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# Mapping Vegetation Dynamics: A Comparative NDVI Study of Madha and Pandharpur taluka in Solapur District, Maharashtra

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***Abstract***

*Vegetation monitoring is essential for evaluating environmental conditions, agricultural productivity, and ecological sustainability, particularly in semi-arid regions. The present study focuses on the comparative analysis of vegetation dynamics in Madha and Pandharpur talukas of Solapur district, Maharashtra, using the Normalized Difference Vegetation Index (NDVI) derived from Sentinel-2 MSI satellite imagery. Remote Sensing and GIS techniques were employed to assess the spatial distribution and health of vegetation in both talukas. Cloud-free satellite images from the same season were selected to maintain temporal consistency and reduce seasonal bias. Administrative boundary shapefiles were used for accurate spatial analysis. The results reveal significant differences in vegetation conditions between the two talukas. Pandharpur exhibits comparatively higher NDVI values, extensive green cover, and healthier vegetation due to better irrigation facilities, fertile soils, and intensive agricultural practices. In contrast, Madha is characterized by lower NDVI values, scattered vegetation patches, and semi-arid conditions associated with limited irrigation and water scarcity. The study highlights the influence of climatic conditions, water availability, and land-use practices on vegetation dynamics. The findings provide valuable insights for sustainable agricultural planning, drought assessment, water resource management, and ecological conservation in semi-arid regions of Maharashtra.*

***Keywords:*** *NDVI; Remote Sensing; GIS; Vegetation Dynamics; Sentinel-2 MSI; Madha Taluka; Pandharpur Taluka; Solapur District; Semi-Arid Region; Vegetation Health; Land Use; Agricultural Productivity.*

## Introduction

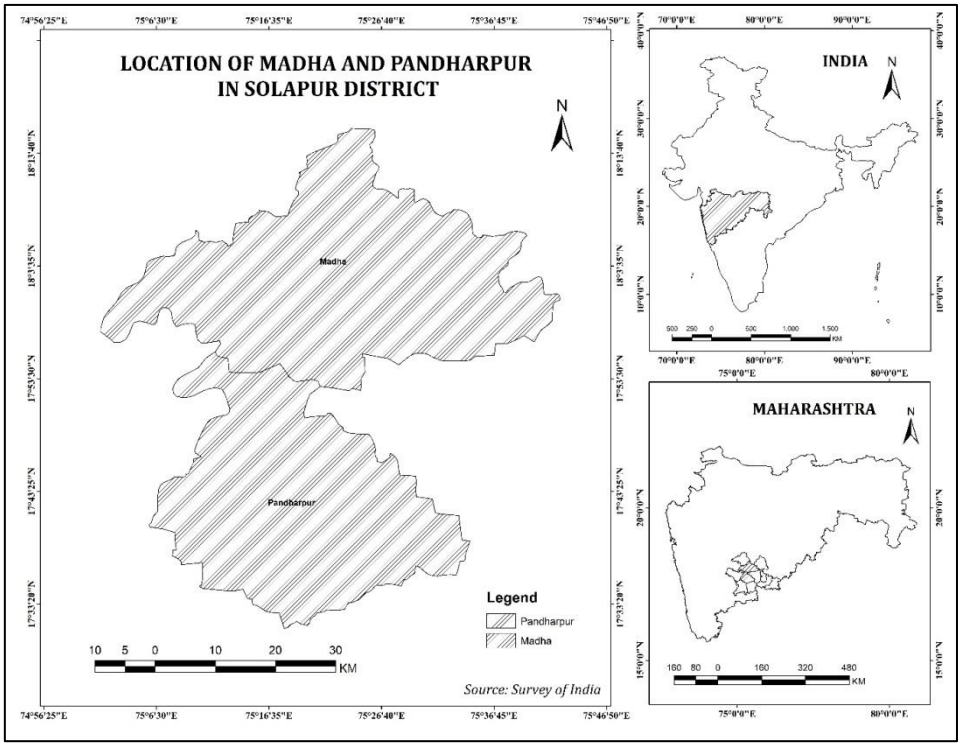
Vegetation monitoring plays a critical role in assessing environmental sustainability, agricultural productivity, and the impacts of climatic variability, particularly in semi-arid regions. Remote sensing techniques have become indispensable tools for evaluating vegetation health at multiple spatial and temporal scales. Among various spectral indices, the Normalized Difference Vegetation Index (NDVI) is one of the most extensively applied indicators for quantifying vegetation greenness and vigor (Tucker, 1979). NDVI provides reliable information on biomass distribution, land-use and land-cover changes, and ecological stress conditions, thereby serving as an effective parameter for regional-scale environmental assessment (Rouse et al., 1973). NDVI has demonstrated significant utility in detecting both spatial and temporal variations in vegetation dynamics, especially in semi-arid environments where vegetation patterns are highly sensitive to rainfall variability, soil moisture availability, and land-use practices. Solapur district, located in the rain-shadow zone of the Western Ghats, is characterized by semi-arid climatic conditions, recurrent drought events, and the predominance of dryland agriculture (Government of Maharashtra, 2020).

