JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

ASSESSMENT OF VEGETATION HEALTH & DROUGHT USING NDVI & SAVI IN ANANTAPUR DISTRICT, ANDHRA PRADESH BY GEOSPATIAL TECHNOLOGY

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Abstract

This study aims to assess vegetation health and drought conditions in Anantapur District, Andhra Pradesh, utilizing the Normalized Difference Vegetation Index (NDVI) and Soil-Adjusted Vegetation Index (SAVI) through geospatial technology. By analyzing Landsat 8 and Landsat 9 satellite imagery from the years 2013 and 2024, we investigate changes in vegetation cover and health over this period, correlating these changes with drought occurrences. NDVI and SAVI are employed to quantify vegetation density and health, accounting for soil brightness effects, which is particularly relevant in arid regions like Anantapur. The analysis reveals significant variations in vegetation health, highlighting areas of stress and resilience. The findings indicate a correlation between reduced vegetation indices and drought severity, providing insights into the impacts of climate variability on local ecosystems. This research contributes to understanding vegetation dynamics in response to environmental stressors and offers valuable information for sustainable land management and drought mitigation strategies in the region.

Key words: SAVI, NDVI, LANDSAT 8-9, Ecosystem & Drought

Introduction:

Drought is a recurring environmental challenge in Anantapur district, Andhra Pradesh, one of the most arid regions in southern India. With an economy largely dependent on rain-fed agriculture, the region frequently faces significant agricultural distress due to erratic rainfall and prolonged dry spells. Assessing vegetation health is crucial for understanding the impact of drought and implementing effective mitigation strategies.

Remote sensing and geospatial technology provide valuable tools for monitoring vegetation dynamics and drought severity. Vegetation indices such as the Normalized Difference Vegetation Index (NDVI) and the Soil-

Adjusted Vegetation Index (SAVI) are widely used for assessing vegetation health and minimizing soil background effects in arid regions. NDVI helps in analyzing vegetation vigor, while SAVI is particularly useful in areas with sparse vegetation and high soil reflectance.

This study aims to assess vegetation health and drought conditions in Anantapur district using NDVI and SAVI derived from satellite imagery. By integrating geospatial techniques, the study seeks to evaluate spatial and temporal variations in vegetation cover and their correlation with drought patterns. The findings will provide critical insights for policymakers, farmers, and researchers in developing sustainable land and water management strategies to mitigate the adverse effects of drought in the region.

Study area:

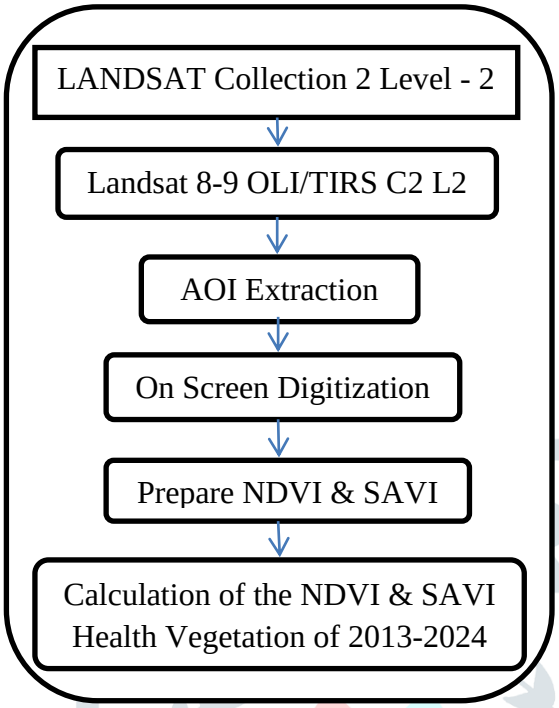
Anantapur is a significant district in Andhra Pradesh, covering an area of 10,205 square kilometers and divided into 31 mandals across three revenue divisions: Anantapur, Guntakal, and Kalyandurg. The district is situated between 14° 17' and 15° 15' North Latitude and 76° 50' and 78° 13' East Longitude. It is bordered to the north by Kurnool District and Bellary District in Karnataka, to the southeast by Sri SathyaSai District, to the east by YSR Kadapa District, and to the west and southwest by Karnataka (Fig:1). Anantapur shares borders with Kurnool and Nandyal to the north, Kadapa to the east, and Sri SathyaSai to the south, while also neighboring Karnataka's Chitradurga and Bellary districts to the west and southwest. This district is part of the Rayalaseema region, known for its susceptibility to drought, necessitating continuous monitoring for effective water and agricultural management. Geographically, Anantapur features a mix of black cotton soil in the north and poorer red soil in the south. It is home to two prominent hill ranges, the Mutchukota and Nagasamudram Hills, which encompass a significant portion of the forested area. Key rivers in the district include the Penna, Chithravathi, and several others, contributing to the region's water resources. With an average elevation of approximately 1,300 feet and an annual rainfall of about 508.2 mm, Anantapur is recognized as one of the driest districts in Andhra Pradesh.

