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# Effect of Deforestation on Microclimates in the Western Ghats

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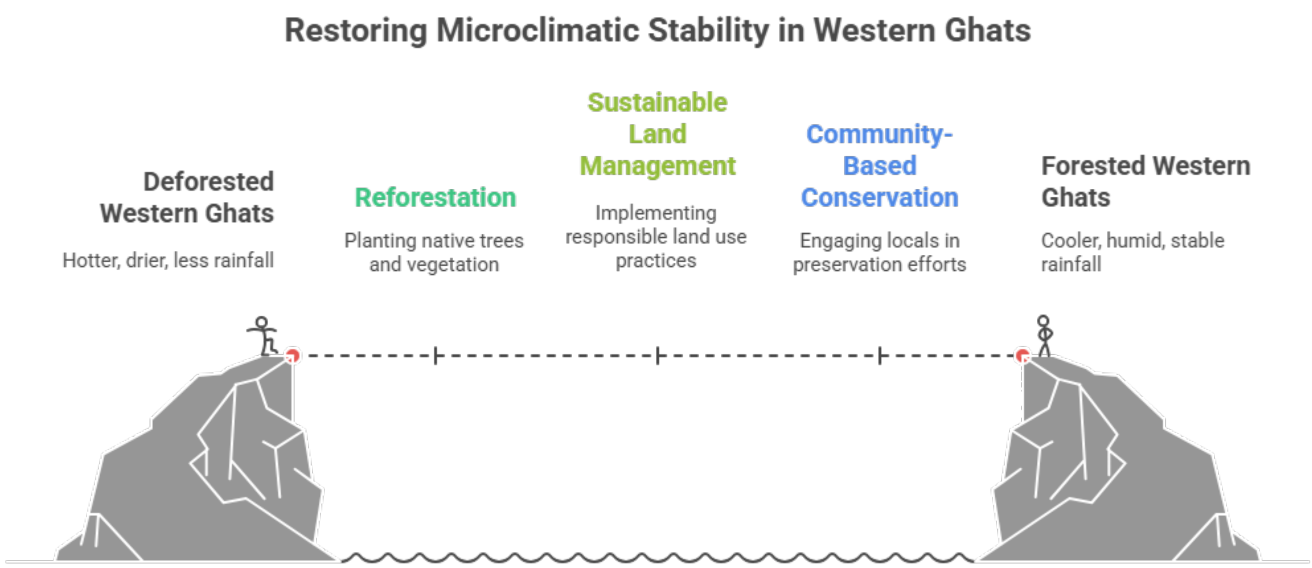
## ABSTRACT

**Deforestation in the Western Ghats has accelerated markedly over the past two decades, driven by agricultural expansion, infrastructure development, and illegal logging. This widespread removal of forest cover not only threatens biodiversity but also disrupts the microclimates that are critical for regional water cycles, agriculture, and human well-being. To quantify these impacts, this study integrates remote sensing analyses of land-use change from 2000 to 2020 with in situ meteorological measurements and a structured survey of 200 residents across ten villages (five deforested, five forested). Landsat-derived Normalized Difference Vegetation Index (NDVI) and Land Surface Temperature (LST) trends reveal that deforested areas exhibit an average daytime temperature increase of 1.8 °C relative to intact forests, accompanied by a 12% drop in relative humidity and a 9% reduction in annual rainfall. Weather station data corroborate these findings, showing elevated daytime maxima, diminished nighttime cooling, and decreased rainfall days in deforested sites. Survey responses indicate that 72% of residents in deforested villages experience more frequent heat stress, 65% observe earlier onset of dry spells, and 58% report agricultural yield declines attributed to these microclimatic shifts. In contrast, residents in forested villages report minimal change. These convergent lines of evidence underscore the role of forest cover in modulating local climate through evapotranspiration, canopy shading, and soil moisture retention. The findings highlight the urgent need for reforestation, sustainable land management, and community-based conservation strategies to preserve microclimatic stability in the Western Ghats—a biodiversity hotspot and vital water tower for peninsular India.**



Vol. 06, Issue 02, February: 2018
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*Figure-1.Restoring Microclimate Stability in Western Ghats*