Within this district, Madha and Pandharpur represent two contrasting agro-ecological settings. Madha is predominantly dependent on monsoon-driven agriculture and is characterized by limited irrigation facilities, whereas Pandharpur benefits from irrigation support derived from the Bhima River (locally known as Chandrabhaga) and associated canal networks, resulting in comparatively enhanced vegetation conditions. A comparative assessment of NDVI patterns across these talukas facilitates a deeper understanding of the influence of geographical, hydrological, and agricultural determinants on vegetation health and productivity. Such analyses are instrumental in evaluating land productivity, identifying ecologically vulnerable zones, and promoting sustainable agricultural planning (Jensen, 2015).

Through the analysis of satellite-derived NDVI data, the present study seeks to (i) examine the spatial distribution of vegetation cover in Madha and Pandharpur, (ii) quantify variations in vegetation density, and (iii) identify the underlying environmental and anthropogenic factors responsible for observed differences. Furthermore, extending the comparative framework to include Beed district enables a broader regional understanding of how climatic variability, land-use patterns, and natural resource availability collectively influence vegetation cover dynamics. The integration of geospatial techniques and NDVI-based analysis provides a scientific basis for drought assessment, sustainable land-use planning, and environmental management in semi-arid landscapes (Jensen, 2007; Patil and Shinde, 2020). In conclusion, this study aims to contribute to the scientific understanding of vegetation dynamics in semi-arid regions of Maharashtra through a systematic NDVI-based comparative analysis. The findings are expected to support evidence-based decision-making related to land management, water resource allocation, and agricultural development in the study area.

**The study area**

The study area is located in Solapur district of Maharashtra state in the Western Maharashtra region of India. Geographically, it lies between latitudes 17.9°N to 18.3°N and longitudes 75.2°E to 75.6°E, with a smaller focused range between 17.9°N to 18.1°N and 75.1°E to 75.4°E. The region is part of the Deccan Plateau and experiences a semi-arid climate with low to moderate rainfall. Agriculture is the main occupation, with crops such as jowar, sugarcane, and pulses commonly grown. The area's location influences its climate, soil characteristics, and overall land use patterns.




**Objectives:**

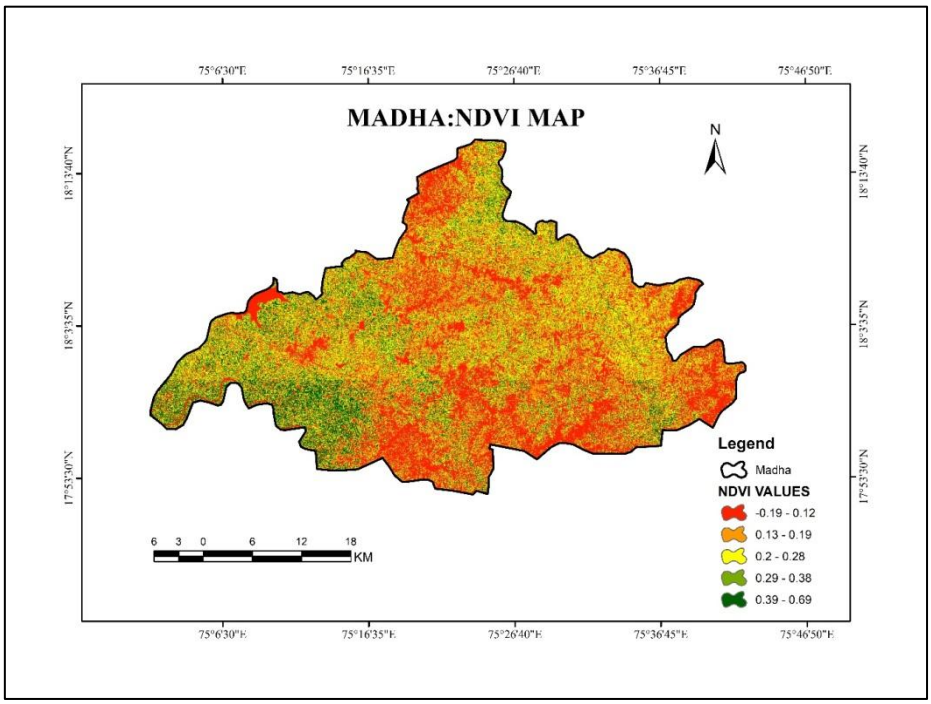
1. To analyze and generate maps of the Normalized Difference Vegetation Index (NDVI) for Madha and Pandharpur talukas using satellite imagery in order to assess the spatial distribution of vegetation.
2. To compare NDVI values between Madha and Pandharpur talukas to identify differences in vegetation health and density.

