GIS AS A DECISION SUPPORT TOOL FOR PLANNING A COSTAL GREEN BELT BY USING SPATIAL AND THREE DIMENSIONAL MODELS

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ABSTRACT: Costal environment is one of the most important geomorphological system which consisting unique vegetation cover. Especially in tropical islands like Sri Lanka, has its own variety of vegetation cover in diversified conditions. After the '2004 tsunami' devastation, a significant amount of vegetation has been washed away from the coastal zone and thereafter many governmental and non-governmental campaigns were conducted for rebuilding this environment. 'Green belt' was popular topic and implanted in many areas. But pre-planning process was always questioned because of the sustainability of them were getting down. Due to several low considered factors, such as human activities, geomorphological aspects as well as bio geographical factors many green belts were failed. This study was designed to identify a better pre planning mechanism for coastal green belts. The study was conducted in coastal zone of 'Kalutara' divisional administrative area which consisting several isolated green vegetation spots. Therefore, as a pre planning tool, Geographic Information Systems (GIS) were introduced in two dimensional (2D) and three dimensional (3D) aspects. As the first objective of the study, existing vegetation cover was identified using high resolution satellite images and field verification was conducted with a GPS survey. The vegetation spots were observed with the height levels for pre modelling activities. As the second objective the surface height of the Digital Elevation Model (DEM) and field measurements of the vegetation patches were combined and generated virtual surface model. As the third objective this model was forecasted to the other zones which excluded vegetation cover. But this was modelled with the several constrain factors which gives the realistic conditions of the study area. Socio-economic factors and other natural factors were also considered during the process. Topographical data, field observations and demographic data were used for multi criteria analysis and 3D modelling. ArcGIS software was used for spatial data handling and modelling activities. According to the results, several potential spaces were identified along the coastal zone which can be developed towards a green belt. These areas can be further examined with soil and other biological factors. As the conclusion, it was identified that the finalized model had a better representation of the study area and interpretation was less time consuming and convenient. These models can be altered according to the new criteria and repeatable to obtain different results. Therefore, preplanning mechanism is improved with GIS as a better decision support tool.

1 INTRODUCTION

Costal vegetation cover is an important indicator for understanding the value of natural resources in any country. Specially, islands like Sri Lanka have an immense contribution from the costal vegetation cover which often aids multifunctional processes for conserving shoreline and peripheral areas. “The seashore of Sri Lanka contains four major types of vegetation: (a) the sandy shore; (b) sand dune; (c) mangrove; and (d) salt-marsh. (Silva and Premachndra, 1998). Further, diversification can be identified due to the complexity of coastal environmental process as well as the climatic variations around the country.

1.1 Importance of the study

The coastal environment of Sri Lanka, always strongly interact with human activities. As usual this has more negative impacts on the coastal vegetation. But hotel and tourism industry has also focused on preserving nature to retrieve scenic beauty and recreational value, as a way of tourist attraction. In fact, there are many disturbances for the natural growth of vegetation due to several factors. Physical factors, such as coastal erosion, tsunami, storm surge, soil degradation, salinity variations, climate change and sea level rise have significant effects. But human effects such as, deforestation of mangroves for furniture, fishing boat and equipment preparation, development activities, constructional activities, sand excavation and environmental pollution. However, Sri Lankan communities are strongly convinced the value of these coastal vegetation with the tsunami devastation occurred on 26th of December 2004. The most of the areas with rich vegetation cover has been a resistant for the severe waves and their velocity. These vegetation shields had been damaged, but they have saved thousands of lives and infrastructure to the nation. Therefore, the proper management and conservation is always important and this approach has geographical perspective with other physical and socio economic considerations.

1.2 Problem statement

After the devastating tsunami, many governmental and non-governmental campaigns were conducted to rebuild the vegetation cover. Coastal green belts, green villages, mangrove restoration are popular themes that had been funded and implemented. In fact there are successfully driven operations with community participation as well. But sometimes there were questions and arguments regarding the sustainability. When considering the “Green Belts” it always became a challenge, because of the structure is in a continuous form along the shoreline. “A Greenbelt could be defined as a strip of natural or artificially created coastal vegetation designed to prevent coastal erosion, and mitigate the adverse impacts of Natural coastal hazards on human lives and property. The greenbelt area however is a country specific and site specific stretch of vegetation in the coastal zone, defined in relation to risk factors and vulnerability to coastal hazards.” (IUCN, 2007). In most regions, the vegetation cover is distributed as a form of isolated spots or strips where to be connected along the shoreline areas. If human interactions were ignored the sustainability could be affected. Therefore, pre planning is essential and spatial (Geographical) perspective with socio economic conditions should be considered. With the suitability of green

belt development on the shoreline, there are possibilities of modelling the output or the result for better decision making efforts.

1.3 Study area

The study area is one of the costal divisional secretaries (a type of local administrative boundary) in western province of Sri Lanka. It is well known as “Kalutara” that refers to “the bank or the mouth of river Kalu”. “The coastline of Sri Lanka is 1620 km, in length inclusive of bays and inlets, but excluding lagoons, while the coastal region comprises 74 Divisional Secretaries’ Divisions with a coastal boundary. The coastal region which makes up 24 percent of the country’s entire land area of 65,510 sq km, also accounts for 25 percent of the population, 70 percent of the tourist hotels, 67 percent of industrial units, 17 percent of agricultural lands and 20 percent of home gardens. It is also home for a large number of high priority archaeological, historical, religious, cultural, scenic and recreational sites.” (IUCN, 2007). The coastline of Kalutara already has natural and manmade green strips. In addition, there are several isolated green patches or spots which is less considered and lesser known. Most of these minor environmental systems are in the risk of disappearing from the coastline as their value has been always covered by the known or popular locations.

