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Remote Sensing-Based Soil Salinity Assessment: Comparison of Normalized Difference Salinity Index (NDSI) and Soil Adjusted Vegetation Index (SAVI) Performance in Daund Tahsil, Pune District, Maharashtra

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Abstract

Soil salinization poses a severe global threat to agricultural sustainability, particularly within arid and semi-arid ecosystems. This environmental degradation and loss of soil fertility are primarily driven by unsustainable irrigation practices, the overapplication of chemical fertilizers, and continuous monoculture of water-intensive cash crops. This study focuses on Daund Tahsil, located in the Pune District of Maharashtra, India, a region severely impacted by accelerating soil salinity. Contiguous expanses of salt-affected lands are predominantly concentrated across the north-western sector of the Tahsil. The primary objective of this research is to accurately map and delineate these degraded zones by leveraging the Normalized Difference Salinity Index (NDSI) and the Soil Adjusted Vegetation Index (SAVI). Utilizing satellite-based remote sensing data alongside sophisticated Digital Image Processing (DIP) workflows offers a highly efficient framework for modern soil degradation assessment. For this purpose, Landsat 8 Operational Land Imager (OLI) data was processed to generate both the NDSI and SAVI frameworks, which served as the foundation for constructing comprehensive soil salinity maps of the study area. Soil salinity maps were prepared using two primary indices: the Normalized Difference Salinity Index (NDSI) and the Soil Adjusted Vegetation Index (SAVI). Methodologically, the NDSI computes salinity variations using the Near-Infrared (NIR) and Red (R) spectral bands, while the SAVI integrates these same bands with a soil brightness correction factor (L) to minimize background noise. Based on the derived spatial indices, Daund Tahsil was categorized into four distinct zones: highly saline, moderately saline, slightly saline, and non-saline. The spatial analysis reveals that highly saline land encompasses the largest geographic portion of the study region.

Keywords: Soil salinity, NDSI, SAVI, Soil brightness, Land degradation.

Introduction

Soil salinization has emerged as a severe global threat, particularly within arid and semi-arid environments. Saline soils are characterized by elevated concentrations of soluble salts. In agricultural systems, this phenomenon is primarily accelerated by unsustainable farming practices, including inefficient irrigation management, over-application of chemical fertilizers, and the continuous cultivation of water-intensive cash crops such as sugarcane. When salt levels escalate, they stunt plant development, slash agricultural yields, and trigger widespread land degradation. In India, this ecological crisis is highly pronounced across Western Maharashtra, where a combination of flood irrigation and unscientific sugarcane farming has severely salinized and waterlogged the terrain. Although sugarcane occupies under 10% of Maharashtra's total cultivated acreage, it monopolizes nearly 70% of the state's irrigation water. This disproportionate water use has transformed the region's dense black soils into heavy, compacted, and sterile ground, rendering vast tracts completely uncultivable. This monoculture system dominates over two-thirds of the irrigated farmlands within the Sangli, Kolhapur, and Pune districts. Within Pune, the Daund and Baramati Tahsils exhibit the highest concentrations of alkaline and saline soils, with visible surface salt crusts forming during the dry season. Consequently, Daund Tahsil has experienced a sharp increase in abandoned fallow land. The immediate priority in this region is to halt the expansion of these degraded zones and restore existing soils. To implement effective remediation strategies in Daund Tahsil, the precise boundaries of affected soils must be mapped. Utilizing satellite remote sensing offers a highly efficient solution, as researchers can calculate specific salinity and vegetation indices to accurately detect and monitor soil degradation from space.

Objectives:

