



Assessment of Climate Change Impacts in Andhra Pradesh Using Spatio-Temporal Ndzi Analysis and Geo-Informatics

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DOI: <https://doi.org/10.68050/JAMS.2026.795>

Received: 02 October 2026; Accepted: 10 October 2026; Published: 17 October 2026

ABSTRACT

A comprehensive spatial analysis of the Normalized Difference Vegetation Index (NDVI) in Andhra Pradesh, focusing on the years 2011 and 2021 to assess changes in vegetation cover over the decade. This analysis intends to understand vegetation dynamics as well as their effects on ecosystem health and land management. We collected data using satellite imagery and NDVI calculations, yielding a quantitative assessment of vegetation cover across categories are sparse, very low, moderate and dense. The method used change detection to identify shifts in vegetation classes and evaluate trends in afforestation and deforestation.

The findings show considerable changes in vegetation cover between 2011 and 2021. Sparse vegetation increased from 40.66 to 44.44% while very low vegetation decreased from 33.71 to 20.91%. Moderate vegetation rose notably from 24.46 to 32.14% and dense vegetation, although minimal, increased from 1.18 to 2.52%. Change detection analysis indicated that 21.74% of the area remained as sparse vegetation, with 12.57% transitioning from sparse to moderate vegetation, indicating localized improvements. However, significant areas of dense vegetation shifted to lower classes, indicating environmental stress. Afforestation efforts accounted for 12.68% of land while deforestation impacted 15.59% causing concerns about ecosystem equilibrium.

In conclusion, the study illustrates a refined connection between vegetation recovery and continuing difficulties related to land degradation and climate change in Andhra Pradesh. The results underline the necessity for strategic land management and conservation initiatives to preserve environmental stability and promote sustainable growth in the region.

Keywords: Afforestation, Deforestation, NDVI, RS & GIS

INTRODUCTION

The Normalized Difference Vegetation Index is a widely used remote sensing tool that uses satellite imagery to assess vegetation quantity and health. It calculates the ratio of near-infrared light, which plants reflect, to red light, which plants absorb. This ratio produces a value that indicates vegetation presence and condition.

In coastal environments, NDVI is used to monitor and manage ecosystems such as mangroves, salt marshes, sea grass beds, and coastal forests. These ecological systems are dynamic and highly sensitive to natural events and anthropogenic activities, including development, pollution and climate change. NDVI helps track vegetation changes, assess environmental impacts and support conservation and restoration efforts.

NDVI has advantages and shortcomings in coastal areas. Coastal environments are highly variable, with frequent changes and mixed land water boundaries, so data interpretation requires caution. Despite these challenges, NDVI remains a valuable tool for monitoring coastal vegetation and supporting sustainable management.

Study area:

Andhra Pradesh is a state situated in the south-eastern region of India, recognized for its diverse geography, rich culture, and significant economic contributions. The state lies between latitudes $12^{\circ}41' \text{ N}$ and 19.07° N and longitudes 77° E and $84^{\circ}40' \text{ E}$. It is bordered by Telangana to the north and west, Chhattisgarh to the northwest, Odisha to the north, the Bay of Bengal to the east, Tamil Nadu to the south and Karnataka to the southwest and west. The total area of state is approximately 275,045 square kilometers, making it one of the larger states in India. The state features a coastline of around 974 kilometers, which is the second longest in the country. The state is characterized by three main physical division's fertile delta areas formed by major rivers such as the Godavari and Krishna, which flow eastward into the Bay of Bengal a range of weathered hills that includes Arma Konda, the state's highest peak and a drier, semi-arid region located in the southwest of the state. Additionally, Kolleru Lake, a significant freshwater body, is situated between the Godavari and Krishna deltas. The state experiences hot summers, a southwest monsoon season and mild winters, with distinct seasonal patterns that influence agriculture and water resources. The state is divided into three primary regions Coastal Andhra, Uttarandhra and Rayalaseema. Among these, Y.S.R.Kadapa is the largest district, covering an area of 12,507 square kilometers. The state is home to several major rivers, including the Godavari, Krishna and Pennar. These rivers are essential for irrigation, drinking water and supporting the local ecosystem (fig.1).

