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Assessment And Evaluation Of Long – Term Vegetation Change Using Normalized Difference Vegetation Index (Ndvi): A Three Decade Case Study In Rampurhat I Cd Block Of Birbhum District, West Bengal, India

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***Abstract*:** Vegetation is a vital component of the earth's surface, plays a crucial role in maintaining ecological balance, influencing biodiversity, hydrological cycle and regulating local climate. It acts as carbon sink of nature by absorbing CO_2 from atmosphere during photosynthesis process. But in present vegetation experiences substantial changes across the world due to many physical and human activities, which become the principal factor of environmental degradation. This present study aims to examine temporal vegetation dynamics in Rampurhat I CD Block characterised by rural-urban landscape, of Birbhum district, West Bengal, using NDVI, one of the most crucial techniques of remote sensing, derived from Landsat imagery of 1994, 2004, 2014, & 2024. All NDVI rasters were classified into four categories of vegetation density. Change detections were performed for three decadal intervals by differencing NDVI rasters and applying a ±0.02 threshold to detect loss, no change and vegetation gain zones. Results are showing considerable decline in vegetation cover, particularly between 1994 and 2004, moderate recovery during 2004 – 2014 and renewed decline in most recent decade. Urban area exhibits low vegetation density likely due to urban expansion while, rural areas have moderate to high density but experienced gradual decline due to agricultural development. Field survey, conducted both in urban and rural regions confirmed this analysis. The findings of this research emphasize on the urgency of sustainable land use management and recourse planning to preserve ecological integrity within the study region.

***IndexTerms* -** Vegetation Change, NDVI, Remote sensing, Change detection, Change detection

I. INTRODUCTION

Vegetation is the life giving resources of nature, essential for sustaining a healthy planet, maintaining ecological balance, supporting biodiversity and providing countless benefits for humans and the environment. Vegetation plays an important role in regulating the climate by influencing temperature, rainfall patterns, humidity and CO_2 levels. It acts as a Carbon sink which absorbs the CO_2 during photosynthesis process and reduce the greenhouse effect and mitigate the temperature extreme. Also Plants release Oxygen that is vital for Human and animal respiration. Vegetation plays a crucial role in regulating the hydrological cycle by influencing the rainfall, surface runoff and groundwater recharge. Forests help to maintain the water quality by filtering the pollutants. It regulates the river flow and reduces the risk of hazards like Flood and Drought.

However, over the past few decades, vegetation cover is undergoing significant changes globally due to many factors like climate, soil and human activities. These changes include mainly shifts in vegetation types, expansion or contraction of forests, grasslands or agricultural lands and alteration in the timing of vegetation growth. Climate change, rapid urbanization, deforestation, mining and many of other undesirable human actions have led to widespread degradation of vegetation cover in many parts of the world. Simultaneously, afforestation efforts, reforestation and shift in land use have contributed vegetation gains in certain regions.

Understanding these changes is very crucial, not only for ecological conservation but also for sustainable planning of land use management and climate resilience. To monitor and assess these spatio-temporal changes in vegetation, Normalized Difference Vegetation Index (NDVI) has been emerged as one of the most important and effective Remote sensing tools. NDVI analysis is crucial for vegetation monitoring because it provides standardised measure of vegetation health and density using remotely sensed data. It helps researchers in studying vegetation health, detecting changes over time and monitoring the recovery of vegetation after disturbances.

This present study focuses on Rampurhat I CD Block of Birbhum district, located in the western part of West Bengal, India, which is characterised by rural-urban landscape with a mixed land use patterns comprised of agricultural lands, settlements, fallow lands and forest patches. Over the years this region has experienced notable changes in land use patterns due to socio-economic development, shifts in agricultural practices and infrastructure development. This research aims to assess this transformation by NDVI change analysis from 1994 to 2024 by visualizing and quantifying vegetation changes using maps and statistics, identifying zones of vegetation gain and loss through change detection maps, and by field observation. This analysis attempts in providing valuable insights for sustainable land use planning, environmental monitoring, resource management and policy making in semi-urbanizing regions like Rampurhat I CD Block.

