Urban Development Pressure: Challenges in Ensuing Green Cover in Unawatuna – Rumassala Area, Sri Lanka

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Abstract

The continuous development of cities has created significant issues in the planning and management of an area's environment and landscapes. This is due to the requirement for supported products such as housing, business facilities, infrastructure networks, and environmental protection. Decades of uncontrolled development have had a significant impact on both the natural environment and the quality of human life. The goal of this study is to examine the change in green cover owing to development over the last few years and to estimate the development pressure index to ensure green cover in the Unawatuna-Rumassala area. Defining the development pressure to prioritise green cover in order to protect the Unawatuna-Rumassala region as an ecotourism destination. Based on the model builder methodology in ArcGIS, this study presents an improved way of analysing development pressure. The development pressure index focuses on finding areas that are prone to significant development pressure. The development pressure was identified using the following criteria: accessibility, population density, building density, and land use and land cover. In 2009 and 2016, Landsat satellite images were utilised to analyse the Normalized Difference Vegetation Index (NDVI), which aids in identifying changes in green cover over time. The simulation findings demonstrate that NDVI levels have changed dramatically between 2009 and 2016. On elevated and low topographic slopes where human activity was prevalent, moderate NDVI values shifted to low NDVI values. Furthermore, development pressure has concentrated in the Rumassala protection zone, having a significant impact on the area's ecosystem. The increased development pressure in the studied area has also resulted in biodiversity deterioration.

Keywords: Development Pressure Index, Normalized difference vegetation index (NDVI), Green cover, Urbanization, Urban Planning

Introduction

According to world data atlas in Sri Lanka, the tourism sector has contributed significantly to the Gross Domestic Product (GDP), such that in 2000 this sector contributed approximately 1.2 billion US dollars and it increased to 11.2 billion US dollars in the year 2019, growing at an average annual rate of 9.61%. According to the Department of Statistics, in 2019, inbound tourism travel for Sri Lanka was estimated at 3,607 million current US dollars. However, the development of touristic areas by the expansion of the built environment surrounding and near touristic locations created pressure on land. Therefore, tourism has become a major challenge in planning land use allocation, managing the environment and landscapes of tourism sites, and ensuring sustainable tourism development (Samat, N. & Harum, N., 2013).

Based on the study done by Hardin (2007) infrastructures including road network has been developed to enhance residential and commercial development. These human activities can alter natural habitats, the transformation of green space to urban and suburban uses is the fastest growing threat to the exotic plants, animals, and open spaces which will result in significant loss of biodiversity (Hardin, P. J., et al., 2007; Lambin, E. F., 2005; Samat, N. & Harum, N., 2013).

Decades of poorly planned development have taken a heavy toll on the quality of both our lives and the natural environment (Ewing, R. L. et al., 2005). Even at low densities, poorly planned development can fragment natural habitats, significantly reducing the value of remaining open spaces for biodiversity, recreation, and other uses (Ewing, R. L. et al., 2005). If development continues at prevailing densities, land will be consumed at an even faster rate than population growth, particularly in rural and suburban areas. This expanding footprint will put additional pressure on diminishing wildlife resources and their habitats and has the potential to drive more plants and animals toward extinction (Larkham, P. J., 2014). As our sprawling communities push further and further out, the remaining green cover and wildlands in and around cities and suburbs disappear, taking with them the habitats on which wildlife depends (Larkham, P. J., 2014; Samat, N., & Harun, N., 2013).

Therefore, the development of the area must be undertaken with a better understanding of its sustainability to ensure its sustainability. According to the United Nations, sustainable planning is a commitment to the responsibility of governments and all stakeholders to ensure

the long-term richness and quality of life of future generations. Many studies emphasise that controlling land use development is one of the approaches used to ensure sustainable development (Lambin, E. F., 2005; Samat, N. & Harum, N., 2013). Proper planning and development strategy during the expansion of development is able to protect the natural environment.

Analyzing development pressure for a specific topic is the primary task in the context of planning and developing modern urban land use (Hidayat, D. G., & Guo, J. Y. (2007)). Nevertheless, site analysis is a complex process and involves consideration of a multi-criteria decision that is limited to not only the physical condition of urban land uses, but more attention should be paid to integrating social, economic, and environmental factors as well (Alibegovi, D.J., & Villa,.K., 2006).

The increasing demand for additional land for the creation of new projects and the development and redevelopment of the former urban infrastructure and industrial development were among the main motivating factors for the subsequent urbanisation process (Larkham, P. J., 2014). However, when the push factors such as urban population growth are combined with pull factors, mainly economic progress, they are the two primary causes of great urbanisation (Alibegovi, D.J., & Villa,.K., 2006; Hidayat, D. G., & Guo, J. Y. (2007)). Meanwhile, the spatial pattern and changes over time of the urban patch are vital. An understanding of the factors that sparked the process and appropriate physical planning is imperative to meet the current and future needs of the cities.

