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## SPATIO-TEMPORAL ANALYSIS OF VEGETATION COVER AND ITS IMPACT ON MICROCLIMATE: A STUDY IN AJODHYA HILL OF PURULIA DISTRICT, WEST BENGAL

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### ABSTRACT:

Large-scale hydropower and irrigation projects in the Purulia district of West Bengal, especially in the Ajodhya hilly region had led to a significant forest destruction. Such projects also trigger localized microclimatic shifts. A noticeable shift in forest cover and its associated microclimates is found here. This study evaluates the pre-dam and post-dam environmental dynamics of the Ajodhya hill in the Purulia district by analyzing the changing relationship between the Normalized Difference Vegetation Index (NDVI) and Land Surface Temperature (LST) using multi temporal Landsat imagery (Landsat 4-5TM & Landsat 8OLI). The results reveal that an inverse relationship is found between NDVI and LST. Green cover area is decrease in the post dam period and land surface temperature is increased but a reverse situation is found in pre dam period. The results reveal a critical need of sustainable, biodiversity focused land management in Ajodhya hill, Purulia district.

**Key Words-** Contemporary Forestation, Sustainable Environment, Biodiversity, Microclimate, Hydro-power.

### INTRODUCTION:

The Ajodhya hilly region is a western most part of Purulia district, West Bengal, India. It is characterized by undulating topography, semi-arid climate and covered by deciduous forest. Over the last three decades this region has seen hydro-power development, like- Purulia Pumped Storage Project and several irrigation projects. These projects are very important for water security and electricity development purpose. But due to these developmental projects several hectares of

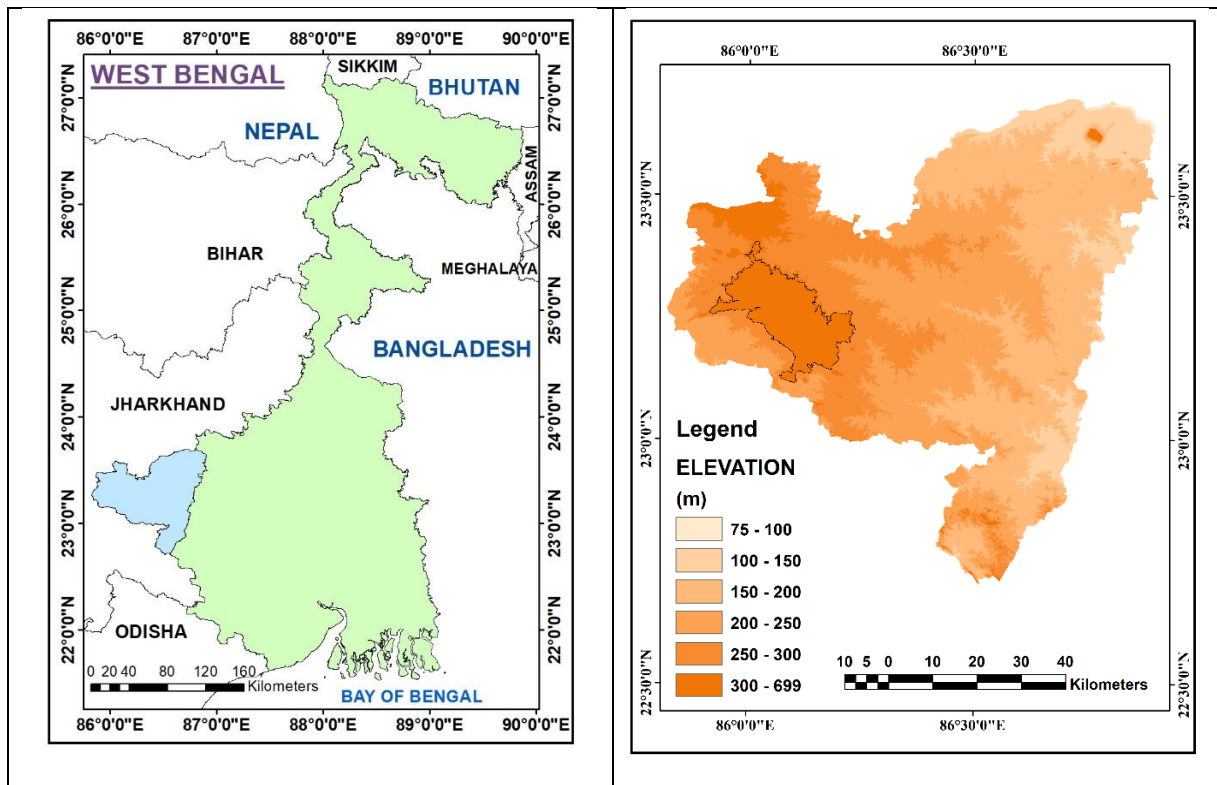
forested lands are destructed. It creates a threat on native biodiversity and alterations to the micro climate. Land Surface Temperature (LST) is a key factor in monitoring these localized climate shifts and it is also influenced by the decreasing amount of forest cover which is described through NDVI techniques. This paper analyzes the transition of vegetation cover and thermal dynamics from pre-dam to post-dam period using NDVI and LST techniques.