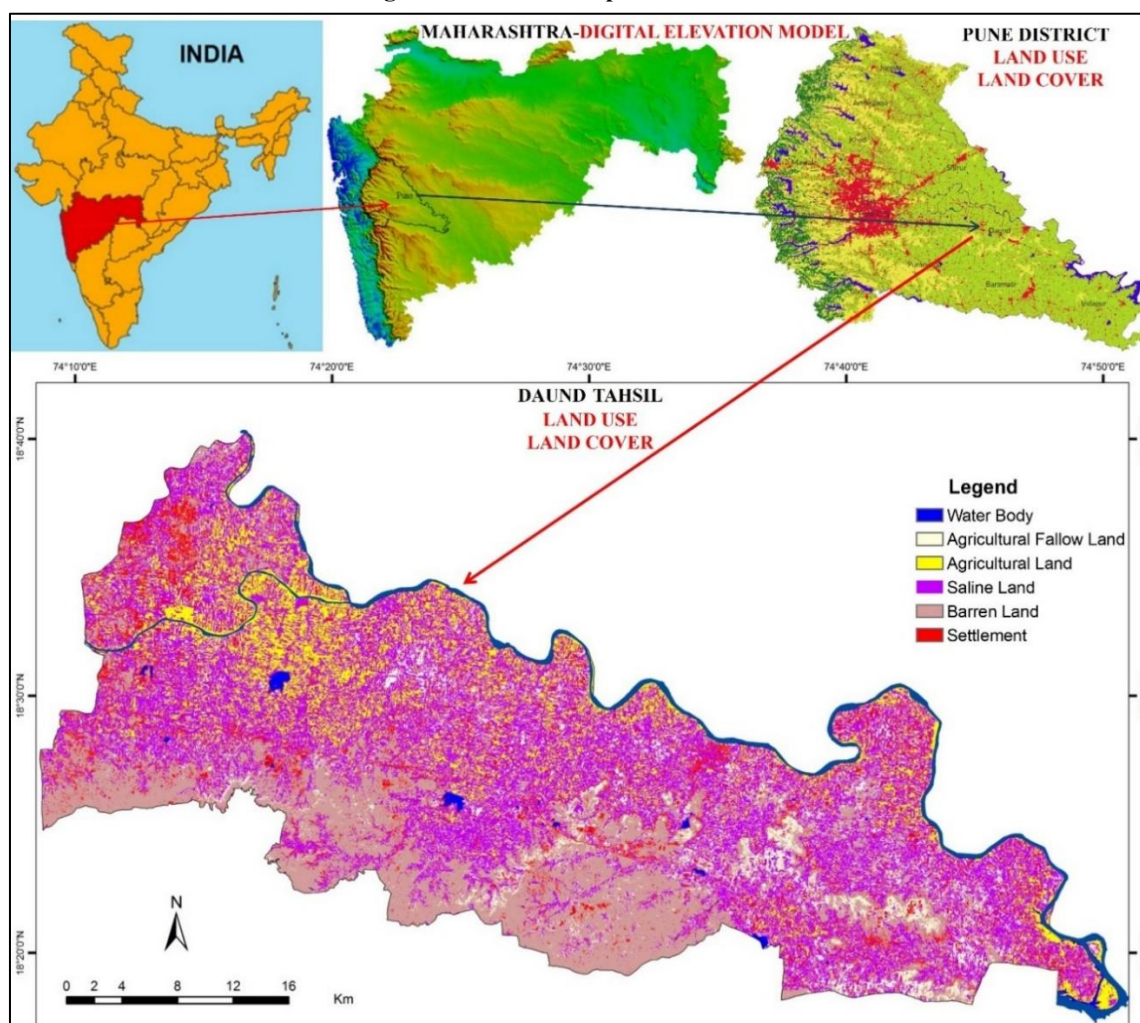
The present work examines soil salinity within the Daund Tahsil of Pune District by utilizing two remote sensing metrics: the Normalized Difference Salinity Index (NDSI) and the Soil Adjusted Vegetation Index (SAVI). The specific research objectives are:

1. To map and identify regions vulnerable to soil salinization across the study area using NDSI and SAVI computations.
2. To evaluate and compare the geographic and spatial variations of both NDSI and SAVI values across the region.

Study Area

The current investigation focuses on the Daund Tahsil, located within the Pune District of Maharashtra, spanning a total geographic expanse of 1,360 square kilometres. Geographically, this region is bounded by latitudes 18°17' N to 18°40' N and longitudes 74°08' E to 74°50' E (Figure 1). From a geological standpoint, the Daund Tahsil belongs to the Deccan Basalt Province (DBP), featuring a predominantly flat terrain characterized by subtle, gentle slopes. The local climate is categorized as semi-arid and tropical, heavily shaped by southwest monsoon patterns. Under Koeppen's climate classification system, it specifically falls into the Tropical Savanna ('Aw') category. Positioned along the southern banks of the Bhima River, the study region's drainage system is dominated by the Bhima River alongside its primary tributaries, the Mula and Mutha Rivers. The regional flora mostly consists of tropical dry deciduous vegetation, shifting to a mixed deciduous composition near the banks of the Bhima River. Soil profiles across the study area are divided into four main depth categories: extremely shallow (under 10 cm), very shallow (10 to 25 cm) situated between hills and plains, shallow (25 to 50 cm) located on hill ranges, and moderately shallow to deep (exceeding 50 cm). The dominant soil type consists of well-drained, fine-textured black soils, though medium-textured patches exist. The majority of the landscape is covered by moderately shallow to deep soils. The low-lying basins of the Bhima and Mula-Mutha rivers feature deep, clayey, and well-drained black soils. While highly fertile, these soils require artificial irrigation to successfully sustain key regional crops like sugarcane, jowar, bajra, groundnut, and onion. Consequently, agriculture serves as the primary economic mainstay for the local population. Daund Tahsil features extensive irrigated terrain primarily dedicated to growing sugarcane. Consequently, the region hosts multiple sugar-processing factories and related industrial facilities