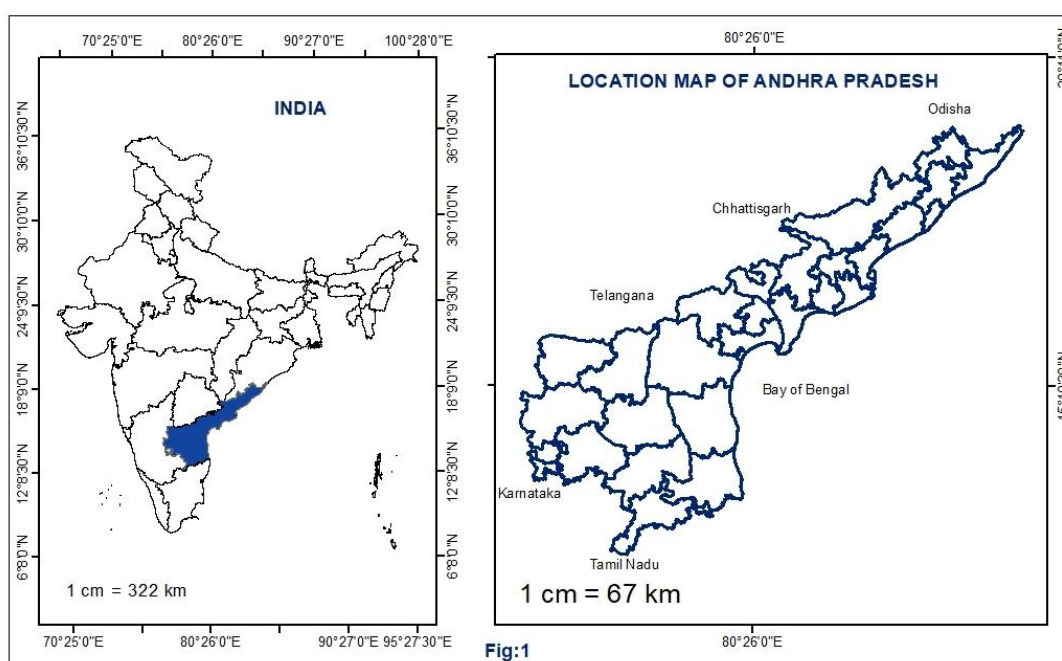


Fig:1

Objectives:

To analyze the Normalized NDVI of healthy vegetation in the state of Andhra Pradesh from 2011 to 2021 by Remote sensing data to measure changes in vegetation health and facility conservation efforts.

To quantify afforestation and deforestation trends in the study area area between 2011 and 2021.

DATA COLLECTION & METHODOLOGY

The collection of secondary data from the Bhuvan portal focuses specifically on the Oceansat-2 Ocean Color Monitor (OCM) data. The aim is to gather relevant information for analysis and research purposes. The primary source of data for this study is the Bhuvan portal.

For the OCM L1C Geo-referenced Data, select data from the eight spectral bands in the Visible and Near-Infrared (VNIR) range. Ensure that the selected data has a spatial resolution of 1 km and coverage. The data formats include Geo-TIFF and Net-CDF. Thresholds should be selected according to the study area's vegetation, season, soil conditions and the statistical distribution of NDVI values. The Normalized Difference

Vegetation Index was computed with NIR (OCM2-B8) and Red (OCM2-B6) bands.

Formula: $NDVI = \frac{NIR-RED}{NIR+RED}$ or $\frac{OCM2-B8-OCM2-B6}{OCM2-B8+OCM2-B6}$

Data Processing:

Once the data is downloaded, it will be processed using appropriate software tool such as ArcGIS to prepare it for analysis. Validate the downloaded data by cross-referencing it with other reliable datasets or ground truth data to ensure accuracy and reliability. The steps detailed above ensure that the collected data is relevant accurate and suitable for subsequent analysis.

