Earth Pro and population data from Resource Profile-2018 in Rathnapura DSD

It has highlighted the amount of GS that belongs to a person in the area. In that case, a person in New Town has more GS (around 417m^2) while a person who lives in Rathnapura Town has around 57m^2 of GS. According to UN and WHO recommendations, one person needs 30m^2 of GS while WHO recommended that a person needs 9m^2 of GS. However, the GSPCI calculations revealed that the study area exceeds both recommended scales (Table 3 and 5).

Table 2: Required total green space area for healthy living of people in study area according to UN standards

GND Name	Number of population in 2018	GSPCS(UN)	TGS (m2)
Rathnapura Town	1,766	30	52,980
Rathnapura Town West	1,832	30	17,404
Rathnapura Town North	4,467	30	42,436.5
Mihindugama	8,050	30	76,475
Kospelawinna	5,134	30	48,773
New Town	7,064	30	67,108

Data source: Google Earth Pro 2019/02 imagery and population data from Resource Profile-2018 in Rathnapura DSD

Table 3: Required additional green spaces for the study area according to UN standards Data

GND Name	EGS (m^2)	TGS (m^2)	AGS (m^2)
Rathnapura Town	139,332	16,777	122,555+
Rathnapura Town West	438,638	17,404	421,234+
Rathnapura Town North	101,135	42,436.5	58,698.5+
Mihindugama	485,691	76,475	409,216+
Kospelawinna	2,952,345	48,773	2,903,572+
New Town	1,669,960	67,108	1,602,852+

Source: EGS data from 2019/02 imagery of Google Earth Pro

+ Mark has indicated extra EGS corresponding to the requiring scale

Table 4: Required total green space area for healthy living of people in study area according to WHO standards

GND Name	Number of population in 2018	GSPCS(WHO)	TGS (m^2)
Rathnapura Town	1,766	9	15,894
Rathnapura Town West	1,832	9	16,488
Rathnapura Town North	4,467	9	40,203
Mihindugama	8,050	9	72,450
Kospelawinna	5,134	9	46,206
New Town	7,064	9	63,576

Data source: Google Earth Pro 2019/02 imagery and population data from Resource Profile-2018 in Rathnapura DSD

Table 5: Required additional green spaces for the study area according to WHO standards

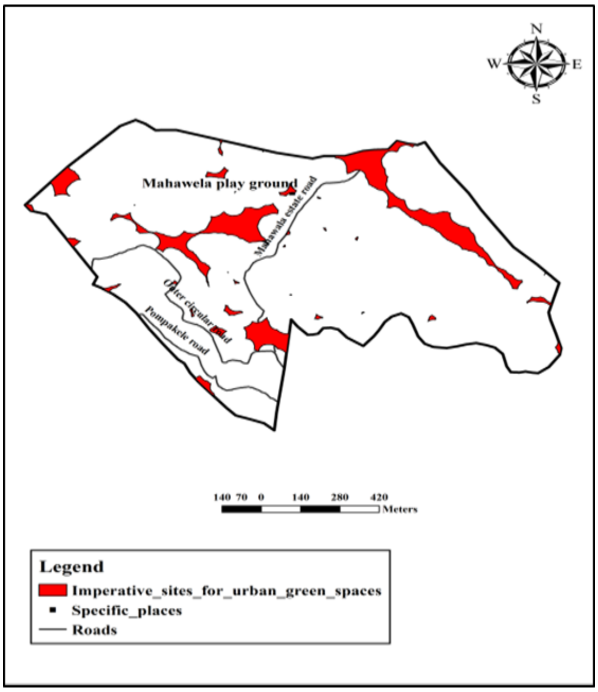
GND Name	EGS (m^2)	TGS (m^2)	AGS (m^2)
Rathnapura Town	139,332	15,894	123,438+
Rathnapura Town West	438,638	16,488	422,150+
Rathnapura Town North	101,135	40,203	60,932+
Mihindugama	485,691	72,450	413,241+
Kospelawinna	2,952,345	46,206	2,906,139+
New Town	1,669,960	63,576	1,606384+

