Identification of Suitable Areas for Concentrated Development in Colombo Municipal Council Area, Using GIS Based Multi-Criteria Evaluation

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Abstract

More than half of the world's population lives in urban areas, which are becoming increasingly congested because of uncontrollable population growth. Zoning is an essential tool in successful urban planning which is a method used to regulate the land use and making concentrated development zones. Defining this concentrated area need to follow some scientific method, because urban areas are connected with complex activity system and different indicators are used to find out those activity systems. Hence different indicators are needed to find the concentrated development zone. GIS based Multi-criteria evaluation (MCE) method can be used to identify the different suitability in urban planning perspective. Colombo is one of the emerging cities in South Asia as well as it is the commercial capital of Sri Lanka. Even though there are under- utilized lands available, it is difficult to get the highest and best use from present use. On the other hand, city need to address the demand for commercial and other developments. This study aims to identify most suitable areas for concentrated development within Colombo Municipal Council area. A GIS based multi-criteria analysis was used to identify the most suitable areas for concentrated development with the criteria of Roads, Population density, Building density, Railway stations, Underserved settlement and Sewer network. The outcome shows that several areas within Colombo Municipal Council area have the potential for concentrated development, yet some areas of concentrated development zone does not. Further four criteria were used for urban growth evaluation which includes: Slope, land fertility, distance

to urban center, and distance to road. The final suitability map identified four levels for suitability as Very High, High, Moderate and Low.

Keywords: Suitability analysis, Multi Criteria Evaluation, Zoning Plan, Concentrated zone

INTRODUCTION

Colombo is the fastest development city of the country and commercial capital of Sri Lanka. There is a approximately 650,000population within the CMC area and 1,132,514 population within the Colombo commercial city. Approximately 0.8 million commuters circulate within and via Colombo commercial city. Among them are the daily commuters who travel for work and education purposes, those who travel frequently or occasionally to obtain administration, health, and other services and for shopping and entertainment purposes. As a result, year by year the city center overcrowding and it's converting to congested surface, in results of that, can be identified several problems (traffic jam, garbage disposal, increasing building density, pollution, informal land uses and encroachment etc..,). Thus Colombo requires proper planning and several institutions (E.g., UDA,NPPD) have prepared zoning plan for Colombo. But the problem is every zoning area is not utilized to its maximum for proposed land use (declared as a commercial but there can be seen residential land uses) and this issue the reduced highest and the best use of the land that affects the property valuation and rating assessment, rental figures, beauty of the city, management of the city such as garbage disposal, traffic management, wastewater and draining system etc. For an example during a rainy day there can be seen huge traffic block all around the area even peak time as well. There are socio-economic, physical and environmental aspects that are connected with land use in urban areas. Now urban growth management is becoming a challenge to urban planners and developers and is placing pressure on allocating proper lands for development when finding suitable area for different purposes which need to evaluate those indicators. Recently GIS integrated multi criteria evaluation developed some methods for finding suitable areas. Colombo city also face this zone demarcation issue and there is a lack of studies focused on this aspect. This research is

focused on at this aspect and main objective of this research is to develop some methodology for finding more suitable area for concentrated development zone in Colombo.

LITERATURE REVIEW

The significant proportion of the world's population lives in cities, and this proportion is increasing gradually. The proportion of the world's population living in cities is expected to rise from 55% in 2018 to 60% in 2030. (UN, 2018). Urban development is a process that creates positive change or growth or the addition of components such as physical, economic, environmental, social and demographic. Urban development should be encouraged as well as it should be controlled. Otherwise, it will give negative impacts to areas in terms of physical, economic, environmental, social and demographic components. High population growth creates concentrated urban areas and those areas need to be control. Urban development should aim at controlling haphazard development of urban areas and zoning is one of the tools for that.

