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Remote Sensing Approach to Identify Salt Affected Soil in Agricultural Land of Gautam Buddha Nagar District

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Abstract—*Present research deals with the problem of monitoring salt affected soils of Gautam Buddha nagar district, Uttar Pradesh, based on Remote Sensing data of Landsat 8 OLI & TIRS satellite. Effectiveness of saline indices viz. Salinity Index (SI) and Normalized Differential Salinity Index (NDS1) for the identification of salt affected soil in the area were tested. Since salt-affected soils can also be characterized by stressed vegetation, Normalized Differential vegetation Index (NDVI) is also used. After enhancing the image using image fusion (HCS technique), followed by spatial filtering method the image was subjected to supervised classification using mahalanobis classifier was used to isolate the area covered with agricultural land. Five landuse classes namely water bodies, agricultural land, urban builtup, rural builtup and wasteland were isolated for the study. Results of the analysis helped to produce SI, NDSI and NDVI maps of the District. The results revealed that according to NDVI around 16.83% of agricultural land is highly affected by salt deposition. While 5.19% and 3.92% of the cropland is salt affected as per NDSI and SI respectively. Results reveled that vegetation cover delineation using NDVI is proved to be a good indicator of salt-affected soils while, salinity indices (SI and NDSI) are not efficient enough for the detection of salt in agricultural lands*

KEYWORDS: *Salt affected soil, Agricultural land, Remote sensing technology, NDVI, NDSI, SI.*

INTRODUCTION

Soil salinity and sodicity is a genuine ecological issue. Soils with electrical conductivity of the saturation extract (EC) more than 4 deci-Siemens per meter (dS/m) at 25°C, Exchangeable Sodium Percentage (ESP) less than 15 and pH (soil reaction) less than 8.5 are referred to saline soils, which means excess of soluble salts such as sulphates, carbonates and chlorides in the salt solution soil. On the other hand soil with pH greater than 8.5, ESP more than 6% and a preponderance of carbonate and sodium by bicarbonate are referred to sodic soil [18]. Kant et. al. (1997) effectively delineated, mapped and digitally classified salt affected and waterlogged zones of India using bands 3, 4, 5 and 7 of Landsat TM image with an accuracy of about 96 percent. Interesting studies have been done for salt recognition in soil using microwave and thermal remote sensing techniques synergistically in recent years.

Salt – affected soils are extensive worldwide. In India, the issues related to salts in soil grows every year as an outcome of secondary salinization due to human activities like urbanization and improper irrigation practices. The spatial distribution of salt affected soil over the area is exceedingly delicate and measured by a range of factors such as parent material, penetrability, water table level, groundwater quality, topography, irrigation, drainage, rainfall and humidity [3]. Around 7 million hectares area of India including the states of West Bengal, Uttar Pradesh, Gujarat, Punjab , Rajasthan, Maharashtra, Delhi, Haryana, Tamil Nadu, Kerala and Orissa are facing soil problems due to salt accumulation out of which about 2.8 million hectares of salt-affected soils are present within the Indo-Gangetic alluvial plain [1].

Salt deteriorates crop land producing the degeneration in the efficiency of crops and thus favoring the decline in agricultural yields [14]. Understanding when, where and how salts impact may occur, is very critical to the sustainable advancement of any agricultural land framework. Ground-based measurement of EC and pH is usually recognized as the most efficient technique for quantification of salt affected soil [13]. Traditional methods of measuring soil salinity are expensive, tedious and need extensive man power for land surveying and mapping. The dynamic nature of salt affected soil in space and time makes it more challenging to use traditional techniques for comparison over large area [6]. Over few decades, remote sensing information is been extensively used as a cost effective method to map salt affected soil, either directly or indirectly, in a real - time at different scales [11]. Spatial modelling, which is the use of numerical mathematical statements to simulate real phenomenon and processes, has followed several methodologies for evaluating and predicting salt problems in soil (salinity or sodicity).

Several indices also proved beneficial for image enhancement in terms of land resource applications like NDVI, NDSI, NDWI, NDBI etc. [20]. These indices are used to identify and monitor temporal variation of the object. Moreover, these combinations have the advantage of reducing the effect of external factors, such as solar irradiance, atmospheric influence etc. [5]. Vegetation indices have advantage of reducing effect of solar irradiance, atmospheric influence and spectral contribution of soils to vegetation [5]. Knipling (1970); Viollier*et al*. (1985); Rouse *et al*. (1974); Tucker (1979) and Perry and Lautenschlager (1984) applied physical and physiological based ratio for the reflectance of visible and near infrared radiation from vegetation. Vegetation indices have been applied for crop yield estimation and modeling by Singh *et al*. (2005); Ray *et al*. (2005); Manjunath and Potdar (2004); Mukherjee and Sastri (2004) and Badarinath*et al*. (2004). Comparison of vegetation indices has been done by Jaishanker*et al*. (2005). Since the time satellite recording of spectral radiance of ground objects in visible and near-infrared bands became possible, many others have developed various indices based on the certain combinations (sum, difference, ratio, linear-additional) of bands.

