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# Assessing Development Pressure on Environmentally Sensitive Areas within Kotikawatta-Mulleriyawa Pradeshya Sabha, Sri Lanka.

S. Ranasinghe[1], S. Somasekera[2], K. Deheragoda[3]

*[1,2]Urban Development Authority, 6th & 7th Floor, Sethsiripaya Battaramulla, Sri Lanka.*
*[3]Emeritus Professor, Department of Geography, University of Sri Jayawardenapura, Gangodawila, Nugegoda*

## Abstract

History has shown that urbanization is a key driver of growth. However, it is evident that the pressure it generates upon the land leads to an inappropriate land use change, and especially in environmentally sensitive areas. Kotikawatta- Mulleriyawa is one of the local government areas located at the fringe of the Colombo-Capital City which is a greater planning area in Sri Lanka, experiencing the fastest growth during the past two decades with rapid conversion of wetlands and low-lying areas. The urban planning attempts to regulate the land use conversion through identification of zones which has not been successful due to the demarcation of development zones without scientific analysis. As a result, environmentally sensitive lands had been converted and continuing to be used for urban activities leading to the reduction of wetlands by 8%, and 10% respectively in the decades 2000 and 2010 and by 5% during last three years. Therefore, it is pertinent to conduct an analysis, based on systematic indicators to identify areas with high risk and thereby identify the most suitable areas for development. This research attempts to identify the risk areas in Kotikawathta-Mulleriyawa utilizing Development Pressure Index (DPI) and Environmental Sensitivity Index (ESI) calculated based on 12 parameters and required data had been selected based on those parameters. The multi-factor 2 weighted summation method then deployed to evaluate the magnitude of the development pressure and environmental sensitivity and the risk levels had been derived by combining the weighted DPI and ESI. Geospatial Technology Applications such as GIS and multi-criteria analysis had been used for the study and the findings revealed that 18% of the area was identified as a very high risk area. Approximately 43% of the Kotikawatta-Mulleriyawa Pradeshiya Sabha Area was identified as high and very high risk areas which are not suitable for development. Further, this paper introduces a scientific methodology to identify the magnitude of urban pressure and the sensitivity of the environment, for the demarcation of zones with high risk, enabling the decision makers to target such areas and to come up with strategic methods to address them.

**Keywords:** Development Pressure, Environmental Sensitivity, Environmental Vulnerability, Spatial Analysis, Kotikawatta - Mulleriyawa

Corresponding author.
E-mail address: sukhithameth1@gmail.com (S. Ranasinghe)

## 1. Introduction

Rapid in-migration of people to cities has been a continues trend since past two centuries to date in the world over, and it has been witnessing a rapid change of space in the cities of Asia and some urban places in Latin America and Africa during the past five decades. Currently, 55% of the world's population lives in urban areas, a proportion that is expected to increase to 68% by 2050 (United Nations, 2023). According to the world bank, the expansion of urban land consumption outpaces population growth by as much as 50%, which is expected to add 1.2 million km² of new urban built-up area to the world in the next three decades (United Nations, 2023).

The extent of developable land in an urban space is generally constant or restricted. Consequently, a continuous demand and pressure on the urban fringe areas by the rapid urbanization and high development intensity is inevitable. As cities expand, the demand for land for housing, infrastructure, and economic activities, encroaches environmentally sensitive areas in urban fringe leading to alteration of land use patterns and the conversion of natural habitats into built environments with damage and loss of natural ecosystem services (Seto et al, 2012). (Alberti, 2005) and (Grimm et al, 2008) also emphasizes that, such urban patterns significantly influenced ecosystem functions, often resulting in destruction of the natural conservation areas, habitat fragmentation, loss of biodiversity, and disruptions in hydrological cycles. Additionally, this phenomenon can result in reduced green spaces and increased urban heat island effects (Kabisch et al, 2017).

Measuring such changers in urban fringe areas in order to evaluate their impact is a challenging task in urban spatial planning. Thus, the necessity in identification of priority areas based on the magnitude of impact eventually leads to a quantitative analysis which indicates the intensity of such impact. The application of index which reflects the likelihood of trend thereby becomes an advance tool in spatial planning. In this context, the Development Pressure Index and Environmental Sensitivity Index portray a vital importance in identification and demarcation of priority conservation areas.

Development pressure index is one of the planning tool used for the identification of the likelihood of future development areas which indicates the need for increased level of service or capacity. In planning context, various indicators are employed to assess development pressure in cities, including the examination of urbanization direction and rate. In the Langat Basin of Malaysia, development pressure has been identified based on land use changes (Majid et al, 2021). (Majid et al, 2018) have investigated development pressure effects through metrics like parcel proximity to roads in metropolitan areas, shifts in county population, and variations in population density (Mendelsohn et al, 1994). Other than population growth, employment growth and land convesion rate, real estate development, utility system extensions, access management plans and school and business expansions are used to evaluate the emerging development pressure along the state trunk highway in Wisconsin (Guo et al, 2007). (Li et al, 2022) used population density, building volume and building foot print to evaluate population pressure, and land pressure in analysing urban carrying capacity in China. Research by (Raghavendra et al, 2014) demonstrates that road infrastructure investments have a direct impact on urban growth, with well-connected road networks stimulating economic activity and job creation, thus intensifying development pressure within urban areas, as exemplified in their study of Bangalore, India. All these researches had been demonstrating that the parameters used for calculation of Development Pressure Index is established on the purpose of the study and the availability of required data for such analysis.