Data source: EGS data from 2019/02 imagery of Google Earth Pro

+ Mark has indicated extra EGS corresponding to the requiring scale

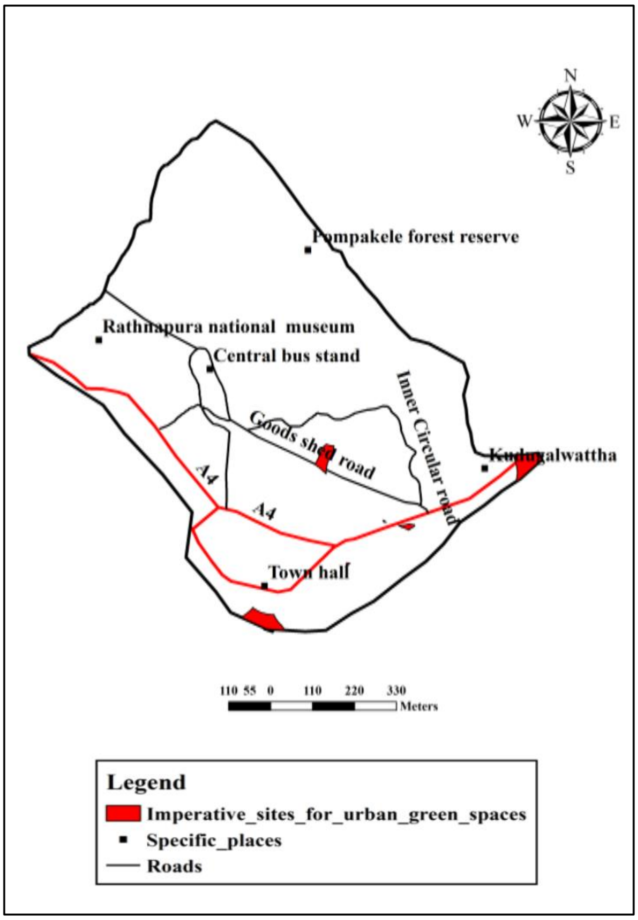
Table 2 and Table 4 show the required total GS according to UN and WHO respectively for each GND. Accordingly, both scales express that the GSPC (Table 1) is enough for the study area and extra GS are there (Table 3 and 5). These amounts of extra GS in each division can be taken as a margin level for green area management. For instance, Rathnapura Town has 123,438m^2 of extra GS according to the WHO recommended scale (Table 5). In the green area, management can be applied this value to keep EGS in Rathnapura Town stable or without reduction for healthy living of the community. Whatever the current GSPCI, if the minus change of EGS in the future, it will cause the reduction of GSPCI according to recommended level in the study area. As determined by the buffer zone analysis based on UN recommended GSPCI shows the shortage of UGS in three GND such as Mihindugama (Figure 2), Rathnapura Town North (Figure 3), and West (Figure 4). The shortages of GS are in the area as approximately 114,624m^2, 8,474m^2, and 38,617m^2 respectively. Figures 2 to 4, the shortage of UGS is shown nearest to the roads. Both results of GSPCI calculations and buffer analysis show different results about the requirement of GS. GSPCI said that the area exceeds given scales on the other hand buffer analysis that is based on UN scale shows there needs additional GS for some areas. But WHO recommended GSPCI based buffer analysis doesn't show any shortage of GS in the study area.

Figure 2: Imperative or required sites of UGS in Mihindugama in the study area – 2019 according to UN recommended GSPCS



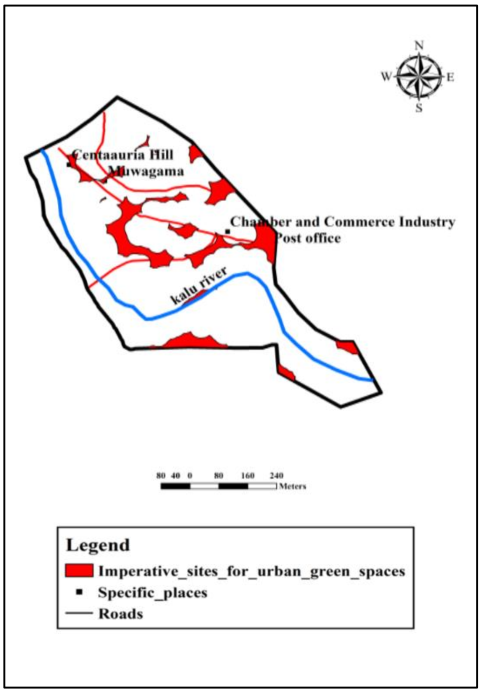
Data source: Google Earth Pro, 2019

Figure 3: Imperative or required sites of UGS in Rathnapura Town -North in the study area – 2019 according to UN recommended GSPCS