Zoning is used to regulate the development in order to get positive impacts. Zones are used as a way of grouping areas with similar characteristics such as land use together and setting outcomes for the area through policy and zones are typically based on land uses such as residential, industrial and commercial (Planning Institute of Australia, 2015). Presently zoning mostly concern about establishment of concentrated development zone to answer urban congestion. Concentrated development is a technique as well as a form that provides a solution to suburban sprawl. It is a planning approach for managing expansion within a region by channeling resources (Marshall, 1993). Concentrated development in planning is a centered (that is, focused on a strong CBD) urban form that is characterized by mixed use and generally high density (Filion, 2000). Within the concentrated domain, a predominance of mixed land use and a lack of huge monofunctional zones account for typically low distances between work, retail, education, and recreation. It is connected the roadways, buildings near to the street, parking on the street and behind buildings, manicured sidewalks and public areas, and conveniently situated transportation stops are all common form

components of concentrated development which is used for improving the air quality, improve public transportation and quality of the life (Marshall,1993). The type of zones was defined based on the proposed Land use of the area which is mentioned in the Development plan of the area. Each zone differentiate from another zone with the types of uses. E.g., In a residential zone residential developments will be encouraged but industrial developments will not and vice versa. There are several types of zoning available such as Residential zone, Commercial zone, Industrial zone, Concentrated zone, Conservation zone, Agriculture zone, Mixed development zone etc.

The purpose of zoning is to allow Government Authorities to regulate and control land with compatible uses to facilitate adequate and economical provision of public improvements, provide opportunity to stimulate development in areas, to protect and conserve property values by preventing incompatible land uses, to facilitate the adequate provision of transportation, water, sewage disposal, schools, parks and other public facilities and to limit overcrowding of the above facilities. The zoning was define based on several factors such as existing land uses, availability and proposed physical and social infrastructure facilities, land value, existing and proposed residential and commuter population, environment sensitivity of the area, material and population flow pattern and etc.

Based on the above factors, the concentrated development zone is defined where the development pressure or development pattern was highly focused with the availability of adequate infrastructure facilities. Therefore, concentrated development zone can be defined with the availability of roads, population density, building density, railway stations, underserved settlement and sewer network. When developing concentrated zone, identification of lands is so important. A wide range of methods are used to address urban changes, the majority of which depend on multiple approaches to address various impacts on change.

Land Use Suitability Analysis
Land use suitability assessment can be considered as an integral part of the urban planning and management (Ramya and Devadas, 2019). The main

purpose of the land suitability analysis is to identify the most suitable specific area for the particular land use and to estimate the potential of land for alternative land uses considering a different criterion based on several factors (Jafari and Zaredar, 2010). Today land-use suitability assessment can be considered as a most important tool for land-use planning and management (Ramya and Devadas, 2019). The purpose of land-use suitability assessment is to indicate the suitability of a specific area for particular land use and to estimate the potential of land for alternative land uses considering a wide range of criteria based on environmental, social, and economic factors (Jafari and Zaredar, 2010).

Different kind of land suitability analysis have been conducted in several countries for the urban development, such as Bangladesh (Ullah and Mansourian, 2015), China (Qiu et al., 2017), South Korea (Park et al., 2011) etc. When studding the above cases, they are widely used Geographical Information System and Multi-Criteria Decision Analysis (GIS-MCDA) for land-use suitability analysis (Montgomery et al., 2016, Vladica et al., 2017).

Multi-criteria Evaluation

Multiple-Criteria Evaluation is used by decision makers to analyze the potential actions or alternatives based on multiple incommensurable factors/criteria, using decision rules to aggregate those criteria to rate or rank the alternatives (Eastman 2009; Figueira et al. 2005; Malczewski 1999). Multiple-Criteria Evaluation is used to find solutions to site selection problems. But scholars assume homogeneity within the study area, which is unrealistic for site selection problems (Malczewski,1999).