Aims &Objectives:

1. To analyze vegetation health by utilizing NDVI and SAVI to assess the health of vegetation in Anantapur District from 2013 to 2024.
2. To monitor drought conditions by evaluating the temporal changes in vegetation health and correlating them with drought conditions in Anantapur District.
3. To compare NDVI and SAVI in order to assess the effectiveness of these indices in detecting variations in vegetation health under different soil and moisture conditions, and to determine which index provides more accurate results for the study area.

4. To utilize geospatial technology by employing geospatial technology and remote sensing techniques to analyze Landsat 8 and 9 satellite imagery for mapping and monitoring vegetation health and drought conditions.

Methodology:



Data: The Landsat 8-9 OLI/TIRS-C2 Level 2 dataset comprises more than 2 million Earth observations taken across six spectral bands. These images were analyzed through data modeling techniques to produce comprehensive maps. The satellite imagery was obtained at no cost from the USGS Earth Explorer platform. The analysis was conducted using ArcGIS 10.3 and Microsoft Office tools.

Result & Discussion:

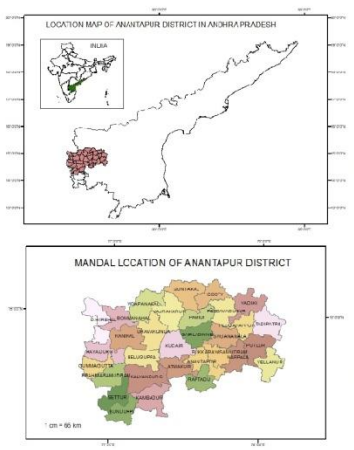


Fig:1

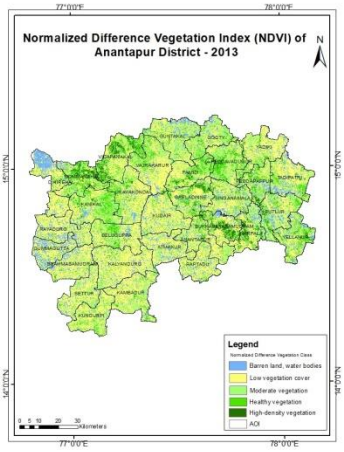


Fig:2

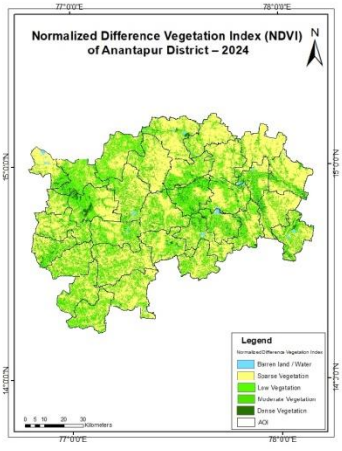


Fig:3

NDVI (Normalized Difference Vegetation Index)

NDVI is a widely used remote sensing index for assessing vegetation health and density. It is calculated using the Near-Infrared (NIR) and Red spectral bands from satellite imagery.

