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Satellite-Based Vegetation Monitoring in Charkhi Dadri District: Trends of Deforestation and Afforestation from 1995 to 2024

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Abstract
Using high-resolution satellite imagery from USGS Landsat 5 and Landsat 9, this study looks at the vegetation dynamics of Charkhi Dadri district, Haryana, India, from 1995 to 2024, with an emphasis on afforestation and deforestation patterns. By using spectral analysis and indexes like the NDVI, these datasets were crucial in identifying changes in the vegetative cover. According to the report, urbanization, mining, and agricultural growth were the main causes of the deforestation that resulted in the loss of 545.08 sq. km of vegetation. This is the study's unfavourable conclusion. Afforestation operations, on the other hand, resulted in the recovery of 160.85 sq. km, indicating that reforestation efforts were successful in some places. 323.55 square kilometres have unaltered vegetation, whereas 351.88 square kilometres are completely devoid of vegetation.
The district's southern and southwestern areas, where deforestation is most prevalent, show a net loss of vegetation, according to these data. In spite of that, reforestation initiatives in the central and northeastern regions demonstrate beneficial ecological interventions. Vegetation patterns in Charkhi Dadri are greatly influenced by the semi-arid environment, little groundwater, unequal rainfall distribution, and human activity.
In order to address the high pace of deforestation, this study highlights the necessity of more robust conservation laws, sustainable land use practices, and improved afforestation initiatives. It emphasizes how crucial it is to strike a balance between environmental sustainability and development in order to preserve the district's ecological integrity and keep its primarily agrarian economy.
Keywords: Charkhi Dadri, Normalized difference vegetation index (NDVI), afforestation, deforestation, Landsat 05 and 09, remote sensing and GIS.

Name of the Sub- theme: Urban challenges and climate resilience.

Introduction

One of the most important ecosystems on the planet, forests are crucial for preserving ecological balance and fostering biodiversity. Forests play an important role in the global climate system by providing essential oxygen, carbon sequestration, and water filtration. "Just 3.59% of Haryana's land area is covered by forests" (Forest Survey of India, 2020). However, human activities like illicit logging, deforestation, and land conversion for agriculture pose serious dangers to forests. These actions exacerbate climate change by causing habitat loss, decreased biodiversity, and greenhouse gas emissions.

Deforestation is the process of removing or destroying forests on a big scale. The strictest definition of deforestation is the substitution of non-forest for forest. Deforestation is implicitly assumed by the World Bank and FAO to include both temporary and permanent reduction of forest cover.

"The process of clearing forests for agriculture, logging, or other purposes, leading to the permanent loss of tree cover and its associated ecological services" is how **Houghton (2005)** defined deforestation.

However, reforestation—the act of growing trees in previously unforested areas—offers a method to improve biodiversity, restore ecological balance, and slow down climate change.