The selection of the Multiple-Criteria Evaluation is very important because it has a considerable effect on the final outcome. These methods include explicit statements of preferences of the decision-makers (Rushemuka,2014). Those preferences are represented by various quantities, goal, utilities, weighting scheme, constraints, and other parameters. Decision makers analyze and getting support for decision out of formal analysis of alternative options, attributes, evaluation criteria, goals or objectives, and constraints.
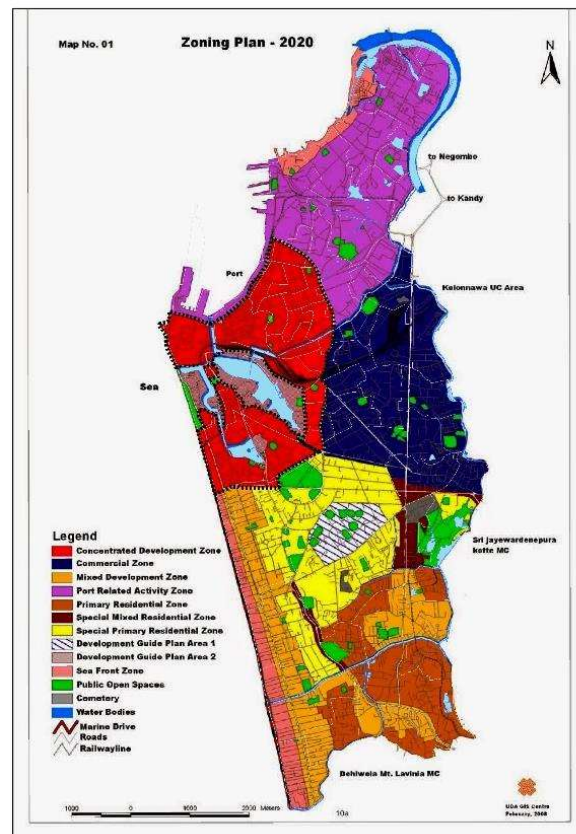
GIS based Multicriteria Evaluation

GIS-based GIS based Multicriteria Evaluation facilitates the calculation and analysis of spatial criteria. Those are distance, travel time and slope. GIS based Multicriteria Evaluation methods can be employed to spatial problems. It is very important that accessibility for any field is a vibrant research community. Applying Multicriteria Evaluation with and in GIS has been an active and growing topic of research since early 1990s (Malczewski 2006). These literatures show the use of many different combinations of methods and approaches in different studies. Main application areas are transportation, environment/ecology, forestry, urban and regional planning, waste management, hydrology/water resources and agriculture.

STUDY AREA

The study is focused on Colombo Municipal Council area to implement concentrated development which is now belong to concentrated development zone as indicated in Colombo Development Plan 2020.

The area of CMC limits identified as highly commercialized area with rapid development around the area comprises with modern and ultra-modern, luxury and high luxury commercial establishments and there are several types of recently built condominium apartments all around the area with semi and

