

Neue Studie: Der Einfluss steigender CO₂-Werte auf die Begrünung Indiens – einer Region ohne Nettoerwärmung seit 75 Jahren

geschrieben von Chris Frey | 9. Februar 2026

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Jahrzehntelange Satellitendaten bestätigen, dass sich die Erde seit den 1980er Jahren erheblich begrünt hat – gemessen an den steigenden Werten des Blattflächenindex (LAI).

Der CO₂-Düngungseffekt (CFE) steigert die Pflanzenproduktivität durch verbesserte Lichtausnutzungs- und Wassernutzungs-Effizienz. Mit anderen Worten: Bei erhöhtem CO₂-Gehalt wird die Photosyntheserate nicht so stark beeinträchtigt wie bei begrenzter Sonneneinstrahlung und Wasserverfügbarkeit.

Eine neue [Studie](#) zeigt, dass Indien den zweitgrößten Beitrag zur globalen Begrünung beisteuert und dass die CFE „in den letzten zwei Jahrzehnten zu einer erheblichen Ausweitung der globalen Vegetationsdecke beigetragen hat“.

Die Autoren stellten fest, dass die CFE die Trendwerte der Nettoprimärproduktion [NPP] in ganz Indien im Vergleich zu den Trendwerten ohne Berücksichtigung der CFE „fast verdoppelt“ hat.

Interessanterweise hat sich trotz des erhöhten CO₂-Gehalts ein Großteil Indiens seit 2000 abgekühlt. Während sich die südliche Halbinsel und Teile Ostindiens in diesem Jahrhundert erwärmt haben, „verzeichneten die zentralen und nordwestlichen Regionen einen Abkühlungstrend“.

Es ist anzumerken, dass der jährliche mittlere Nicht-Erwärmungstrend Indiens seit 1950 anhält (wie in Sanjay et al., 2020 [gezeigt](#)).

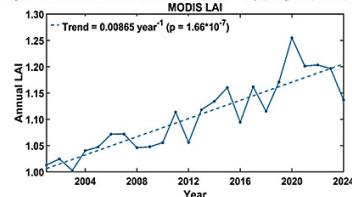


Figure S2: Time series of annual LAI over India for the period 2001-2024.

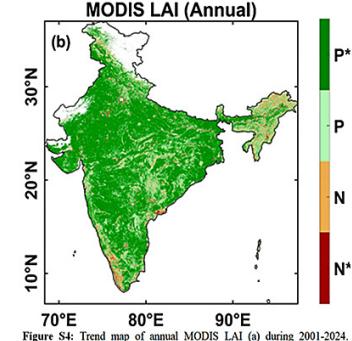


Figure S4: Trend map of annual MODIS LAI (a) during 2001-2024.

LAI Leaf Area Index/global green cover

Quelle: Das et al., 2026

In deutscher Übersetzung:

der Trends der Nettoprimärproduktion in Indien unter Einbeziehung des direkten Effekts der CO₂-Düngung in MODIS-Daten

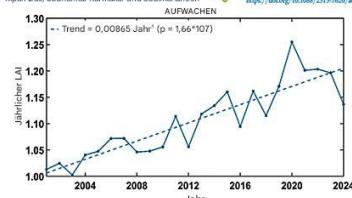


Abbildung S2: Zeitreihe des jährlichen LAI über Indien für den Zeitraum 2001-2024.

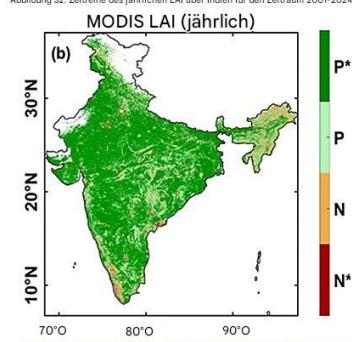


Abbildung S4: Tendekarte des jährlichen MODIS LAI (a) im Zeitraum 2001-2024.

LAI Blattflächenindex/globale Grünbedeckung

Abstract

India is the second-largest contributor to global greening. Despite significant increase in green cover, satellite-based MODIS estimates reveal no significant increase in vegetation productivity, with major forested areas showing declines in net primary productivity (NPP), due to warming. A major limitation of MODIS vegetation productivity dataset is that it does not consider the improved biochemical rate of plant photosynthesis under higher atmospheric CO₂ levels, known as CO₂ fertilization (CFE). In this study, we incorporate the direct effect of CFE into satellite-based MODIS vegetation productivity estimates and reassess NPP trends across India from 2001 to 2024. Our analysis confirms that the NPP trend values nearly doubled after accounting for the direct effect of CFE, significantly reducing the percentage of grids exhibiting a negative trend from 21.21% to 8.86% across total vegetated land and from 51.81% to 25.23% across forested land, compared to the trends observed without CFE. Notably, most of the grids showing negative trends transitioned into statistically non-significant categories, either negative or positive. These grids are primarily located along the Western Ghats and southern peninsular India, where vegetation productivity showed only a modest increase in response to the direct effect of CFE. This limited response is likely due to concurrent warming in these regions, which dampens the benefits of CFE. In contrast, northwestern India, where atmospheric moisture stress and temperature have declined, exhibited a stronger increase in vegetation productivity after accounting for CFE – enhancing already positive trends. Overall, our findings suggest that incorporating the direct effect of CFE significantly improves the estimation of vegetation productivity trends across India. However, regional climate patterns have a strong influence on the magnitude of the increase in vegetation productivity due to the direct effect of CFE. This study enhances understanding of climate-vegetation interactions under increasing atmospheric CO₂ concentration and climate change.