Data source: Google Earth Pro, 2019

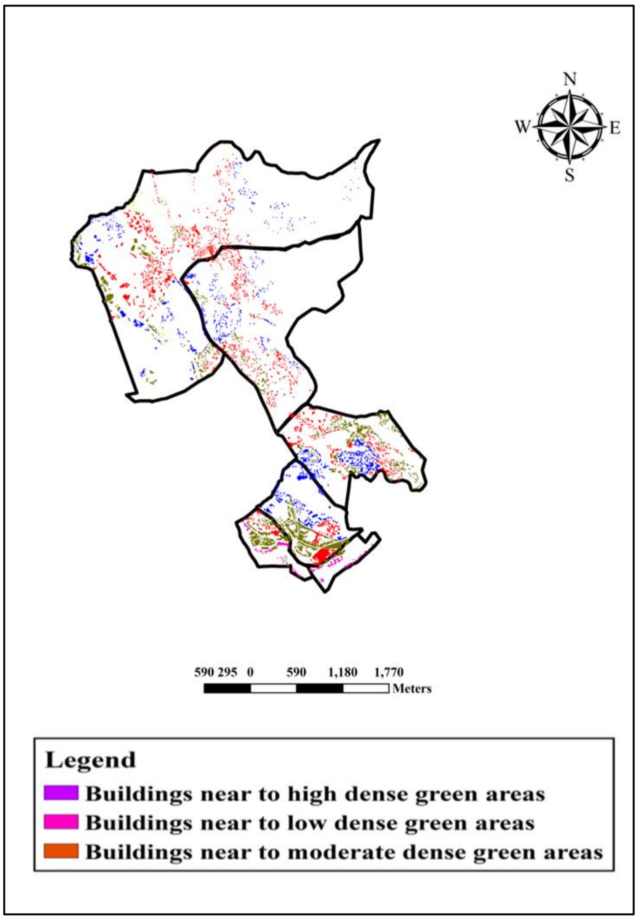
Figure 4: Imperative or required sites of UGS in Rathnapura Town –West in the study area – 2019 according to UN recommended GSPCS



Data source: Google Earth Pro, 2019

Moreover, the study has analysed the distance to each built-up area from each green space (Figure 5). Then the study revealed there are approximately 0.25km^2 of built-up area is near to the high dense green areas, 0.42km^2 of built-up area is near to the moderate dense green areas, 0.36km^2 of built-up area is near to the low dense green areas, 0.03km^2 of built-up area is near to the riverine forests out of 1.08km^2 of total built-up area. Accordingly, there is a shortage of UGS for 0.02km^2 (20,000m^2) of the built-up area according to these data. This shortage shows in Kospelawinna, New Town, and Mihindugama GNDs as 440m^2, 12,497m^2, and 211m^2 respectively. New Town has a majority of GS except at its middle left area (Figure 5). Areas at the middle left are highly concentrated with built-up areas and the absence of GS. That is the reason of New Town area shows the shortage of GS near to the built-up areas although GSPCI exceeds recommended levels. Mihindugama (Figure 5) shows built-up areas and EGS mix together. But the reason to show a shortage of GS near built-up areas is the high distance between EGS and built-up areas.

Figure 5: Classification of buildings that considering nearest to the EGS in study area-2109



Data source: Google Earth Pro, 2019

Kospelawinna illustrates the large area belongs to EGS but as figure 6 built-up areas are located far away from EGS. The reason for that is, built-up areas and EGS are concentrated in separate places. Therefore accessibility to UGS is low in New Town and Kospelawinna although they have EGS that exceed the GSPCI scales. Built-up areas mean where the people are living. So there is a problem of shortage of GS near to the built-up areas. New Town is the administrative zone in RMC. Residential purposes are not much in there but people are highly concentrating in day time for various purposes. Therefore, the location of GS nearest to the built-up areas is essential to the healthy living of the people. The study area has enough GS according to GSPCI calculations but there are not easy accessibilities to GS. According to Figure 6, Rathnapura Town-North, Rathnapura Town-West, and Rathnapura Town have not GS among the majority of built-up areas. But Figure 5 indicates the low distance of GS to all built-up areas of the above-mentioned areas. these three areas have the highest accessibility level to GS. The reason for this is, three GNDs are small in their extent of the area than the Mihindugama, New Town, and Kospelawinna. Therefore the distance between built-up areas and GS is low.