Software used: ArcGIS 10.3 and statistical techniques

RESULT & DISCUSSION

A spatial study of the Normalized Difference Vegetation Index across vegetation types in Andhra Pradesh for 2011 and 2021. NDVI is a common tool that uses satellite images to measure how healthy and dense plants are. The land is divided into four groups based on NDVI values are very low vegetation, sparse vegetation, moderate vegetation and dense vegetation. NDVI measures the difference between near-infrared and red light reflected by plants (fig.2, 3 & table.1).

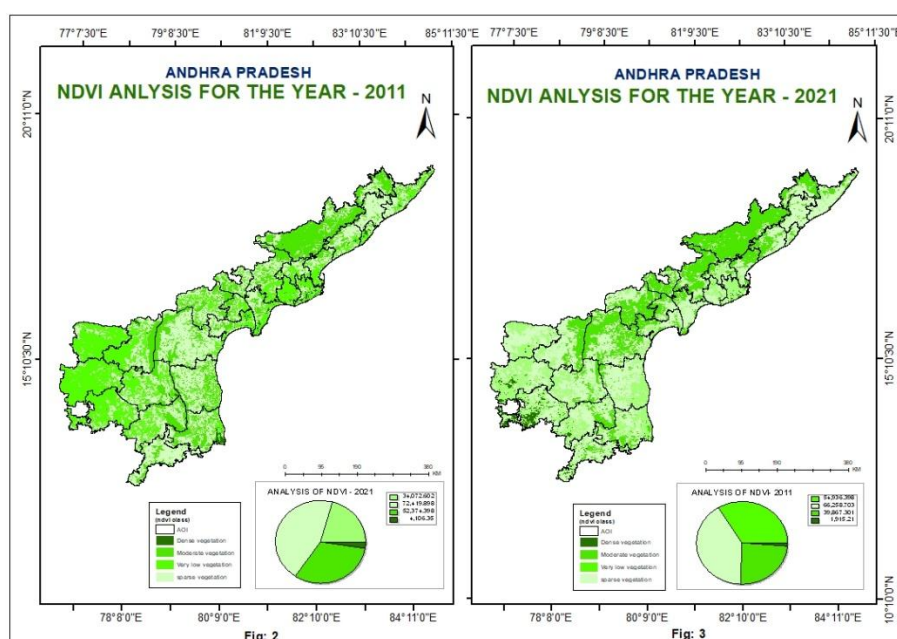


Table: 1

Spatial Analysis of NDVI in Andhra Pradesh- 2011

s.no	Name of the class	2011		2021	
		Area in sq.km	%	Area in sq.km	%
1	Very low vegetation	54936.4	33.71	34072.6	20.91
2	Sparse vegetation	66258.7	40.66	72419.9	44.44
3	Moderate vegetation	39867.3	24.46	52374.4	32.14
4	Dense vegetation	1915.21	1.18	4106.35	2.52



Spatial Analysis of NDVI in Andhra Pradesh- 2011

Sparse vegetation:

The largest proportion of land, accounting for approximately 40.66% or 66,258.7 square kilometers is classified as sparse vegetation. For the category indicate areas where vegetation is present but not densely packed, suggesting a landscape that may be undergoing degradation or is in a transitional state.

Very low vegetation:

Following this, the very low vegetation class encompasses 54,936.4 square kilometers, representing 33.71% of the total area. The classification typically includes regions with minimal plant cover, which could be indicative of arid conditions or land that has been significantly disturbed.

Moderate vegetation:

In contrast, the moderate vegetation class, covering 39,867.3 square kilometers or 24.46% reflects areas with a healthier and more robust plant presence although it still does not reach the density observed in more lush environments.