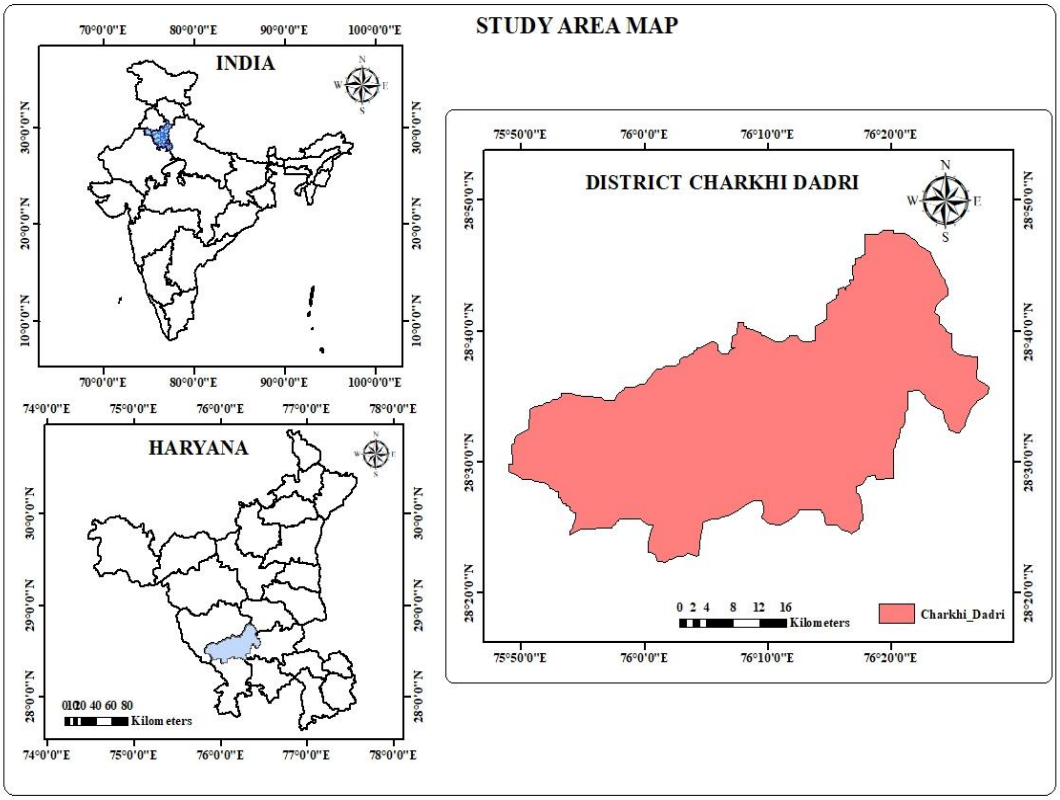
“Afforestation is the practice of growing trees on terrain that was not previously covered by forests”, according to Indian geographer **R. L. Singh**. Singh highlights how crucial afforestation is to halting soil erosion, halting desertification, and reestablishing ecological equilibrium, especially in regions of India where deforestation is occurring. Investigating Charkhi Dadri's afforestation and deforestation trends, evaluating the success of ongoing afforestation initiatives, and examining the socioeconomic effects of these environmental shifts on nearby populations are the objectives of this study. Additionally, it aims to pinpoint the main causes of deforestation in the area and provide viable approaches to sustainable forest management that can lessen environmental deterioration. By comprehending these patterns and the difficulties they present, this study supports initiatives to advance ecological sustainability. In This study supports initiatives to promote ecological sustainability in Charkhi Dadri and other areas of a similar nature throughout Haryana by recognizing these trends and the difficulties they present.

Study Area

On November 16, 2016, the district of Charkhi Dadri, located in the southwest of Haryana, India, became its own independent 22nd district. District Charkhi Dadri is situated between latitudes 28.5921° N and longitudes 76.2653° E. It possesses geographical and climatic characteristics typical of the semi-arid regions of northern India and is bounded by the districts of Bhiwani, Jhajjar, and Rewari. With agriculture as the main economic sector, the district encompasses both rural and urban environments. It is distinguished by its distinct topography, which includes rocky terrain, undulating hills, and a variety of natural landscapes that play an important part in the region.

With an average elevation of about 215 meters above sea level, the Aravalli Mountain range, India's oldest, offers a distinctive topographical contrast to the rest of Haryana, which is primarily flat. Because of its semi-arid climate, Charkhi Dadri has historically had little forest cover. Nonetheless, the nearby Aravalli Hills support its biodiversity and serve as a natural barrier to prevent Rajasthani desert encroachment. The district's trees are essential for preventing soil erosion and replenishing groundwater. Natural vegetation has declined as a result of the region's terrain being drastically changed by mining operations, rapid urbanization, and agricultural growth. Agriculture and livestock are the main sources of income in Charkhi Dadri, which puts more strain on the region's natural resources.

Significance as a Study Area: The district is ideally situated to examine afforestation and deforestation patterns in a semi-arid setting due to its proximity to the Aravalli range. Its environmental problems, such as the threat of desertification, the loss of biodiversity, and shifting land-use patterns, offer a microcosmos of larger ecological and development problems in India's semi -arid regions. understanding the balance between development and environmental sustainability is made easier by studying Charkhi Dadri, especially in areas with comparable ecological and socioeconomic challenges



Government initiatives to expand forest cover have been put in place over time, including the Green Haryana Mission and tree planting campaigns. Water scarcity, low sapling survival rates, and problems with community engagement have all been obstacles to these initiatives. The natural health of the area is nevertheless seriously threatened by illegal forestry, Aravalli mining, and growing urban developments.