Unawatuna-Rumassala is one of the most popular tourist destinations not only in Sri Lanka, but also throughout the world, owing to its blue-yellow-green colour combination. Rumassala forest is home to several bird, reptile, and mammalian species. The entire Rumassala area, including woodlands and coral reefs, has been designated a sanctuary due to its rich biodiversity and numerous rare native herbs. There are several unusual plants among the exotic flora, including "Mal Kaddol" (Bruguier hexangular), "Muna Mal" (Mimusops elengi), and "Diya Danga" (Dolichandrone spathacea), among others. Additionally, and perhaps most significantly, there are many plants known as "Mudu Delum" (Xylocarpus rumphii) on the grounds of the renowned "Velle Devol" as well as the new hotel site that are classified as severely endangered in the 2012 Red Data Book (Wildlife Conservation Society, 2008). Moreover, it is reported that there are just eight of

these plants on the entire island, along with several other threatened species that should be properly preserved and conserved. Dr. Herrich-Schäffer, a German entomologist and physician, discovered several new species of mammals and reptiles in this region for the first time, including a butterfly named "Dark palm dart" (Telicota ancilla), "Kurulu Goya" (Accipiter badius), "Vehi Lihiniya" (Hirundo sp:), and "Rathmuhunath Ko (Wildlife Conservation Society, 2008).

Human settlement growth is one of the risks to Unawatuna's terrestrial ecosystems. A dense concentration of guest-houses, hotels, residences, and other economic activities such as small shops obtains more land for construction from the vegetation cover.Infrastructure development for the tourism industry harms the natural environment. In the tourism sector, these structures are referred to as "eye sores." Unawatuna is a one-of-a-kind location well-known for its tourism business, so there are several prospects for economic operations related to tourism. As a result, human settlement expansion and urbanisation are on the rise. Furthermore, improperly constructed tourist accommodations primarily contribute to deforestation and visual pollution.

As a result, this study examines the change in vegetation cover caused by development over the last few years and evaluates the development pressure index required to sustain the green cover in the Unawatuna–Rumassala area. Defining the development pressure to prioritise green cover in order to preserve the Unawatuna-Rumassala area as an ecotourism destination.

Research methodology

Study Area

This study is being undertaken in the Galle district's Rumassala-Unawatuna area. These two territories are divided into four Grama Niladhari Divisions (GNDs): Unawatuna central, Unawatuna west, Bonavista, and Yaddehimulla. They are also connected to the Habaraduwa Divisional Secretariat Division (DSD). This area is home to approximately 4,124 individuals. This area is associated with Sri Lanka's wet zone. As a result, the average annual rainfall is approximately 2300 mm, and the average annual temperature is approximately 26 °C. This area's soils are composed of red-yellow podzolic soils with soft or hard laterite, rolling and undulating hills, and regosols on beaches and flat land (figure 1).
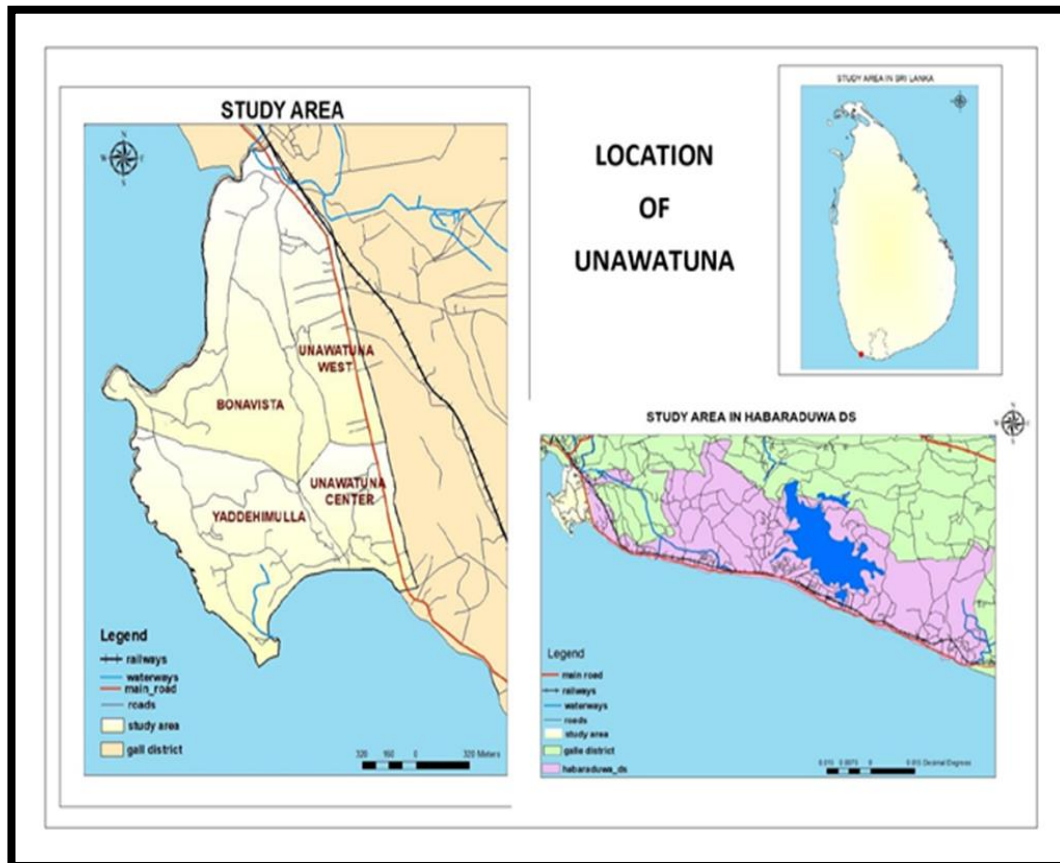
Figure 1: Location of Unawatuna