Formula:

NDVI= (NIR−Red)(NIR+Red)NDVI = \frac{(NIR - Red)}{(NIR + Red)}NDVI=(NIR+Red)(NIR−Red)

Where:

- NIR (Near Infrared Band): High reflectance from vegetation.
- Red (Red Band): High absorption by chlorophyll in plants.

Table: 1
NDVI Classification of AnantapurDistrict– 2013

s.no	NDVI Ranges	Classes of NDVI
1	-0.20 to 0.11	Barren land / Water
2	0.11 to 0.17	Sparse Vegetation
3	0.17 to 0.23	Low Vegetation
4	0.23 to 0.33	Moderate Vegetation
5	0.33 to 0.99	Dense Vegetation

The classification of the Normalized Difference Vegetation Index (NDVI) for the Anantapur District in the year 2013. NDVI is a widely used remote sensing measurement that assesses vegetation health and density by comparing the difference between near-infrared and visible light reflected by vegetation. The table categorizes NDVI values into distinct ranges, each corresponding to specific classes of land cover (Table:1& Fig:2).

The first category, which encompasses NDVI values from -0.20 to 0.11, is classified as barren land or water. This range indicates areas with minimal or no vegetation, reflecting surfaces such as dry soil or water bodies. The subsequent category, with NDVI values between 0.11 and 0.17, is designated as sparse vegetation. This classification suggests the presence of limited plant cover, where vegetation is not sufficiently dense to significantly impact the landscape.

Moving to the next range, from 0.17 to 0.23, the classification shifts to low vegetation. This indicates areas where plant life is more prevalent but still lacks the density characteristic of healthier ecosystems. The moderate vegetation category, which includes NDVI values from 0.23 to 0.33, reflects a more robust presence of plant life, suggesting a healthier and more diverse ecosystem.

Finally, the highest classification, dense vegetation, is represented by NDVI values ranging from 0.33 to 0.99. This range signifies areas with rich and abundant vegetation, indicative of thriving ecosystems that support a variety of flora and fauna. Overall, the NDVI classification in Anantapur district provides valuable insights into the distribution and health of vegetation across the region, which can be critical for environmental monitoring and land management strategies.

Table: 2
NDVI Classification of AnantapurDistrict– 2024

s.no	NDVI Ranges	Classes of NDVI
1	-0.132 to 0.047	Barren land / Water
2	0.047 to 0.124	Sparse Vegetation
3	0.124 to 0.173	Low Vegetation
4	0.173 to 0.248	Moderate Vegetation
5	0.248 to 0.499	Dense Vegetation

(Table:2& Fig:3),presents the classification of the Normalized Difference Vegetation Index (NDVI) for the Anantapur District in the year 2024. NDVI is a widely used remote sensing measurement that quantifies vegetation health and density based on the difference between near-infrared and red light reflectance. The table categorizes NDVI values into distinct ranges, each corresponding to specific classes of vegetation cover.

The first category, which encompasses NDVI values from -0.132 to 0.047, is classified as "Barren land or Water." This range indicates areas with minimal to no vegetation, which may include dry, unproductive land or water bodies. The second category, with NDVI values between 0.047 and 0.124, is designated as "Sparse Vegetation." This classification reflects regions where vegetation is present but is not dense, suggesting limited plant cover or health.

The third range, from 0.124 to 0.173, is identified as "Low Vegetation." This category indicates areas with a greater presence of vegetation compared to sparse regions, although the overall density remains relatively low. Following this, the fourth category, which spans NDVI values from 0.173 to 0.248, is classified as "Moderate Vegetation." This classification signifies a more substantial presence of healthy vegetation, indicating improved growth conditions.

Finally, the highest classification, "Dense Vegetation," includes NDVI values ranging from 0.248 to 0.499. This category represents areas with robust and thriving plant life, suggesting optimal environmental conditions for vegetation growth. Overall, the NDVI classification in Anantapur District provides valuable insights into the distribution and health of vegetation across the landscape, which can inform ecological studies and land management practices.