Review of literature

Deforestation is becoming a bigger problem in Haryana and the adjacent areas, according to several research. In his work "Impact of Agricultural Expansion on Forest Cover in Haryana," Singh (2012) examines how the growth of agricultural land contributes to the loss of forest areas. Singh contends that deforestation has been mostly caused by agricultural practices, especially in the rapidly urbanizing areas of Gurugram and Faridabad. **Singh (2012)**

In the article "Urbanization and its Impact on Deforestation in Haryana," Gupta (2015) emphasizes the link between deforestation and industrialization. Gupta notes that significant

deforestation has occurred in the surrounding areas as a result of urban growth, especially in and around places like Gurugram. **Gupta (2015)**

In "Afforestation Programs in Haryana: A Step Towards Green Development," Rao et al. (2018) talk about the state-run Green Haryana Mission, which tries to expand the state's forest cover. Although more people are planting trees as a result of the program, the authors point out that there are still issues with implementation, land deterioration, and inadequate monitoring. According to the study, afforestation has not been enough to offset the ongoing deforestation, despite the initiative. **(Rao et al. 2018)**

In "Deforestation in the Aravalli Range: Environmental Consequences," Sharma and Gupta (2016) investigate the ecological effects of deforestation in the Aravalli Hills. According to the report, the Aravalli range's deforestation has resulted in soil erosion, decreased water retention, and loss of biodiversity.

Dhanwantri et al. (2021): Their study sheds light on the effects of deforestation, mining, and fast urbanization in Haryana's Aravalli region, especially in the vicinity of Gurugram. The study highlights how urgently afforestation projects are needed to replenish lost forest cover and lessen soil erosion and degradation brought on by human activity. They support the use of remote sensing and GIS to track trends in deforestation and the effectiveness of afforestation initiatives. **Dhanwantri et al. (2021)**

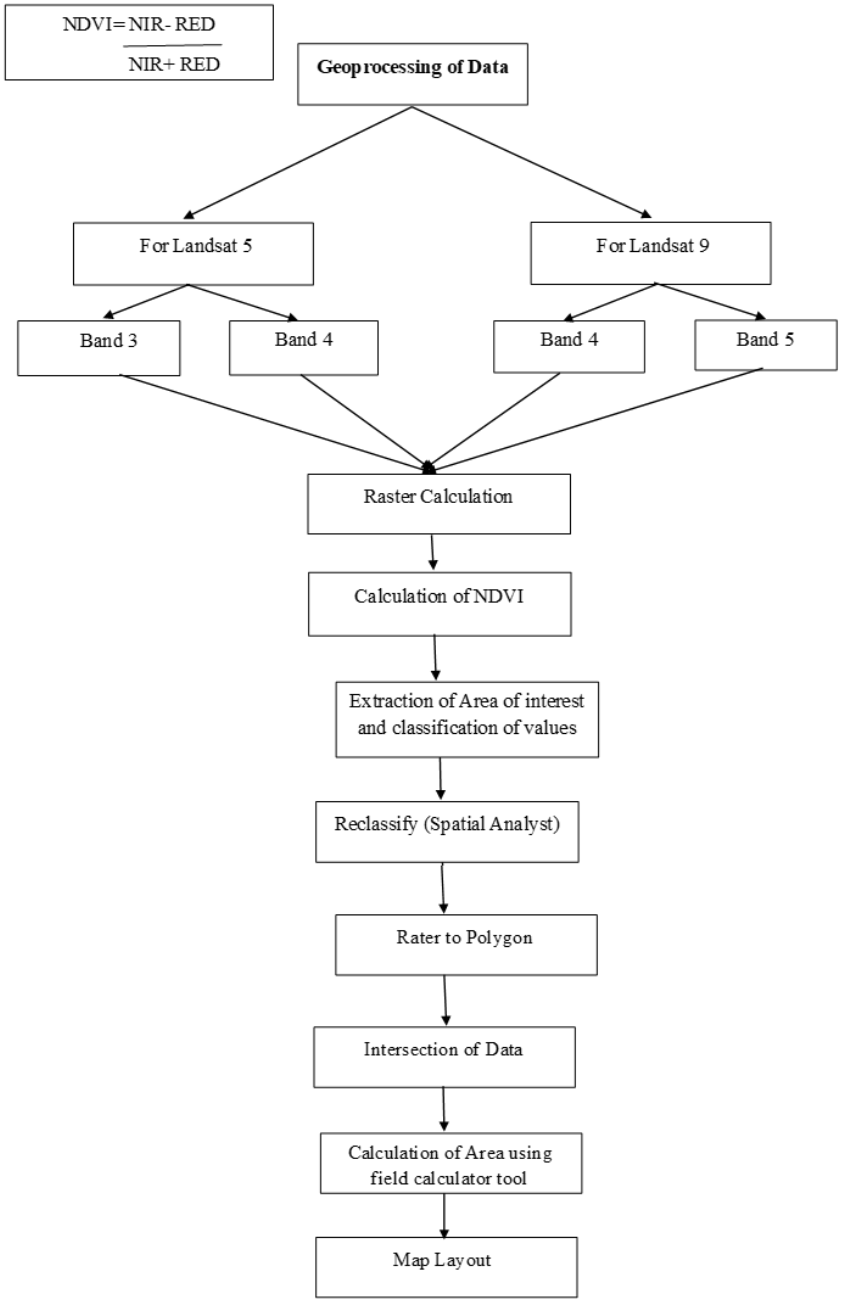
Rani Singh (2014): Singh investigates how local ecosystems are impacted by overgrazing, deforestation, and climate change in her study on ecological degradation in the Aravalli region, which stretches into Haryana. Her research demonstrates that substantial forest loss has resulted from rising human activity and declining rainfall, necessitating restoration initiatives like afforestation to restore the area's biodiversity and soil health. **Singh Rani (2014)**