Excessive urbanization stands as a primary driver behind a multitude of urban challenges, encompassing air pollution, the greenhouse effect, a surge in urban slums, water pollution, and urban flooding (Majid, 2018). Environmental Sensitivity Analysis emerges as a pivotal technical approach to identification of environmentally sensitive areas, offering a structured and objective framework for assessing the potential of significant environmental impacts (González Del Campo, 2017)

The tension between urban development and environmental conservation underscores the need for proficient urban planning and strategic policy formulation. Achieving this equilibrium demands policies that integrate principles of sustainable development, taking into account the ecological significance of Environmentally Sensitive Areas. Past research has demonstrated that harmonious urbanization and ESAs can coexist through strategies such as compact urban design, green infrastructure, and zoning regulations that safeguard vital ecological zones (Pryor, 1982). In the study by (Zhang and Jin, 2021), the Normalized Difference Vegetation Index (NDVI) was used to analyse changes in vegetation cover in Sydney, Australia, revealing its impact on urban environmental quality, thus highlighting its relevance in urban planning and management. In addition, research by Gol et al, 2017) underscores that stream order and watershed analysis are essential tools for effective river basin management, aiding in the identification of environmentally sensitive areas and guiding conservation and development strategies within river basin cities.

Spatial analysis tools such as geographic information systems (GIS) and Remote Sensing (RS) have become essential in assessing urban growth and its impact. The research proposes an integrated framework involving remote sensing and ecosystem modelling to assess the impacts of urbanization on ecosystem services. These tools support exact land cover classification and change detection and spatial modelling of urban sprawl, supporting informed decision making.

A geographic information system is helpful to perform various spatial analysis by combining aggregation methods to derive a set of growth indicators. In addition, the advantage of scoring and weighing process is that it supports to normalise the multiple indicators into single index where the variation is strongly visible with high comparison capacity.

One of the main objectives of this research is to gain a comprehensive understanding of the pattern and magnitude of urbanization process in Kotikawatta-Mulleriyawa area and to identify the level of environmental sensitivity and its respective locations in order to introduce a scientific method for the demarcation of development zones and control urban development. In addition, exploring the applicability and usability of advance geospatial techniques in identifying rate of urbanization and its impact is another objective of this study. The insights gained can guide regulatory measures for balanced urban growth and ecological preservation, providing actionable insights for sustainable urban planning within the Ramsar Wetland City framework, offering valuable lessons for similar urban areas worldwide.

## 2. Materials and Methods

The Colombo Metropolitan Region of Sri Lanka is recognized as the most populated, economically active and the fastest developing region with contribution of more than 40% to the national Gross Domestic Product (GDP) and allocation of more than 28% population of the country (Western Region Megapolis Project - Sri Lanka, 2017). The location of both administrative and commercial capitals of Sri Lanka within this region strengthen the rate of urbanization and agglomeration impacts. The rapid urbanization process in the core area out spills and easily reaches the urban fringe where land and other infrastructure are available. Kotikawaththa- Mulleriyawa is one of the four local authorities encompassing the Administrative capital city planning area located about 8 Km from both capital cities. The total extent of 19.9 $Km^2$ of its area is bounded by Kelani river from North and East and Kolonnawa Urban Council area from West and Sri Jayawardesnapura Kotte Municipal Council area from South. Due to its location on Kelani river basin, the topography of the area varies from -2m MSL to 66m MSL with average of 13.5m MSL owning large extent of wetlands with rich biodiversity.