Dense vegetation:

The dense vegetation category is the smallest, comprising only 1.18 % of the total area or 1,915.21 square kilometers. This classification signifies regions with a high density of vegetation, which is often crucial for biodiversity and ecological stability.

Spatial Analysis of NDVI in Andhra Pradesh- 2021

Sparse vegetation:

The map data reveals that the largest proportion of land, accounting for 44.44 % of the total area, is classified as sparse vegetation, which encompasses an area of 72,419.9 square kilometers. For that indicates that a significant portion of the landscape in Andhra Pradesh is characterized by limited vegetation cover, which may be indicative of environmental conditions or land use practices that hinder more robust plant growth.

Very low vegetation:

In contrast, the class representing very low vegetation occupies 34,072.6 square kilometers, constituting 20.91% of the total area. This suggests that a considerable area is experiencing minimal vegetation, potentially due to factors such as urbanization, agricultural practices, or natural degradation.

Moderate vegetation:

Covering 52,374.4 square kilometers, makes up 32.14 % of the area indicating a healthy level of plant growth that could support local ecosystems and biodiversity.

Dense vegetation:

Dense vegetation: It is the least represented category, with only 4,106.35 square kilometers or 2.52 % of the total area. The low percentage highlights the scarcity of areas with high vegetation density, which is crucial for carbon sequestration, habitat provision, and overall ecological balance.

Change Detection of NDVI for the period 2011 to 2021:

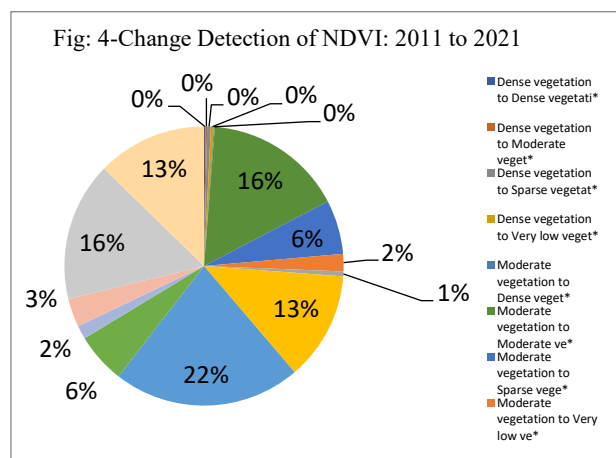
A detailed analysis of the changes in the Normalized Difference Vegetation Index across various vegetation classes in region over a decade, from 2011 to 2021. The table categorizes the transitions between different

vegetation types, providing both the area affected by these changes in square kilometers and the corresponding percentage of the total area analyzed (table.3 & fig.4).

Table: 3

NDVI Change Detection of Andhra Pradesh: 2011 to 2021

s.no	Change Detection of Classes	Area in sq.km	%
1	Dense vegetation to Dense vegetation	291.04	0.18
2	Dense vegetation to Moderate vegetation	296.68	0.18
3	Dense vegetation to Sparse vegetation	691.94	0.43
4	Dense vegetation to Very low vegetation	550.08	0.34
5	Moderate vegetation to Dense vegetation	174.17	0.11
6	Moderate vegetation to Moderate vegetation	26131	16.11
7	Moderate vegetation to Sparse vegetation	10153.5	6.26
8	Moderate vegetation to Very low vegetation	3263.02	2.01
9	Sparse vegetation to Dense vegetation	920.04	0.57
10	Sparse vegetation to Moderate vegetation	20388.8	12.57
11	Sparse vegetation to Sparse vegetation	35251.4	21.74
12	Sparse vegetation to Very low vegetation	9472.1	5.84
13	Very low vegetation to Dense vegetation	2531.8	1.56
14	Very low vegetation to Moderate vegetation	5353.34	3.3
15	Very low vegetation to Sparse vegetation	26092.9	16.09
16	Very low vegetation to Very low vegetation	20621.8	12.72



The data reveals that the most significant area, 35,251.4 sq.km or 21.74% remained as sparse vegetation, indicating a stable state within this category. In contrast, the transition from sparse vegetation to moderate vegetation accounted for 20,388.8 sq.km representing 12.57 % of the total area suggesting a notable increase in vegetation density in certain regions. The transition from moderate vegetation to moderate vegetation itself was substantial, covering 26,131 sq.km, which is 16.11 % of the area indicating areas that maintained their vegetation status over the decade.