Source: Prepared by the author using data of Habaraduwa Divisional Secretariat, 2020

Data and Methods

The study was primarily supported by geospatial information compiled by the departments of surveying and census and statistics. The development pressure index was analysed using an integrated GIS framework (ArcMap 10.4) and the model builder technique. The development pressure index is used to identify places that are particularly vulnerable to development pressure. To determine the development pressure, the following factors were employed: Accessibility, population density, building density, and land use/land cover were all considered (Figure 2).
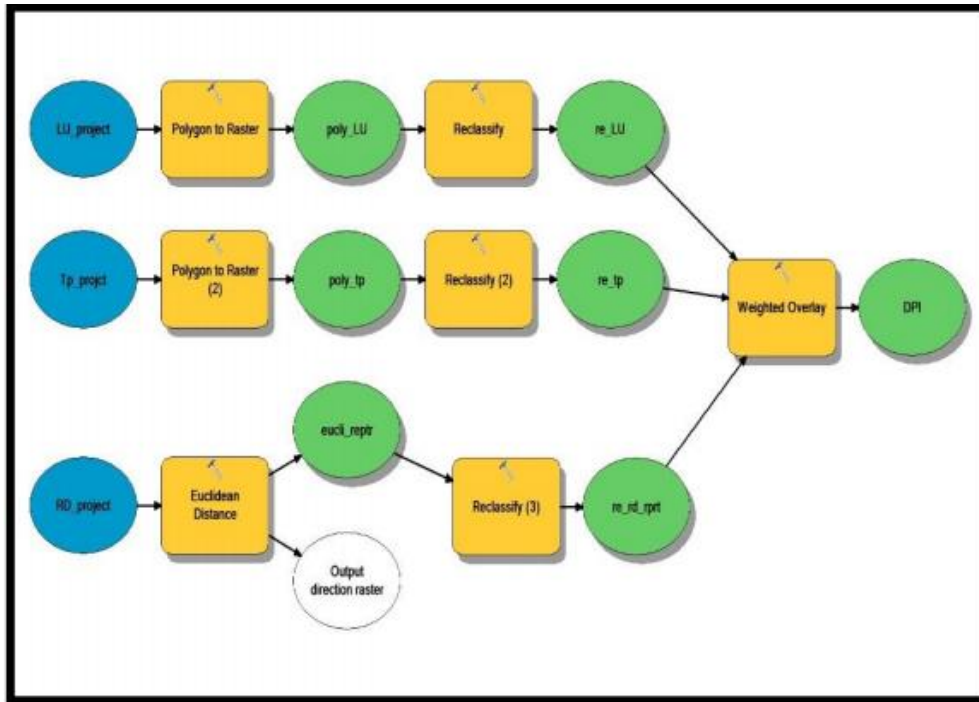
Figure 2: Model builder chart of the methodology

Source: Created by author, 2020

The Normalized Difference Vegetation Index (NDVI) approach was used in this work to extract features from a satellite image of Unawatuna and Rumassala. The USGS provided satellite images and NDVI analysis was performed using Landsat 8 and 7 images. Vegetation cover is a critical biophysical indicator for detecting human-induced disturbances in vegetation cover, which can be evaluated using vegetation indices generated from satellite pictures. Additionally, NDVI is a straightforward numerical indicator that may be used to examine remote sensing measurements taken from a remote platform and determine whether or not the target or item being observed has live green vegetation (Bhandari et al., 2012).

The following formula for the NDVI calculation,

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

NDVI is Normalized Difference Vegetation Index

NIR is near-infrared light and Red

Results and Discussion

In the context of contemporary urban land use planning and development, the preliminary task is to conduct a development pressure study on a given subject. However, site analysis is a complex process that requires examination of multiple criteria, not only for the physical state of urban land uses but also for the integration of socioeconomic and environmental elements.

Exaggerated demand for extra land for new projects, development, and redevelopment of existing urban infrastructures, as well as industrial development, were important catalysts for the ensuing urbanisation process. However, the two most fundamental reasons for major urbanisation are push factors such as urban population expansion and pull factors such as economic progress. Given the importance of the spatial pattern and changes in the urban patch over time, it is critical to understand the variables that provoked the process and to implement appropriate physical planning in order to accommodate the cities' present and future demands.

Access to a road is a critical criterion in development pressure agglomeration because it enables movement and connectivity between settlement locations. Thus, when developing this index, it is necessary to evaluate the accessibility of public infrastructure in terms of distance from a certain site via a particular mode of transportation. In any case, road accessibility is the primary consideration, which must be limited to a radius of 1–5 kilometres. It did, however, reveal the road distance.