Figure 6: Land use map of the study area – 2019

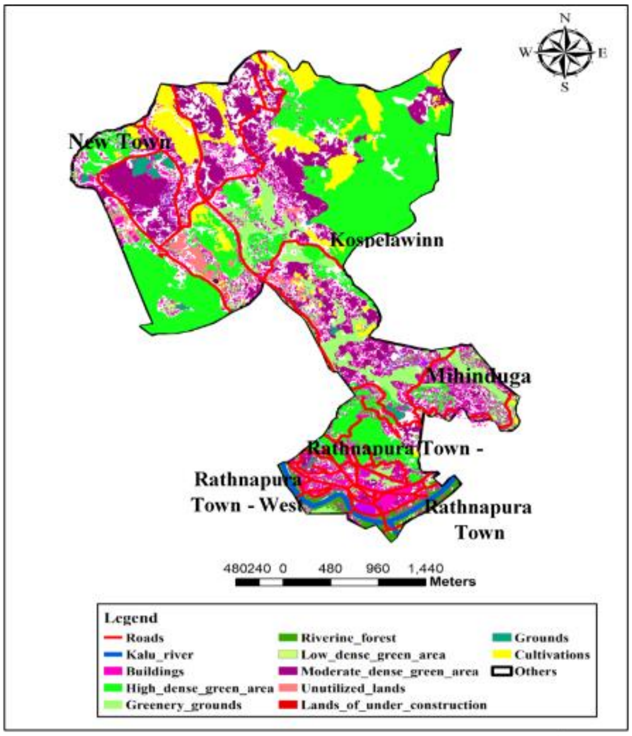
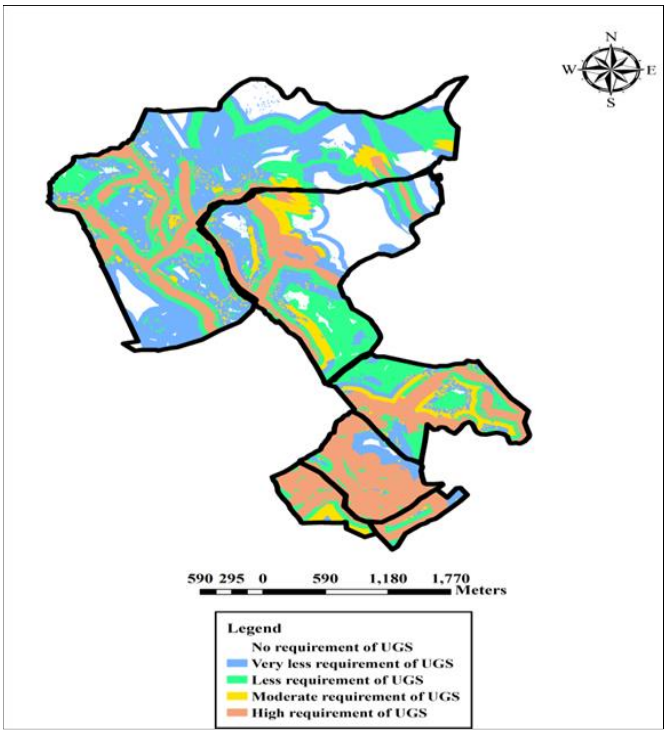


Figure 6: Land use map of the study area – 2019
Data source: Google Earth Pro,2019