There is currently little study specifically on Dadri, and these all-research publications lack long-term data on the efficacy of afforestation activities in the area, despite the fact that previous studies offer insightful information about deforestation and afforestation patterns in Haryana and comparable locations. Many studies, like Dhanwantri et al. (2021), concentrate on the short-term effects of mining and urbanization but do not offer long-term tracking of afforestation programs and their effectiveness in terms of soil recovery and biodiversity restoration. By analyzing the patterns of afforestation and deforestation in Charkhi Dadri from 1995 to 2024, this study seeks to close these research gaps.

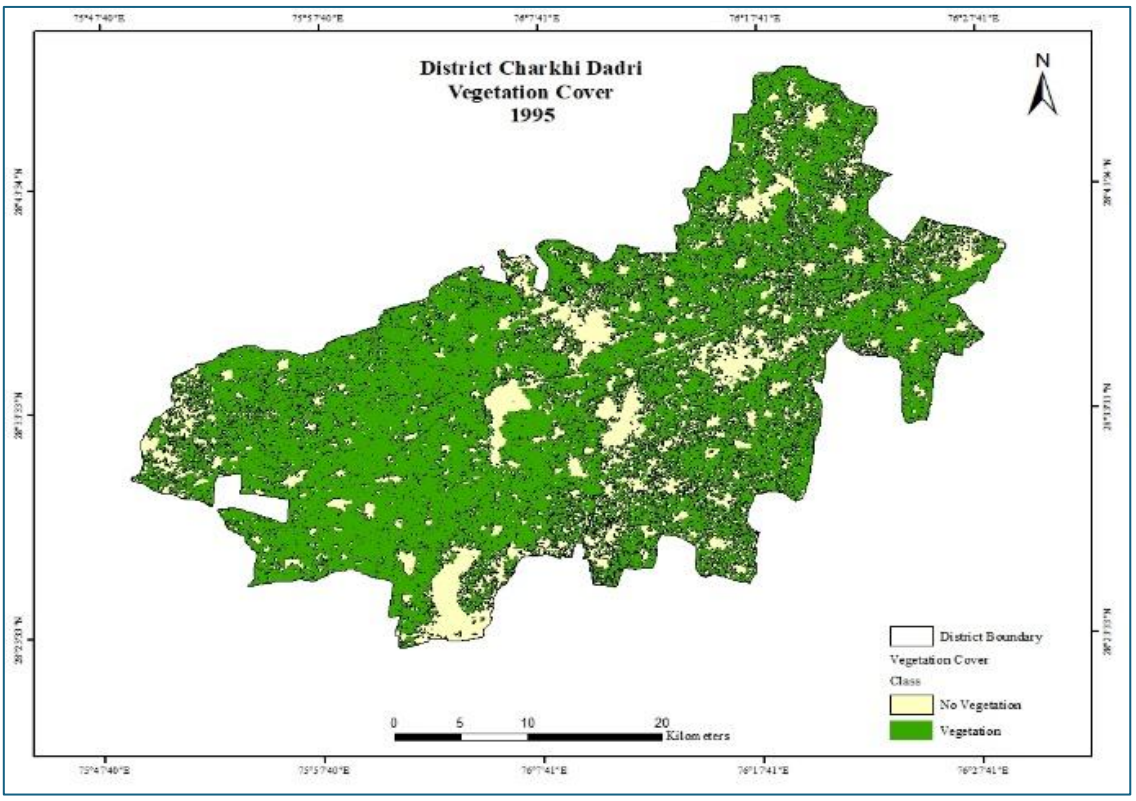
Methodology

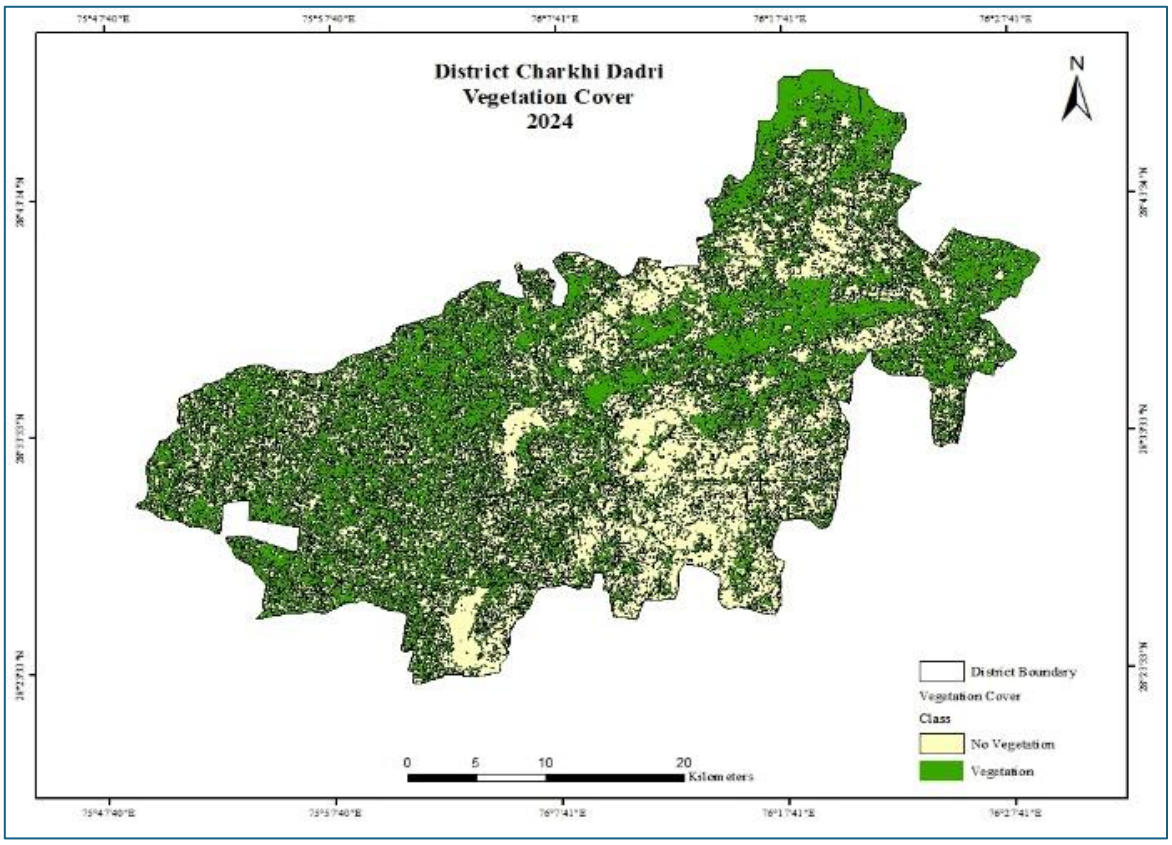
The USGS Earth Explorer platform provided the Landsat 5 and 9 imageries used in this investigation. For analysis, cloud-free imagery was given priority in order to guarantee a precise assessment of the vegetation. Examine the patterns of afforestation and deforestation in the research region with these Landsat images:
LC09_L1TP_147040_20240408_2024_04_08_02_T1,
LT05_L1TP_147040_199550316_20200912_02_T1

