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Analysis of land suitability for development activities in Eastern and Northern coasts of Sri Lanka using spatial technology

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Abstract: Natural resources in North and Eastern provinces of Sri Lanka were severely affected due to the civil war. This was more significant along the coastal zone from Mannar to Batticaloa. It has been establishing more economic development activities in Northern and Eastern provinces after the war. Arial photography, Geographical Information Systems (GIS) data and satellite images have proven their importance as additional tools in identifying prospective areas for natural resources and also for locating suitable sites for establishing new development activities. In this study integrated approach of remote sensing techniques, Arial photo interpretation and GIS techniques were applied to produce reliable information for identification of most suitable locations for the development activities in the Northern and Eastern coastal zones of Sri Lanka.

Keywords: *coastal zone, land suitability index, weightage*

Introduction

Both Northern and Eastern provinces have been heavily affected by the civil war. The Northern province's population was 1,311,776 in 2007. The majority of the population is Sri Lankan Tamils, with a minority Sri Lankan Moor and Sinhalese population. The Eastern province's population was 1,460,939 in 2007. The province is the most diverse in Sri Lanka, both ethnically and religiously. Majority of the people earn their livelihood as , fishers and in the civil and business sectors. Small scale industry such as chemical, light manufacturing and were present before the civil war. Part of the study area which is belonging to Eastern province has high demographic pressure compared to Northern Province and frequently experiencing coastal flooding. Also the Eastern and Northern coasts of Sri Lanka were seriously affected by the tsunami which took place in December, 2004. This has created severe environmental and socio-economic impacts in the region. After this incident, a 100 meter coastal buffer zone has recommended by the Coast Conservation Department. However, it was not implemented due to various reasons. Set back limits are also to be considered when identifying land suitability for development activities in the coastal zone.

The study area

The study area covers coastal zones (as defined in the Coast Conservation Act No. 57 of 1981) of Northern and Eastern provinces of Sri Lanka (Figure 1). This region is mainly affected by the Northeast monsoon from December to March. The Northern province has an area of 8,880 km^2 which is surrounded by Bay of Bengal to the East, the and to the West, to the North, and the , and provinces to the South. The Northern Province is divided into 5 , 33 and 912 Grama Niladhari (GN) Divisions (villages). The

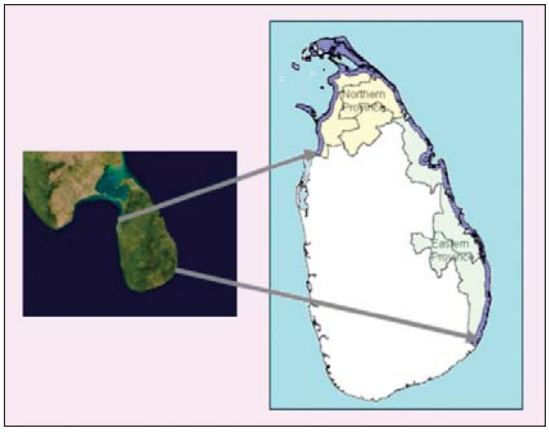

Figure 1: The study area

province is divided into two distinct geographic areas: and the Vanni. Eastern province has an area of 9,996 km^2. The Eastern Province is divided into 3 , 45 and 1,085 Grama Niladhari (GN) Divisions.

Materials and Methods

The main objective of the research is to identify and demarcate suitable locations for development activities within the study area. The research was basically based on secondary data which were collected from text books, publications, national atlas, project reports, web sites etc. In some occasions, aerial photographs and satellite imageries were used to identify the past and present status of the environmental and socio-economic conditions of the study area. Available historical and recent data i.e. different kinds of maps, statistical reports and other relevant documents were used to correlate the variation of environmental and socio economical conditions of the study area within last thirty years. Different types of thematic maps were introduced using these data. Arc GIS (version 9), Arc View (version 3.2) and ERDAS IMAGIN software were used to prepare these maps and for data analysis process.

Preparation of the base map and thematic maps

The base map was prepared using 1:50,000 topographic maps of Survey Department of Sri Lanka using Arc View 3.2(a) version. The base map falls within few Divisional Secretariat Divisions of Ampara, Batticola, Trincomalee, Mullativu, Jaffna, Kilinochchi, and Mannar districts. However, in some areas, the coastline is not clearly defined in the 1:50,000 sheets and therefore, satellite image data and aerial photographs were also used to complete this task. The attribute data were entered using Excel, Access, etc. and similar software having the facilities to create data tables. GIS software which were used in this research have the capability to link external attribute data to the relational database. After creating the attribute data tables, they were linked to a geo-referenced map. The data which were collected as raw data or tabulated data from various institutions were entered to attribute tables. Then they were linked to the base map to produce thematic layers.