On the other hand, the shifts from dense vegetation to lower vegetation classes, such as sparse and very low vegetation, were also significant, with areas of 691.94 sq.km (0.43%) and 550.08 sq.km (0.34%) respectively. These transitions may reflect environmental stressors or land-use changes impacting the dense vegetation zones. Conversely, the transition from very low vegetation to sparse vegetation was considerable, covering 26,092.9 sq.km (16.09%) suggesting some recovery or improvement in vegetation health in previously degraded areas.

The analysis of vegetation cover in Andhra Pradesh shows a mix of conditions, with a notable presence of sparse and very low vegetation. For that situation raises alarms about land degradation and climate change, stressing the need for sustainable land management practices. Meanwhile, the few areas with dense vegetation underscore the urgent need for conservation efforts to protect these vital ecosystems. The data reveals a complex relationship between stability and change in the region's vegetation, pointing to both challenges and opportunities for recovery.

Afforestation & Deforestation:

Afforestation involves establishing trees in areas without prior tree cover to create new forests, helping to fight climate change improvement biodiversity and recover soil quality while also offering economic benefits. In contrast deforestation is the large scale removal of trees for agriculture, urban growth or sorting leading to environmental harm increased greenhouse gas releases and trouble of water cycles.

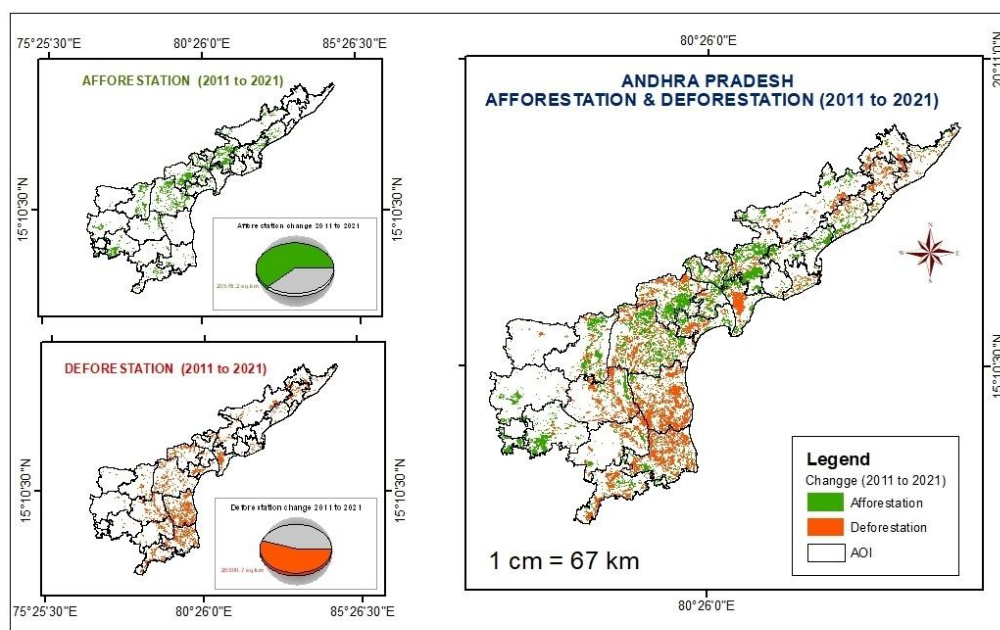


Fig.5

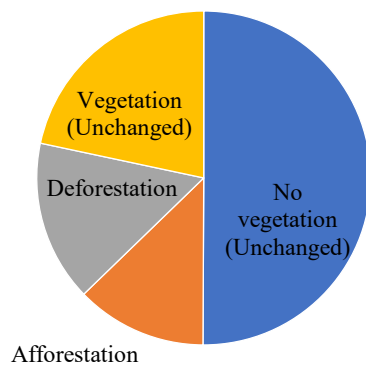
Table: 4

Andhra Pradesh

Analysis of Afforestation and Deforestation: 2011 to 2021

s.no	Change of Class	Area change in sq.km	%
1	No vegetation (Unchanged)	81256.7	50.07
2	Afforestation	20576.2	12.68
3	Deforestation	25300.7	15.59
4	Vegetation (Unchanged)	35144.6	21.66

Fig:6- Analysis of Afforestation & Deforestation : 2011 to 2021



Analysis of Afforestation and Deforestation from 2011 to 2021

The map (fig.5 & 6) and pie chart presents a detailed analysis of land cover changes in Andhra Pradesh from 2011 to 2021, focusing specifically on afforestation and deforestation trends. The data is categorized into four distinct classes, each representing different changes in vegetation cover (table.4).

No vegetation (Unchanged):

The first category, accounts for a significant area of 81,256.7 square kilometers, which constitutes approximately 50.07 percent of the total land analyzed. This indicates a substantial portion of the region has remained devoid of vegetation over the decade, suggesting stability in areas that are either barren or have not been subject to any vegetative growth.

Afforestation:

In contrast, the afforestation efforts in the state have resulted in an increase of 20,576.2 square kilometers, representing 12.68 percent of the total area. This positive change highlights the initiatives taken to restore and enhance forest cover, reflecting a commitment to environmental sustainability and biodiversity conservation.