Figure 1: Location Map of Daund Tahsil



Database and Methodology

Data Sources:

The dataset utilized in this research was gathered from the following three primary sources:

1. **Survey of India (SOI) Topographical Maps:** Base maps were created using 1:50,000 scale SOI toposheets. Seven specific sheets encompassing the Daund Tahsil region (47 J/2, J/3, J/6, J/7, J/10, J/11, and J/15) were georeferenced and mosaicked within ArcGIS. Features including roads, railways, contours, wells, and stream networks were subsequently digitized.

2. **LANDSAT-8 Satellite Imagery:** Data with a 30-meter spatial resolution from the LANDSAT-8 Operational Land Imager (OLI) was retrieved via the USGS portal. These scenes were merged to evaluate soil salinity indices, specifically the Soil Adjusted Vegetation Index (SAVI) and the Normalized Difference Salinity Index (NDSI), to generate salinity maps for the study area.
3. **Global Positioning System (GPS) Data:** Field mapping across Daund Tahsil was executed using a handheld Garmin GPS receiver. This device facilitated ground-truthing of saline terrains, recorded spatial coordinates for all collected soil samples, and logged exact locations of surface salt encrustations.

Methodology:

High-resolution multispectral satellite imagery combined with digital image processing (DIP) provides a powerful approach for mapping soil salinity via various environmental indices. This study utilizes standard mathematical formulas to compute the Normalized Difference Salinity Index (NDSI) and the Soil Adjusted Vegetation Index (SAVI) to map soil salinity across Daund Tahsil. Mechanistically, NDSI evaluates the normalized ratio between Red (R) and Near-Infrared (NIR) band reflectance to isolate salinity levels. While NDSI quantifies salinity by calculating the ratio of difference-to-sum reflectance in the Red (R) and Near-Infrared (NIR) wavelengths, SAVI supplements these bands with a soil brightness correction factor (L) to improve detection accuracy and better identify white, salt-encrusted surfaces. Based on these calculated index values, the region was categorized into four zones: highly, moderately, slightly, and non-saline land.

Formula for the calculation of the NDSI (Normalized Difference Salinity Index):

$$\text{NDSI} = (R - \text{NIR}) / (R + \text{NIR}) \dots (\text{Khan et al., 2005})$$

Where

R = reflectance value of the pixel of red band of the LANDSAT 8 satellite imagery

NIR = reflectance value of the pixel of the near infrared band of the LANDSAT 8 satellite imagery

Formula for the calculation of the SAVI (Soil Adjusted Vegetation Index):

$$\text{SAVI} = [(NIR - R) \times (1 + L)] / (NIR + R + L) \dots (\text{Huete A. R., 1988})$$