1.1 Objective of Research:

1) To assess and evaluate the spatio-temporal transformation in vegetation cover in Rampurhat I CD Block from 1994 to 2024 using Normalized difference Vegetation Index (NDVI)
2) To identify vegetation gain and loss zones through NDVI based change detection analysis, area calculation and field observation.

II. STUDY AREA

Rampurhat I CD Block is Located in the western part of the Birbhum district of West Bengal, India. Birbhum district is a part of ancient rarh region. Western part of this district is generally a part of Choto Nagpur region. This region mostly has reddish lateritic soil of low fertility. But on the eastern part there are flood plains of major rivers like, Ajay, Mayurakshi, Barakeshwar and Brahmani, that have fertile alluvial soil.

Rampurhat I CD block is the part of Brahmani-Mayurakshi basin, occupying the area between Brahmani river in north and Mayurakshi river in south. Geographically it is located at 24.1860556°N and 87.781944°E. It has total area of about 283.63 km^2. It is bounded by Nalhati I CD Block to the north, Rampurhat II CD Block to the east, Mayureshwar I and Mahammad Bazar CD Block to the south and Shikaripara CD Block of Dumka (Jharkhand) to the west. This Block is predominantly rural, with a small urban area. The rural area is characterised by villages and agricultural land. Rampurhat town is the urban center of this block, providing various services including, education, banking, health etc.

This region is characterised by sub-tropical monsoon. Agricultural land is the dominant land use. The main growing crops are Paddy, Wheat, Potato, Sugar cane, and also oil seeds, pulses etc. However, in recent years, population growth, urban area expansion, infrastructural development, shifting land use practices etc. have brought notable transformation in the vegetation cover.

This block includes both rural and urban area, making it ideal for assessing the transformation of vegetation under the influence of urban area expansion and land use changes. Hence this present study uses NDVI based analysis to study spatio-temporal changes from 1994 – 2024, providing valuable insights to land use planners for sustainable resource management, environmental researchers and policy maker

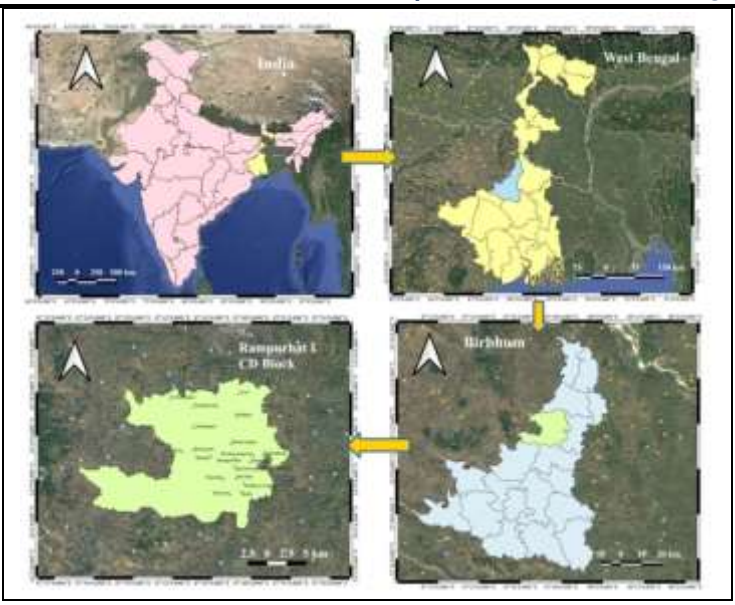

Figure 1: Location map of study area

III. DATA SOURCE AND RESEARCH METHODOLOGY

In this present research we choose Rampurhat I CD block of Birbhum district as study region for vegetation change analysis. It is a region, consisting of predominantly rural area with small urban patches. This research is done using Landsat 5 TM, Landsat 7 ETM+ and Landsat 9 OLI-2 imagery and by conducting field survey in both urban and rural area to track the changing dynamics and differential spatial distribution of vegetation covers within the study region. For field observation, the Rampurhat urban area (municipal limits) and some surrounding rural regions like, Barshal, Belia, Madhya Gopalpur, Srikrishnapur Pakhuria etc. have been selected.

