Remote sensing approach to identify salt-affected soils in Hambantota District

P.G. Chandana[1], K.D.N. Weerasinghe[2], S. Subasinghe[3] and S. Pathirana[4]
[1]Department of Geography, Faculty of Humanities and Social Sciences, University of Ruhuna, Matara, Sri Lanka.
[2]Department of Agricultural Engineering, Faculty of Agriculture, University of Ruhuna, Kamburupitiya, Sri Lanka.
[3]Department of Crop Science, Faculty of Agriculture, University of Ruhuna, Kamburupitiya, Sri Lanka.
[4]School of Environmental Science & Management, Southern Cross University, Australia.

Abstract

Present research deals with the problem of monitoring saline soils of Hambantota district, southern Sri Lanka, based on Remote Sensing data of TM sensor of Landsat 7 satellite, using ILWIS 3.2 functions. Effectiveness of saline indices viz. Salinity Index (SI) and Normalized Differential Salinity Index (NDSI) for the identification of soil salinity in the area were tested. Since salt-affected soils can also be characterized by stressed vegetation, Normalized Differential Vegetation Index (NDVI) is also used.

Supervised classification was used to isolate the area coverd with Acacia leucophloea. Five landuse classes namely water surfaces of tanks, swamps and canals [Water], scrublands [Scrub], Acacia leucophloea [Acacia], Paddy cultivation [Paddy] and other vegetation [Other vegetation] were isolated for the study. The ground truth data and 1:50000 topographic maps were used to picking up training sites for all classes.

After geometric correction, Histogram equalization stretch and filtering operations in ILWIS, the image was visually interpreted in individual bands and various band combinations. Supervised classification was employed using the identified five classes with maximum likelihood, minimum mahalanobis distance and minimum distance methods including the bands 2, 3 and 4.

Results of the analysis helped to produce SI, NDSI and NDVI maps of the Hambantota District. Supervised classification helped to produce land cover maps in respect to Vegetation (Acacia and Other vegetation), Paddy fields, Scrub lands and Water bodies.

The results revealed that 35% of land area of Hambantota District was covered with Acacia leucophloea and its associates which appeared to be a good indicator of salt-affected soils, using GIS and Remote Sensing techniques. The saline indices of SI and NDSI used in arid areas to identify saline soils cannot be used in Hambantota district due to the growth of Acacia leucophloea vegetation and its associates.

Key words: Saline soil, GIS & Remote Sensing, Supervised Classification

Introduction

The salt-affected land area in Sri Lanka is about 223,000 hectares or about 3 percent of the total land area of the island, mainly found in the dry zone which receives an annual rainfall between 500 – 800mm during the North-East monsoon, with a moisture deficit period (drought) of 6 to 8 months (Vivekanandan, 1989).

Recent advances in the application of GIS and Remote Sensing technology in mapping and monitoring degraded lands, especially in salt-affected soils, have shown great promise of enhanced speed, accuracy and cost effectiveness. The present study is mainly focused on salt-affected lands in Hambantota district, Southern Sri Lanka.

The main purpose of this study was to monitor saline soils of Hambantota district, southern Sri Lanka, based on Remote Sensing data of TM sensor of Landsat 7 satellite, using ILWIS 3.2 functions. To achieve the main objective, following studies were carried out.

(i) Test the applicability of saline indices viz. Salinity Index (SI) and Normalized Differential Salinity Index (NDSI) for the identification of soil salinity.
(ii) Validation of the Normalized Differential Vegetation Index (NDVI), for saline soil identification.
(iii) Test the *Acacia leucophloea* trees and its associates as an indicator to identify salt-affected soils in Southern dry zone.

Materials and Methods

The study was conducted in Hambantota district in Southern Sri Lanka which lies between latitude 5° 50′ to 6° 50′ N and longitude 80° 20′ to 81° 50′ E.

Digital map of Sri Lanka (1:25000), prepared by the survey department was used as the base map. Topographic and digital map sheets of Timbolketiya, Kataragama, Yala, Hambantota and Tissamaharama of scale 1: 50,000, were used for references.

A clouds free Lansat 7 image acquired in March 2001 and data recorded by sensor TM (Thematic mapper) in four wavebands (B1: 0.45 - 0.52 ìm, B2: 0.52 – 0.60 ìm, B3: 0.63 – 0.69 ím and B4: 0.76 – 0.90) with spatial resolution of 30m x 30m has been used to identify the salt-affected areas using the supervised classification.

GPS system (with 15m accuracy) was used to take the locations of training sites for the classification purposes of water surfaces of tanks, swamps and canals [Water], scrublands [Scrub], areas covered with *Acacia leucophloea* [Acacia], Paddy [Paddy] and other vegetation [Other vegetation].

Data Analysis

ArcView 3.2a and ILWIS 3.2 for Windows system were used for remote sensing and GIS analysis. Information about soil quality, soil types, agricultural practices and necessary ground truth data of the study area were used for the study.