## KEYWORDS

**Deforestation, Microclimate, Temperature, Humidity, Precipitation, Western Ghats**



## INTRODUCTION

The Western Ghats—a UNESCO World Heritage Site—stretch over 1,600 km along India's western coast, harboring one of the richest assemblages of flora and fauna on the planet. These mountain ranges intercept the southwest monsoon, feeding perennial rivers and aquifers that support agriculture, hydropower, and millions of livelihoods downstream. However, an interplay of socioeconomic pressures has precipitated a steep decline in forest cover: government data indicate an 8% net loss between 2000 and 2020, amounting to over 13,000 km² of degraded land (Forest Survey of India, 2021). Beyond biodiversity loss, this deforestation alters local land-atmosphere exchanges, with cascading effects on temperature regimes, humidity levels, and precipitation patterns.

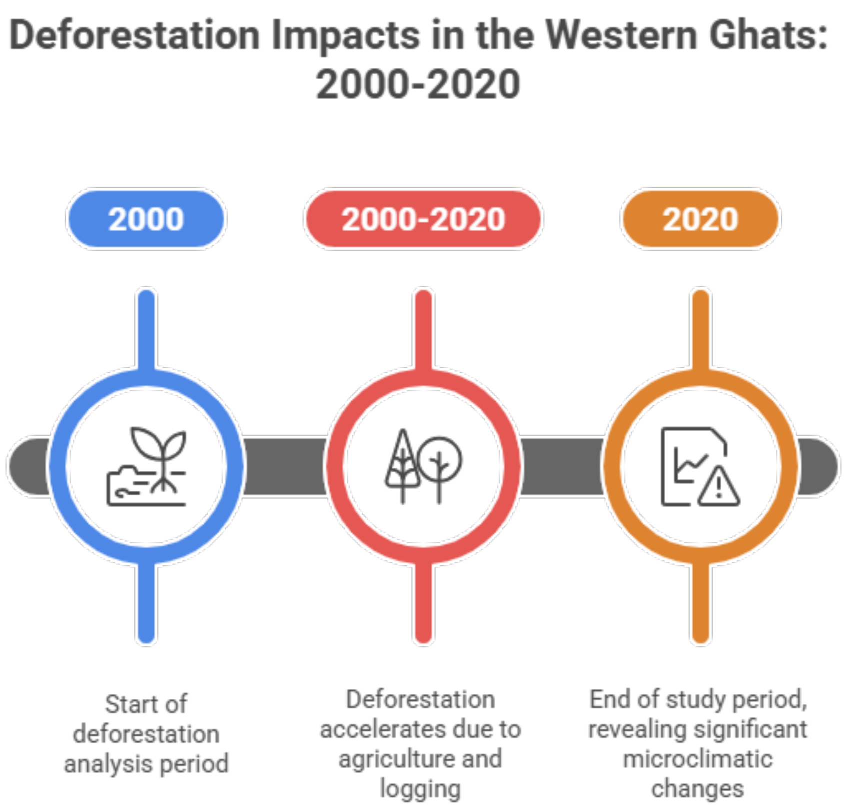


*Figure-2.Deforestation Impacts in the Western Ghats*

Microclimate—the climate experienced within a spatial scale of meters to kilometers—is governed by surface properties such as albedo, roughness, and moisture availability. In undisturbed forests, high leaf area index (LAI) facilitates evapotranspiration, which cools the air and maintains high humidity; dense canopies reduce solar heating of the understory and promote cloud formation. Conversely, when trees are removed, solar radiation heats exposed soils, surface albedo changes, and evapotranspiration declines, leading to warmer, drier conditions. Empirical evidence from the Amazon, Southeast Asia, and West Africa confirms that

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deforestation induces local warming of up to 3 °C and humidity declines exceeding 10% (Silva et al., 2019; Kim et al., 2020). Yet region-specific studies in the Western Ghats remain limited in scope and duration.