Data source: Google Earth Pro, 2019

According to Table 1 Mihindugama, New Town, and Kospelawinna GNDs are the owners of the highest area of GS in the study area but weaknesses of the accessibility of UGS cause to shortage of GS near to the built-up areas in those areas. Figure 7 shows the areas of required urban green spaces in the study area as high, moderate, less, and very fewer requirement levels of UGS. These requirements are based on the distance to the streams, distance to the roads, residential areas, and available type of UGS. Generally, all GNDs show a high requirement of UGS is about approximately 18% of the total land area. But the majority of the lower part of the study area (figure 7) indicates a high requirement of UGS among them because these areas are highly vulnerable to flood, noise pollution, air pollution and highly consistent with residential or built-up areas. Moreover, the amount of moderate requirement of UGS is approximately 6.07% of the total land area. Approximately 6.5% of the total land area no needs additional UGS. In comparison with the other previous studies in Sri Lanka concerning the GSPCI calculation, Jayasinghe et al, 2018 used WHO and UN recommended scales of GSPCI for Galle city. It has used GIS techniques for calculation of GSPCI as same as the current study while Li and Pussella used Landsat imageries and NDVI (Normalized Difference Vegetation Index) for calculate GSPCI for Colombo city and followed UN, WHO and EU recommended scales of GSPCI as different from the current study. The method used for buffer analysis was also used by Senanayake et al, 2013 in “Assessment of green space requirement and sites analysis in Colombo, Sri Lanka – A GIS and Remote sensing approach”. It was used GSPCI calculation for finding green space requirements for its study area as same as this study. But the collecting data about EGS is differing. The current study used digitizing Google Earth Pro imagery and geometric calculations for that purpose but that study used THEOS satellite imagery and NDVI (Normalized Difference Vegetation Index) calculations for the purpose. But the GSPCI calculations were done in the same way using the same formulae. As well as this study has used buffer analysis as same as the current study. That study has taken the perimeters of each EGS when calculating buffer radius. But the difficulty of taking perimeters of a large number of polygons, the current study has taken the average value of perimeter of all EGS polygons to calculate the buffer radius.

Figure 7: Level of the requirement of UGS for the study area



Data source: Google Earth Pro, 2019 and Townhall in RMC

CONCLUSION

The study area was selected RMC and six GNDs in RMC were selected from them for the study while satellite images, GIS techniques were used to achieve the objectives of the study. To GSPCI calculations as UN and WHO recommendations that the study area exceeds the UN recommendation of 30m^2 of GS per person and WHO recommendation of 9m^2 per person. In that case, the study assumed the population equally distributed all over the area when calculating GSPCI. But the study again calculated which amount of area can be covered by one EGS through a buffer analysis base on the same GSPCI calculations according to WHO and UN. At that time, the study identified and proved there are shortages of UGS in three GNDs according to the UN. The GNDs are Rathnapura Town North, Rathnapura Town West, and Mihindugama. According to WHO recommendations there is no problem regarding EGS. Meanwhile, the study revealed that three GNDs in the study area called Mihindugama, New Town, and Kospelawinna show a shortage of EGS near the residential areas. Moreover, weighted sum analysis revealed that approximately 18% of the study area needs additional UGS highly. At the same time, approximately 6.5% of the study area is not required additional UGS. According to these results of the study has proved the GSPCI calculation for areas is not enough measurement to identify the amount of EGS that need for healthy living of a person and it is not accurate perfectly when considering EGS enough or not for any area. But in GSPCI calculations there can be identified the capacity of EGS to fulfill the healthy living of a person according to the buffer analysis. However, in the near analysis for measuring the distance between EGS and residential places help to know accessibility to the EGS by the people. The weighted sum analysis for EGS is based on a few urban issues in the area in that case this study has created a map about where the locations those demand for the UGS. Consequent to the study, only the GSPCI calculation is not enough for finding the need of GS for healthy living of people. It is somewhat successful for determining the environmental sustainability of an area but must be applied approaches and conditions with GSPCI scales to determine the required GS for healthy living of the people. As this study, GIS approaches can be applied with GSPCI to achieve these purposes. But space for developing UGS or vacant lands couldn't be identified when mapping the area. But 46% of land out of 12.52km^2 belongs to EGS. Therefore by enhancing the qualities of those EGS; the area can recover the required lands of UGS.

REFERENCES

EPA. (2020, July 22). https://www3.epa.gov

WHO Regional Office for Europe. (2016). *Urban Green Space and Health: Intervention Impacts and Effectiveness.*

Urban Development Authority. (2018). *Rathnapura development plan:2018-2030 (Volume 1: Part 1).*

Rathnapura Divisional Secretariat Division. (2018). *Resource Profile.*

Arvanitidis, Paschalis A., Lalenis, K., Petrakos, G., Psycharis , Y. (2009). Economic aspects of urban green space: a survey of perceptions and attitudes. *International Journal of Environmental Technology and Management, 11*, 143-168.

Bardhan, R., Debnath, R., Bandopadhyay, S. (2016). A conceptual model for identifying the risk susceptibility of urban green spaces using geo-spatial techniques. *Model of earth system environment*.