Considering accessibility, the indicator was that areas experiencing strong development pressure will be located within 200 metres of the road network (Figure 3). From a distance of 200 metres, the optimum places for identifying development potential are defined by a 1–200 metre buffer zone. Because humans can travel short distances, for this study, the Euclidian distance between both sides of the major road is generated and classed. As can be seen in the following map, the road network has been expanded throughout the Rumassala forested area. It was a critical factor in the loss of forest cover, and as a result, residents began encroaching on land parcels for the purpose of building their residential areas.
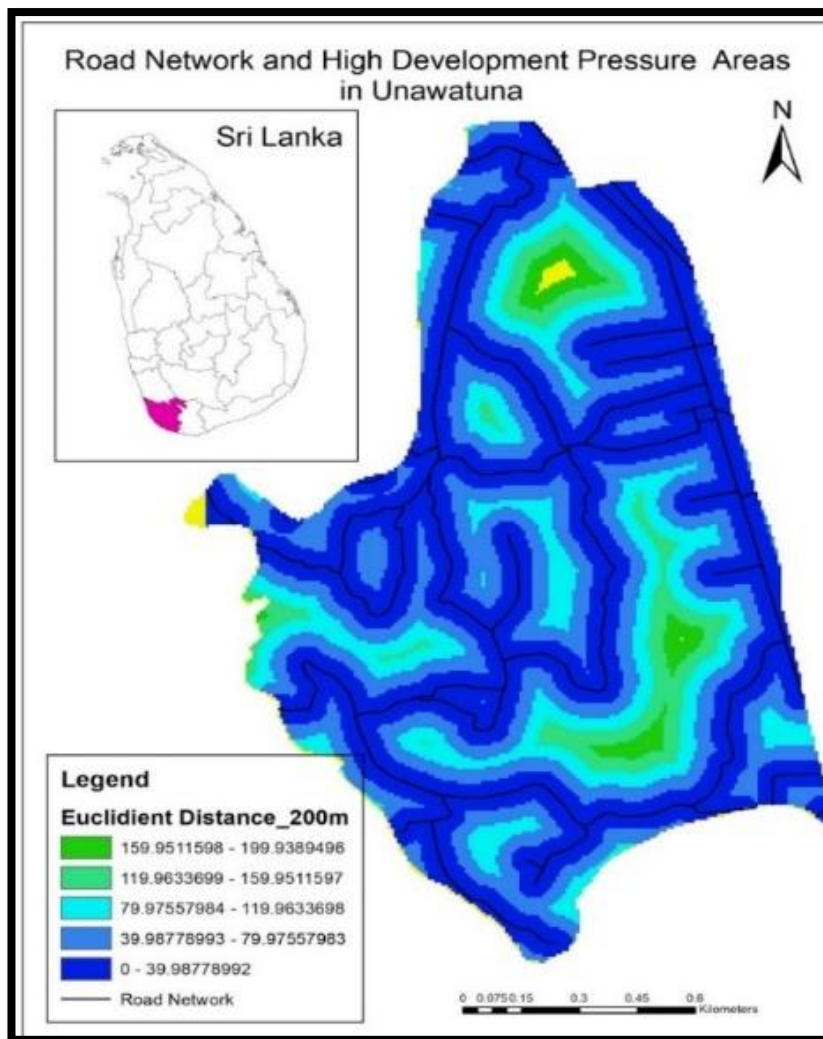
Figure 3: Road network in Unawatuna and Rumassala