Where

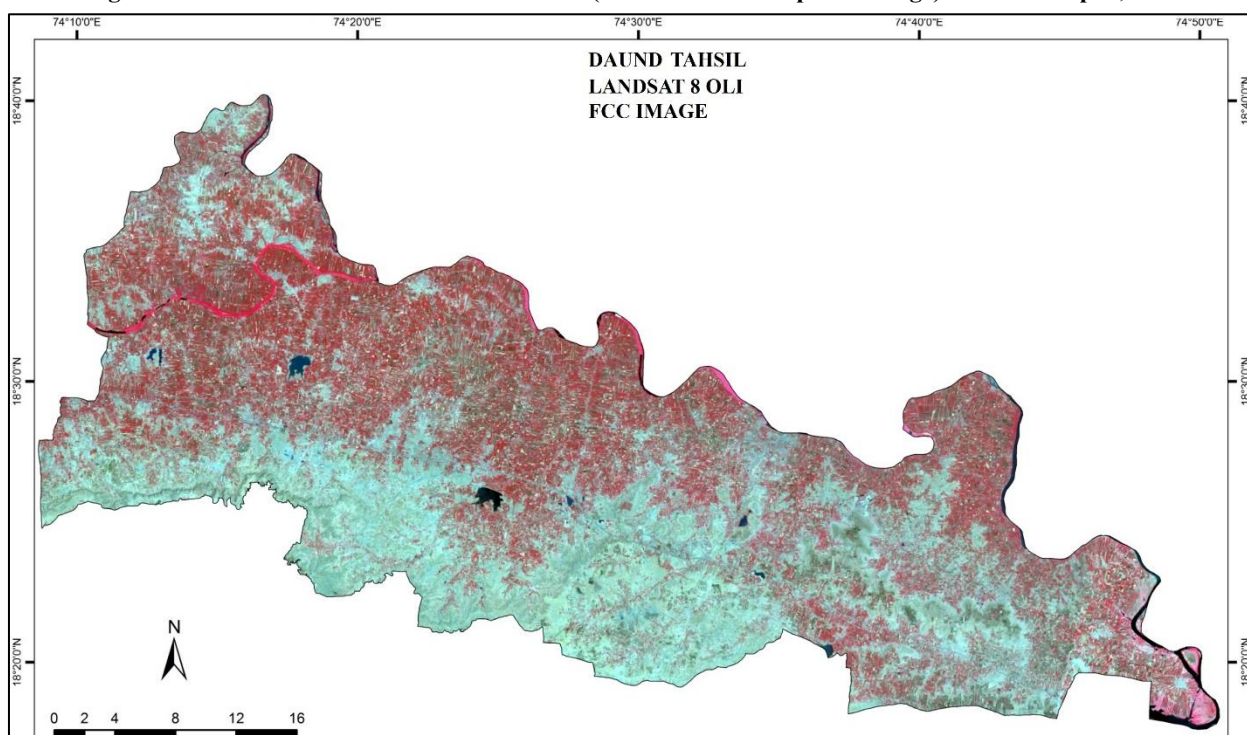
R = reflectance value of the pixel of red band of the LANDSAT 8 satellite imagery

NIR = reflectance value of the pixel of the near infrared band of the LANDSAT 8 satellite imagery

L = the correction factor for soil brightness

Introduced by Alfredo R. Huete in 1988, the Soil Adjusted Vegetation Index (SAVI) modifies the traditional Normalized Difference Vegetation Index (NDVI) to mitigate soil brightness distortions in areas with sparse vegetation. By incorporating a soil brightness correction factor, designated as 'L', SAVI minimizes background soil noise to more accurately isolate the true reflectance of the canopy. This adjustment represents a significant advancement over NDVI, which fails to account for varying soil backgrounds. The parameter 'L' fluctuates based on the density of the living green canopy. In regions with dense forest or dense crop cover, 'L' drops to zero, making SAVI mathematically identical to NDVI. Conversely, in entirely barren or non-vegetated landscapes, 'L' is set to one. For general applications, a default value of 0.5 is typically applied, as it consistently yields reliable results across diverse landscapes.

Figure 2: Daund Tahsil – Landsat-8 OLI FCC (False Colour Composite Image) dated 17th April, 2017



Results and Interpretation

Spatial assessment using the Normalized Difference Salinity Index (NDSI), as detailed in Table 1 and Figure 3, reveals that severe soil salinity impacts roughly 24% of Daund Tahsil. This degradation is concentrated across the northern, western, central, eastern, and southeastern sectors. The final classification indicates that highly saline terrain dominates the majority of the Daund Tahsil region. Areas with moderate salinity constitute about 20% of the region, appearing in patches adjacent to highly saline zones within the northern, western, central, and eastern territories. Meanwhile, minor salinity occurs within southern valley landscapes and in isolated patches near highly degraded areas. This low-salinity classification underscores the expanding footprint of land degradation, signaling the initial phases of soil salinization within these specific zones. Based on the Soil Adjusted Vegetation Index (SAVI) analysis, soil salinity is a widespread issue in Daund Tahsil, impacting various zones with differing intensities (Table 2 and Figure 4). Severe salinization dominates the landscape, covering roughly 24% of the region across the western, northern, central, eastern, and southeastern sectors. Adjacent to these regions, moderate salinity accounts for 15% of the land, appearing in fragmented patches. Low-level salinity is the most expansive category at approximately 29%, primarily concentrated in the southern valleys and interspersed among heavily salinized fields. This minor salinity tier is particularly critical for environmental monitoring, as it marks the initial, shifting threshold where soil degradation begins.