1.4 Objectives

The main objective of the study, is focused on developing a virtual 3D model for the coastal green belt. There are three defined objectives,

- Identification of existing vegetation cover using satellite images and field verification process with vegetation spot height measurements.
- Developing a virtual three dimensional model using topographic heights and field measured vegetation spot heights.
- Forecasting of the model into other zones which are excluded with the vegetation cover.

2 METHODOLOGY

The identification of the existing green patches was based on satellite image interpretation. High resolution images were used and resource mapping was done for the study area. This approach gave a better understanding of the area with adjoining environmental conditions. After this process the field verification was conducted with GPS devices. The HAGA meter was used to detect the height of the vegetation cover as a set of spot heights. This dataset was overlaid on top of a Digital Elevation Model (DEM) and exaggerated the values. The spot heights value were interpolated using Inverse Distance Weighted (IDW) method. As the highest points were taken on the vegetation patches, higher weights were assigned to the exact locations and nearby areas were modelled. Combining topographic and vegetation spot heights, the virtual 3D vegetation model was derived. (Figure 1) This model was further forecasted to other areas which excludes proper vegetation cover. In this process the physical

and human conditions that were acting as constrain factors, also considered and modelling was controlled further by adding the factors.

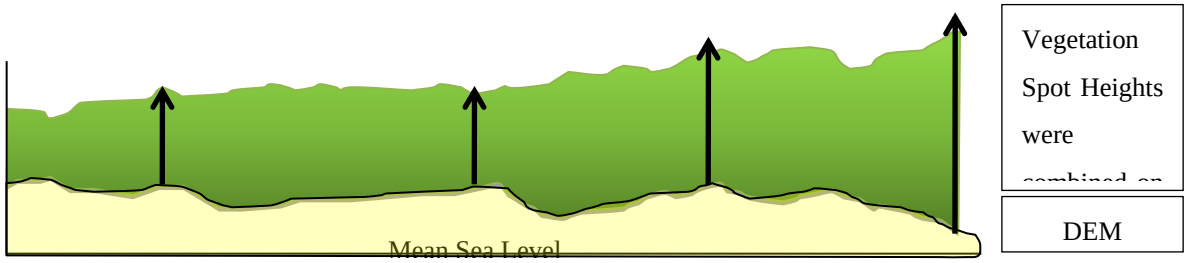

Figure 1. Model structure of the virtual 3D model

3 RESULTS

The available green areas were detected throughout the study area as small patches or spots. They are the resources for a green belt which should be developed by connecting each other. The 3D model has represented the possibilities of connecting the areas. Figure

Figure 2. A portion of the 3D virtual model with building layer overlaid on the surface

When the model was forecasted into the other areas, the human and the physical factors were considered and they were introduced as constrains. Human settlements, roads, fishing or other social activities were removed with a buffer to avoid the effects to the green belt. Figure 3 indicates a closer view of the model with roads and buildings that are influenced to the model.

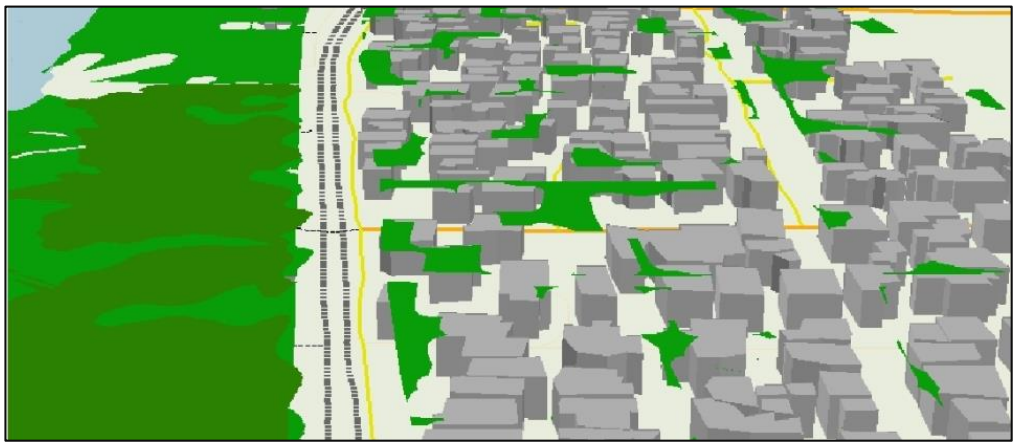

Figure 3. A closer view of the model with constrain factors of human settlements and roads

According to the model, the isolated green patches can be connected by developing them along the shoreline. Two nearby patches have to be attracted according to the distributed pattern. In this scenario, soil conditional and vegetation types are not considered and structural models have been created. But implementation stages the soil and vegetation factors must be introduced with specific criteria.

4 CONCLUSIONS

According to the results, the modelling of existing resource has provided a strong way of representing and interpreting the pre planning process. Therefore, GIS technology is crucial for decisions which has to be taken from the beginning. Though, two dimensional mapping gives a great visual understanding, the 3D perspective is also important. Modern surface detection techniques like LiDAR (Light Detection and Ranging) has more capabilities of building accurate 3D models. But the cost is higher and they cannot identify the socio economic conditions, which should be collected with the field survey. Therefore this methodology can be identified as cost effective and simplified mechanism. Though, field survey was time consuming, it has an immense value of understanding the environment with both physical and human interactions. It is a value addition for the virtual model to be built in more realistic patterns.

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