The main purpose of this study was to monitor salt affected soils of Gautam Buddha district, Uttar Pradesh, by testing the applicability of saline indices viz. Salinity Index (SI), Normalized Differential Salinity Index (NDSI) and vegetation index Normalized Differential Vegetation Index (NDVI) based on Remote Sensing data of Landsat OLI& TIRS satellite, using GIS functions.

Material and Method

Gautam Buddha Nagar district falls in Yamuna sub – basin at latitude 28024^{0}14.731” N and longitude of 77032^{0}33.870” E. The district covers an area of approximately 1442 sq. km. Satellite data of Landsat 8 OLI and TIRS of Path - 146, row - 40 were obtained from U.S. Geological Survey (USGS), for the detection salt affected soil in the cropland of the district. Satellite images used in this study was acquired on 9th February 2014. Image was subjected to image enhancement (HCS fusion, spatial filtering) and classification (mahalanobis supervised classifier) in order to delineate agricultural land of the area. Further, two salinity based indices and one vegetation based index as shown in table no. 1, were used to create images for the identification of salt affected soil.

Table 1: List of spectral indices used in the study

S. No.	Vegetation Indices	Formula
1	Normalized Differential Salinity Index (NDSI)	**(R – NIR) / (R + NIR)**
2	Salinity Index (SI) Tripathi*et al*.(1997)	**SI = R/NIR X 100**
3	Normalized Differential Vegetation Index (NDVI)	**(NIR – R) / (NIR + R)**

Where; R is the Red band and NIR is the Near Infrared Band of the image

The Normalized Difference Vegetation Index (NDVI) is a numerical indicator that uses the visible and near-infrared bands of the electromagnetic spectrum, and is adopted to analyze remote sensing measurements and assess vegetation cover estimation. Vegetation has a direct relation with the salt concentration in the soil. Lesser the vegetation, more are the chances of soil been affected by salt.

Results and Discussion

Through NDVI Model, we got 3 different classes (less, medium and high-vegetated area) within the agricultural land of the study area as shown in figure 1 and table 2.

Table 2: Area of different classes of vegetation using NDVI

S. No.	Classes	Area (Sq. Km)	Area (%)
1	Non-Vegetated	704.24	48.83
2	Low Vegetated	236.30	16.38
3	Medium Vegetated	263.19	18.25
4	High Vegetated	191.33	13.26

The total area of the map is around 1442 km^2 in which the non-vegetated area covers 704.24 km^2 area (48.83%), low vegetated area covers 236.3 km^2 (16.38%), medium vegetated area covers 263.19 km^2, (18.25%) and the high vegetated area covers 191.33 km^2 (13.26%) respectively.

The NDSI of 4th (Red) and 5th (NIR) band of Landsat OLI & TIRS satellite provides the area under salt stress condition. Through NDSI Model, we got 3 different classes (less, moderate and high salt affected area) within the agricultural land of the study area as shown in figure 2 and table 3.