Figure 1- Colombo Zoning Plan

high luxury facilities. Within the CMC limits there are 15 subdivisions area each had its own land use pattern, demand, lifestyle, amenities etc.
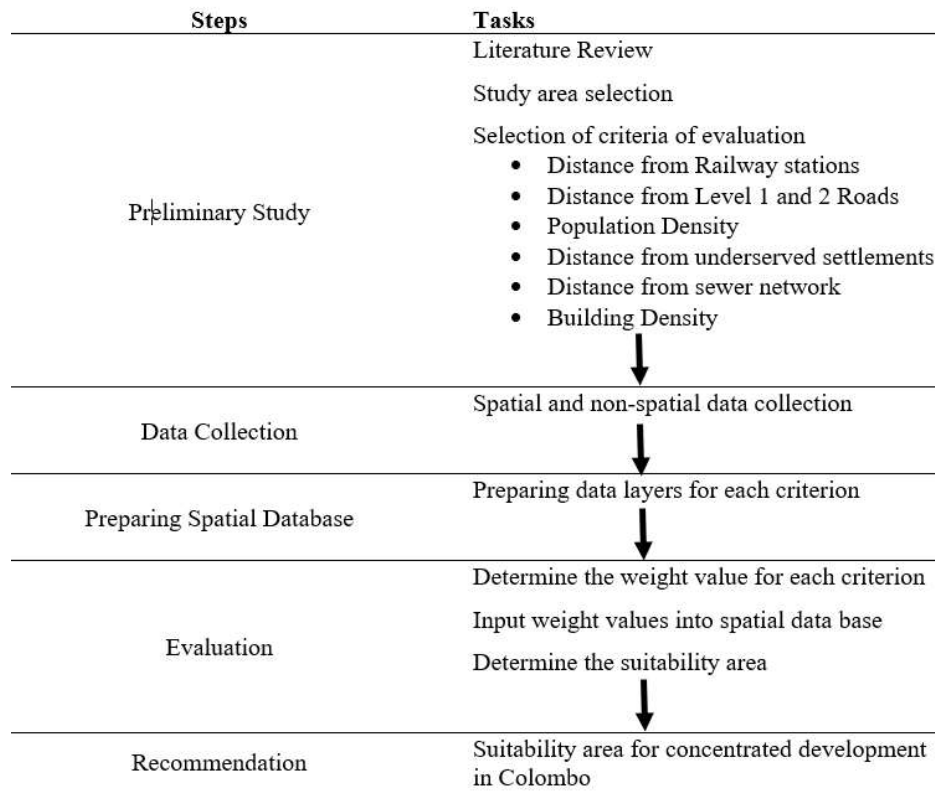
When considering as a single entity of CMC, it is a Central Business District of Sri Lanka. There are major development projects can be seen around the area such as Port City, Lotus Tower and New Kelani Bridge etc.

Further, majority of government ministries and public institutions, majority of companies and banks head offices, most reputed schools in the country, other private sector offices, modern shopping malls, conference halls, cinema halls and recreational facilities are located in this area.

Environment is very good for commercial activities, and somewhat of congested is a common issue of the area. Superior transport service operates by public and private around the area. The lie of the lands is almost flat and buildable. Lands are used for residential and commercial purposes. Generally, soil is mixed clay can bear heavy load of constructions. Infrastructure facilities are available all around the area.

METHODOLOGY

Data and Methods

Steps	Tasks
Preliminary Study	Literature Review Study area selection Selection of criteria of evaluation • Distance from Railway stations • Distance from Level 1 and 2 Roads • Population Density • Distance from underserved settlements • Distance from sewer network • Building Density
Data Collection	Spatial and non-spatial data collection
Preparing Spatial Database	Preparing data layers for each criterion
Evaluation	Determine the weight value for each criterion Input weight values into spatial data base Determine the suitability area
Recommendation	Suitability area for concentrated development in Colombo

Figure 2 - Flow of Methodology

According to the figure 2, the study consisted with several steps and tasks. The most important steps in the methodology are selection of criteria, preparing spatial database, determining the weight value of each criterion and find the suitability area in the GIS environment. By reviewing literature, local contexts, available data, above criteria have been selected for demarcate the most suitable areas for concentrated development in Colombo Municipal Council area. The spatial database was prepared according to the criteria selected, where each criterion represents a particular data layer. The spatial data has been collected from following institutions and other sources.

Table 1: Data and sources

No	Data Type	Source of Data	Map Scale
1.	Railway stations	Survey Department/ Google Maps	1:1,000
2.	Buildings	Survey Department/ Google Maps	1:1,000
3.	Level 1 Roads	Survey Department	1:1,000
4.	Level 2 Roads	Survey Department	1:1,000
5.	Population	Census Department	-
6.	Underserved settlements	Urban Development Authority	1:500
7.	Sewer network	Colombo Municipal Council	1:500

After identifying the criteria, values have been assigned for each pixel by reclassifying the layers to simplify the interpretation of raster data. Pixel size was 20m by 20m. Areas which will contribute for more potential for a concentrated development has assigned with value 5 and gradually 4,3,2,1 and 0 for the areas which do not have the potential for a concentrated development.