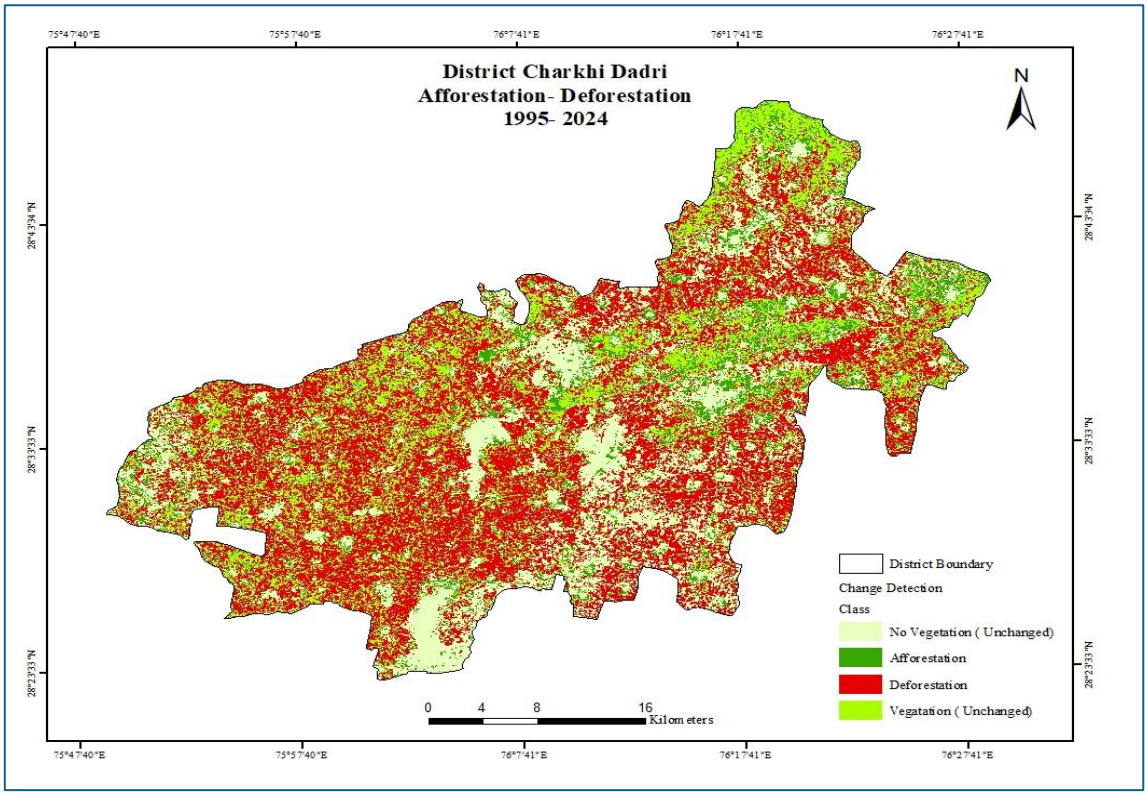
Images from Landsat 5 To examine changes in vegetation and land cover, Bands 3 (red, 0.63–0.69 µm) and 4 (near-infrared, 0.76–0.90 µm) were used. Images from Landsat 9 The usage of Bands 4 (red, 0.64–0.67 µm) and 5 (near-infrared, 0.85–0.88 µm) ensured consistency and comparability with previous results. Using ArcGIS and Qgis software, the study region encompasses the Charkhi Dadri district in Haryana, with an emphasis on determining changes in afforestation and deforestation from 1995 to 2024. To guarantee spatial alignment, every image was georeferenced to a single coordinate system (WGS 84, UTM Zone 43N). The Normalized Difference Vegetation Index, or NDVI for short, is a widely used tool for analyzing sensor data to determine the density and health of vegetation.