Data Analysis

There are six important factors or parameters considered in the preparation of land suitability map. Index maps produced for each factor based on their influence on land suitability for establishing future development activities. Some of these factors show high influence on land suitability while some act against it. For an example, road accessibility very useful when identifying land suitability for any development activity however, areas closer to forests and other natural resources including tanks can be considered as less suitable areas. This implies that all factors or parameters which were concerned in the preparation of land suitability map behaved in different manner. Therefore, weightage values were introduced to identify the strengths and weaknesses of these parameters on land suitability for future development projects. One of the standard multi criteria decision analysis methods has been applied to calculate the weightage values of each parameter. According to this method, each parameter compares with other parameters and calculates values based on their importance. When considering a single parameter, its influence on selecting land suitability varies with its conditions. Therefore, index values were introduced for different conditions within the same parameter.

Rivers and streams

Few main rivers of Sri Lanka and number of other small rivers and streams flow through the study area into the sea. During the rainy season, some parts of the area especially closer to the main rivers experience floods. However, still there is no proper flood control system introduced for managing such floods within the study area. Major rivers in the study area are shown in the Figure 2. Buffer zones were created for these rivers and streams. Thereafter, River and Stream Index (RSI) values were assigned based on the distance from rivers or stream to buffer zones.

Forests

The study area belongs to dry zone of Sri Lanka. It is hard to find natural forests in this region. However, there are parts of large national park like Yala and few other national parks are belonging to the study

area (Figure 3). Locations closer to these parks are ideal places for establish tourist hotels. However, these forests can be affected after such projects will be introduced. Hundred meter buffer zones were created for these forests and national parks. Thereafter, to identify the land suitability for future projects, Forest Buffer Index (FBI) values were introduced based on the distance from these buffer zones.

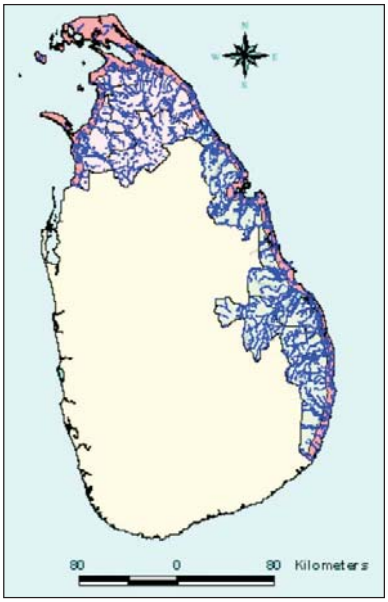

Figure 2: Rivers and streams of the study area

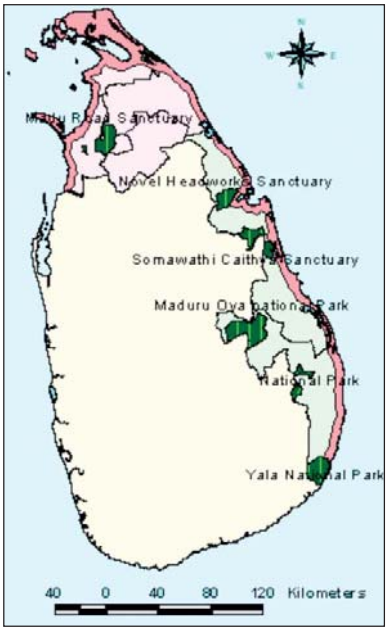

Figure 3 Forests in the study area

Tanks and lagoons

There are number of tanks and lagoons exist in the study area (Figure 4). Tanks have been using for irrigation, inland fisheries industry, etc. Also lagoons have been utilizing for multidisciplinary tasks. After implementing new projects, tanks and lagoons can be polluted. Therefore, tanks and lagoons in the study area are to be protected when introducing new development projects. Thus, buffer zones were created for both tanks and lagoons. After creating buffer zones, Tanks and Lagoon Index (TLI) values were assigned where locations far away from the buffers have the heist TLI values and are the most suitable areas for establishing new projects.