Source: Created by author using GIS digital data, 2020

The land-use/land-cover component was the next most significant factor to examine. Various land uses in the city have been categorised as follows: built-up, bare land, shrubs, beaches, agricultural, and other similar uses of land. High concentrations of residential and social infrastructure amenities, as well as the Galle-Matara main road, are concentrated in the Unawatuna area, with mixed development activities occurring along the Yaddehimulla road. The built-up area is designated as a high development pressure area in this study (Figure 4).
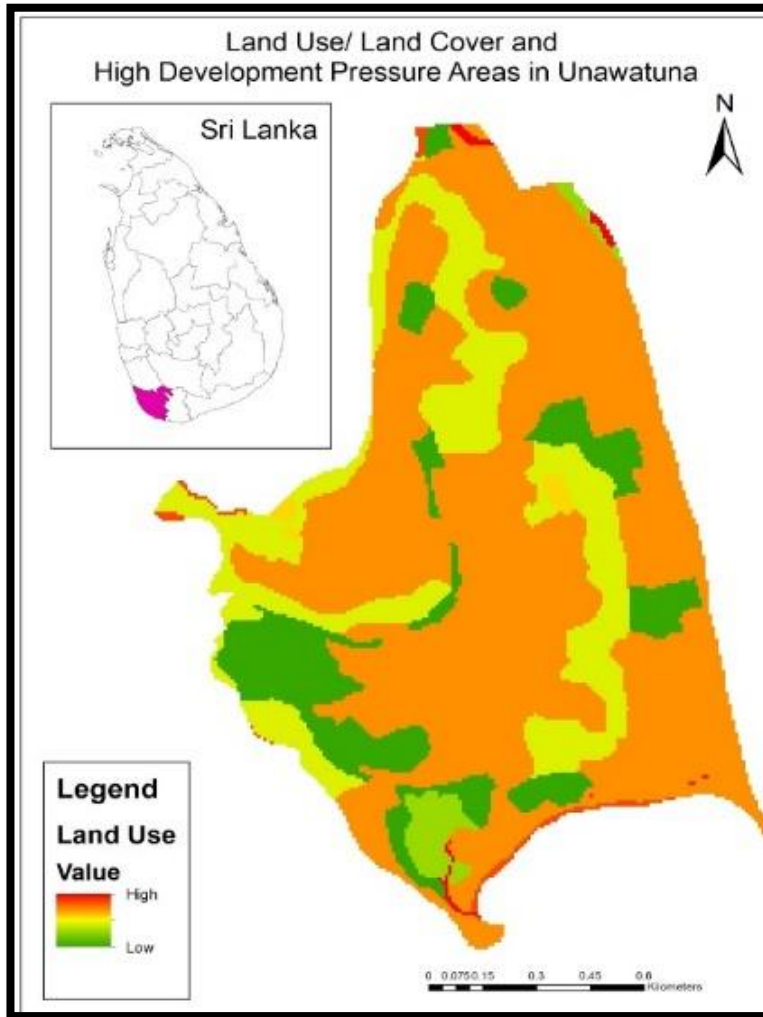
Figure 4: Land-use/land cover in Unawatuna and Rumassala

Source: Created by author using GIS digital data, 2020

When it comes to building density in the study area, the landscape has been able to absorb a significant amount of development pressure in the buildable area. Because of the high density of construction projects such as hotels, restaurants, shops, hospitals, schools, and residences, the high buildable areas have been completely covered. The classification has been done on the basis of the information provided by the high shape length. Along the Galle–Matara main road and the Yaddehimulla road, there are numerous high-rise projects with extensive lengths and multiple stories. According to the building classification system, this region has been identified as having a high population density. Because of the high level of economic activity and infrastructure facilities, there is always a considerable amount of development pressure. According to the figure 5, it can be identified that there are high densities of buildings in the Unawatuna East and South areas.
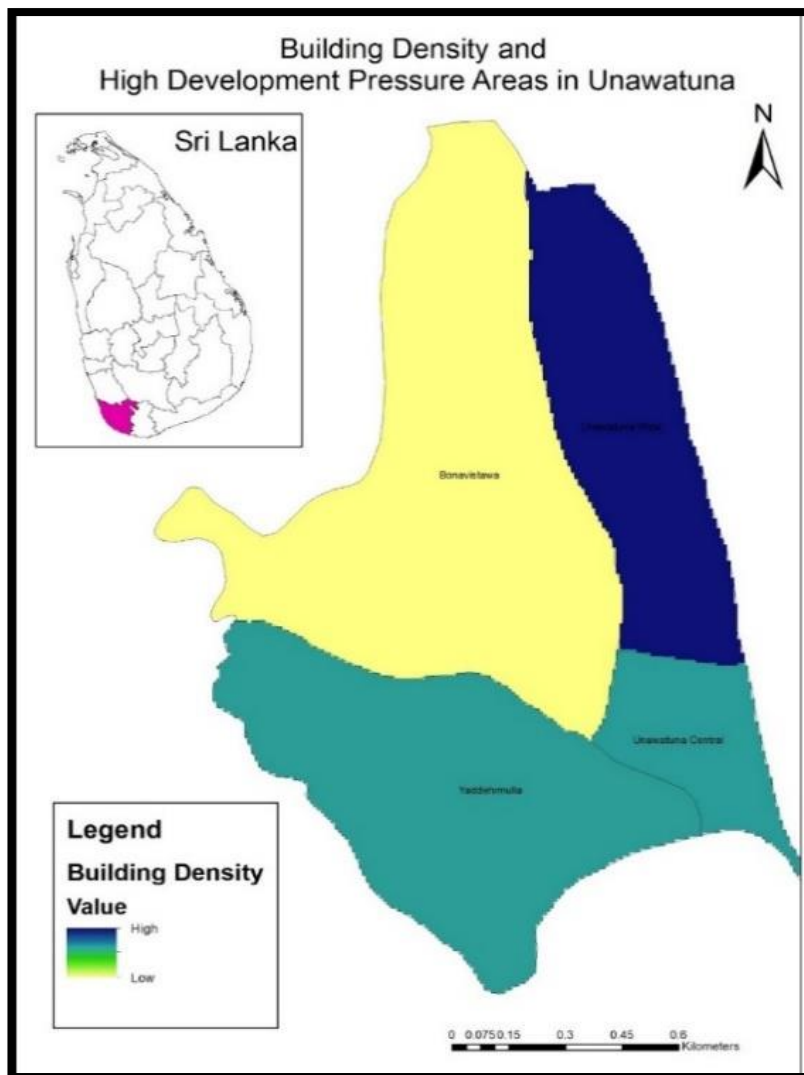
Figure 5: Building density in Unawatuna and Rumassala