**Table 2: Criteria Selection and Weighted Score**

	Criterion	Distance	Value
1	Distance from Railway stations	200 m 500 m 1000 m >1000 m	5 4 3 0
2	Distance from Level 1 Roads	200 m 500 m 1000 m >1000 m	5 4 2 1
3	Distance from Level 2 Roads	200 m 400 m 600 m >600 m	5 4 2 1
4	Population Density	0-35 per sq.km. 35-90 per sq.km 90-180 per sq.km 180- 290 per sq.km >290 per sq.km	1 2 3 4 5
5	Distance from underserved settlements	100 m 200 m 500 m >500 m	1 3 4 5
6	Distance from sewer network	50 m 100 m 200 m >200 m	5 4 3 1
7	Building Density	<108638 108638 - 454300 454300- 908600 908600- 1372800 1372800 -2600000	1 2 3 4 5

RESULTS AND DISCUSSION

A research process presents an overall picture for carrying out the research. It mainly consists of various components of research methodology in this study and each component plays an important role in finding suitable areas for concentrated development in CMC area. Seven spatial map layers were designed for all seven criteria to identify the relevant areas for each criterion and finally overlayed the all the criterion map layers to identify the suitable area for the concentrated development. Each criterion is explained as follow.

Distance from Railway stations

Railway infrastructure is a crucial factor for a development. Railway transport is one of most dependable mode of transport since it is the least affected by weather situations and traffic as well as suitable for bulky and heavy goods. Hence distance from railway stations is considered as an important factor. Area up to 1000 meters is considered as suitable areas giving high suitability for the nearest areas and areas which are further from 1000 meters has been neglected as they are not suitable for concentrated development.
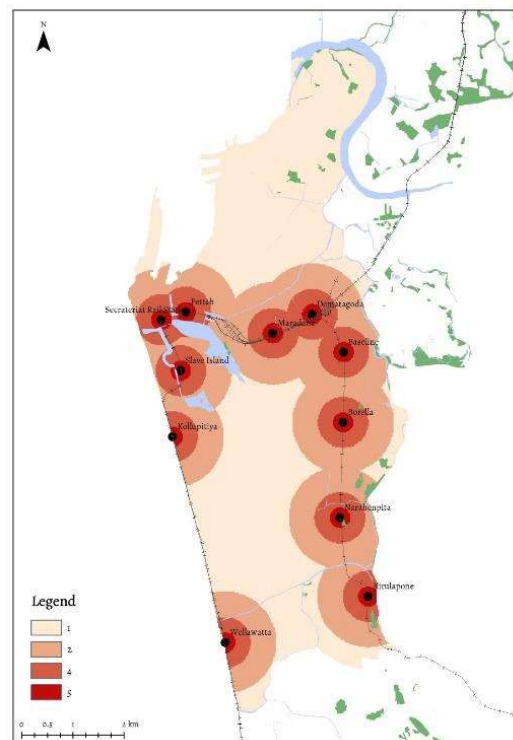
Figure 3 - Distance from Railway Stations