Landsat imageries obtained from USGS Earth Explorer were processed in Google earth engine (GEE) using JavaScript to create NDVI maps for four selected year: 1994, 2004, 2014 and 2024. All images were atmospherically and radiometrically corrected, clipped to study area and cloud masked. After processing in GEE the NDVI rasters were exported and reclassified into four categories of vegetation density such as, Low, Moderately low, Moderate and High in ArcGIS 10.8 software. Area under each classes was calculated for all selected years. Change detection was also performed for three decades to assess vegetation loss, no change and gain zones using a ±0.02 threshold. An Accuracy assessment was conducted by generating 80 equalized stratified random points ArcGIS, validated with Google earth pro and computing a confusion matrix. During field survey we take photographs of vegetation and land cover and interacted with both urban and rural people and documented their words to validate the remote sensing analysis. All outputs are presented through thematic maps, table of area calculation, graphs and field photographs.

Combining all methods and approaches we achieved the aim to assess and evaluate the changing dynamics of vegetation cover in Rampurhat I CD block over past three decades.

Table 1: Details of Satellite data sources used in NDVI analysis

Year	**Satellite**	**Sensor**	**Spatial resolutions (m)**	**Source**
1994	Landsat 5	TM	30	USGS Earth Explorer
2004	Landsat 5	TM	30	USGS Earth Explorer
2014	Landsat 7	ETM+	30	USGS Earth Explorer
2024	Landsat 9	OLI-2	30	USGS Earth Explorer

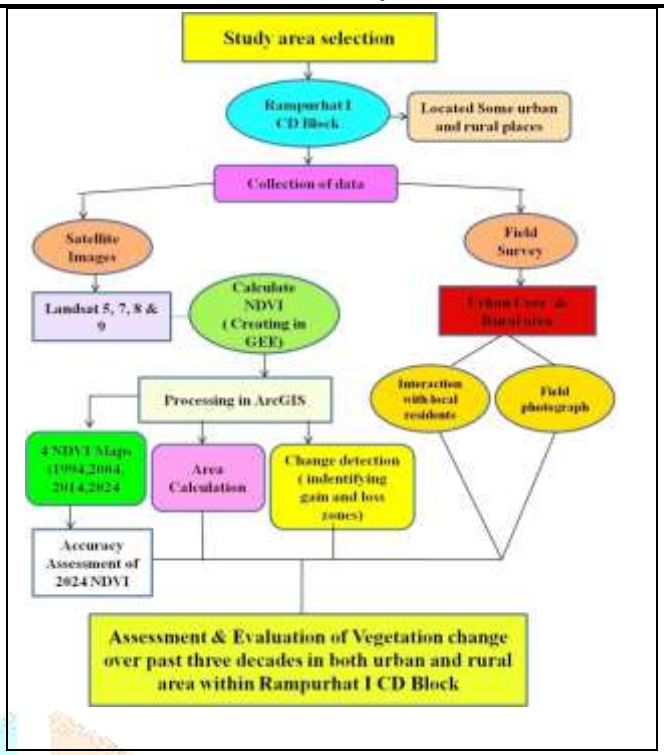

Figure 2: Methodological framework for this present study

IV. RESULT AND DISCUSSION

4.1 Temporal NDVI analysis (1994, 2004, 2014 and 2024):

NDVI or Normalized Difference Vegetation Index is one of the most important Remote sensing techniques, which is essential for studying the vegetation cover. It is useful for measuring vegetation density, vegetation health and assessing the transformation over time. It is an important indicator that is used to study the degradation of ecosystem vegetation and decrease in green (Meneses-Tovar, C. L., 2011). NDVI also helps to monitor crop health, detect stress and to estimate crop yields by assessing overall health and biomass of crop. It works by analyzing the absorption and reflection of different wavelengths of light, particularly in the visible and near-infrared spectrum. NDVI is calculated by a formula that normalizes the difference between near-infrared (NIR) and red light reflectance. The value ranges of NDVI are between -1 to +1. Close to +1 value indicates high vegetation cover. Values near 0 indicate sparse vegetation, bare soil or non vegetated areas. Negative values suggest water bodies or non vegetated areas.