Source: Created by author using GIS digital data, 2020

The population density (people per square kilometer) of the city was calculated based on the data collected from the devitional secretariat Habaraduwa. As a result, according to the literature, places with a high population density make a significant contribution to the high level of development pressure. For the purpose of determining the development pressure in Unawatuna, four GN divisions are taken into consideration. The localities of Bonavista, Unawatuna West, Yaddehimulla, and Unawatuna Central were the ones represented (figure 6).
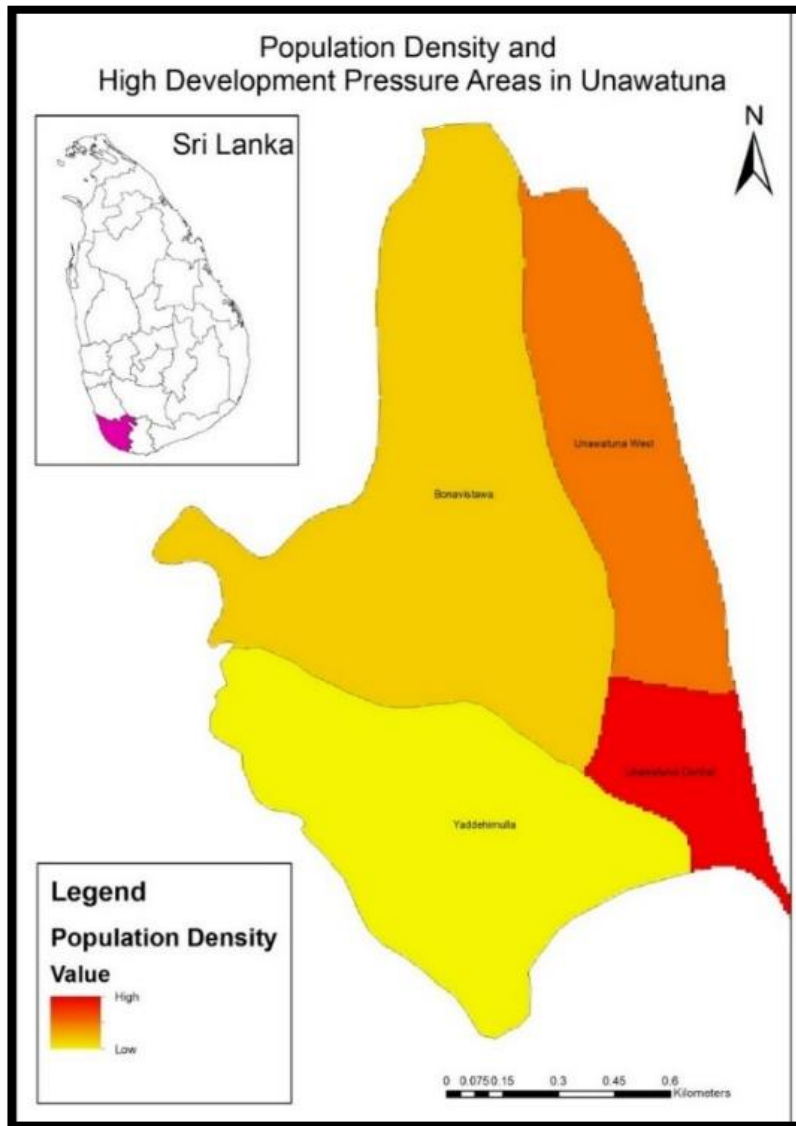
Figure 6: Population density in Unawatuna and Rumassla

Source: Made by author using GIS digital data, 2020.