Figure 3: Daund Tahsil – Normalized Differential Salinity Index (NDSI)

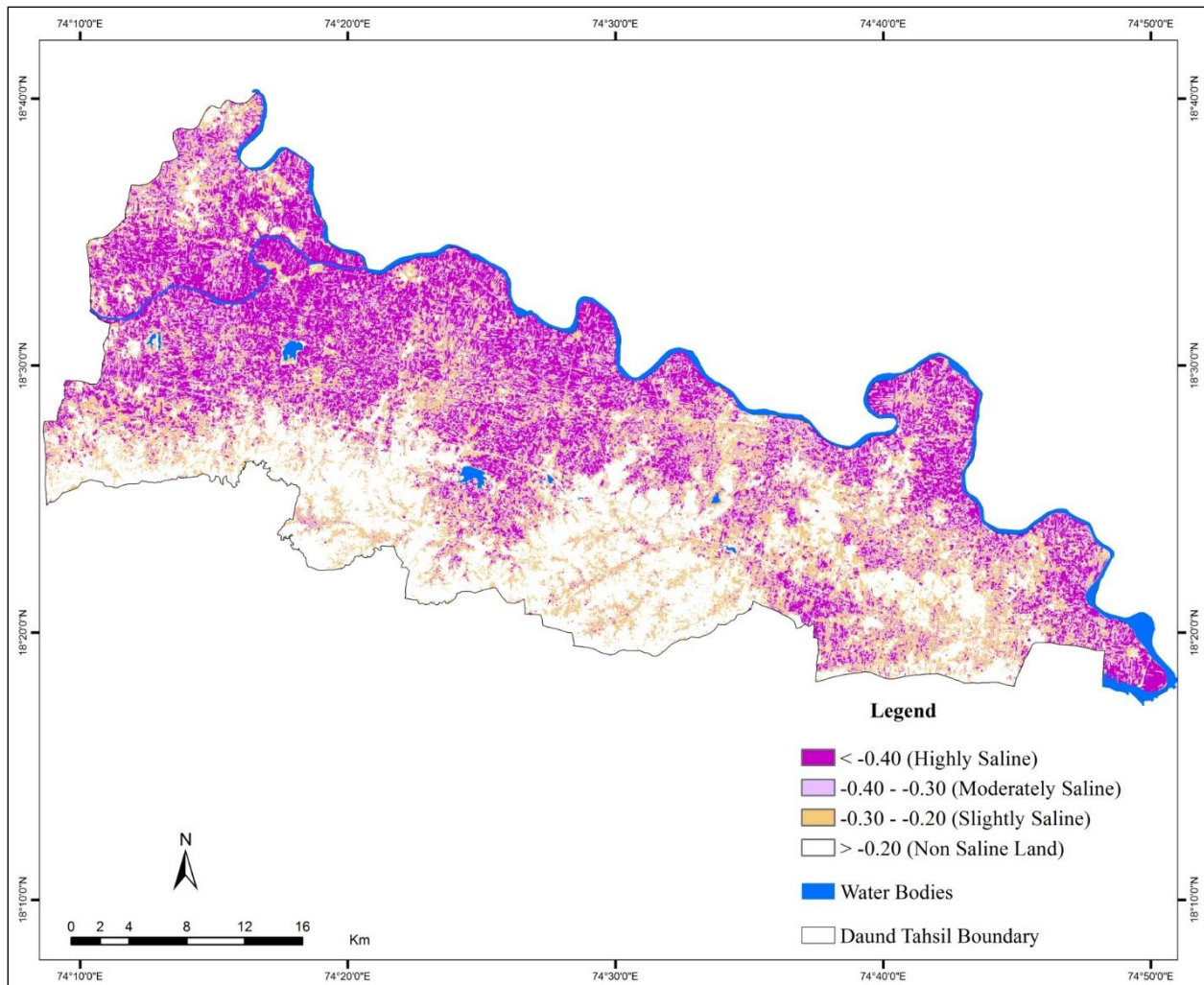


Table 1: Normalized Differential Salinity Index: Area under Saline Soils in Daund Tahsil

S. No.	Classes (NDSI values)	Area (sq. km)	Area (%)
1	Highly Saline land (NDSI less than -0.40)	323.62	23.79
2	Moderately Saline land (NDSI from -0.40 to -0.30)	272.05	20.00
3	Slightly Saline land (NDSI from -0.30 to -0.20)	314.36	23.11
4	Non-saline land (NDSI more than -0.20)	373.71	27.47
5	Water bodies	76.65	5.63
	Total	1360.39	100.00

Figure 4: Daund Tahsil – Soil Adjusted Vegetation Index (SAVI)