Soil-Adjusted Vegetation Index (SAVI) Calculation

SAVI is an improved vegetation index that minimizes the influence of soil brightness in areas with sparse vegetation. It is particularly useful in arid and semi-arid regions where vegetation cover is low.

Formula:

SAVI=(NIR−Red)(NIR+Red+L)×(1+L)SAVI = \frac{(NIR - Red)}{(NIR + Red + L)} \times (1 + L)SAVI=(NIR+Red+L)(NIR−Red)×(1+L)

Where:

- **NIR** = Near-Infrared Band (Landsat Band 5 for Landsat 8)
- **RED** = Red Band (Landsat Band 4 for Landsat 8)
- **L** = Soil brightness correction factor (varies based on vegetation density)
  - **L = 0** for dense vegetation
  - **L = 1** for bare soil
  - **L = 0.5** (commonly used for moderate vegetation cover)

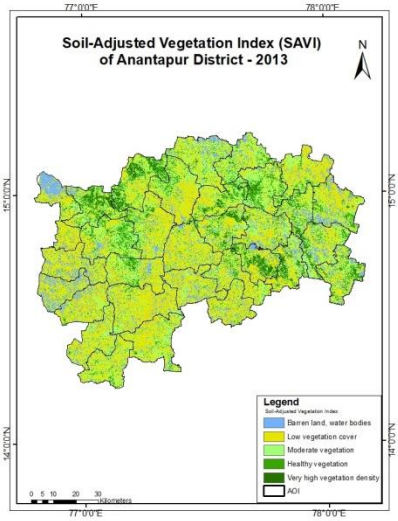


Fig:4

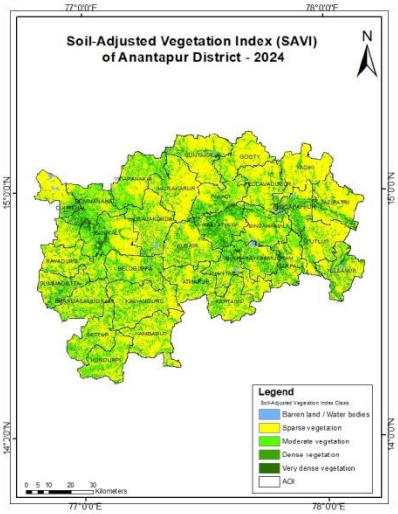


Fig:5

Table: 3
SAVI classification of Anantapur District– 2013

s.no	SAVI Ranges	Classes of SAVI
1	-0.30 to 0.16	Barren land or water bodies
2	0.16 to 0.25	Grasslands or Dry Shrubs
3	0.25 to 0.35	Agricultural land or Sparse Forest
4	0.35 to 0.49	Dense shrubs or Cultivated crops.
5	0.49 to 1.48	Forests or well-Irrigated croplands.

The Soil Adjusted Vegetation Index (SAVI) classification for the Anantapur district as of 2013, categorizing various land cover types based on their SAVI values. The SAVI is a remote sensing index that adjusts for soil brightness, making it particularly useful in areas with sparse vegetation. The classification is divided into five distinct ranges, each corresponding to specific land cover types (Table:3 & Fig:4).

The first category, which encompasses SAVI values from -0.30 to 0.16, is identified as barren land or water bodies. This range indicates areas with minimal vegetation cover, where either the soil is exposed or water bodies are present. The next range, from 0.16 to 0.25, is classified as grasslands or dry shrubs, suggesting a landscape characterized by low-growing vegetation that may be subject to arid conditions.

Moving to the third category, SAVI values between 0.25 and 0.35 are associated with agricultural land or sparse forest. This classification highlights regions where agricultural activities are prevalent or where tree cover is limited, indicating a transitional landscape between open fields and denser vegetation. The fourth range, from 0.35 to 0.49, is designated for dense shrubs or cultivated crops, reflecting areas with more robust vegetation, either in the form of shrub land or actively farmed fields.