According to the information, the Unawatuna area has been classified as having significant development pressure because of the concentration of commercial activities and residentially clustered neighbourhoods in the area. Therefore, the development of residential clusters along the main road in Unawatuna is becoming more intense as a result. People who want to live in close proximity to commercial activities and facilities, as well as in a mixed-use development with development and in close proximity to urban centres. In turn, the area's building density is increasing as a result of these developments.
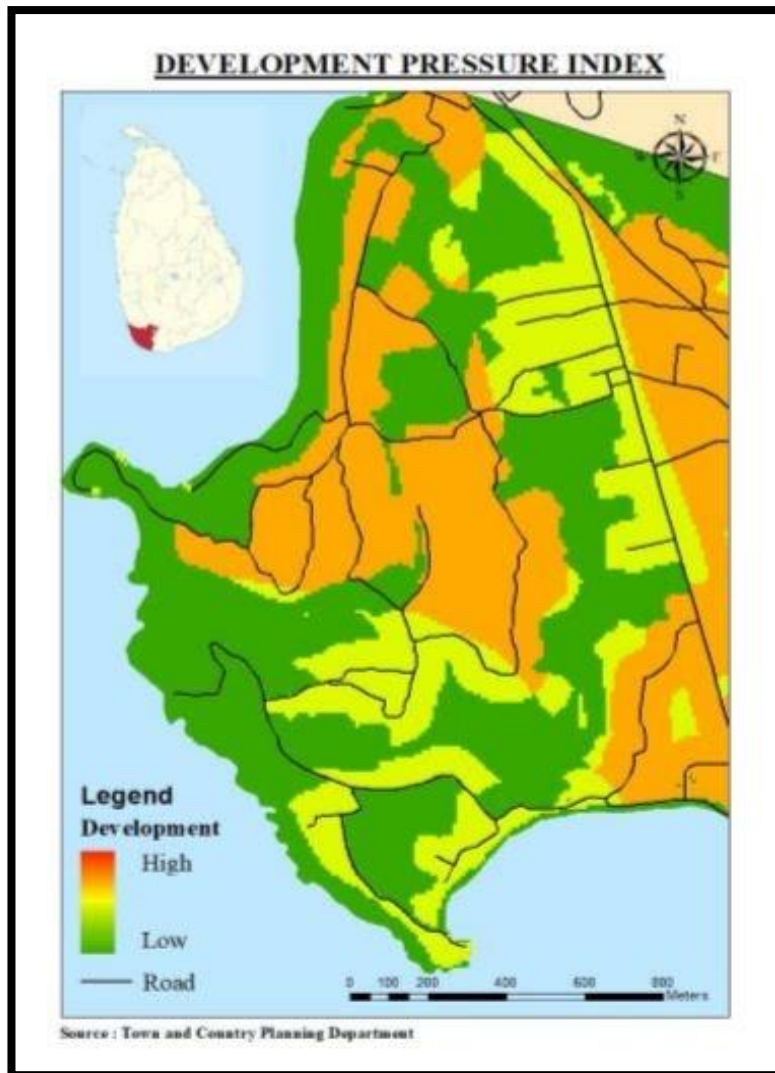
Figure 7: Development Pressure Index in Unawatuna area

Source: Department of town and country planning, 2021

As depicted on the figure 7, high development pressure zones are located along the main road from Galle to Matara, as well as other secondary roads and hilly areas around Rumassala. It also appears that there is moderate development pressure in Unawatuna Bay. It is anticipated that the very sensitive and precious environment in the Rumassala area would be threatened as a result of the high development agglomeration. The study region has only a small amount of developable land. As a result, the terrestrial region is being pushed towards rapid development and is becoming increasingly vulnerable to urban expansion. As a result, the increased development pressure will have a detrimental effect on the green cover of the landscape. Additionally, when monitoring the area, the buildings near the beach would be a direct obstruction to the study area's ability to enjoy a view of the sea.

There are strong indicators now that development and other economic pressures are accelerating the rate at which development pressure is increasing. While numerous human activities have the potential to change natural ecosystems, the conversion of green space to urban and suburban uses is the most rapidly expanding threat to open spaces.

Another aspect is that remote sensing information provides the data essential to detect changes in heterogeneous urban landscapes over a long period of time. Accordingly, NDVI calculations were utilised to determine the influence of green cover in the area in order to determine changes in vegetation cover over the course of the study. Due to the increasing number of people living in the neighbourhood, as well as the presence of commercial activities, urban management and planning are being challenged. According to the United Nations Environment Programme, information on land use and land cover change is essential to make sophisticated decisions on where to build developable areas while also preserving appropriate open and green space for sustainable urban development.
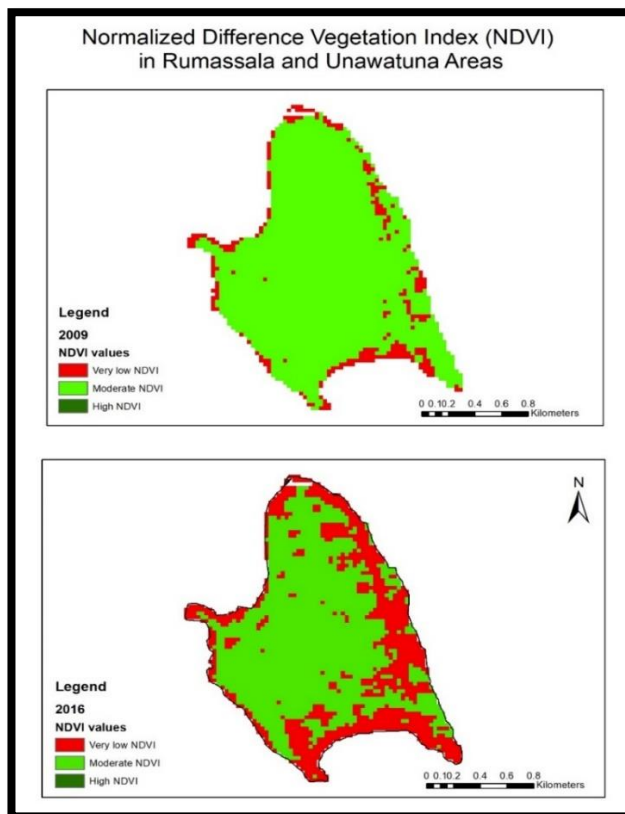

Figure 8: NDVI index in Rumassala and Unawatuna area

Source: Created by author using satellite and GIS digital data, 2021.