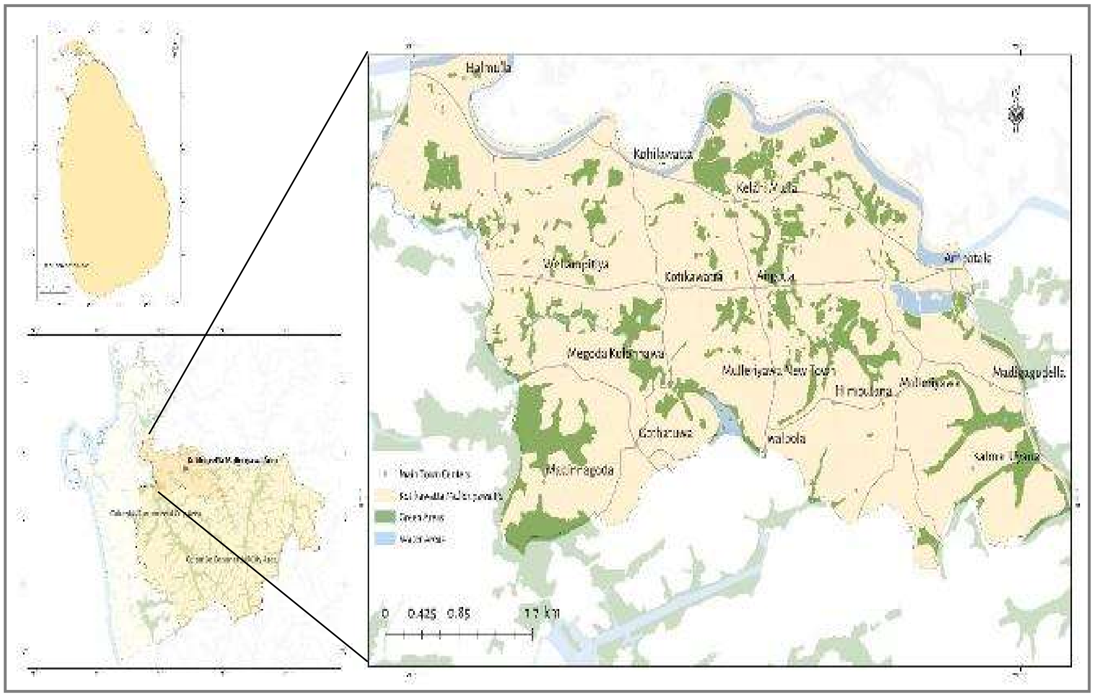


Figure 1: Location Map
Source: Urban Development Authority Sri Lanka 2022

In the early decades of the year 2000, Kotikawatta-Mulleriyawa area has been identified as low density development area in draft Western region megapolis plan and its population growth was 1.5% per annum. The high rate of urban growth in core area resulted in the high land value and scarcity of land and pressure on intensive development. Due to the close proximity to the capital cities, the Kotikawatta – Mulleriyawa area has become highly attractive to the spill out urban population from core area as the most suitable residential destination with comparatively low land value. A sudden growth of population therefore, had been recorded in 2001 Census with 2.5% growth rate which continues to the following decade. Among other suburban areas, Kotikawatta- Mulleriyawa Pradeshiya Sabha area had recorded highest population growth during 2001 – 2011(Figure 2).

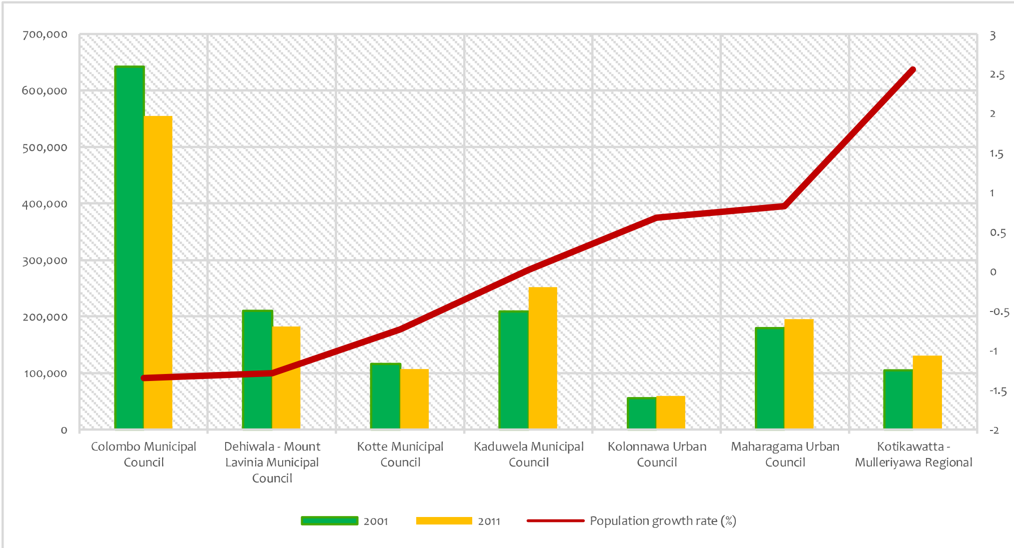


Figure 2: Population & Growth Rate of Kotikawatta –Mulleriyawa Pradeshiya Sabha
Source: Department of Census and Statistics Sri Lanka 2001 & 2021

Conversely, proximity to the Colombo harbour with less than 10km distance together with adequate road network and land availability, logistic and warehouse activities are also located within Kotikawatta Mulleriyawa Pradeshiya Sabha resulting in a competitive change of land use pattern. 48% of the total land area is used for residential activities while 20% is covered consumed by water bodies, wetlands, open spaces and agriculture lands in Kotikawatta mulleriyawa Pradeshiya Sabha. With the incensement of population, land area used for residential and home garden had been increased and simultaneously, the drastic decrease of extent of wetlands is evident.

In 15th October 1990, the RAMSAR Convention on wetlands came in to force in Sri Lanka and the city of Colombo was declared as RAMSAR city among other five cities in the world for the first time in 25th October 2018, considering the ecologically importance of the wetlands in and around Colombo city. (RAMSAR COPE 13). Consequently, wetlands in Kotikawatta-Mulleriyawa Pradeshiya Sabha, were designated as RAMSAR wetlands. These wetlands act as green lungs and water discharging network with more than 280 fauna species and more than 250 flora species (Dayananda, 2004). On the contrary, in the decade of 2000, wetland in this particular area had been reduced by 8% and further decreased by 10% in the decade of 2010 (UDA-Sri Lanka, 2019). Moreover, the Kotikawatta-Mulleriyawa Pradeshiya Sabha had been frequently inundated due to the overflow of Kelani river in rainy seasons and internal flash floods due to the blockage of natural drainage system.