Figure 4: Tanks and lagoons in the study area

Road accessibility

Road accessibility is one of the main factors that have to be considered when planning new development projects. Transportation facilities in the study area are poorly developed and also many roads were destroyed during the war. The road network of the study area is shown in the Figure 5. Based on the road accessibility, Road Accessibility Indexes (RAI) were assigned. Locations closer to main roads have the highest RAI and areas far away from any kind of roads have the least RAI value.

Coastal erosion trends

According to the Coastal Erosion Master Plan of Sri Lanka, some of the areas recorded as the highest costal erosion affected areas (Figure 6). The areas highly affected by coastal erosion are considered as the "key areas" and the "singular areas" in the Coastal Zone Management Plan. Based on the coastal erosion trends in the study area, different Coastal Erosive Indexes (CEI) were assigned based on coastal erosion sensitivity. Low CEI were assigned for areas with high coastal erosion sensitive. These areas are the least suitable locations for implementing development projects.

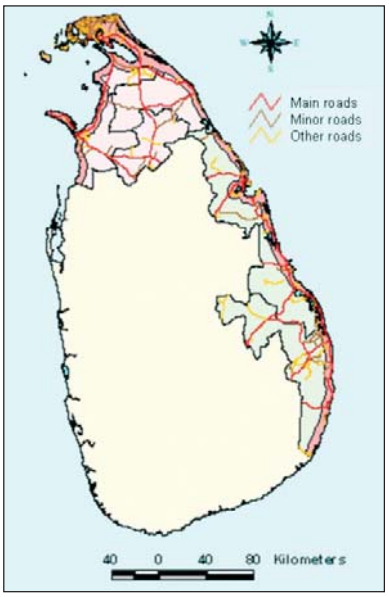

Figure 5: Road accessibility in the study area

Figure 6: Key areas and singular areas defined in the Coast Erosion Master Plan

Flood risks

Heavy rainfall from North-East monsoons is the principal cause of coastal floods in the study area. In addition, the drainage, land use pattern and topography of the area are also significant factors that contribute for floods. It has been observed that coastal floods are frequently experience in the study is. Therefore flood risks (**Figure 7**) in the study area have to be considered for analyzing land suitability of the area. Flood Risk Index (FRI) has been introduced based on flood hazardous map. Highest flood risk areas are least suitable areas for development activities. Therefore, high flood risk areas have the least FRI values.

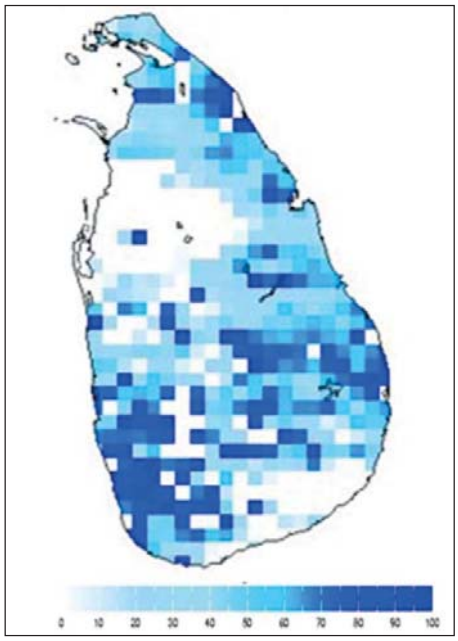

Figure 7: Flood hazardous map (http://iri.columbia.edu/~mahaweli)

A simple equation has been introduced to calculate the Land Suitability Index (LSI) values. This equation combines the weightages and ranks / index values of all six parameters at any location along the study area.

$$LSI = W_1{*}I_{1N1} + W_2{*}I_{2N2} + W_3{*}I_{3N3} + W_4{*}I_{4N4} + W_5{*}I_{5N5} + W_6{*}I_{6N6}$$

LSI – Land Suitability Index Value,

W_1, W_2, ..W_6 are weightage values of the parameters (obtained by the Principal Component Analysis)

I_1 = River and Stream Index (RSI),

I_2 = Forest Buffer Index (FBI),

I_3 = Tanks and Lagoon Index (TLI),

I_4 = Road Accessibility Indexes (RAI),

I_5 = Coastal Erosive Indexes (CEI),

I_6 = Flood Risk Index (FRI); are indexes of the parameters

N1, N2, ….., N6 are relevant rank number of the parameter

Arc GIS and ERDAS IMAGINE software were used to overlay of six thematic maps (Figure 8). This process leads to assigning a Land Suitability Index value for any location within the entire study area. These values indicate the probability of land suitability at any location. However, it was noted that there is wide range of LSI values scattered in the area. Therefore, LSI values were reclassified and introduce six land suitability classes (Table 1).