This present study aims to explore the spatio-temporal analysis of vegetation with interval of 10 years. There are four NDVI maps that are used to track the transformation of vegetation cover from 1994 to 2024 in the Rampurhat I CD Block.

The four NDVI maps (Fig. 3) show the spatial distribution of vegetation cover over time. In 1994 there was a dominance of Moderate vegetation and a notable portion of high vegetation, indicating healthier vegetation environment. However, a sharp decline is observed with expansion of low vegetation to 88.05 km2, while high vegetation completely disappeared, indicating significant degradation possibly due to land use conversion due to anthropogenic pressure or climatic factor. in 2014 we show that moderately low vegetation increased to 230.28 sq. km but the moderate and high vegetation remained low, reflecting long term stress on vegetation health. By 2024 the study region shows some signs of recovery where moderate vegetation increases to 69.48 and a minor return of high vegetation (0.03 sq. km). The bar chart is the visual representation of this trend, highlighting the initial decline and gradual regeneration.

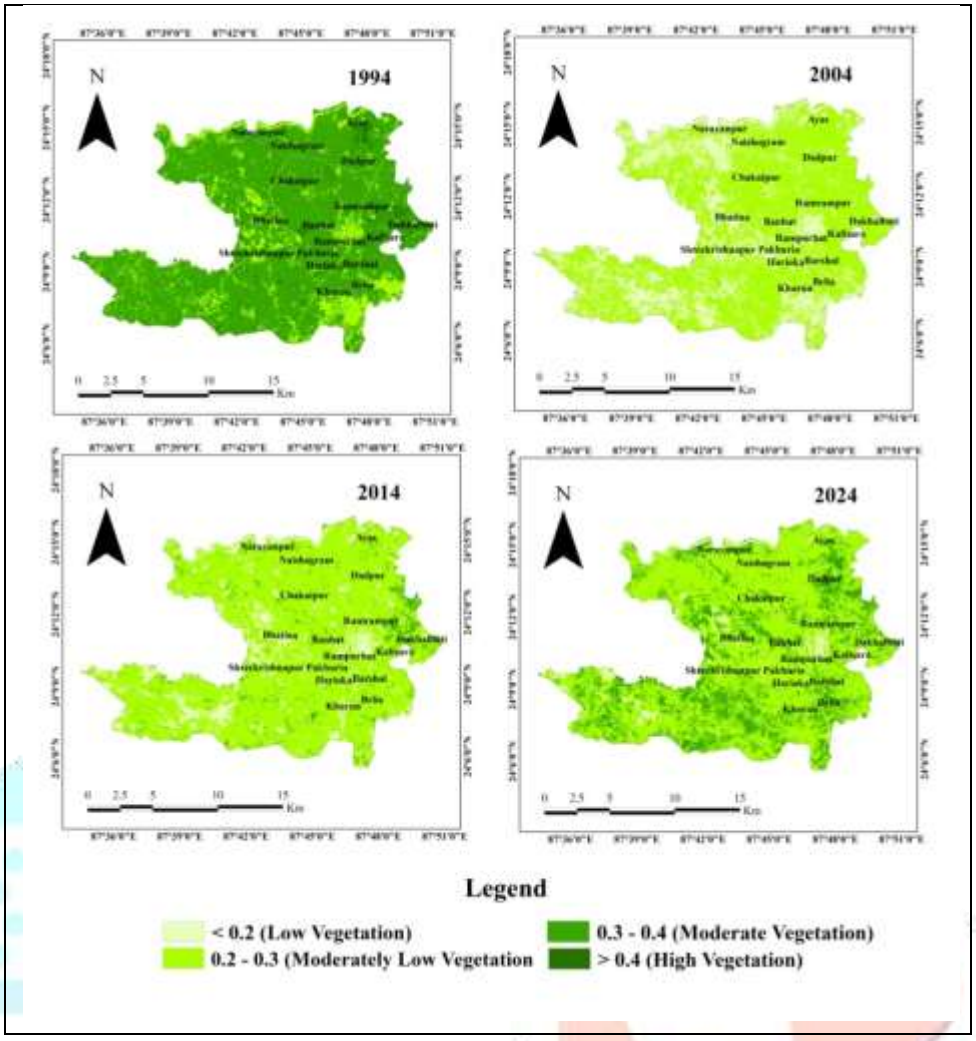

Figure 3: NDVI maps of Rampurhat I CD Block

The overall trend indicates a phase of initial vegetation loss subsequently followed by partial recovery possibly caused by land use change, intensive cultivation or environmental factors. This suggests the need of implementing sustainable land management strategies to ensure ecological stability in the region.