Distance from Level 1and 2 Roads

Another crucial infrastructure that required for development is main roads. Roads open more areas and stimulate economic and social development. Also, as per the regulations that are in practice within the concentrated development zone if there is a road with 24-meter building line facing to a 2000sq meter land then that site can be developed with unlimited FAR ratio. So, areas which are closer to level 1 or 2 roads are considered as most suitable areas for a concentrated development. The highest values have been assigned for the areas within 200 meters and gradually decreasing up to 1000 meters.
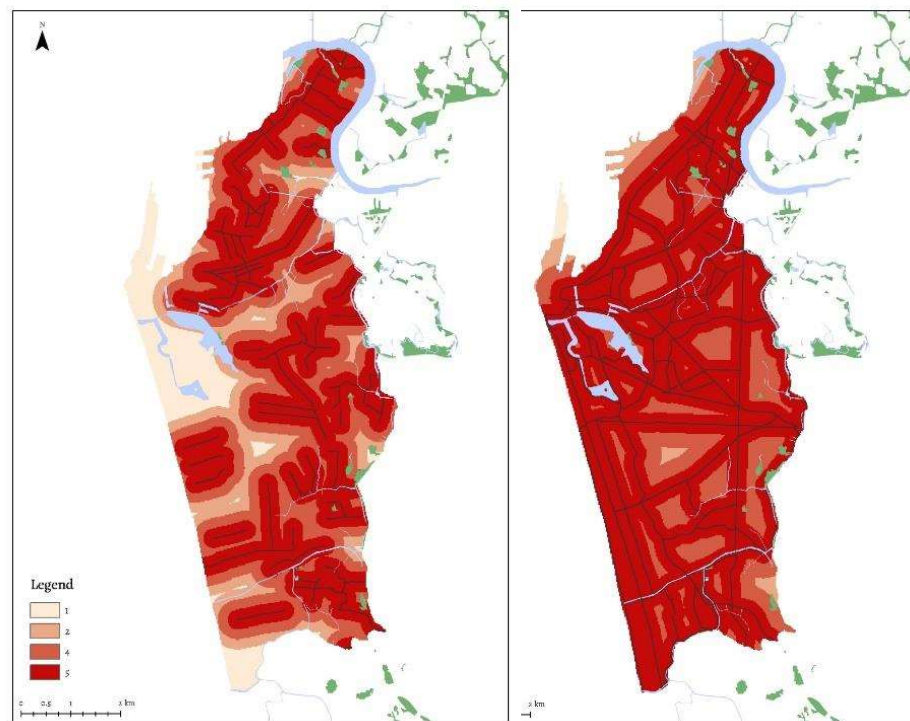
Figure 4 - Distance from Level 1and 2 Roads

Distance from underserved settlements

Areas which are located further from the underserved settlement areas are considered as potential areas since the development attraction for the locations which are close to those areas are less.

Distance from sewer network

Sewer management is a major task in cities. Sewers plays a vital role in public health by safely transporting wastewater to the waste water treatment works. Hence the areas that can be connected to the sewer network is considered as a potential area for a concentrated development.
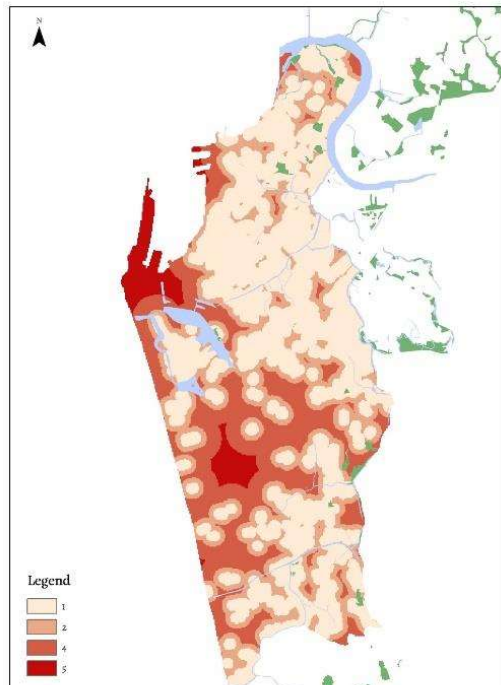
**Figure 6 - Distance from underserved settlements**
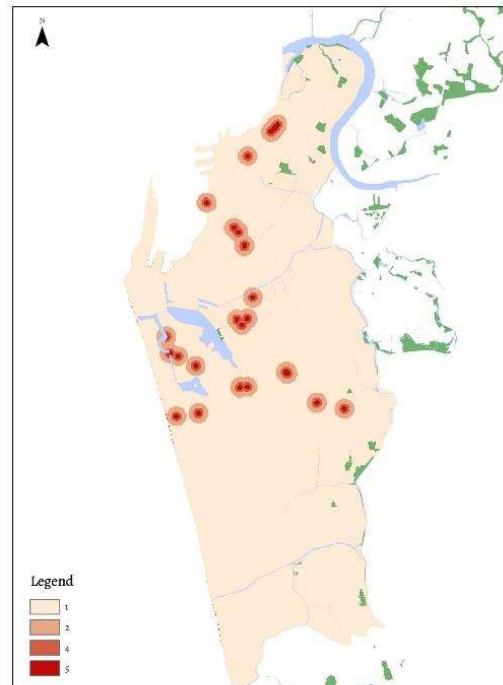
Figure 5 - Distance from a connection point of Sewer Network