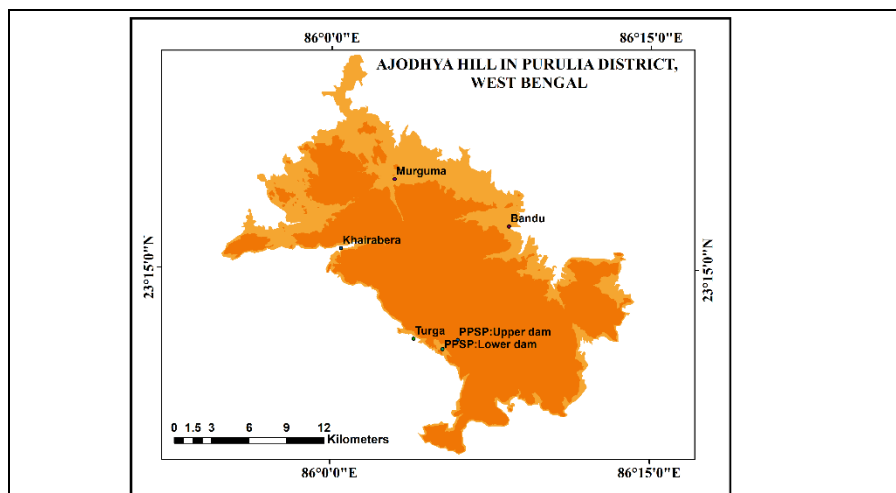
**OBJECTIVES:**

1. To assess the spatio-temporal variations in vegetation cover during pre-dam and post-dam periods.
2. To estimate the changes in local microclimate across the study area.

**STUDY AREA:**

The study focuses on the Ajodhya hilly region in Purulia district which is a marginal part of Chotanagpur plateau (height above 300m). It is extended from 23°9' N-23°20' N to 85°58' E-86°12'E. It is a part of Pre - Cambrian metamorphic terrain composed of Chotanagpur Granite Gneissic Complex. It is covered by many residual hills, waterfalls, lake, springs, river etc. This area is covered by deciduous forest, specially dominated by Sal.





**Fig.1. Location Map of the Study Area**  
**Source: MDPI Journal**

**MATERIALS AND METHODS:**

In the present study the Land Surface Temperature and Normalized Difference Vegetation Index in Ajodhya hilly region was carried out with the help of Landsat images which collected from the USGS Earth Explorer.

Satellite	Sensor	Path	Row	Year of acquisition	Cloud Cover (%)
Landsat4-5	TM	139	44	1987	0
Landsat8	OLI	139	44	2013	0

**Derivation of NDVI from Landsat Images**

The above mention data are used for NDVI to understand the vegetation density and vegetation health. NDVI is calculated using Near-Infrared (NIR) band and red band. The algorithm stands as-

$$NDVI = (NIR-Red) / (NIR+Red)$$

Land Surface Temperature (LST) is calculated through this algorithm-

**Step.1. Top of Atmosphere (ToA)**

$$L\lambda = ((LMAX\lambda - LMIN\lambda / QCALMAX - QCALMIN) * (QCAL - QCALMIN)) + LMIN\lambda \dots (1)$$

Lλ = Spectral Radiance, QCAL= Quantized cali. pixel (DN value), LMAXλ = Radi. Max Band to QCALMAX, LMINλ= Radi. Min Band to QCALMIN, QCALMAX= Maximum quantized calibrated, QCALMIN= Min. Maxi. quantized calibration.

$$L\lambda = ML \times Qcal + AL \dots (2)$$

Where,  $L\lambda$  = Spectral radiance (TOA),  $ML$ = Radiance multiplicative Band,  $AL$ = Radiance Add band,  $Q_{cal}$ = Quantized and calibrated standard product pixel values (DN) of thermal band.

### Step.2. Brightness Temperature (BT)

The band radiance generated from the equations was converted to BT from the top of the atmosphere (ToA).

The conversion equation is written below.

$$BT = K2 / \ln (K1/L\lambda + 1) - 273.15 \quad \dots\dots (3)$$

Where, BT = Brightness Temp. (°C),  $L\lambda$ = ToA Spectral Radiance, K1 and K2= constant.