Result and Discussion







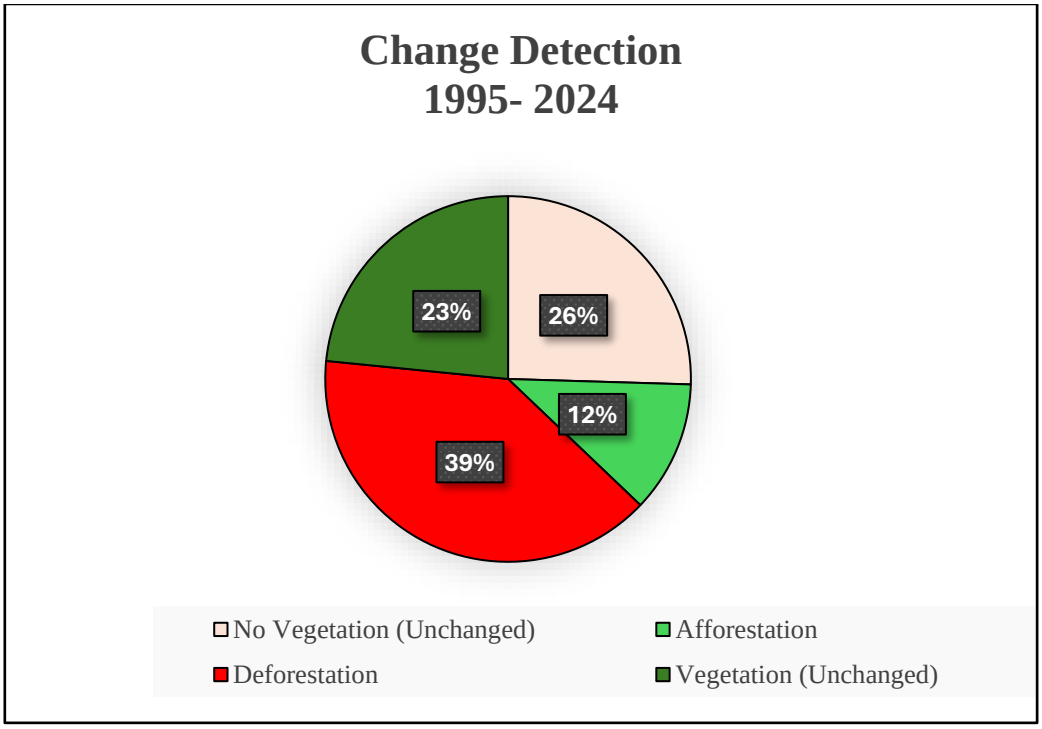
Light Green Areas (Unchanged Vegetation): These are regions where, from 1995 and 2024, the amount of vegetation stayed constant. mostly found in the center and northern areas, with vegetation remaining stable remain stable over the time

Green Areas (Afforestation): These regions exhibit newly planted vegetation as a result of either natural or man-made initiatives, such as plantation drives, discovered sporadically throughout the district, especially in the central and northeast regions, suggesting a favourable ecological improvement.

Red Areas (Deforestation): These are areas where the amount of vegetation has drastically declined over time, mostly in the south, southwest, and portions of the southeast, most likely as a result of industrialization, agriculture, or urbanization.

Yellow Areas (Unchanged Non -Vegetation): These are regions that did not have any vegetation in 1995 or 2024. primarily found in the southwest and south.
The vegetation cover in Charkhi Dadri changed significantly between 1995 and 2024, according on an analysis of satellite images from USGS Landsat 5 and Landsat 9

No Vegetation (Unchanged)	351.88
Afforestation	160.85
Deforestation	545.08
No Vegetation (Unchanged)	323.55



The data shows notable changes in land cover, with 160.85 sq. km of newly afforested regions being overshadowed by 545.08 sq. km of deforestation. While 351.88 sq. km of land is left without vegetation during the course of the period, 323.55 sq. km of land is covered by unaltered vegetation, suggesting areas with stable ecological conditions.

conclusion

Despite modest gains from afforestation (160.85 sq. km), the analysis of Charkhi Dadri's vegetation from 1995 to 2024 shows a considerable net loss in vegetation owing to deforestation (545.08 sq. km). This disparity emphasizes how urgently better conservation initiatives and sustainable land management are needed to preserve current vegetation and repair degraded areas.

Over the time

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