Deforestation:

On the other hand, deforestation has led to a loss of 25,300.7 square kilometers, which is about 15.59 percent of the total area. This figure raises concerns regarding the environmental impact of land-use changes, as deforestation can lead to habitat loss, increased carbon emissions, and disruption of local ecosystems.

Vegetation (Unchanged)

Lastly, the category shows a change of 35,144.6 square kilometers, making up 21.66 percent of the area. This suggests that while some regions have experienced deforestation, others have maintained or improved their vegetative cover, possibly due to natural regeneration or effective management practices.

The analysis indicates a complex interplay between afforestation and deforestation in Andhra Pradesh, with a notable amount of land remaining unchanged in terms of vegetation. The data underscores the need for continued monitoring and strategic planning to balance development with ecological preservation in the region.

CONCLUSION

Spatial analysis of the Normalized Difference Vegetation Index in Andhra Pradesh from 2011 to 2021 reveals key insights into the region's vegetation dynamics. The findings indicate that sparse and very low vegetation



predominates, raising concerns about land degradation and the impacts of climate change. The increase in sparse vegetation from 40.66 percent to 44.44 percent over the decade suggests that environmental stressors and land-use practices may be hindering the growth of more robust plant communities. Conversely, the shift from sparse to moderate vegetation highlights positive trends in vegetation recovery, indicating that certain regions are experiencing improved plant health. The analysis of afforestation and deforestation trends further underscores the complexity of land cover change in Andhra Pradesh. While afforestation efforts have increased forest cover by 12.68 percent, the 15.59 percent loss of land to deforestation remains a significant challenge. This duality underscores the urgent need for sustainable land management practices that can mitigate deforestation's adverse effects while promoting afforestation initiatives. Moreover, the substantial area of land with unchanged vegetation suggests that some regions have stabilized or are undergoing natural regeneration. This stability provides an opportunity for targeted conservation efforts to protect existing ecosystems and enhance biodiversity.

In conclusion this study's data highlight the intricate balance between human activities and ecological health in Andhra Pradesh. It calls for a concerted effort from policymakers, conservationists, and local communities to implement sustainable practices that foster both economic development and environmental stewardship. Continued monitoring and strategic planning will be essential to ensure the resilience of the region's ecosystems amid ongoing environmental challenges.

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