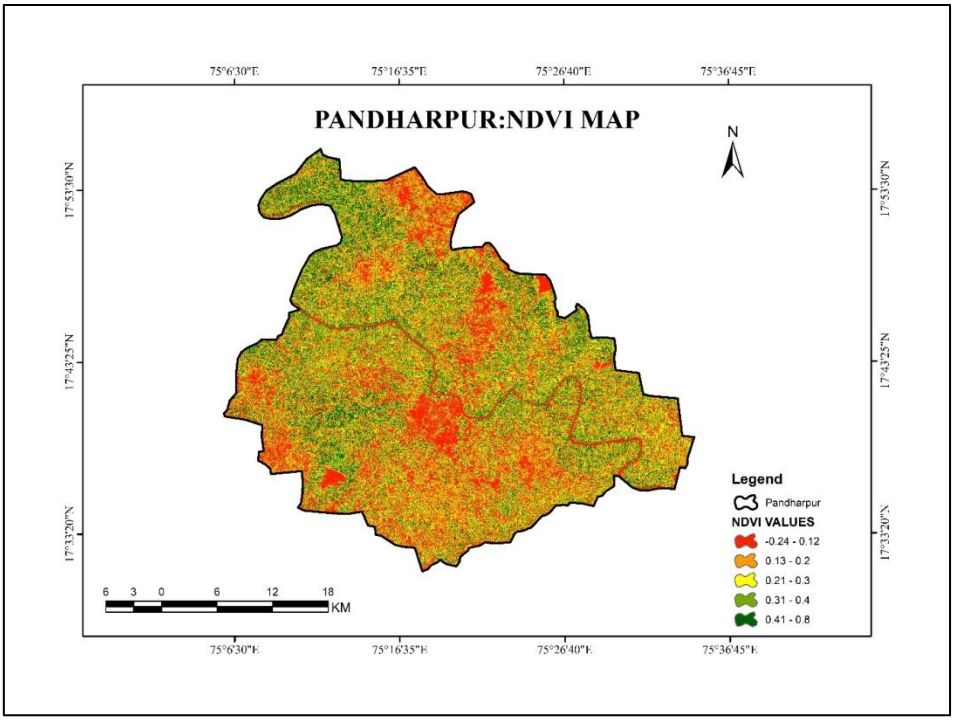
**Research Methodology:**

The methodology of this study included the use of Remote Sensing and GIS techniques to calculate and compare NDVI values for Madha and Pandharpur talukas in Solapur district.

**Data Collection:**

Based on availability and cloud-free conditions, satellite images were obtained from Sentinel-2 MSI. To ensure consistency and eliminate seasonal bias, images from the same season/month were selected. Administrative boundary shapefiles of Madha and Pandharpur talukas were obtained from official sources for clipping and analysis purposes.




**Results**

Comparative NDVI analysis reveals marked differences in vegetation distribution and health between Madha and Pandharpur talukas in Solapur district. Pandharpur exhibits extensive green and yellow zones, indicative of robust and well-established vegetation cover, while red zones representing low NDVI values are present but spatially limited. Central and northern regions of Pandharpur demonstrate medium to high NDVI values, likely reflecting intensive agricultural activity, availability of irrigation, and favorable soil-moisture conditions. Spatial mapping further highlights pockets of vigorous vegetation, particularly in cultivated and irrigated plots, underscoring the taluka's agricultural productivity. Quantitative and qualitative observations suggest that Pandharpur supports higher vegetation density and demonstrates greater crop vigor compared to Madha. The taluka exhibits a more favorable agro-climatic setting, likely due to a combination of irrigation infrastructure, enhanced soil moisture retention, and consistent cultivation practices. In contrast, Madha displays widespread low NDVI values, suggesting semi-arid conditions, post-harvest fallow lands, or regions under vegetative stress. Both talukas show mixed NDVI patterns, but the spatial continuity and prominence of high NDVI zones in Pandharpur underscore its superior vegetative health.