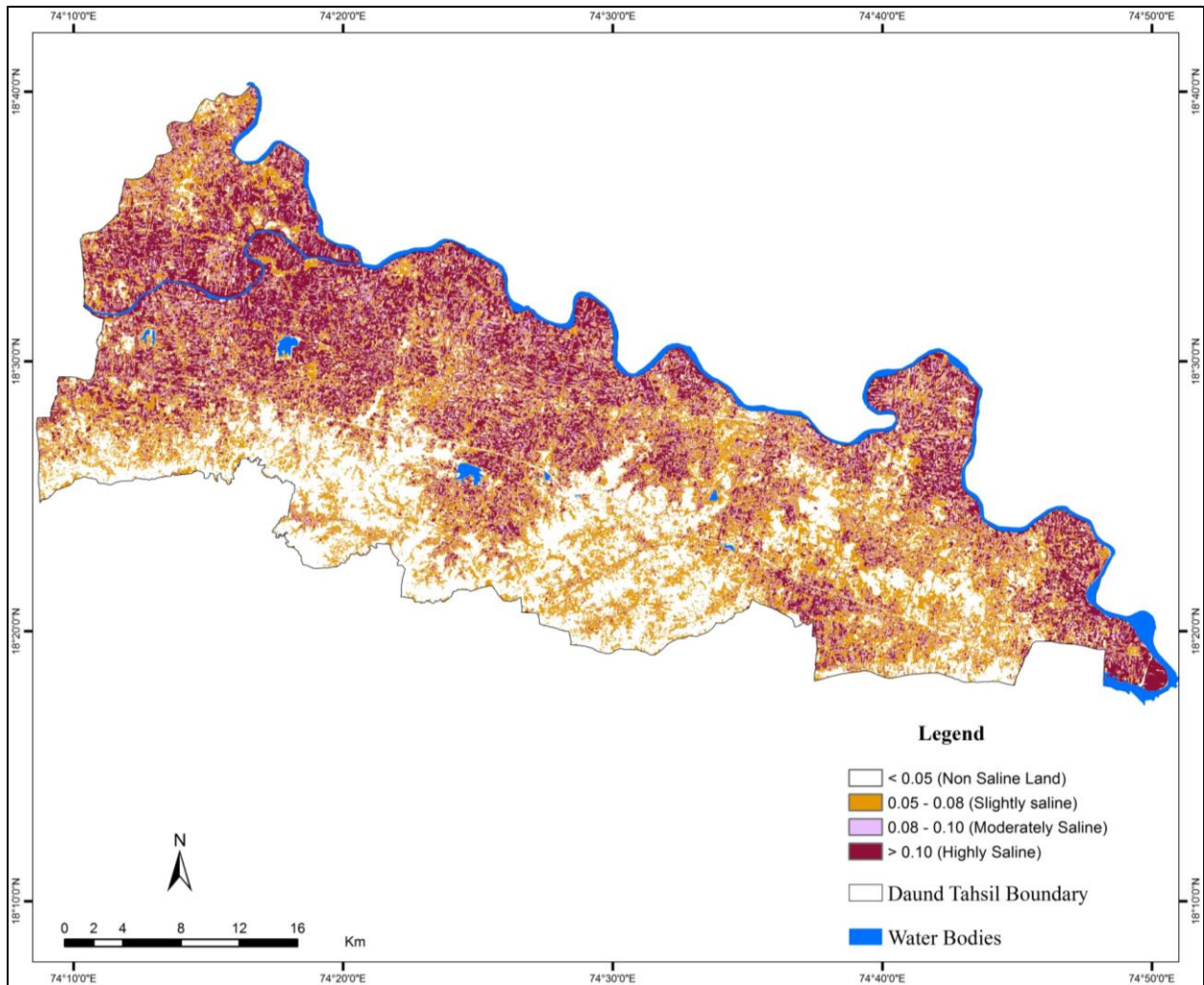