Table 1:
Reclassification of land suitability classes

Range of LSI	Segment Number	Land Suitability
< 2.00	1	Least Suitable
2.00 – 4.00	2	Less Suitable
4.00 – 5.00	3	Moderately Suitable
5.00 – 6.00	4	High Suitable
6.00 – 8.00	5	Very High Suitable
> 8.00	6	Highest Suitable

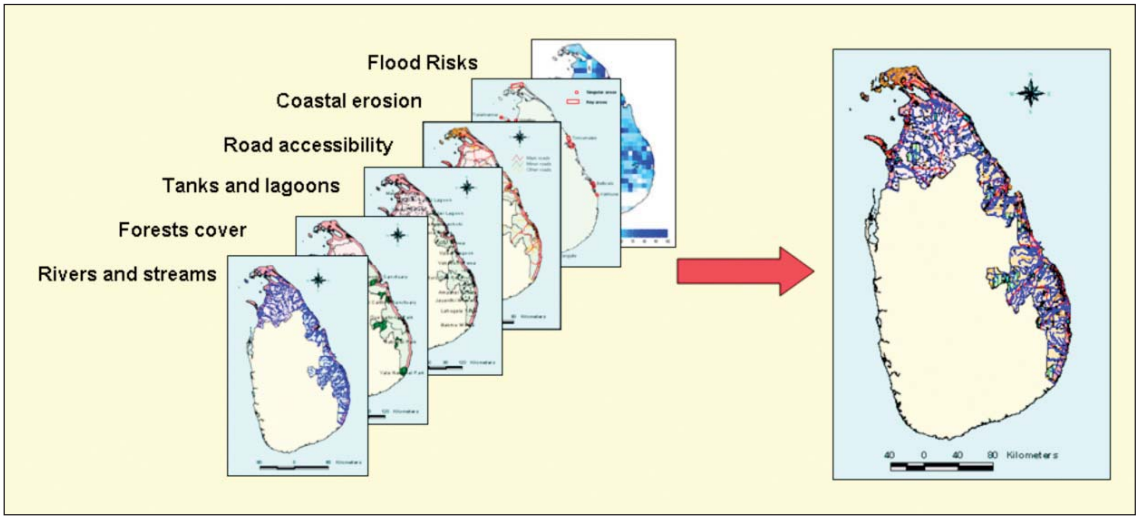

Figure 8: Thematic map overlay

Finally, Northern and Eastern coastal zone of Sri Lanka was classified into six different land suitability classes based on the above LSI values (Figure 9). The locations demarcated as segment number 1 have to be protected and are the least suitable areas for future projects. Most suitable areas or locations for future development activities are demarcated as segment number 6. However, this is a general classification and a detailed classification can be prepared based on facilities needed for each individual project and its activities.

Results and Discussion

The main objective of this research is to initiate a preliminary coastal management plan for the Northern and Eastern coastal zone of Sri Lanka using spatial technology. There are many issues to be discussed in a coastal zone management plan. This is more significant when introducing new development projects in the

coastal zone. Therefore, in this study, Northern and Eastern coastal zone of Sri Lanka have been categorized into several land suitability classes based on environmental and socioeconomic conditions. The most suitable classes are ideal locations for establishing regional development activities whereas the places with least suitable classes have to be protected without establishing development activities. However, by implementing proper solutions and techniques, least suitable and less suitable areas can be improved as moderate to high suitable areas.

resources, tourism and some other industries were totally destroyed during the war period. Geographical setting of the area and existing resources can be utilized to establish development activities such as tourist hotels, fisheries harbors, etc. The government of Sri Lanka identified the importance of reestablishment of new development activities within the Northern and Eastern coastal sector and planed to initiate new projects within this region. However when implementing such activities, When implementing such activities, present socio-economic and