Bilgili , B. C., Gökyer , E. (n.d.). Urban Green Space System Planning.

Brilhante, O., Klaas, J. (2018). Green city concept and a method to measure green city performance over time applied to fifty cities globally: Influence of GDP, population size, and energy efficiency. *Sustainability*.

Cilliers, E. J., Timmermans, W. (2013). Approaching value-added planning in the green environment. *Journal of place management and development*, 144-154.

Chang, Qing; Li, Xue; Huangb, Xiulan; Wu, Jiansheng; (2012). A GIS-based Green Infrastructure Planning for Sustainable Urban Land Use and Spatial Development. *Procedia Environmental Sciences, 12*, 491 – 498.

Dickinson, D.C. (2018). Green space Perth: A social-ecological study of green space in Perth, Western Australia.

Gantiva, J.A.F., Páez, D., Rajabifard , A. (2018). Methodological proposal for measuring and predicting Urban Green Space per capita in a Land-Use Cover Change model: Case Study in Bogota. *International Federation of Surveyors*.

Gavrilidis, A.A., Niță, M.R., Onose, D.A., Badiu, D.L., Năstase, I.I., (2017). A methodological framework for urban sprawl control through sustainable planning of urban green infrastructure. *Ecological Indicators*.

Jayasinghe, D.B.C., Hemakumara, G.P.T.S., Hewage, P. (2017-2018). GIS-based assessment of the green space per capita in the city of Galle, Sri Lanka. *Sri Lanka Journal of Advanced Social Studies*, 5-26.

Kim, G., Miller, Patrick A., Nowak, David J. (2018). Urban vacant land typology: A tool for managing urban vacant land. *Sustainable Cities and Society*, 144-156.

Kim, G. (2016). The public value of urban vacant land: Social responses and ecological value. *Sustainability*.

Kleerekoper, L., Esch, M. V., Salcedo, T. B. (2012). How to make a city climate-proof, addressing the heat island effect. *Resources, conservation, and recycling*, 30-38.

Kolscar, Ronald A., Szilassi, P. (2018). Assessing the accessibility of urban green spaces based on isochrone maps and street resolution population data through the example of Zalaegerszeg, Hungary. *Carpathian Journal of Earth and Environmental Sciences*.

Konau, S. K. (2016). *Urban Green Spaces: Bridging cultural, ecological, and political planning gaps to make the city of Colombo a leading 'Greener-City'.*

L, Li., PUSSELLA, P. G. R. N. I. (2017). Is Colombo city, Sri Lanka secured for urban green space standards? *Applied Ecology and Environmental Research*.

Lashari, Z. A., Mangi, M. Y., Sahito, N., Brohi, S., Meghwar, S., Khokhar, Q. U. D. (2017). Land Suitability Analysis for Public Parks using the GIS Application. *Sindh University Research Journal (Science Series), 49*(3), 505-512.

M'Ikiugu, Martin M., Kinoshita, I., Tashiro, Y. (2012). Urban Green Space Analysis and Identification of its Potential Expansion Areas. *Procedia - Social and Behavioral Sciences, 35*, 449 – 458.

Manlun, Y. (2003). *Suitability analysis of urban green space system based on GIS.*

Megayanti, T., Fitria, D. (2020). Participatory Rural Appraisal implementation in identifying public open space. *Journal of Architectural Research and Education, 2*(1), 19-24.

Neema, N. M., Ohgai , Akira ;. (2013). Multitype green-space modeling for urban planning using GA and GIS. *Environment and Planning B: Planning and Design*, 447-473.

Pena, João Carlos de C., Martello, F., Ribeiro, Milton C., Armitage, Richard A., Young, Robert J., Rodrigues, M. (2017). Street trees reduce the negative effects of urbanization on birds. *PLoSONE, 12*(3).

Richardson, Elizabeth A., Pearce, J., Mitchell, R., Kingham, S. (2013). The role of physical activity in the relationship between urban green space and health. *Public Health, 127*(4), 318-324.

Senanayake, I.P., Welivitiya, W.D.D.P., Nadeeka, P.M. (2013). Assessment of green space requirement and site analysis in Colombo, Sri Lanka – A Remote Sensing and GIS Approach. *International Journal of Scientific & Engineering Research, 4*(12), 20-34.

World Health Organization Regional Office for Europe. (n.d.). *Urban green spaces: a brief for action.*