## Materials

The data required for the study has been determined based on the criteria selected to identify Development Pressure Index and the Environmental Sensitivity Index during the literature review. Accordingly, 10 data sets have been identified to compute the DPI and ESI by summing up the criteria disclosed in reviewing the previous researches. This limits the search for data sets and unnecessary acquisition of data sets. A systematic search had been performed to locate the available data sets in known spatial data repositories in other organizations and their public services of spatial data and information by summing up the criteria disclosed in reviewing the previous researches. The usability, reliability and accuracy of the spatial data are pre requisites in geo -spatial analysis. For this study a single time point data sets have been employed for the analysis and both spatial, non-spatial and also remote sensing data have been used. Total of 10 parameters were successfully obtained and assembled for the current study (Table 1).

Table 1: Data used for the study

| No. | Name of Data Set | Type | Spatial Unit | Source | Coordinate System |
|---|---|---|---|---|---|
| **1** | Road- 2023 | Vector | 1:2000 | Urban Development Authority | SL99 |
| **2** | Grama Niladhari Division-2017 | Vector | 1:50,000 | Department of Survey | SL99 |
| **3** | Population-2022 | Table | Grama Niladhari Division | Department of Census & Statistics | - |
| **4** | Building Foot Print-2023 | Vector | 1:2000 | Urban Development Authority | SL99 |
| **5** | Land Use- 2023 | Vector | Category blocks | Urban Development Authority | SL99 |
| **6** | Contour-2017 | Vector-Extracted from LIDAR data | 5m | Department of Survey | SL99 |
| **7** | LADSAT9-2023 | Image | 30m | USGS image repository | WGS84 |
| **8** | Soil Types-2022 | Vector | 1: 50,000 | Geological Survey & Mines Beuro | WGS 84 |
| **9** | Flood - 2016,2018.2022 | Vector | 1:50,000 | Disaster Management Centre | SL95 |
| **10** | Wetland Biodiversity-2022 | Table | By wetland Location & Name | Sri Lanka Land Development Corporation | - |

## Methods

The methods used in this research aim to comprehensively address the research objectives by utilizing a structured scientific approach to discover urban growth trends and magnitude, and environmental sensitivity and risk areas in order to evaluate the impact of DP on ES. Initially, the study identified essential parameters for the development pressure and environmental sensitivity assessments calculated by means of multi-factor weighted summation. Subsequently, the study implemented separate models for development pressure indicators and environmental sensitivity indicators.

Principally, the employed methodology has four main phases as: 1). selection of parameters for each index and identification of required and available data sets, 2). obtain data and performing data pre-processing. 3). data processing and generate intermediate outputs, and 4). combine intermediate out puts to form the final result. The entire research activities were performed in ArcGIS platform utilising UCL Depth MAP and QGIS software for subsequent modelling and analysing when required. The methodology employed for this study is shown in the figure 03 below.

***Selection of parameters:*** The review of relevant literature put forward various parameters aligned with the purpose of respective analysis. Among them, a total of 12 parameters have been selected to employ for this study with 6 parameters for each index. The selected parameters and factor weights are given in Table No.2.

***Data pre-processing and transformation***: Performing a data pre-processing is the next important phase in this study. The selected data sets had been generated by different organizations for various purposes and contain irrelevant information for this study. Performing a data pre-processing enhanced the quality, consistency, usability and inter-operability of data with other data sets without duplicates, missing values, structure errors, and outliers etc.

The scale differences, coordinate differences and attribute differences had been equalised and for the smart handling, the number of categories in the land use, building and road data sets had been reduced by aggregating under suitable main categories. In land use and building data set, level four data classification had aggregated under level 2 classification and in road data set the number of classes were brought down to four categories. After quality and consistency improvement, the data sets had been reclassified using both class and value domains upon the requirement for analysis. In line with the objective of the study and to enable quantification of out puts, all data sets had been transformed in to raster format. A 500m grid was used in cases where rasterization is logically unsuitable.

The tabular data sets of population-2023 and wetland bio diversity-2022 had been transformed to the vector format for rasterizing using Grama Niladhari Division -2017 dataset and extracted wetland locations from Land Use -2023 data set.