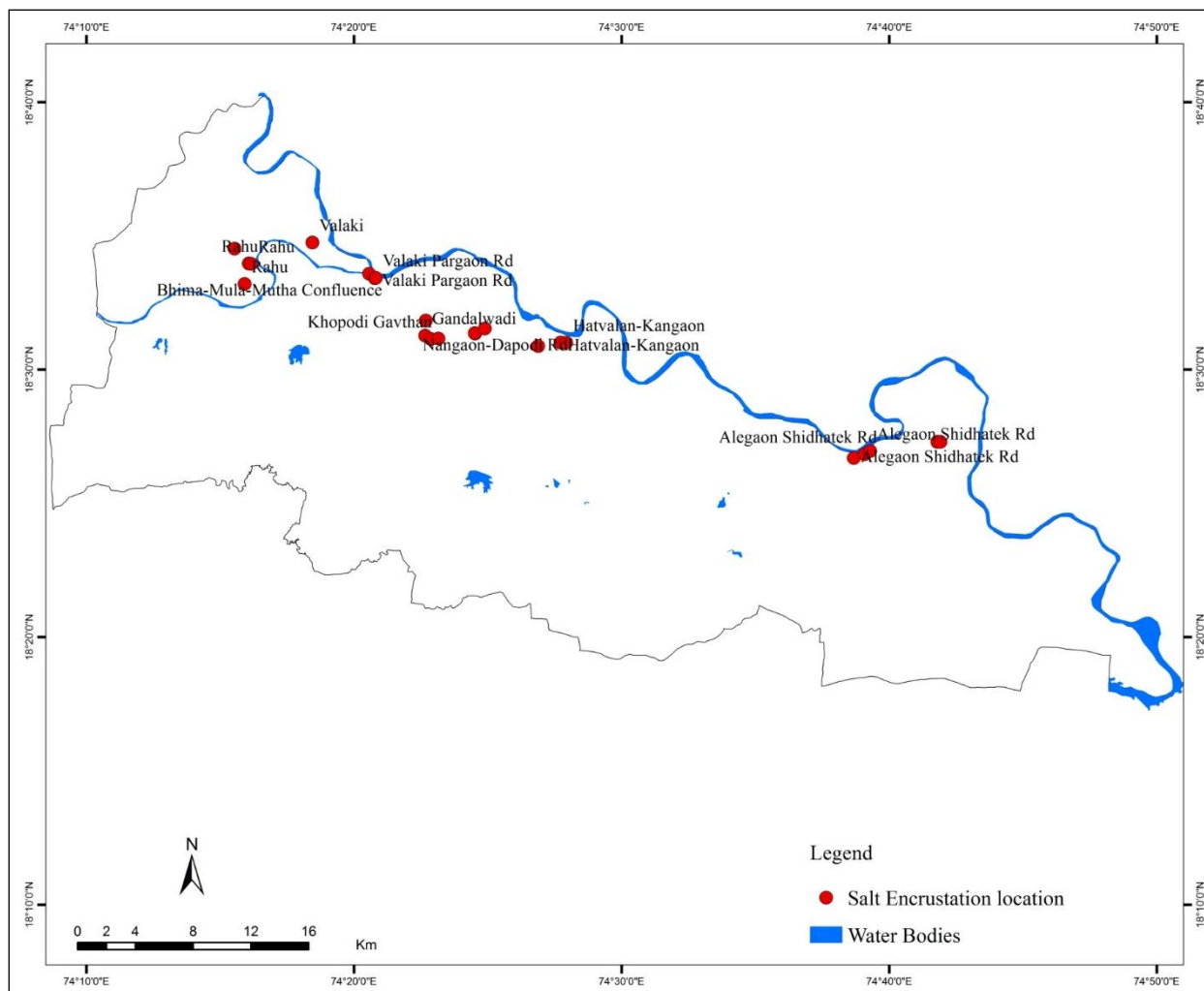