**Comparative NDVI Analysis of Madha and Pandharpur Talukas**

| Feature | Madha | Pandharpur |
|---|---|---|
| Vegetation Health | Predominantly low to medium | Overall medium to high |
| Dominant Spectral Signatures | Red and orange (indicative of stressed vegetation) | Yellow and green (indicative of vigorous vegetation) |
| Agricultural Regime | Predominantly rainfed, limited irrigation | Intensive, likely irrigated farmlands |
| Vegetation Distribution | Scattered green patches | Extensive, continuous green cover |
| Overall Ecological Condition | Semi-arid landscape with stressed vegetation | Relatively robust vegetation cover with higher productivity |

**NDVI Class Distribution and Vegetation Status**

| NDVI Class | Madha NDVI Range | Pandharpur NDVI Range | Vegetation Condition |
|---|---|---|---|
| Very Low | –0.19 to 0.12 | –0.24 to 0.12 | Barren lands, exposed soil, water bodies, dry terrain |
| Low | 0.13 to 0.19 | 0.13 to 0.20 | Sparse vegetation, degraded or fallow fields |
| Medium | 0.20 to 0.28 | 0.21 to 0.30 | Moderate vegetation growth, early crop stages |
| High | 0.29 to 0.38 | 0.31 to 0.40 | Dense vegetation, healthy crops |
| Very High | 0.39 to 0.69 | 0.41 to 0.80 | Very dense vegetation, irrigated and high-yield crop zones |

The NDVI-based assessment underscores Pandharpur's superiority in vegetation health, highlighting its agro-ecological advantage in terms of irrigation, soil moisture, and crop intensity. Madha's dominance of low NDVI areas reflects semi-arid constraints, water scarcity, and post-harvest or fallow conditions. The spatial heterogeneity of NDVI within both talukas indicates localized variability in vegetation stress, agricultural management, and natural resource availability. These insights provide a robust framework for targeted agricultural interventions, precision irrigation planning, and sustainable land management strategies in semi-arid regions of Western Maharashtra.

**Conclusion:**

The analysis of Normalized Difference Vegetation Index (NDVI) values for Madha and Pandharpur talukas in Solapur district provides valuable insights into the spatial distribution and health of vegetation in these regions. NDVI is a widely used indicator to assess vegetation density, vigor, and overall ecological health through satellite imagery. In this study, Sentinel-2 MSI images were used to calculate NDVI values for both talukas, ensuring cloud-free images from the same season to minimize temporal or seasonal bias. Administrative boundary shapefiles were employed to accurately extract and analyze the areas of interest. The results indicate that Pandharpur exhibits a higher maximum NDVI value of approximately 0.80, whereas Madha's maximum NDVI reaches only around 0.69. This difference suggests that Pandharpur generally has healthier and denser vegetation compared to Madha. A higher NDVI typically reflects greater photosynthetic activity, which is often associated with well-irrigated agricultural land, fertile soils, and optimal crop management practices. On the other hand, lower NDVI values, as seen in Madha, may indicate sparse vegetation, stress due to water scarcity, or degraded lands. The distribution of NDVI classes in Pandharpur is also more variable, indicating a wider range of vegetation health levels across the taluka. This variation implies a mosaic of land types, including irrigated croplands, fallow fields, and areas of natural vegetation, contributing to an overall healthier landscape. In contrast, Madha shows a narrower range of NDVI values, reflecting less heterogeneity in vegetation conditions. This uniformity may be due to widespread drylands or semi-arid conditions limiting vegetation growth and reducing crop diversity. Despite these differences, both talukas share similar low-NDVI categories. These low-NDVI areas correspond to barren, dry, or uncultivated land, characteristic of the semi-arid climate of the Solapur district. Such areas are prone to water stress and exhibit limited vegetation cover, affecting the overall ecological balance. The presence of these low-NDVI zones in both talukas underscores the challenges posed by climatic conditions, soil quality, and water availability in sustaining healthy vegetation cover. Another important observation is the significant presence of high to very high NDVI values in Pandharpur. These areas correspond to irrigated or intensively managed agricultural regions where crops are growing well. This pattern suggests that Pandharpur benefits from better irrigation infrastructure, more fertile soils, or improved crop management practices, resulting in higher vegetation density and health. Conversely, Madha lacks extensive high-NDVI zones, indicating limited irrigation facilities and greater exposure to environmental stressors, which constrain crop productivity. In conclusion, the NDVI analysis reveals that Pandharpur taluka demonstrates healthier, denser, and more variable vegetation cover than Madha. Both regions share low-NDVI areas that reflect barren or semi-arid conditions, but the predominance of high-NDVI zones in Pandharpur highlights its better vegetation management and irrigation capacity. These insights can inform sustainable agricultural planning, natural resource management, and strategies to mitigate vegetation stress in semi-arid regions like Solapur. By using NDVI mapping and comparison, policymakers and researchers can identify priority areas for intervention, promote crop health, and enhance the overall ecological sustainability of the region.

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

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