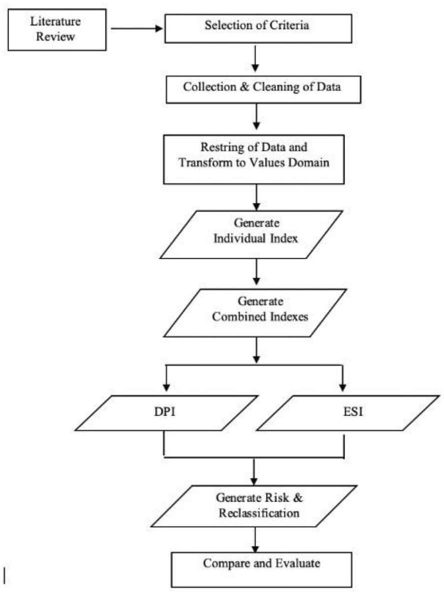


Figure 3: Methodology of the Research Study

***Sub-Individual Indexes and combined indexes:*** The richness of the acquired data sets for the study allows to generate separate thematic indicators in relation to Kotikawatta - Mulleriyawa Pradeshiya Sabha area. In line with the main objective of the study, the selected parameters are grouped according to their influence on urbanization and environment. In particular, 7 parameters of Accessibility, Connectivity, Population density, Building Density and land Use were selected as most suitable indicators of Development Pressure Index. Similarly, 5 parameters of Hydro system, Vegetation Quality, Soil Quality, Bio Diversity Richness and Flood Vulnerability were selected as most suitable parameters for the computation of Environmental Sensitivity Index.

To understand the development pressure and environmental sensitivity, identification of factors contributing to overall pressure and sensitivity is important and it becomes a parameter in this study. For each selected parameter, a sub-index was developed based on a unique attribute which is most suitable to describe the factor as an index by assigning a score value. The scale of the score of sub-indexes range from 1 to 5 and such score were based on the comparative importance among them. The sub-indexes were then weighted equally assuming that they are equally contributing to the target index. Finally, combining the sub-indexes, the main indexes of Development Pressure Index and Environment Sensitivity Index (Table No 2) were calculated using following equations.

Equation 1: Development Pressure Index

**Development Pressure Index =**

[{(AI) * 0.2} + {(CI) * 0.2} +{(PDI)*0.2} + {(BDI) * 0.2} + {(LI) * 0.2}]

Equation 2: Environmental Sensitivity Index

**Environmental Sensitivity Index =**

[{(HSI) * 0.2} + {(VQI) * 0.2} +{(SQI)*0.2} + {(BRI) * 0.2} + {(FVI) * 0.2}]

The rapid pressure of urban development has significantly affected urban environments and had profound impacts on biodiversity and the performance of urban ecosystems at both local and global levels (Grimm et al, 2008). The high development pressure areas there by identified as most influential area on environment and the impact in terms of risk had been framed by utilizing both the urban Development Pressure Index and the Environmental Sensitivity Index using the following equation.

Equation 3: Risk Level

**Risk Level =**

[{(Development Pressure Index)} * 0.5} + {(Environmental Sensitivity Index) * 0. 5}]

The combination values of both DPI and ESI are again reclassified in to five (5) categories as: 1= Very Low, 2= Low, 3= Moderate, 4= High, 5= Very High for better understanding of the phenomena and representation.

Further, to gain a comprehensive understanding of the behaviour pattern of development pressure and environment sensitivity, Geographically Weighted Regression (GWR) computation method had been used to evaluate the effect of the contribution of each individual parameter against the computed risk index. The usefulness of the GWR is that it modelled the local relationship by considering the no stationary variable and assists the decision makers to identify the impotency of the parameters.