As shown by the NDVI analysis, there has been a significant change in the spatial pattern of vegetation land cover between 2009 and 2016. Elevated and low topographic slopes, where human activities were dominant, saw moderate NDVI levels drop to low NDVI values. The Normalized Difference Vegetation Index (NDVI) is influenced by development and human activities (such as forest clearances and industrial and tourism activities). When comparing the 2002 and 2020 scenarios (Figure 9), we can see how the forest areas of Unawatuna have shrunk. According to the findings of the study, which were based on field observations and satellite images, human actions are more significant than natural occurrences in the degradation of forests and vegetation cover in the studied area. The high concentration of guest houses, hotels, residences, and other commercial activity requires more land from the plant cover in order to construct their structures than the vegetation cover can support. The extraction of timber is a significant contributor to the reduction in vegetation cover.

Figure 9: Google earth images of Unawatuna bay area 2002 and 2020

Source: Google earth pro images, 2021.

Zoning plans should be enacted as soon as reasonably practicable in the Unawatuna and Rumassala areas as a guideline for maintaining the environment in the surrounding areas. According to the criteria of the Urban Development Authority, we have developed a zoning plan for this purpose. Conservation and development criteria have been used to determine the boundaries of four zones under these guidelines. These areas include the Development Promotion Zone, the Moderate Development Zone, the Controlled Development Zone, and the Nature Conservation Zone. Development Promotion Zone (figure 10). The allowable limitations for the zones that have been identified are listed in the following section (Table 1). These restrictions are derived from the Urban Development Guidelines, which were included in the city's planning regulations at the current count.
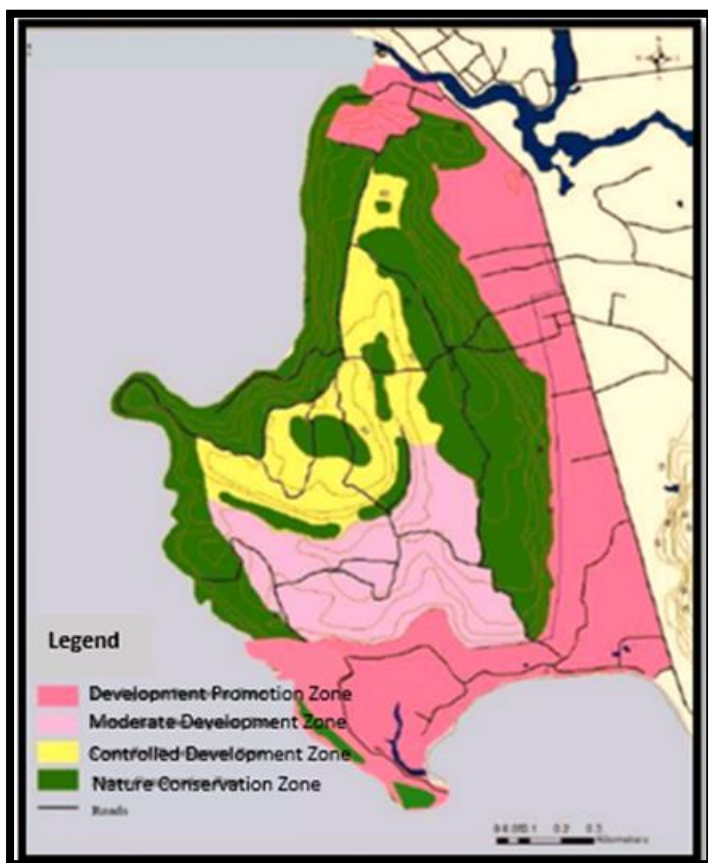
Figure 10: Zoning plan for Unawatuna & Rumassala

Source: Department of town and country planning, 2021

Table 1: Permissible limits for the development in Unawatuna and Rumassala area

	Nature of conservation	Controlled development	Immediate development	Development promotion
Plot coverage	5%	35%	50%	More than
Plot size	-	40P	20P	-
Boundary walls	Not permitted	Not permitted	Not permitted	Not permitted
Green mesh or transparency wall	Permitted	Permitted	Permitted	Permitted
Expansion for buildings	Not permitted	Not permitted	Not permitted	Not permitted
Permitted heights	-	7.5m (Canopy height)	11.5 m (G*2)	45m and 60m

Source: Urban development authority, 2020

Conclusion

An improved method for analysing development pressure is described, with the goal of extracting the high-development zones in Unawatuna and Rumassla as a result. In the normalised difference vegetation index (NDVI) technique, the amount of green cover in a region was measured in order to determine how anthropogenic activities were influenced by that green cover. The changes in vegetation patterns between 2009 and 2016 are clearly highlighted by this fact. Apart from the study, poorly planned industrial and residential development have had a significant negative impact on the quality of each of our lives as well as the environment. Even at high densities, poorly designed development will fragment natural habitats, thereby diminishing the value of remaining open spaces for diversity, recreation, and a variety of other purposes and functions. As a result, the suggested zoning plan, which includes the Development Promotion Zone, the Moderate Development Zone, the Controlled Development Zone, and the Nature Conservation Zone, can be implemented to ensure that green cover is maintained in the direction of the ecotourism destination.

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