Building Density

According to the literature compact developments considered as more efficient as well as cost effective. Hence in this study building density has been analyzed using point density tool and where the areas have high density has given a high number (5) considering those areas are more suitable for concentrated development.

Population Density

High population density eases the provision of infrastructure which will leads to an economic growth where there is an optimal pupation density. Also, Population density is one of most fundamental and influential factors for business.
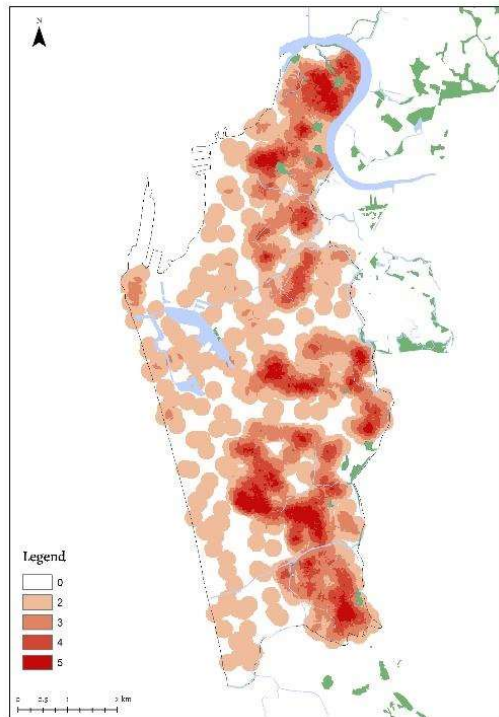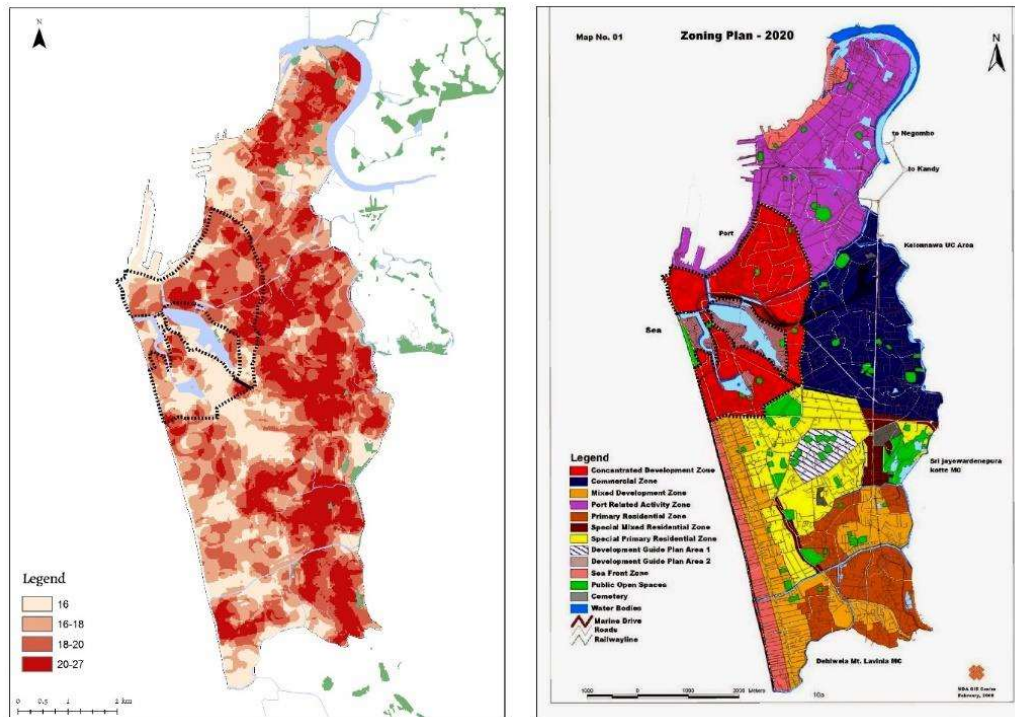