Table 2: Independent variables

| Type of Index | Core Values | Type of the analysis &Features | Features and Score | | Index Weight | Overall Weight | | |
|---|---|---|---|---|---|---|---|---|
| **Accessibility Index** | Road Layer (Road Types) | Density Index- Level of Density | - Major roads (A-class) | 5 | 100 | 0.20 | Development Pressure Analysis 0.5 | Risk Analysis |
| | | | - Minor roads (B&C-class) | 3 | | | | |
| | | | - Local roads | 1 | | | | |
| **Connectivity Index** | Spatial Integration | UCL Depth map - Integration Value | - (9,855.049756 - 16,979.98438) | 5 | 100 | 0.20 | | |
| | | | - (6,525.641055 - 9,855.049755) | 4 | | | | |
| | | | - (4,128.46679 - 6,525.641054) | 3 | | | | |
| | | | - (1,931.057048 - 4,128.466789) | 2 | | | | |
| | | | - (0 - 1,931.057047) | 1 | | | | |
| **Population Density Index** | Population Growth Rate | Density Analysis - Population Growth Rate | - (4.2 - 7.3) | 5 | 50 | 0.20 | | |
| | | | - (2.3 - 4.2) | 4 | | | | |
| | | | - (0.8 - 2.3) | 3 | | | | |
| | | | - (-0.2 - 0.8) | 2 | | | | |
| | | | - (-0.8 - -0.2) | 1 | | | | |
| | Population Density | Density Analysis - Population Density | – (17936 - 36645) | 5 | 50 | | | |
| | | | – (10325 - 17936) | 4 | | | | |
| | | | – (7230 - 10325) | 3 | | | | |
| | | | – (5970 - 7230) | 2 | | | | |
| | | | – (2874 - 5970) | 1 | | | | |
| **Building Density Index** | Building Footprint Analysis | Density Analysis - Building Footprint | – (76,615.52942 - 103,920) | 5 | 50 | 0.20 | | |
| | | | – (52,163.76472 - 76,615.52941) | 4 | | | | |
| | | | – (29,342.11766 - 52,163.76471) | 3 | | | | |
| | | | – (10,595.76472 - 29,342.11765) | 2 | | | | |
| | | | – (0 - 10,595.76471) | 1 | | | | |
| | Building Volume Analysis | Density Analysis - Building Volume | – (324,846.5099 - 478,820) | 5 | 50 | | | |
| | | | – (217,816.157 - 324,846.5098) | 4 | | | | |
| | | | – (133,318.5099 - 217,816.1569) | 3 | | | | |
| | | | – (45,065.41177 - 133,318.5098) | 2 | | | | |
| | | | – (0 - 45,065.41176) | 1 | | | | |
| **Risk Land-use Index** | Types of the Land use | Factor Analysis | Commercial and Residential | 5 | 100 | 0.20 | | |
| | | | Play aground, Open space | 3 | | | | |
| | | | Agricultural Lands | 2 | | | | |
| | | | Wetland and Water Bodies | 1 | | | | |
| **Hydro system Index** | Hydro system Analysis using 1 meter contour line | Factor Analysis | 1st order Catchment Area | 5 | 100 | 0.20 | Environmental Sensitivity Analysis 0.5 | |
| | | | 2 nd order Catchment Area | 3 | | | | |
| | | | 3 rd order Catchment Area | 2 | | | | |
| | | | 4 th order Catchment Area | 1 | | | | |
| | Vegetation Cover | Factor Analysis | High Density Vegetation (0.36 – 0.74) | 5 | 100 | 0.20 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Vegetation Quality Index** | Analysis (NDVI Analysis) | | Low density Vegetation (0.36– 0.27) | 4 | | |
| | | | Wasteland area (0.27– 0.14) | 3 | | |
| | | | Buildup area (0.14- 0.015) | 2 | | |
| | | | Water area (0.015 – (- 0.28)) | 1 | | |
| **Soil Quality Index** | Soil type | Factor Analysis | Wetlands and water Bodies | 5 | 100 | 0.20 |
| | | | Bog and half-dog soils | 4 | | |
| | | | Alluvial soils of variable texture | 2 | | |
| | | | Red-Yellow Podzolic soils | 1 | | |
| **Biodiversity Richness index** | Wetland and Land Cover | Factor Analysis | Conservation Wetlands | 5 | 100 | 0.20 |
| | | | Other Wetlands and Water Bodies | 4 | | |
| | | | Agricultural Lands | 2 | | |
| | | | Built-up Lands | 1 | | |
| **Flood vulnerability index** | Flood Data | Factor Analysis- Vulnerability Frequency | - Annual | 5 | 100 | 0.20 |
| | | | - 5y return period | 3 | | |
| | | | - 10y return period | 1 | | |

## 3. Results and Discussion

The study generates 10 sub-indexes using 12 parameters described in table No. 2 above. Subsequently, the DPI and ESI was computed with weighted summation of 5 sub-indexes for each index. The output index of DP had revealed that 30% of the total area of Kotikawatta- Mulleriyawa has experienced a very high development pressure and approximately 60% of the total area has experienced both high and very high development pressure. In the contrary, 54% of the total area is characterised with environmentally high and very high sensitivity, revealing the need for attention in future developments. Further, the combination of parameters in computing the DP and ES demonstrate the combined effect in relation to the location.