The Landsat digital satellite data were registered to digitized base map of the area, using an image-to-map registration algorithm using ILWIS 3.2 for Windows. To register the image, Affine transformation was used.

Two indices: Salinity Index (SI) and Normalized Difference Salinity Index (NDSI) proposed by Tripathi et al. (1997) were applied to identify the salt-affected soils.

$$S.I = (\text{Band } 1 \times \text{Band } 3)^{1/2}$$

$$NDSI = (\text{Band } 3 - \text{Band } 4) / (\text{Band } 3 + \text{Band } 4)$$

Iormalized Differential Vegetation Index (NDVI) was included in the analysis to identify salt-affected soils which are usually characterized by stressed vegetation which is an indirect measure of the presence of salt i the soil.

NDVI = (Band 4 - Band 3) / (Band 3 + Band 4)

mage classification

fter geometric correction, histogram equalization stretch and filtering operations in ILWIS , the nage was visually interpreted in individual bands and various band combinations. Supervised assification was employed using the identified five classes with Maximum likelihood, Minimum Iahalanobis Distance and Minimum Distance methods including the bands 2, 3 and 4.

esults and Discussion

pplication of Remote Sensing indicators for salinity identification

alinity Index helps to generate a color composite image to isolate and interpret salt-affected lands Figure 1).

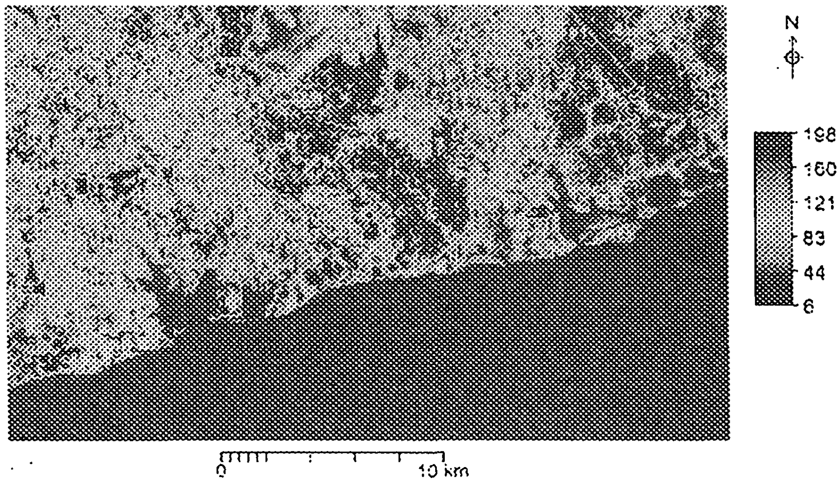

Fig. 1: Salinity index map of the study area

n the map (Figure 1), red color exhibited the high reflectance of DN (Digital Number) values while lue color gave low DN values. As Nasir and Yohei, (2000) and Nasir et al, (2001), reported, water odies and vegetation have low DN values, due to energy absorption while bare lands and scrub ands have higher values due to energy reflection. However, salt-affected areas also exhibit low DN alues which may be due to healthy vegetation cover of Acacia and other salt tolerant associates in alt-affected areas.

pplication of Normalized Difference Salinity Index (NDSI) helps to generate a color composite nage (Figure 2).

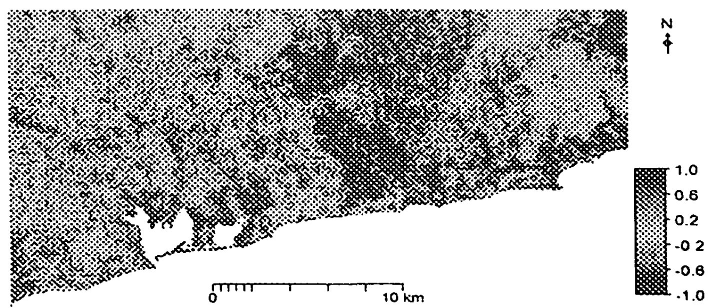

Fig. 2: Normalized Difference Salinity Index map of the study area

The red color in the map (figure 2) indicates the high reflectance of DN values while blue color represents the lower DN values. Since NDSI is the reciprocal of NDVI which gives lower values for the vegetation cover.

Vegetation cover can be seen near tanks and salterns as well. Higher DN values for some water surfaces were also recorded which may be due to the surface illumination.

As Tripathi et al. (1997) reported, the SI and NDSI indeces can be successfully used to identify bare salt-affected soils. However this is not applicable to Hambantota district since most of the salt-affected lands are covered with Acacia and its associates.

Vegetation Index

Application of Normalized Differential Vegetation Index (NDVI) helps to generate better and visual interpretation of healthy vegetation in contrast to other features (Figure 3).