Figure 7 - Building Density
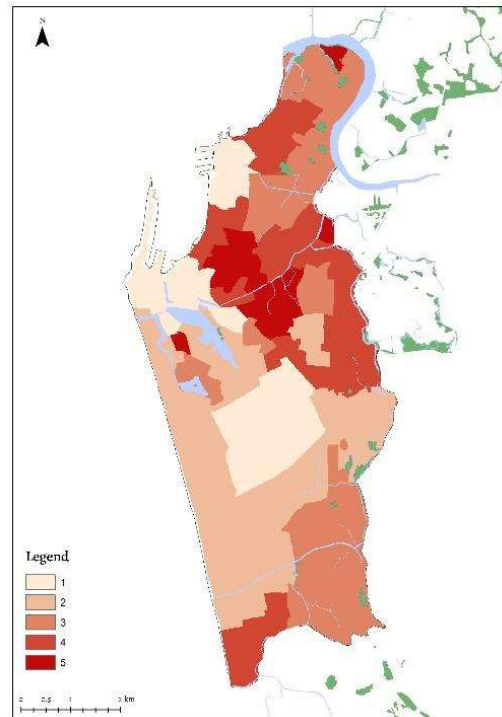
Figure 8 - Population Density

Overall Suitability

Figure 9 - Comparison between suitability map for concentrated development with existing zoning plan

From 41 km2 area of the study area, 9.5 km^2 (23%) is highly suitable followed by 18 kms^2 (44%) moderately suitable and 9.7 km^2 (23.5%) that is barely suitable. The remaining 3.8 km^2 (9.5%) is found to be not suitable. After overlaying each criterion map on the suitability index map, the following findings were revealed. Red colour patch towards North and South of Beira Lake area shows the concentrated development zone and next to the right side towards Dematagoda and Borella has demarcated as the commercial zone in the zoning plan 2020 of City of Colombo Development Plan. However, results indicated that the area towards North of Beira Lake which is already demarcated as concentrated development zone and the area towards Dematagoda, Borella which is currently

demarcated as commercial zone has the more potential for concentrated development.

CONCLUSION

The potential areas for concentrated development were identified with convenient access to railway station, main road, population density, sewerage facilities and building density. The results clearly indicated that there is a great potential for concentrated developments towards the Central Business District of Colombo and along the Baseline Road. Although the outcome shows that several areas within Colombo Municipal Council area have the potential for concentrated development yet some areas of concentrated development zone which is proposed in the zoning plan of City of Colombo Development Plan 2020 does not

LIMITATIONS

The group has been experienced few limitations and difficulties such as lack of data and difficulties in accessing the data sources, data are too old and data bases are not upgraded in well manner.

Further, there is a gathering restriction due to current pandemic situation of the country, all members were unable to gather in one place to discuss the subject matters. However, the group used online flat form to discuss matters.

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