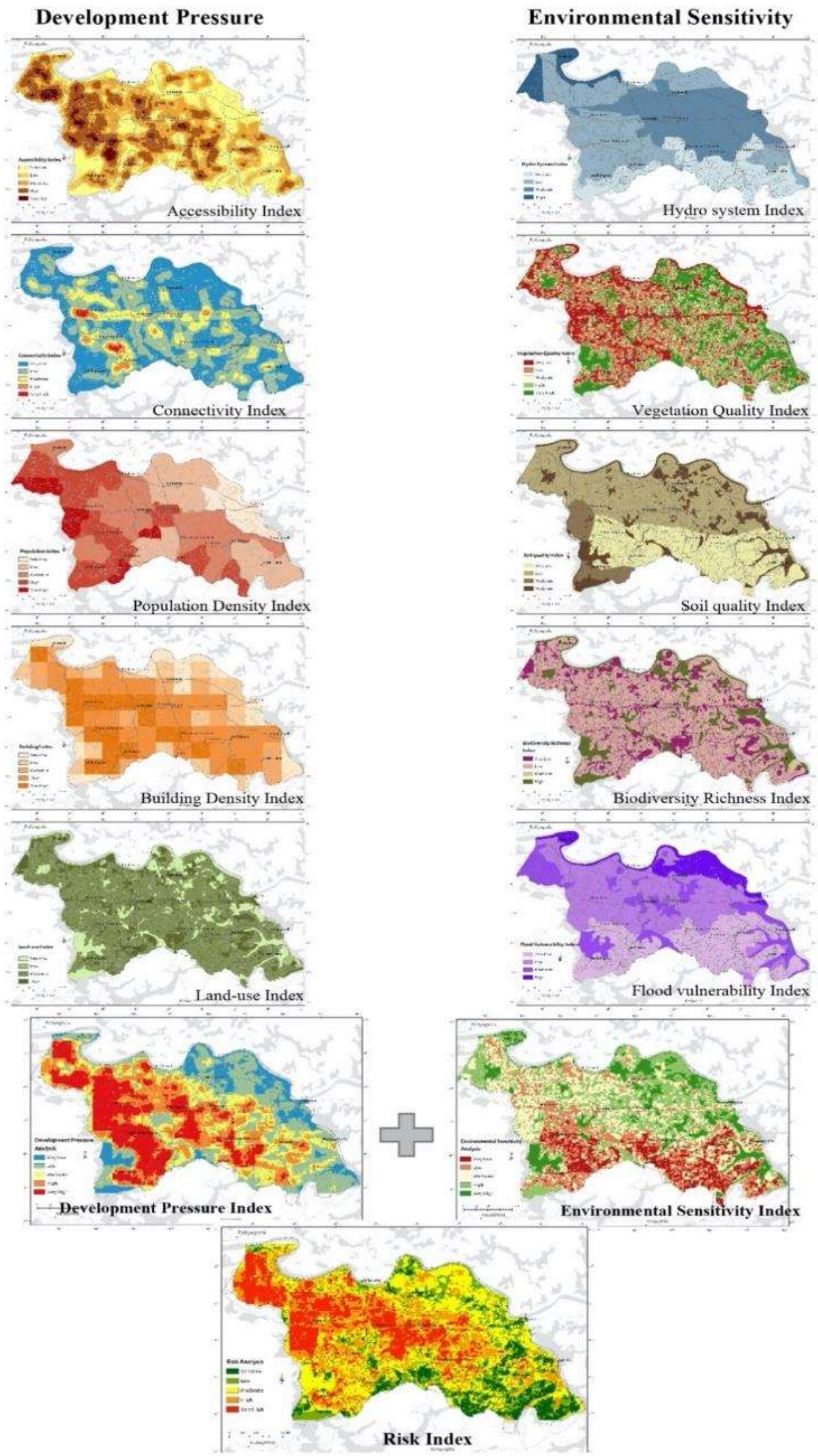


Figure 4: Index maps

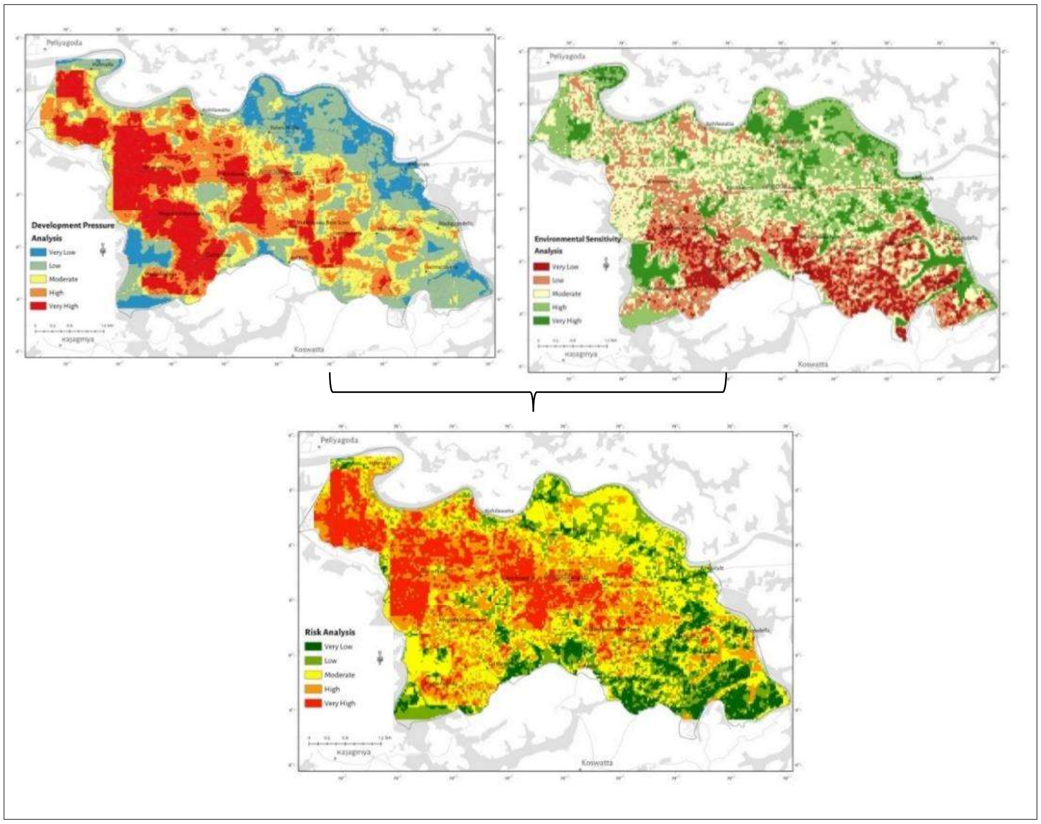


Figure 5: Risk Index

**Risk Index:** The final output of risk index has been calculated upon the weighted summation of Development Pressure Index and Environmental Sensitivity index. As per the index, (Table No 3) 3.6 $Km^2$ (18%) of the area located at the border of the commercial Capital city of Colombo falls within the very high risk category. Approximately 43% of the Kotikawatta-Mulleriyawa Pradeshiya Sabha Area falls within the cumulative of high and very high risk area. The areas of Angoda, Mulleriyawa, Mulleriyawa New Town gain high risk due to enhancement of the accessibility as a result of widening of Kelaniya koswatta road. In comparison with population growth index, these are the areas where a high population growth was experienced during last decade. As per the Risk Index, very low risk lies in Wenawatta, Megoa Kolonnawa area where large extent of low lying and marshy areas prevail with less connectivity with rest of the area.