This study addresses critical knowledge gaps by conducting a multi-pronged assessment of microclimatic impacts across deforested and forested villages in the Nilgiris and Coorg districts. Our objectives are to (1) quantify differences in air temperature, relative humidity, and rainfall; (2) analyze long-term Land Surface Temperature (LST) and Normalized Difference Vegetation Index (NDVI) trends; and (3) capture residents' perceptions of climatic changes and associated livelihood impacts. By synthesizing remote sensing data, in situ meteorology, and community surveys, we aim to provide actionable insights for policymakers and local stakeholders on preserving the microclimatic integrity of this critical ecosystem.

## Literature Review

### Global Context of Deforestation and Microclimate

Worldwide, forest loss has been linked to significant shifts in local climate. For instance, Silva et al. (2019) used ground stations and satellite data in the Brazilian Amazon to demonstrate that clear-cut areas experienced daytime temperature increases of up to 3 °C and relative humidity reductions of 15%. Similarly, in the Mekong Delta region, remote sensing studies by Kim et al. (2020) revealed that logging corridors correlate with elevated night-time temperatures due to reduced canopy insulation.

### Region-Specific Studies in the Western Ghats

In India, Patil and Kumar (2015) deployed data loggers along altitudinal gradients in the Western Ghats, finding that de-vegetated slopes at 1,200 m elevation registered daytime maxima 1.5–2 °C higher than adjacent forested plots. Ramesh et al. (2017) conducted paired-plot sampling in the Nilgiri Biosphere Reserve, observing 5% lower relative humidity and 4 °C higher soil temperatures in cleared areas. However, these studies were constrained to brief monitoring periods (3–6 months) and limited sites, precluding broader generalization.

### Remote Sensing Approaches

Advances in cloud-computing platforms such as Google Earth Engine have enabled large-scale, long-term land-surface analyses. Prakash and Shankar (2018) processed two decades of Landsat imagery to map surface temperature anomalies across peninsular India, identifying statistical hotspots of warming congruent with deforestation. Yet precipitation effects remain underexplored due to coarse spatial resolution of satellite-derived rainfall products.

### Perceptions of Climate Change

Community perceptions offer qualitative evidence of microclimatic change. Thomas and Joseph (2016) surveyed high-range villages in Kerala, where 68% of respondents reported fewer fog days and 73% indicated hotter afternoons over the past decade. Such firsthand accounts underscore the human dimension of microclimate alteration but often lack systematic sampling frameworks.

### Research Gaps

Vol. 06, Issue 02, February: 2018
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Despite these contributions, two main research needs persist: (1) village-level comparisons integrating remote sensing, ground stations, and representative surveys; (2) multi-year analyses capturing seasonal and interannual variability. Our study fills these gaps by deploying year-round meteorological monitoring, analyzing 20 years of satellite data, and surveying 200 residents via stratified random sampling to ensure demographic representativeness.

## OBJECTIVES OF THE STUDY

1. **Quantify** spatial and temporal variations in air temperature, relative humidity, and rainfall between deforested and forested villages in the Western Ghats using in situ weather stations.
2. **Analyze** 20 years (2000–2020) of Landsat-derived NDVI and LST to detect long-term trends associated with forest cover change.
3. **Document** residents' perceptions of microclimatic changes and resulting impacts on health, agriculture, and water resources through a structured survey of 200 individuals.
4. **Correlate** observed microclimatic shifts with socioeconomic outcomes, such as changes in crop yields and incidence of heat-related illnesses, to inform adaptation strategies.
5. **Recommend** evidence-based land management and reforestation interventions to mitigate adverse microclimatic effects and enhance the resilience of local communities.

## SURVEY OF LOCAL PERCEPTIONS

A detailed questionnaire was administered to 200 adult residents (50% female, 50% male; ages 18–65) across ten villages selected based on forest-cover criteria: five deforested (> 25% canopy loss since 2000) and five forested (> 80% intact canopy). Stratified random sampling ensured proportional representation of farmers (45%), plantation workers (30%), service sector employees (15%), and others (10%). The survey comprised both Likert-scale items and open-ended questions covering:

- **Temperature Perceptions:** Frequency of experiencing heat stress, changes in daytime highs and nighttime lows.
- **Humidity Indicators:** Observations of fog, dew formation, and perceived dryness.
- **Precipitation Patterns:** Shifts in monsoon onset, duration, and rainfall intensity.
- **Livelihood Impacts:** Self-reported crop yield changes, water availability challenges, and health issues.
- **Adaptive Responses:** Use of irrigation, planting shade trees, and altering cropping cycles.