Table 2: Area statistics of each NDVI classes in the sudy area for the years 1994, 2004, 2014 & 2024 (in km^2)

Year	Low (< 0.2)	Moderately Low (0.2 – 0.3)	Moderate (0.3 – 0.4)	High (> 0.4)
1994	0	45.28	228.04	11.03
2004	88.05	195.95	0.34	0
2014	39.45	230.28	14.61	0
2024	13.95	200.89	69.48	0.03

4.2 Change detection analysis

The three change detection maps (Fig. 4) of Rampurhat I CD Block reveal spatial patterns of Vegetation loss and gain zones over three decades. In 1994 to 2004 change analysis we see a straightforward reduction in vegetation in 190.79 km^2 area (67.3%). 74.79 km^2 area have no change and vegetation gains in only 18.76 km^2 area. This period indicates significant disappearance of vegetation, likely due to expansion of agricultural lands and infrastructural development. Between 2004 and 2014, vegetation loss slowed and certain area show moderate gain, indicating moderate recovery, likely due to reforestation and seasonal crop cycles. But certain patches remained under moderately low vegetation that reveals incomplete regeneration. From 2014 to 2024, vegetation gains continued with limited loss. In this decade positive trend continuous

but some areas are still under degradation. Overall this change detection analysis suggests a transition from initial phase of vegetation reduction to subsequent phase of gradual but uneven recovery of over the past three decades.