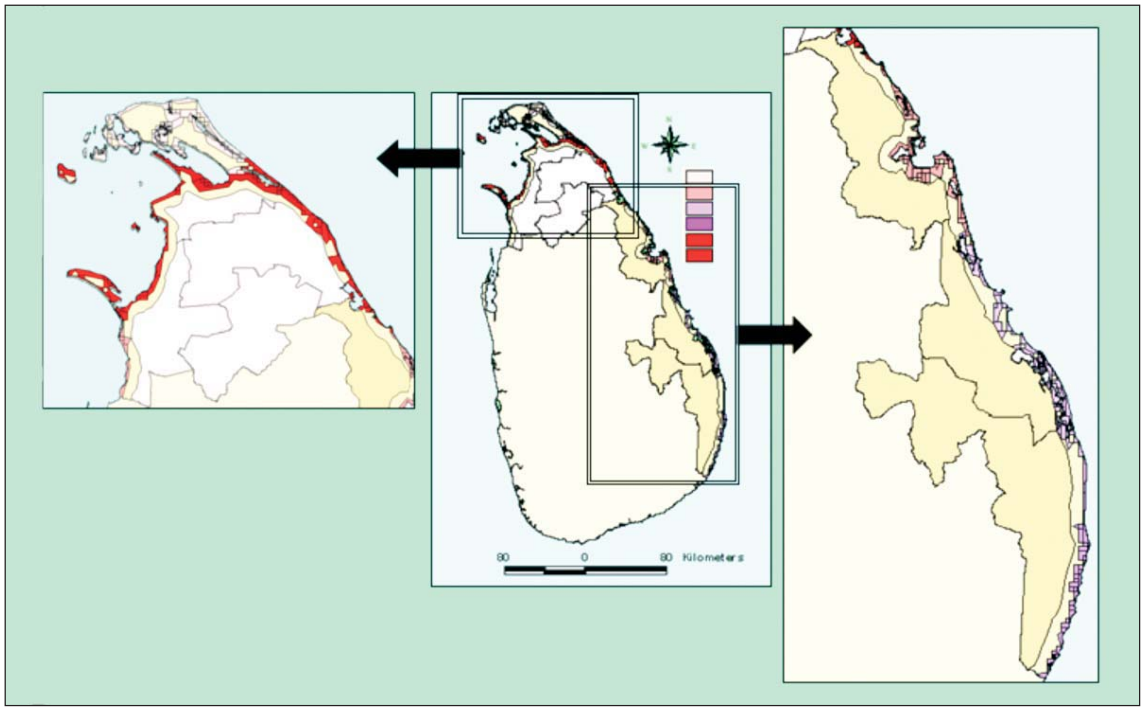

Figure 9 Land suitability of the study area

Conclusion

Northern and Eastern coastal sectors of Sri Lanka play an important role in socio-economic development of the country.

Some of the main income of the country such as fisheries, tourism and many other industries exist within these regions. It has been observed that during 1983 to 2008, socio-economic development activities in the study area were dramatically decreased or could not get the total benefit of them. Some of the natural environmental conditions can be modified. Both natural environmental conditions as well as human interferences may involve in the modification of the existing coastal environment. With the incensement of regional development activities, some of the negative environmental impacts can be accelerated. Incensement of coastal erosion, pollution of the groundwater, surface water and near shore water, destroy the natural coastal and marine ecosystems, land degradation, etc are some of these impacts. Therefore, it is very important to introduce a proper coastal zone management plan for the study area and

it has to be implemented when introducing new regional development activities. This matter was mainly focused in this study and tried to introduce spatial technology i.e. GIS and remote sensing to introduce initial coastal management plane for Northern and Eastern coastal zone of Sri Lanka. Few main factors i.e coastal erosion trends in the area, available natural resources, effect of floods, land use pattern, road accessibility, etc were considered and their strengths of contribution for the preparation of the initial coastal management plan were analyzed. One of the Geographic Information Systems (GIS) techniques i.e. overlay analysis method was applied to identify the most and least suitable locations for establishing and implementing new regional development activities. These regions were classified from very low to very high coastal environmental sensitive areas. The combination of statistical and GIS methods provide a greater flexibility and new trends in decision making activities. These techniques perform producing initial coastal management plan much easier and faster than manual methods.

Recommendations:

- Environmental sensitivity of the region must be concerned when establishing future development activities. Alternative places should be identified when planning such activities within extremely high and very high environmental sensitive areas.
- Extremely high and very high coastal environmental sensitive areas can be improved as moderate to low sensitive areas by introducing proper coast management methods.
- Setback limits should be modified considering the coastal erosions sensitivity and few other environmental conditions at individual locations. Setback limits to be introduced for singular locations but same setback limits should not be applied for the entire coastal zone of Sri Lanka.
- An extensive study is needed for the preparation of a better coastal environmental management plan for the study area.

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