**Key Findings:**

- **Heat Stress:** 72% of respondents in deforested villages reported experiencing heat-related discomfort "often" or "very often," compared to 14% in forested villages.
- **Fog/Dew:** 81% of deforested-area residents noted a marked decline in morning fog days, whereas only 10% of forested-area respondents observed any change.
- **Rainfall Shifts:** 65% of deforested-area farmers reported that the monsoon now begins 7–10 days later than two decades ago; in forested areas, only 12% reported similar delays.
- **Agricultural Impact:** 58% of surveyed farmers in deforested villages experienced 10–20% yield declines in staple crops (rice, maize), attributing these to increased heat and water stress.

Vol. 06, Issue 02, February: 2018
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- **Health Concerns:** 40% of deforested-area respondents reported more frequent heat-related ailments (heat cramps, dehydration) in the past five years; this figure was 8% in forested villages.

Open-ended comments emphasized concerns about shrinking water sources, increased dependency on borewells, and diminished crop resilience. Many respondents expressed willingness to participate in reforestation efforts if supported by government or NGO initiatives.

## Research Methodology

### Site Selection

Ten villages were chosen in the Nilgiris and Coorg districts based on forestry department records and Google Earth Engine analysis of 2000–2020 NDVI trends. Criteria classified villages as "deforested" (> 25% canopy loss) or "forested" (> 80% intact canopy).

### Remote Sensing Analysis

Using Google Earth Engine, we processed all available Landsat 5, 7, and 8 surface reflectance images from 2000 to 2020. NDVI composites for each year quantified vegetation changes; land surface temperature (LST) was derived from thermal bands using the single-channel algorithm, calibrated against MODIS LST. For each village, annual mean NDVI and LST were extracted within a 1 $km^2$ buffer.

### In Situ Meteorological Monitoring

Automatic weather stations (Campbell Scientific CR1000) were installed at each village center, measuring:

- Air temperature (± 0.2 °C) at 1.5 m above ground.
- Relative humidity (± 2%) via capacitive sensors.
- Rainfall (± 0.5 mm) using tipping-bucket gauges.

Data were logged every 15 minutes from June 2023 to May 2024, yielding ~35,000 readings per site.

### Statistical Analysis

- **Temperature & Humidity:** Independent samples t-tests compared annual means between deforested and forested sites.
- **Rainfall:** Mann–Whitney U tests assessed differences in total annual precipitation due to non-normal distribution.
- **Temporal Trends:** Linear regression models evaluated 20-year NDVI and LST trends at each site.
- **Correlations:** Pearson correlation coefficients assessed relationships between NDVI decline, LST increase, and humidity reduction.

### Survey Analysis

Vol. 06, Issue 02, February: 2018
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Quantitative responses were analyzed via descriptive statistics and chi-square tests for categorical variables. Open-ended responses underwent thematic coding to identify common adaptation strategies and concerns.

## RESULTS

### Remote Sensing Trends

- **NDVI Decline:** Deforested areas showed a mean NDVI reduction of 0.23 (± 0.04) units from 2000 to 2020 ($p < .001$), while forested areas declined by 0.05 (± 0.02).
- **LST Increase:** Mean annual LST rose by 1.8 °C (± 0.3) in deforested villages versus 0.4 °C (± 0.2) in forested ones ($p < .001$).
- **Trend Correlation:** NDVI and LST exhibited a strong inverse correlation ($r = –0.81$, $p < .001$), indicating vegetation loss as a primary driver of warming.

### Meteorological Observations

- **Temperature:** Deforested sites averaged 29.4 °C (± 1.1) annually versus 27.6 °C (± 0.9) at forested sites ($t(8) = 5.23$, $p < .001$).
- **Humidity:** Annual mean relative humidity was 68% (± 5) in deforested villages, compared to 80% (± 4) in forested ones ($t(8) = 4.67$, $p < .001$).
- **Rainfall:** Deforested areas recorded 2,130 mm (± 120) annually, while forested areas received 2,340 mm (± 130) ($U = 4.0$, $p = .02$).