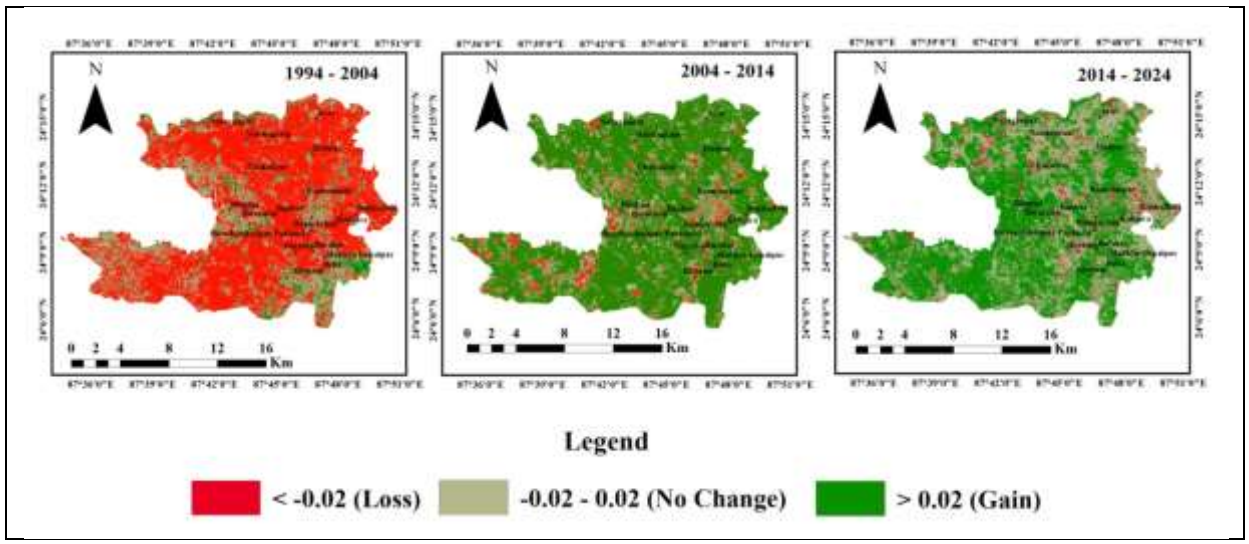

Figure 4: NDVI change detection maps for three time intervals in the study area

Table 3: Area statistics (in km^2) showing vegetation loss, no change and gain for three time intervals in the study area

Period	Loss (Km^2)	No change (Km^2)	Gain (Km^2)
1994–2004	190.79	74.79	18.76
2004–2014	14.54	57.46	208.33
2014–2024	15.68	105.35	163.07

Table 4: Percentage statistics (%) showing the area of vegetation loss, no change and gain for three time intervals in the study area

Period	Loss (%)	No change (%)	Gain (%)
1994–2004	67.3%	26.3%	6.6%
2004–2014	5.2%	20.5%	74.3%
2014–2024	5.5%	37.0%	57.5%

4.3 Accuracy Assessment of NDVI Analysis (2024):

An accuracy assessment is conducted for the 2024 NDVI analysis by generating 80 equalized stratified random points across four classes to create confusion matrix and validate the remote sensing analysis with Google earth pro. The result reveals the overall accuracy is 88.75% and kappa coefficient is 0.85, suggesting strong agreement between the classified map and reference data from Google earth pro. This analysis shows that class I, class II and class III have good accuracy of which most pixels were correctly classified. Class 4 has perfect accuracy with no misclassification. Overall this assessment shows well performed classification with minor errors and an overall strong statistical agreement supported by high kappa value.

Table 5: Confusion matrix and accuracy assessment of 2024 NDVI analysis

Class (C)	**C_1 (Low vegetation)**	**C_2 (Moderately low vegetation)**	**C_3 (Moderate vegetation)**	**C_4 (High vegetation)**	**Total**	**User's Accuracy**
C_1 (Low vegetation)	17	3	0	0	20	0.85
C_2 (Moderately low vegetation)	1	17	2	0	20	0.85
C_3 (Moderate vegetation)	0	3	17	0	20	0.85
C_4 (High vegetation)	0	0	0	20	20	1.00
Total	18	23	19	20	80	
Producer's Accuracy	0.9444	0.7391	0.8947	1.00		
Overall Accuracy					0.8875	
Kappa						0.85

4.4 Field Observation

For validation and complement NDVI analysis a field survey is conducted in Rampurhat I CD block. Some locations were selected in both the urban and surrounding rural area. During survey we clearly observed that Rampurhat, the urban centre, exhibits scattered and low vegetation cover than rural villages. Interactions with local residents in this area revealed that vegetation cover has been decreased due to replacement of large trees and agricultural lands with large buildings, roads and apartment complexes. This observation is consistent with low NDVI value observed in the maps, indicating significant reduction of tree cover and green spaces.

Other hand, during field survey in surrounding rural areas, we observed that this areas exhibits moderate to high vegetation cover, large trees and agricultural lands. Field photographs from these regions prove that. Local residents reported that although vegetation density has been remained high than urban area but some changes have occurred in past few decades due to expansion of agricultural lands and some of built up areas by cutting down large trees.

This survey clearly demonstrates the difference between urban and rural vegetation dynamics, emphasizing the impact of human activities on local ecosystems. This analysis provides valuable insights in the context of ecosystem services, urban planning and micro climatic conditions, as loss of vegetation in the urban regions can cause high temperature, reduced air quality and degradation of water resources. This survey not only give validation of remote sensing analysis but also give understanding that how land use changes affect the vegetation cover and also the entire environment.