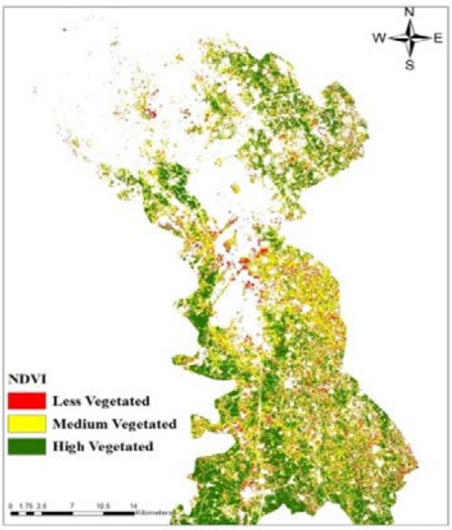

Figure 1: Classification of Vegetation using NDVI

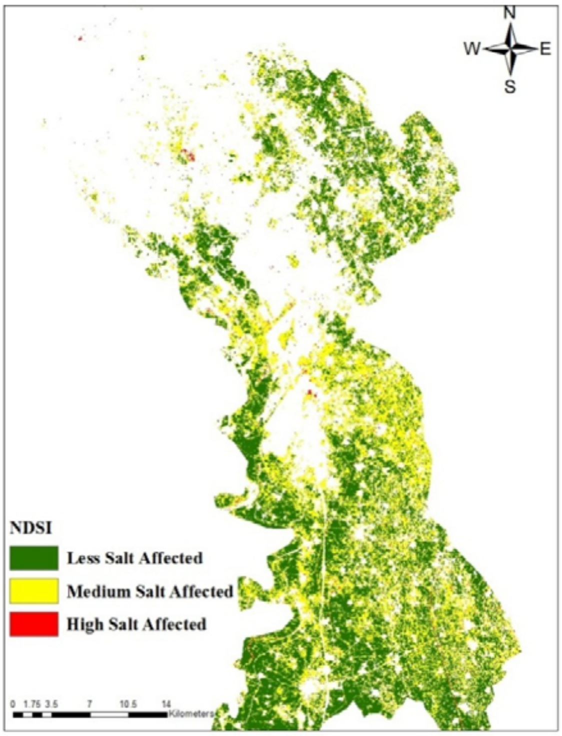

Figure 2: Classification of Salt Affected Soil using NDSI

Table 3: Area of different classes of salt affected soil NDSI

S. No.	Classes	Area (Sq. Km)	Area (%)
1	Non-Vegetated	704.24	48.83
2	Less Salt Affected	355.11	24.62
3	Moderate Salt Affected	307.68	21.33
4	High Salt Affected	74.97	5.19

The total area of the map is around 1442 km^2 in which the non-vegetated area covers 704.24 km^2 area, less salt affected area covers 355.11 km^2 (24.62%), moderate salt affected area covers 307.68 km^2 (21.33%), and the high salt affected area covers 74.97 km^2 (5.19%) respectively.

Further, Salinity Index (SI), which has been proposed by Tripathi*et al.,* 1997, was used to create images for identification of salt affected soil in this study. Through SI Model, we got 3 different classes (less, moderate and high salt affected area) within the agricultural land of the study area as shown in figure 3 and table 4.

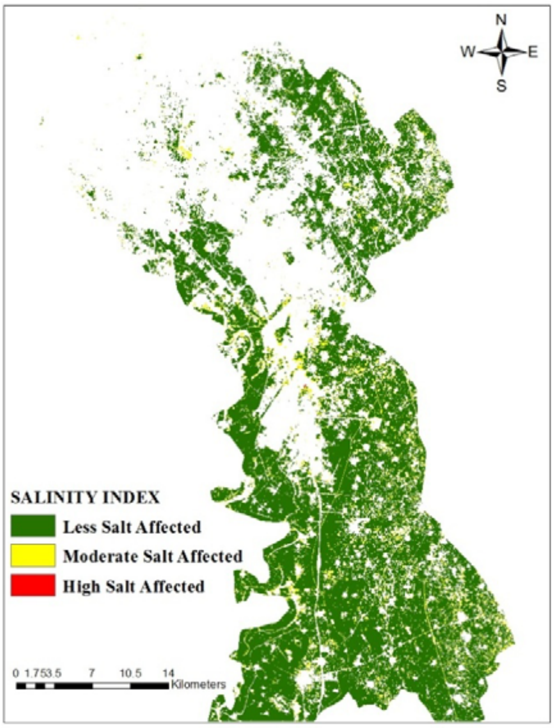

Figure 3: Classification of Salt Affected Soil using NDSI

Table 4: Area of different classes of salt affected soil SI

S. No.	Classes	Area (Sq. Km)	Area (%)
1	Non-Vegetated	704.24	48.83
2	Low Salt Affected	611.31	42.39
3	Moderate Salt Affected	69.83	4.84
4	High Salt Affected	56.62	3.92

The total area of the map is around 1442 km^2 in which the non-vegetated area covers 704.24 km^2 area. According to salinity index low salt affected area covers 611.31 km^2 (42.39%), medium salt affected area covers 69.83 km^2 (4.84%), and the high salt affected area covers 56.62 km^2 (3.92%) respectively.

This study showed the possibilities of accurate salt detection in soil using Landsat imagery. The study concluded that the ratio of Red and NIR is useful for salt affected land detection. Schmid*et al*. (2008) found that crusted saline soil reflects strongly in the visible and near-infrared (NIR) bands; moreover, Singh and Sirohi (1994) noted that a crusted saline soil surface is generally smoother than a non-saline surface and exhibits high reflectance in the visible and NIR bands, which has been confirmed by Rao *et al*. (1995). On the other hand,Metternicht and Zinck (1997) found that the reflectance in the visible and NIR bands is highly affected by both the crust color and surface roughness factors.

NDSI gave much satisfactory results compared to salinity index (SI) in retrieving salt affected areas. Similarly, Khan *et. al.* (2005) also revealed that NDSI yielded the most acceptable results in identifying different salt classes compared to salinity indices (SI) in case of cropped land. Overall NDVI is the best index for salt detection in cropland.

Conclusion

(1.) Lesser vegetation is mainly found in the salt accumulated zones of Gautam Buddha Nagar district which appeared to be a good indicator of salt-affected soils using GIS and Remote Sensing techniques (NDVI).

(2.) The indices of Salinity Index (SI) and Normalized Differential Salinity Index (NOSI) used in agricultural lands to identify salt affected areas are not efficient in giving accurate results.

Second and Following Pages

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