### Step.3. NDVI

The reflectance of red and near-infrared bands is helped to generate NDVI. It was used to distinguish between vegetation and non-vegetation.

$$NDVI = (NIR-RED)/(NIR+RED) \dots(4)$$

Where, In OLI/ TIRS NIR= band 5, RED= band 4, and NIR= band 4, RED= band 3 in TM.

Results of NDVI equation vary between -1 and +1. Where a positive number represents a patch of vegetation and a negative value represents a water body or a barren land.

### Step 4. Vegetation proportion (P<sub>v</sub>)

Vegetation covers to estimate from maximum and minimum NDVI values.

$$P_v = \text{Square} ((NDVI-NDVI \text{ min}) / (NDVI \text{ max}-NDVI \text{ min})) \quad \dots\dots (5)$$

Where,  $P_v$  = Vegetation, NDVI= DN value from NDVI, NDVI min = Minimum NDVI, NDVI max = Maximum NDVI.

### Step.5: LSE

The mean emissivity of the earth's surface is known as land surface emissivity (LSE). It is gathered using an algorithm from the proportion of vegetation and related adjustment variables.

$$E = 0.004 * P_v + 0.986 \dots(6)$$

Where E= Emissivity,  $P_v$  = Vegetation proportion, 0.004 and 0.986 corresponds to a correction value of the equation.

### Step 6: LST

LST is an important for estimating climate change and global warming. It has an impact on the environment. After completion above steps, LST can be retrieved following steps using the formula.

$$LST = BT / (1 + (\lambda \times BT / P) \times \ln(E)) \dots(7)$$

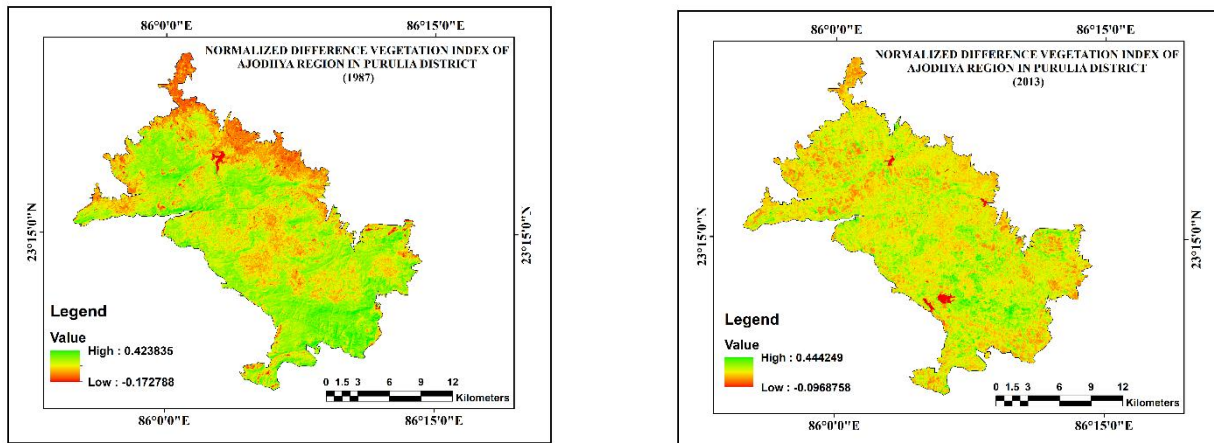
Here, BT = Brightness temp. (°C),  $\lambda$  = Wavelength emitted radiance, E = Emissivity.

NDVI and LST are calculated through Landsat4-5 TM (1987) and Landsat8 OLI (2013) images to understand the temporal changes in vegetation cover and thermal dynamics in pre-dam and post-dam period.

## DISCUSSION:

### •Spatio-Temporal variations in Vegetation Cover:

Ajodhya hilly region is a rich ecosystem of tropical dry deciduous forests. The region is traditionally dominated by Sal (*Shorea Robusta*), Palash (*Butea monosperma*), Mahua (*Madhuca indica*), Kendu (*Diospyros tomentosa*) etc. which are ecologically vital species. Over the last few decades, we observed a significant change in vegetation cover due to many natural as well as anthropogenic causes, like- construction of Purulia Pumped Storage Project which cleared hundreds of hectares of forest land and altered the local hydrology. Based on the satellite images, using NDVI technique we can observed that dense forest cover have degraded on the other hand sparse vegetation and no vegetation parts are increased due to several hydro and irrigation projects in this region. This degradation not only disturbed the local biodiversity but gave impacts on traditional livelihood of the local indigenous peoples.