Overall these findings underscore the need of sustainable land management, conservation of natural resources to mitigate environmental degradation in both urban and rural areas.

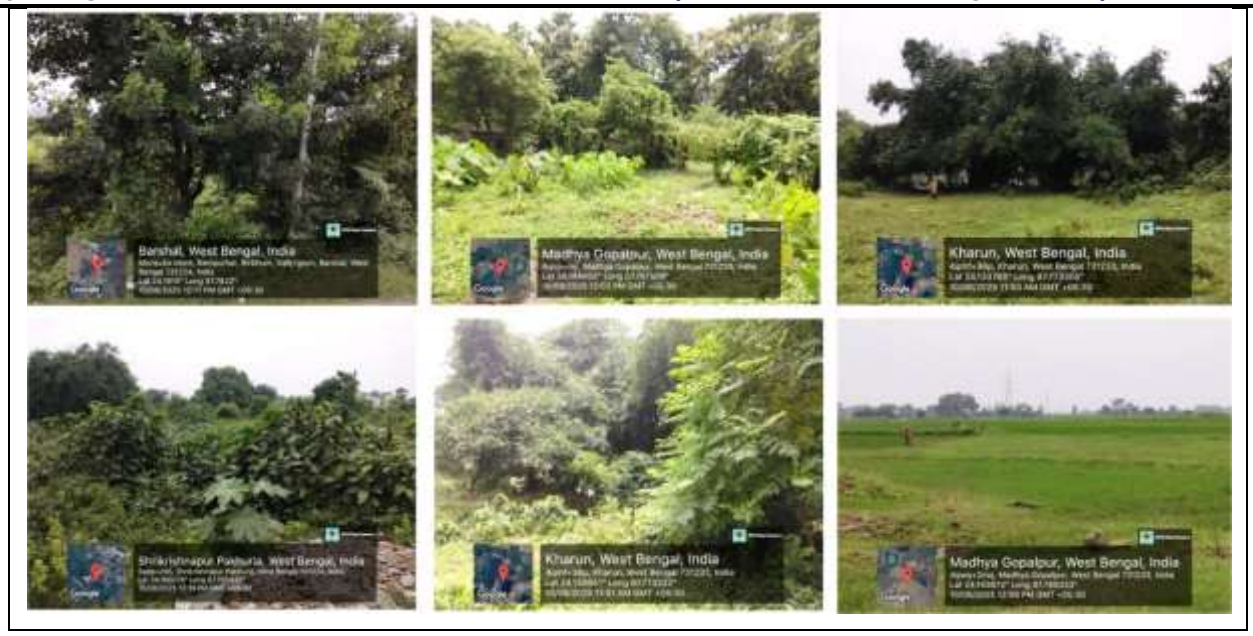

Figure 5: Field photographs showing vegetation cover in rural areas of Rampurhat I CD block

Figure 6: Field photographs showing urban landscape and vegetation cover of Rampurhat I CD block

V. CONCLUSION

This present research aims to assess and evaluate the spatio – temporal distribution of vegetation cover in urban and rural area within Rampurhat I CD block. The NDVI maps, area calculation table and graphs indicate gradual decreasing in vegetation density over past three decades. In 1994 major part of the study region was under moderate and high vegetation but after that vegetation started to decrease and most of the parts become under low and moderately low density. This is mainly due to expansion of built up areas, the primary contributor to NDVI reduction in Rampurhat urban area, while rural regions experienced gradual decrease in vegetation cover mainly due to agricultural development and emerging built up areas.

The field observation and photographs prove the remote sensing results, showing low and sparse and low vegetation in urban locations compared to dense vegetation in nearby rural areas. Interactions with local residents confirmed that undesirable human activities, including cutting down trees, land use conversion and construction have directly influenced vegetation patterns.

This integrated approach provides a comprehensive understanding of vegetation dynamics, highlighting clear difference between urban and rural areas. The results indicate the urgent need of sustainable land management, urban growth policies, green space preservation and wetland conservation to sustain the overall ecological health and resilience of Rampurhat I CD block's landscape.

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