Table 3: Risk Index

| Risk Level | Area (km2) | Local Area |
|---|---|---|
| **Very Low** | 1.8 | Wennawatta, Megoda, Kolonnawa, |
| **Low** | 3.2 | Ambatale,Maligagodalla , Kelani Mulle |
| **Moderate** | 6.1 | Kohilawatta, Salmal Uyana , Himbutana |
| **High** | 4.9 | Angoda , Mulleriyawa , Mulleriyawa New town |

**Spatial comparison of DPI and ESI**: In planning point of view, the most important risk category is very high risk. The study demonstrates that the extent of very high risk area is 3.606$Km^2$ e.i. 18% of total study area. 61% of high risk area is experiencing very high development pressure and 31% of high risk area is experiencing high development pressure. It indicates 92% of very high risk area under high development pressure. In Environmental Sensitivity point of view, moderate level of sensitivity prevails over 45.5% of very high risk area and high sensitivity prevails over 42% of high risk area.

**Modelling Spatial Relationship:** To gain a comprehensive understanding of the behaviour pattern of development pressure and environment sensitivity, Geographically Weighted Regression (GWR) computation method had been utilized to evaluate the effect of the contribution of each individual against the computed risk index. Since the selected parameters are non-stationary variables, the most suitable relationship computation method is GWR. All selected individual parameters and the risk index have strong positive relationship in terms of Person's correlation coefficient. It indicates that all factors have positively contributed to create the risk factor. However, other than population density, all other parameters gained 0.5< value of Person's $r^{2.}$ Among the parameters of DPI, land use possessed the strongest relationship with 0.625 $r^2$ value. Among the parameters of ESI, Vegetation Quality possessed the strongest relationship with 0.783 $r^2$.

The trend and Pattern of Development pressure and environmental sensitivity in – Kotikawatta –Mulleriyawa: Representation of Development Pressure Index and Environmental Sensitivity index of Kotikawatta-Mulleriyawa area in map format discloses a pattern throughout the area. The development pressure agglomerate around the South –West part of the area which is adjacent to both capital cities. The Accessibility Index strengthens this fact together with population density and building density. Nevertheless, the environmentally sensitive area is lying basically in the southern part of the study area. The high sensitive area reinforced by the bio diversity richness.

Hence, the low development pressure and high sensitivity prevails on the Northern part of the study area.

Table 4: Regression Values for Spatial Relationship

| Main Index | Individual Index- (Independent Variable) | Risk Index- (Dependent Variable) | Geographically Weighted Regression (R2) |
|---|---|---|---|
| **Development Pressure Index** | Accessibility Index | Risk Index | **0.605** |
| | Connectivity Index | Risk Index | **0.565** |
| | Population Density Index | Risk Index | **0.493** |
| | Building Density Index | Risk Index | **0.590** |
| | Land-use Index | Risk Index | **0.625** |
| **Environmental Sensitivity Index** | Hydro system Index | Risk Index | **0.467** |
| | Vegetation Quality Index | Risk Index | **0.783** |
| | Soil quality Index | Risk Index | **0.541** |
| | Biodiversity Richness index | Risk Index | **0.675** |
| | Flood vulnerability index | Risk Index | **0.532** |

## 4. Conclusion

This study described the development and application of DPI and ESI that can be used as a predictor of risk areas in Kotikawatta-Mulleriyawa Area. The results of the study revealed that environmentally high and very high sensitive areas in Kotikawattha –Mulleriyawa have been severely affected by the current development pressure and consequently, aggregate the risk of the degradation of the environment and conversion of the land use as a result.

The DPI and ESI indicate the most suitable integration of geographical data sets that can represent the combined effects of the parameters towards the urbanization issue locations and the magnitude. The study confirmed the strong association of used parameters in deriving the respective indexes and their suitability for defining the development pressure and environmental sensitivity.

The Risk Level Index, there by, is crucial and essential in spatial planning in order to identify and demarcate the areas to formulate area- specific development regulations or to launch a strategic development project as planning intervention while preventing the consequences of environmental degradation and land conversion.

Although the structured methodology applied in this study is data extensive procedure, it proved the attain of high accuracy of the output in spatial planning point of view. The used Geospatial analytical tools of Multi-Criteria Evaluation, scoring and weighing processes, and aggregate and evaluation methods ensure the suitable applications of spatial model developments in relation to the development pressure and environmental sensitivity.

The use of single time point data sets limits the detailed analysis of time series change effects on development pressure and environmental sensitivity. Further studies are required to deploy in order to identify the expansion of development pressure over the area during a period of time and its future trends.

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