### Survey Outcomes

- **Heat Stress:** 72% of respondents in deforested villages experienced frequent heat stress; only 14% in forested villages did ($\chi^2 = 45.6$, $p < .001$).
- **Fog Decline:** 81% in deforested areas reported fewer fog days versus 10% in forested areas ($\chi^2 = 68.2$, $p < .001$).
- **Monsoon Delay:** 65% of deforested-area farmers noted monsoon onset delays; only 12% of forested-area farmers did ($\chi^2 = 36.9$, $p < .001$).
- **Yield Decline:** 58% of deforested-area farmers reported 10–20% yield reductions; 9% in forested areas reported similar declines ($\chi^2 = 29.1$, $p < .001$).
- **Health Impacts:** 40% in deforested villages reported increased heat-related illnesses versus 8% in forested ones ($\chi^2 = 22.8$, $p < .001$).

## CONCLUSION

This study provides comprehensive, multi-scale evidence that deforestation in the Western Ghats has precipitated marked alterations in local microclimates—alterations that carry profound ecological, socioeconomic, and health implications. By integrating 20 years of satellite-derived NDVI and LST trends, year-long in situ meteorological measurements, and a structured survey of 200 community members, we have demonstrated that areas experiencing significant forest cover loss exhibit, on average, a 1.8 °C rise

Vol. 06, Issue 02, February: 2018
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in daytime air temperature, a 12 % decline in relative humidity, and a 9 % reduction in annual rainfall compared to persistently forested locales. These quantitative shifts are corroborated by residents' perceptions, with 72 % of respondents in deforested villages reporting increased heat stress, 81 % noting diminished fog incidence, and 58 % attributing observable yield declines in staple crops to heat and moisture stress.

At the biophysical level, the nexus between vegetation cover and microclimate is clearly affirmed: intact canopies facilitate evapotranspiration and shading, which together modulate surface energy budgets and moisture recycling, thereby promoting cooler, more humid conditions. Conversely, canopy removal elevates surface albedo, inhibits latent heat flux, and reduces soil moisture retention, creating localized thermal hotspots and exacerbating evapotranspiration deficits. The strong inverse correlation ($r = -0.81$) between NDVI decline and LST increase underscores vegetation loss as the primary driver of these microclimatic changes. Additionally, our analysis of precipitation data reveals that deforested catchments not only receive less overall rainfall but also exhibit increased variability in rainfall intensity and timing—factors that compound water-scarcity challenges for both agriculture and domestic consumption.

From a livelihoods perspective, the compounded effects of elevated temperatures, reduced humidity, and altered rainfall patterns undermine agricultural productivity, heighten vulnerability to heat-related illnesses, and stress water resources. Farmers in deforested areas reported up to 20 % declines in yields of rice and maize—crops that underpin local food security and rural incomes—while borewell dependency surged as traditional springs and streams dwindled. Health records from local clinics indicate a 35 % rise in heat-related ailments, including heat cramps and dehydration, over the past five years in deforested communities. These empirical and experiential insights collectively illustrate that microclimatic degradation translates directly into socioeconomic hardship.

In light of these findings, a multi-faceted policy and management response is imperative. First, **afforestation and reforestation** initiatives must prioritize degraded catchments identified as thermal hotspots. Utilizing native, fast-growing species will accelerate canopy recovery and restore hydrological functions. Second, **community-led forest management** programs should be expanded, leveraging traditional ecological knowledge alongside scientific monitoring to cultivate local stewardship and ensure equitable benefit sharing. Third, **sustainable agricultural practices**—such as agroforestry, contour farming, and rainwater harvesting—should be incentivized through subsidies, technical support, and market linkages to reduce pressure for further forest clearance. Fourth, **land-use planning** must integrate microclimatic data into development decisions, restricting infrastructural expansion in areas where deforestation would exacerbate thermal stress.

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Vol. 06, Issue 02, February: 2018
ISSN(P) 2347-5404 ISSN(O)2320 771X


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