Finally, the highest SAVI range of 0.49 to 1.48 is classified as forests or well-irrigated croplands. This category represents regions with significant tree cover or intensive agricultural practices supported by adequate irrigation, indicating a lush and productive landscape. Overall, this classification provides valuable insights into the land cover dynamics of Anantapur District, facilitating better understanding and management of its natural resources.

Table: 4
SAVI Classification of Anantapur District - 2024

s.no	SAVI Ranges	Classes of SAVI
1	-0.198 to 0.069	Barren land/water bodies
2	0.185 to 0.259	Sparse vegetation
3	0.185 to 0.259	Moderate vegetation
4	0.259 to 0.371	Dense vegetation
5	0.371 to 0.752	Very dense vegetation

The SAVI (Soil Adjusted Vegetation Index) classification for the Anantapur district in the year 2024, categorizing various types of vegetation based on specific SAVI ranges. The SAVI is a widely used index that helps in assessing vegetation cover by minimizing the influence of soil brightness, thus providing a more accurate representation of vegetation health and density (Table:4& Fig:5).

The first category, which encompasses SAVI values ranging from -0.198 to 0.069, is classified as barren land or water bodies. This range indicates areas with little to no vegetation, where the presence of soil or water significantly affects the SAVI readings. Following this, the second category includes SAVI values from 0.185 to 0.259, which is designated as sparse vegetation. This classification suggests that these areas have limited plant cover, characterized by scattered and less dense vegetation.

Interestingly, the third category also falls within the same SAVI range of 0.185 to 0.259 but is classified as moderate vegetation. This overlap indicates that the classification may depend on additional contextual factors,

such as the type of vegetation or its health, rather than solely on the SAVI value. The fourth category, with SAVI values ranging from 0.259 to 0.371, is identified as dense vegetation. This classification signifies a more robust plant cover, where vegetation is sufficiently dense to significantly influence the SAVI readings.

Finally, the fifth category, which includes SAVI values from 0.371 to 0.752, is classified as very dense vegetation. This range indicates areas with a high concentration of vegetation, suggesting a thriving ecosystem with substantial plant biomass. Overall, the SAVI classification in Anantapur District provides valuable insights into the distribution and density of vegetation, which can be crucial for ecological studies, land management, and conservation efforts in the region.

Table:5
Comparison of NDVI in Anantapur District: 2013-2024

s.no	NDVI values-2013	NDVI values-2024	Classes of NDVI
1	-0.20 to 0.11	-0.132 to 0.047	Barren land / Water
2	0.11 to 0.17	0.047 to 0.124	Sparse Vegetation
3	0.17 to 0.23	0.124 to 0.173	Low Vegetation
4	0.23 to 0.33	0.173 to 0.248	Moderate Vegetation
5	0.33 to 0.99	0.248 to 0.499	Dense Vegetation

Presents a comparative analysis of the Normalized Difference Vegetation Index (NDVI) values for Anantapur district over an eleven-year period, from 2013 to 2024. The NDVI is a widely used remote sensing measurement that helps in assessing vegetation health and density by analyzing the difference between near-infrared and visible light reflected by vegetation. The table categorizes NDVI values into distinct classes, which reflect varying degrees of vegetation cover and land use (Table:5).

In 2013, the NDVI values ranged from -0.20 to 0.99, indicating a diverse landscape with varying vegetation types. The lowest NDVI class, which spans from -0.20 to 0.11, is characterized as barren land or water, suggesting areas with little to no vegetation. The next class, representing sparse vegetation, had NDVI values between 0.11 and 0.17. This indicates regions where vegetation is present but not densely packed. As we move to the low vegetation class, with NDVI values from 0.17 to 0.23, there is a noticeable increase in vegetation density, albeit still limited.

The moderate vegetation class, which encompasses NDVI values from 0.23 to 0.33, reflects areas with a more substantial presence of plant life. Finally, the dense vegetation category, with NDVI values ranging from 0.33 to 0.99, indicates regions with rich and robust vegetation cover, likely comprising forests or well-maintained agricultural lands.