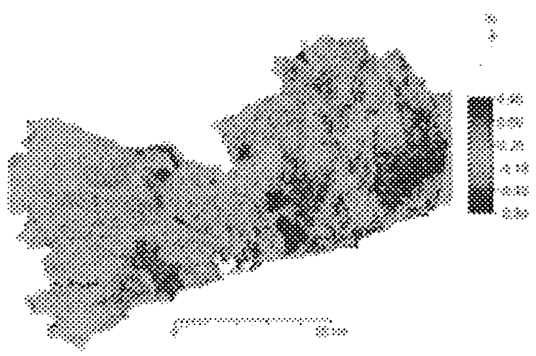

Fig. 3: Normalized differential vegetation index map of the study area

In the NDVI map (Figure 3), the bright red color indicates healthy vegetation areas where NDVI values are closer to 1 due to high reflectance and blue color with lower values of NDVI indicates waterlogged areas. The green to yellow color represent the areas such as scrublands, bare lands and other open areas.

Although stressed vegetation could be an indirect sign of the presence of salts in the soils, higher NDVI values were identified in highly salt-affected areas. This is due to the coverage of salt-affected areas with the vegetation of salt-tolerant species of *Acacia leucophloea* and associates.

Acacia leucophloea and associates, identified as salt tolerant species by Subasinghe and Aruna Kumara (2002), Subasinghe and Liyanarachchi (2001,2002), and they are the prominent vegetation over the salt-affected areas in Hambantota district.

Identification of saline soils in Hambantota district using Supervised Classification

Supervised classification has been incorporated to the present study to classify five classes of land coverage i.e. Acacia vegetation, Paddy, Scrub lands, water bodies and other vegetation. Classification methods of Maximum likelihood, Minimum Mahalanobis Distance and Minimum Distance methods were used for the analysis. The results obtained from the three methods were compared with the 1:50,000 topographic maps. Results revealed that Maximum likelihood method has closest similarity in respect to the different classes of vegetation and water bodies (Figure 4).

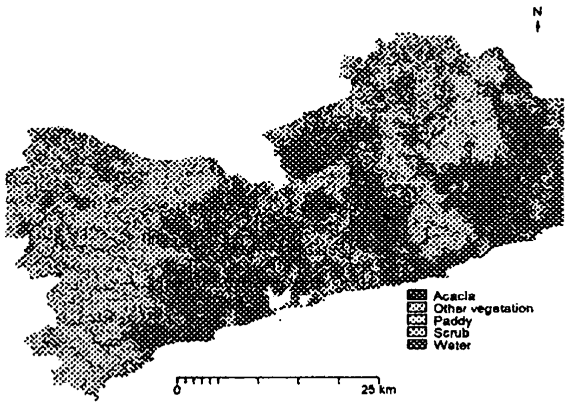

Fig. 4: Classified immage of Hambantota area

Accordingly *Acacia leucophloea* can be identified mainly in the low areas of the district. Using the classified image (Figure 4), Acacia class was extracted and Acacia distribution map was generated (Figure 5).

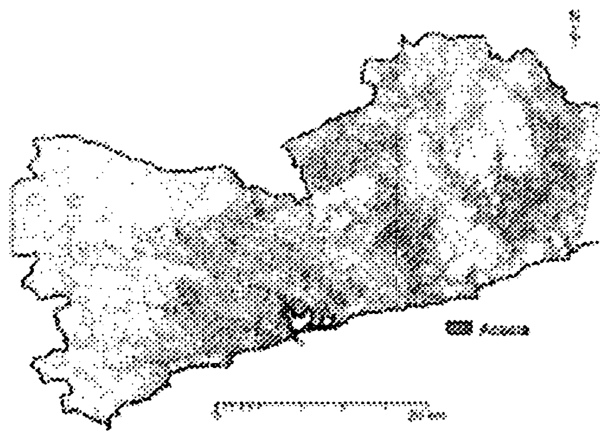

Fig. 5: Acacia distribution map

The results revealed that 35% of land area of Hambantota is covered with *Acacia leucophloea* and its associates. The total land extent and the Acacia coverage of the district are given in the Table 1.

Table 1. Extent of *Acacia leucophloea*

	sq.km	%
Area of Acacia	649.7	35.5
Area without Acacia	1178.3	64.5

It is envisaged to overlay salinity map obtained by the interpolation techniques of Geographical Information Systems, with the Acacia distribution map (figure 5) and develop a new map of salt-affected areas for Hambantota district in future studies.

Conclusion

(1.) *Acacia leucophloea* and its associates are mainly found in the saline areas of the Hambantota district which appeared to be a good indicator of salt-affected soils using GIS and Remote Sensing techniques in Hambantota area.

(2.) The indices of Salinity Index (SI) and Normalized Differential Salinity Index (NDSI) used in arid areas to identify saline soils cannot be used in Hambantota district due to the coverage of saline soils with the vegetation of *Acacia leucophloea* and its associates.

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