Table 2: Soil Adjusted Vegetation Index: Area under Saline Soils in Daund Tahsil

S. No.	Classes (SAVI values)	Area (sq. km)	Area (%)
1	Highly Saline land (SAVI more than 0.10)	330.12	24.27
2	Moderately Saline land (SAVI from 0.08 to 0.10)	207.75	15.27
3	Slightly Saline land (SAVI from 0.05 to 0.08)	388.08	28.53
4	Non-saline land (SAVI less than 0.05)	357.80	26.30
5	Water bodies	76.65	5.63
	Total	1360.39	100.00

Figure 5: Daund Tahsil – Spot Locations of Salt Encrustations



By utilizing Garmin GPS technology, specific sites of salt encrustation within the Daund Tahsil were accurately recorded and mapped (Figures 5 and 6). These field-collected coordinates were subsequently superimposed onto the NDSI and SAVI soil salinity index maps to validate the remote sensing data. Field observations indicate that soil degradation is accelerating across several local villages—including *Nangaon*, *Amonimal*, *Hatavalan* etc. resulting in severe land infertility. A rapid expansion of soil salinization is evident in these villages, where agricultural productivity has been severely compromised by infertility.

Figure 6: Daund Tahsil – Field Visit Photographs of Salt Encrustations



Linear Salt Encrustations in a farm



Severe Salt Encrustation in a farm

Conclusion

Excessive canal irrigation has led to severe waterlogging in the sugarcane-growing regions of Daund Tahsil, causing extensive land degradation through soil salinization. Utilizing Normalized Difference Salinity Index (NDSI) and Soil Adjusted Vegetation Index (SAVI) maps, this study demonstrated strong spatial consistency in mapping salinity distribution across the entire 1,360.39 square kilometres region. The Normalized Difference Salinity Index (NDSI) and Soil Adjusted Vegetation Index (SAVI) maps for Daund Tahsil show strong spatial coherence in detecting soil salinity. Both methods show that salinity is heavily concentrated along the northern and central parts of the study area i.e. along the banks of the Bhima-Mula-Mutha river system, aligned with field-verified salt encrustation spot locations such as *Rahu, Valaki, Galandwadi, Pargaon, Khopodi, Dapodi, Amonimal, Nangaon, Hatavalan, Khorodi, Alegaon, Shirapur etc.* There is a very close spatial agreement between NDSI (less than -0.40) and SAVI (more than 0.10) in terms of highly saline land area. Both indices have estimated approximately 24% of highly saline land area in Daund Tahsil. NDSI estimates a higher proportion of moderately saline land area (20%) than SAVI (15.27%). SAVI captures a broader extent of low-level salinity or stressed vegetation (5.42% higher than NDSI). Both indices consistently classify ~26–27% of the total area as non-saline. NDSI identifies 66.90% (910.03 sq. km) of Daund Tahsil as affected by varying degrees of salinity, whereas SAVI identifies 68.07% (925.95 sq. km). The direct soil surface spectral response (NDSI) and the indirect vegetation response (SAVI) are closely aligned for severe salinity detection, but SAVI reclassifies some moderately saline areas into the slightly saline category due to background soil reflectance adjustments. Soil salinity in Daund Tahsil will expand exponentially without intervention. Failing to take corrective action will cause the region's highly saline soil to expand year after year. Restoring agricultural productivity requires a coordinated approach from farmers and local leaders, integrating biological, agronomic, and engineering solutions.

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Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

References:

1. Divekar, A. B., Gaikwad, S. W., Das, B. A., & Chavan, M. N. (2017). Land Use Land Cover Change Detection Analysis Using Remote Sensing and GIS - A Case Study of Daund Tahsil, Pune, Maharashtra. *International Journal of Multifaceted & Multilingual Studies*, 4(11), 116-121.
2. Divekar, A. B., Gaikwad, S. W., Das, B. A., & Chavan, M. N. (2018). Identification of Saline Land in Daund Tahsil of Pune District, Maharashtra Using Remote Sensing and GIS. *Online International Interdisciplinary Research Journal*, 8, 75-79.
3. Divekar, A. B., & Chavan, M. N. (2022). Assessment of Soil Productivity based on Storie Index Rating using GIS in Daund Tahsil, Pune District, Maharashtra. *Maharashtra Bhugolshastra Sanshodhan Patrika – Peer Reviewed International Research Journal of Geography*, 39(2), 81–87.
4. Divekar, A. B., & Chavan, M. N. (2025). Soil Salinity Mapping and Evaluation based on Normalized Difference Salinity Index - A Case of Daund Tahsil, Pune District, Maharashtra. *Journal of Research and Development*, 17(9), 100–104.
5. Divekar, A. B. & Chavan, M. N. (2026). Relief Analysis of Daund Tahsil, Pune District, Maharashtra Using Geospatial Technology. *International Journal of World Geology, Geography, Agriculture, Forestry and Environment Sciences*, 3(2), 78–87.
6. Engdawork A., K.V. Suryabagavan, Mekuria A. (2018). Soil salinity modeling and mapping using remote sensing and GIS: The case of Wonji sugar cane irrigation farm, Ethiopia. *Journal of the Saudi Society of Agricultural Sciences*, 17(3), 250-258.
7. Patel, B., Patel, B., and Dave, R. (2011). Studies on infiltration of saline-alkali soils of several parts of Mehsana and Patan districts of North Gujarat. Sukolilo, *Journal of Applied Technology in Environmental Sanitation*, 1(1), 87-92.
8. Wang, F., Ding, J., and Wu, M. (2010). Remote sensing monitoring models of soil salinization based on NDVI-SI feature space. *Nongye Gongcheng Xuebao/Transactions of the Chinese Society of Agricultural Engineering*. 26. 168-173.
9. Wang, L., Zhao, Z., Zhang, K., Tian, Y. (2013). Reclamation and utilization of saline soils in arid northwestern China: a promising halophyte drip-irrigation system. *Environmental Science and Technology*. 2013; 47(11):5518-9.