By 2024, the NDVI values have shifted, with the lowest class now ranging from -0.132 to 0.047, and the highest class extending from 0.248 to 0.499. This shift suggests a potential decline in the most severely barren areas and an increase in the NDVI values across the other classes, indicating a possible improvement in vegetation health and coverage over the years. The changes in NDVI values across the various classes highlight the dynamic nature of land use and vegetation in Anantapur District, reflecting both environmental changes and human impacts on the landscape during this period. This analysis provides critical insights into the ecological trends in the region, which can inform future conservation and land management strategies.

Table:6
Comparison of SAVI in Anantapur District: 2013-2024

s.no	SAVIvalues-2013	SAVI values-2024	Classes of SAVI
1	-0.20 to 0.11	-0.198 to 0.069	Barren land/water bodies
2	0.11 to 0.17	0.185 to 0.259	Sparse vegetation
3	0.17 to 0.23	0.185 to 0.259	Moderate vegetation
4	0.23 to 0.33	0.259 to 0.371	Dense vegetation
5	0.33 to 0.99	0.371 to 0.752	Very dense vegetation

A comparative analysis of the Soil Adjusted Vegetation Index (SAVI) values in Anantapur district over an eleven-year period, specifically from 2013 to 2024. The SAVI is a crucial metric used in remote sensing to assess vegetation cover and health by minimizing the influence of soil brightness. The table categorizes SAVI values into distinct classes, which reflect varying degrees of vegetation density (Table:6).

In 2013, the SAVI values ranged from -0.20 to 0.99, indicating a diverse landscape with varying vegetation types. The lowest class, encompassing values from -0.20 to 0.11, was classified as barren land or water bodies, suggesting areas with little to no vegetation. The subsequent class, with SAVI values between 0.11 and 0.17, represented sparse vegetation, indicating regions where plant cover is limited. Moderate vegetation was identified within the range of 0.17 to 0.23, while dense vegetation was classified with SAVI values from 0.23 to 0.33. The highest class, very dense vegetation, included values from 0.33 to 0.99, highlighting areas with significant plant cover.

By 2024, the SAVI values exhibited notable changes, with the range for barren land and water bodies slightly shifting to -0.198 to 0.069. This indicates a potential increase in vegetation or a decrease in barren areas. The class for sparse vegetation saw an increase in its SAVI range to 0.185 to 0.259, suggesting a growth in plant cover in previously sparse areas. Interestingly, the moderate vegetation category remained stable, with values unchanged at 0.185 to 0.259. However, the dense vegetation class expanded to include values from 0.259 to 0.371, indicating an increase in areas classified as dense. Finally, the very dense vegetation category also experienced growth, with its range extending from 0.371 to 0.752.

Overall, the comparison of SAVI values between 2013 and 2024 in Anantapur district reveals significant shifts in vegetation dynamics, with an apparent trend towards increased vegetation density across various classes. This information is vital for understanding ecological changes and guiding future conservation and land management efforts in the region.

Conclusion:

The analysis of NDVI and SAVI values for Anantapur district from 2013 to 2024 reveals significant trends in vegetation health and density, indicating positive ecological changes over the eleven-year period. Both indices demonstrate a marked improvement in vegetation coverage, with NDVI values showing a reduction in barren areas and an overall increase in vegetation health across various categories. The transition from lower NDVI ranges to higher ones suggests enhanced land use practices and possibly successful conservation efforts.

Similarly, the SAVI analysis corroborates these findings, highlighting a shift towards greater vegetation density and a decrease in barren land. The expansion of categories representing sparse, moderate, dense, and very dense vegetation underscores the positive trajectory of the region's ecological landscape.

These findings provide valuable insights into the evolving land use and vegetation dynamics in Anantapur district, reflecting both environmental changes and human influences. The data can serve as a critical resource for guiding future conservation initiatives and land management strategies, ensuring the sustainability of the region's natural resources and promoting ecological resilience. Overall, the analysis indicates a hopeful trend towards improved vegetation health, which is essential for the ecological balance and the well-being of local communities.

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