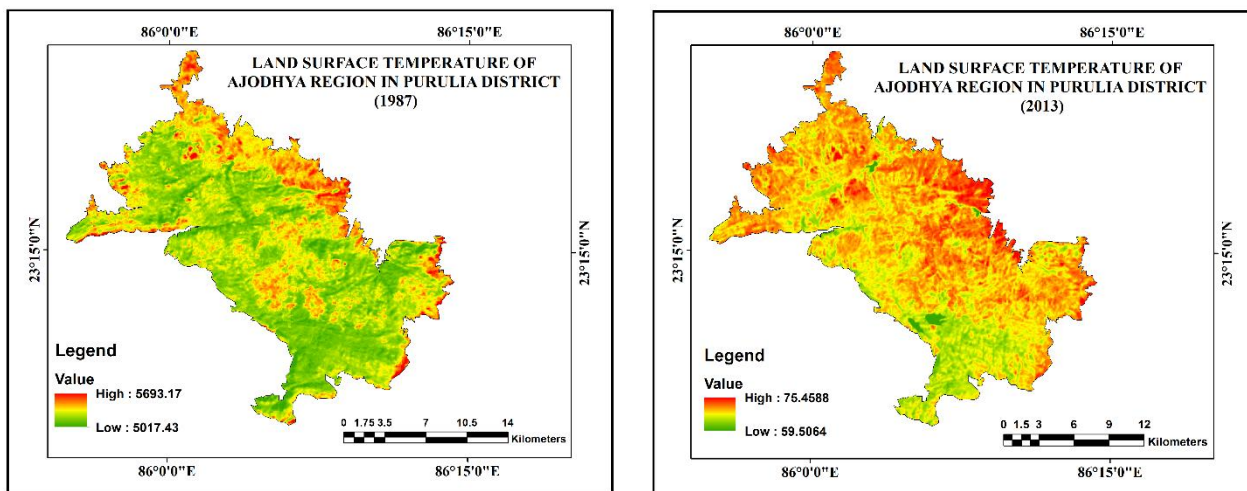


**Fig.2. NDVI (1987 and 2013)**

The results of NDVI ranges between -1 to +1, where a positive value represents vegetation and a negative value represents a water body or a barren soil. During pre-dam period (1987) a large number of areas in Ajodhya region was covered by healthy vegetation, it ranges between -0.17 to 0.42 but after the construction of dams during 2013 it was scattered all over the region with ranging -0.09 to 0.44. The value will grow because after the construction of large hydro-projects government work under the Forest Conservation Act 1980, this diversion is offset by Compensatory Afforestation (CA). However ecological critics argue that the CA focus on numerical tree replacement rather than functional restoration.

### ●Spatio-Temporal Changes in the Microclimate:

Ajodhya hilly region is an easternmost part of Chotanagpur plateau with semi-arid type of climate. Over the past few decades, the microclimate of the Ajodhya hill had experienced localized shifts, driven by land use land cover modification due to construction of large pumped-storage projects, irrigation projects and eco-tourism industries. To evaluate the spatio-temporal variations in the microclimate of the Ajodhya hill we can use Land Surface Temperature (LST) technique which can be derived from thermal remote sensing band of Landsat imagery. Higher vegetation covered areas show a lower LST because dense canopy leads high evapotranspiration, shades the ground, absorbed solar radiation and keeping the microclimate cool. On the other hand, sparse vegetation, barren lands absorb heat and act as a thermal hotspot. Dams and reservoirs create a small scale microclimatic cooling effects against the surrounding dry terrain but due to this projects several hectare of forested lands are destroyed which leads high LST in post dam period.



**Fig.3. LST (1987 and 2013)**

Thermal bands are used for LST calculation. The result depicts that land surface temperature is recorded low in pre dam period but after construction of several dam land surface temperature is rise. Dam and its surrounding vegetation cover records low temperature but others area is recorded high temperature during post-dam period. Forest destruction is main cause. We mainly found low temperature in vegetation covered area and others area are recorded high during both periods.

### CONCLUSION:

Forest degradation has become a serious problem, especially in developing countries. It is mainly socially constructed than naturally invented. The above study has provided local (large) scale data which provide a basis for monitoring the changes in tree cover in the long-time scale. NDVI and LST had a significant relationship, which especially used to detect vegetation pattern/vegetation health changes and its impact on land surface temperature.

Based on the above work we can identify a negative relationship between NDVI and LST. When the vegetation cover was decrease and consequently temperature was increased. The main reason of forest destruction is hydro-projects and dam for irrigational improvement.

It may be concluded on the basis of above study; several hectares of dense forest area are thinning due to dam construction. But if we used sustainable way for development then it is good for natural environment as well as social environment.

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