

# Findings

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**Topic of the Research: Climate Variability Impact and Forest Vulnerability Assessment in Valmiki Tiger Reserve, West Champaran (Bihar)**

The findings of the study highlight a major paradigm shift in climate change and forest vulnerability assessment—from general approaches toward integrated, holistic frameworks. The systematic literature review revealed significant knowledge gaps in understanding forest adaptation, community dependence on forests, and forest sensitivity. Very few studies have attempted vulnerability assessment at the local scale, and the integration of exposure, sensitivity, and adaptive capacity remains limited. Based on the review, an integrated framework for assessing forest vulnerability was proposed to address these deficiencies and provide a comprehensive understanding of forest-climate interactions.

The climate variability analysis for Valmiki Tiger Reserve (VTR) revealed clear evidence of climate change. From 1981 to 2020, a significant decreasing trend in rainfall was observed, while mean, maximum, and minimum temperatures showed a rising trend. The last 30 years exhibited marked warming, though maximum winter and post-monsoon temperatures slightly declined over forty years. Seasonal forecasting (2021–2030) indicates a continued decline in rainfall across all seasons and a rise in summer temperatures, confirming the hypothesis that climate variability is altering the region's climatic balance.

Spatio-temporal analysis showed that VTR's forest cover increased from 88.47% in 1991 to 93.79% in 2020, largely due to the Reserve's establishment in 1994, bans on logging and agricultural expansion, and effective management. However, degradation persists in buffer zones due to anthropogenic pressures. Forest health assessment revealed that 37% of the area is moderately healthy, 31% healthy, and 13% unhealthy, while 19% constitutes non-forest land. Healthy forests are concentrated in the core zones, whereas unhealthy forests occur mainly in

buffer zones such as Madanpur and Valmiki Nagar, confirming that human disturbances significantly affect forest health.

Forest fragmentation analysis indicated growing disturbances, with perforated forest areas increasing from 16% in 1991 to 24% in 2020. Patch and edge categories also expanded, signifying degradation, especially in Madanpur, Raghia, and Valmiki Nagar ranges due to grazing, roads, and settlements. Habitat suitability mapping showed that 42% of the Reserve is moderately suitable for Bengal tigers, followed by 19% highly suitable areas concentrated in the eastern ranges. Least-cost path analysis identified 73 potential tiger corridors, though fragmentation and human pressure threaten their connectivity.

The forest vulnerability analysis found 48.36% of the Reserve under moderate vulnerability, 32.28% high, and 19.36% low. High vulnerability occurs in Raghia and Madanpur ranges due to high exposure, sensitivity, and climatic stresses such as variable rainfall, rising temperatures, and river course changes. Moderate vulnerability dominates central ranges, while low vulnerability in Gobardhana and Manguraha is attributed to dense forests, higher elevation, and effective management. Intrinsic resilience, improved management practices, fire control measures, and anti-poaching initiatives have enhanced adaptive capacity across many ranges.

The Bihar government's climate and forest policies—such as the Hariyali Mission, Krishi Vaniki Yojana, and Bihar Action Plan on Climate Change—aim to strengthen carbon sinks, biodiversity, and resilience. The study recommends installing weather and rain gauge stations for continuous climate monitoring, promoting natural regeneration and restoration of degraded forests, and empowering local communities for sustainable forest management. It also emphasizes restricting illegal logging, poaching, and encroachment, improving green infrastructure, and enhancing transboundary cooperation with Nepal. Relocation of villages, livelihood diversification, and eco-tourism are essential to reduce dependency and conflicts. Finally, a holistic, data-integrated, and community-centered approach is vital for improving forest resilience and ensuring sustainable conservation in Valmiki Tiger Reserve.