Terrestrial vegetation plays a crucial role in offsetting rising atmospheric CO₂ levels and mitigating climate change [1] by absorbing CO₂ during the process of photosynthesis. Over the past decade (2013–2024), global terrestrial ecosystems have stored approximately 3.2 ± 0.9 GtC annually, offsetting nearly 30% of anthropogenic CO₂ emissions [2]. Gross Primary Productivity (GPP), which quantifies the amount of CO₂ absorbed during photosynthesis [3], is a key indicator of land carbon uptake. Since the 1960s, the global land carbon sink has strengthened significantly, largely due to elevated atmospheric CO₂ concentrations [2, 4] known as the CO₂ fertilization effect (CFE) [5]. Elevated CO₂ enhances plant productivity through two distinct mechanisms. The direct effect increases CO₂ availability to the Rubisco enzyme, thereby improving the biochemical rate of photosynthesis per unit leaf area and improving light-use efficiency (LUE) [6, 7]. This improved photosynthesis results in greater carbon allocation for plant growth. In parallel, elevated CO₂ also improves water use efficiency (WUE), allowing plants to grow even under water-limited conditions [8, 9]. Together, these responses lead to an increase in leaf area [10], which enables greater light interception and further enhances GPP. These combined responses are collectively referred to as the indirect effect of CFE [11].

CFE has continued enhancing vegetation productivity in recent decades, often offsetting the negative impacts of climate stress [12, 13]. However, several studies suggest that the strength of CFE has weakened during this period due to increasing climate stress and nutrient limitations [14–16].

Satellite observations show a substantial expansion of global green cover over the past two decades, with India emerging as the second-largest contributor [27].

A recent study by Keenan et al. [11] incorporated the direct biochemical effect of CFE into the MODIS MOD17 algorithm and found that global annual GPP increased by approximately 7.3% between 1982 and 2012. The direct enhancement of LUE from CFE was nearly twice that of the indirect effect from increased leafarea.

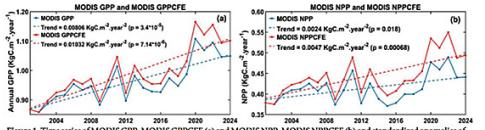


Figure 1. Time series of MODIS GPP, MODIS GPPCFE (a) and MODIS NPP, MODIS NPPCFE (b) and standardized anomalies of MODIS GPP and MODIS NPPCFE (a) and MODIS NPP, MODIS NPPCFE (b) over India from 2001 to 2024. The dashed lines in (a) and (b) represent the trend lines, and the values along them indicate the corresponding trend magnitudes. In figure 5, we present the annual trends of DVPP (figure 5(a)) and TMEAN (figure 5(b)) using MERRA-2 reanalysis data. DVPP exhibited a statistically significant decreasing trend across most parts of India, except for the southern peninsular region, the Western Ghats, and parts of eastern India, where trends were largely non-significant. Only a few grids in south Tamil Nadu showed a significant positive trend. TMEAN largely displayed a warming trend over the southern peninsula and parts of eastern India, while central (excluding Maharashtra) and northwestern regions experienced a cooling trend.

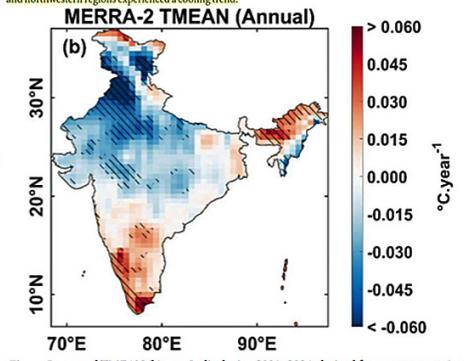
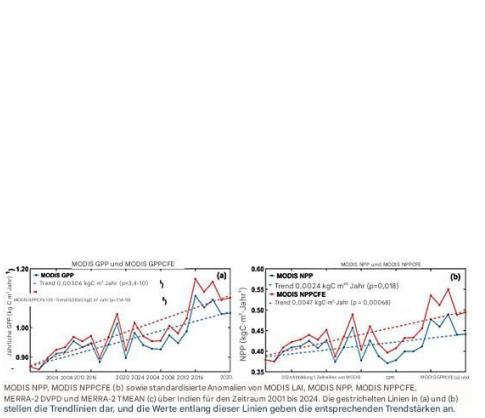


Figure 5. annual TMEAN (b) über Indien während 2001–2024, abgeleitet von MERRA-2-Daten.

annual TMEAN Mean Annual Air Temperature



In Abbildung 5 stellen wir die jährlichen Trends von DVPP (Abbildung 5(a)) und TMEAN (Abbildung 5(b)) anhand von MERRA-2 Reanalysedaten dar. DVPP zeigte in den meisten Teilen Indiens einen statistisch signifikanten abnehmenden Trend, mit Ausnahme der südlichen Halbinselregion der Westghats und Teilen Ostindiens, wo die Trends größtenteils nicht signifikant waren. Nur wenige Raster in Tamil Nadu zeigten einen signifikanten positiven Trend. TMEAN zeigte eine Erwärmungstrend über der südlichen Halbinsel und Teilen Ostindiens, während die zentralen (ohne Maharashtra) und nordwestlichen Regionen einen Abkühlungstrend aufwiesen.

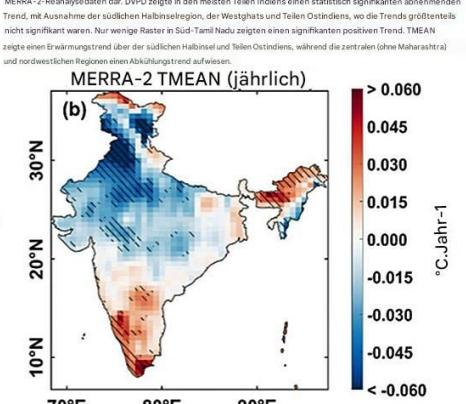
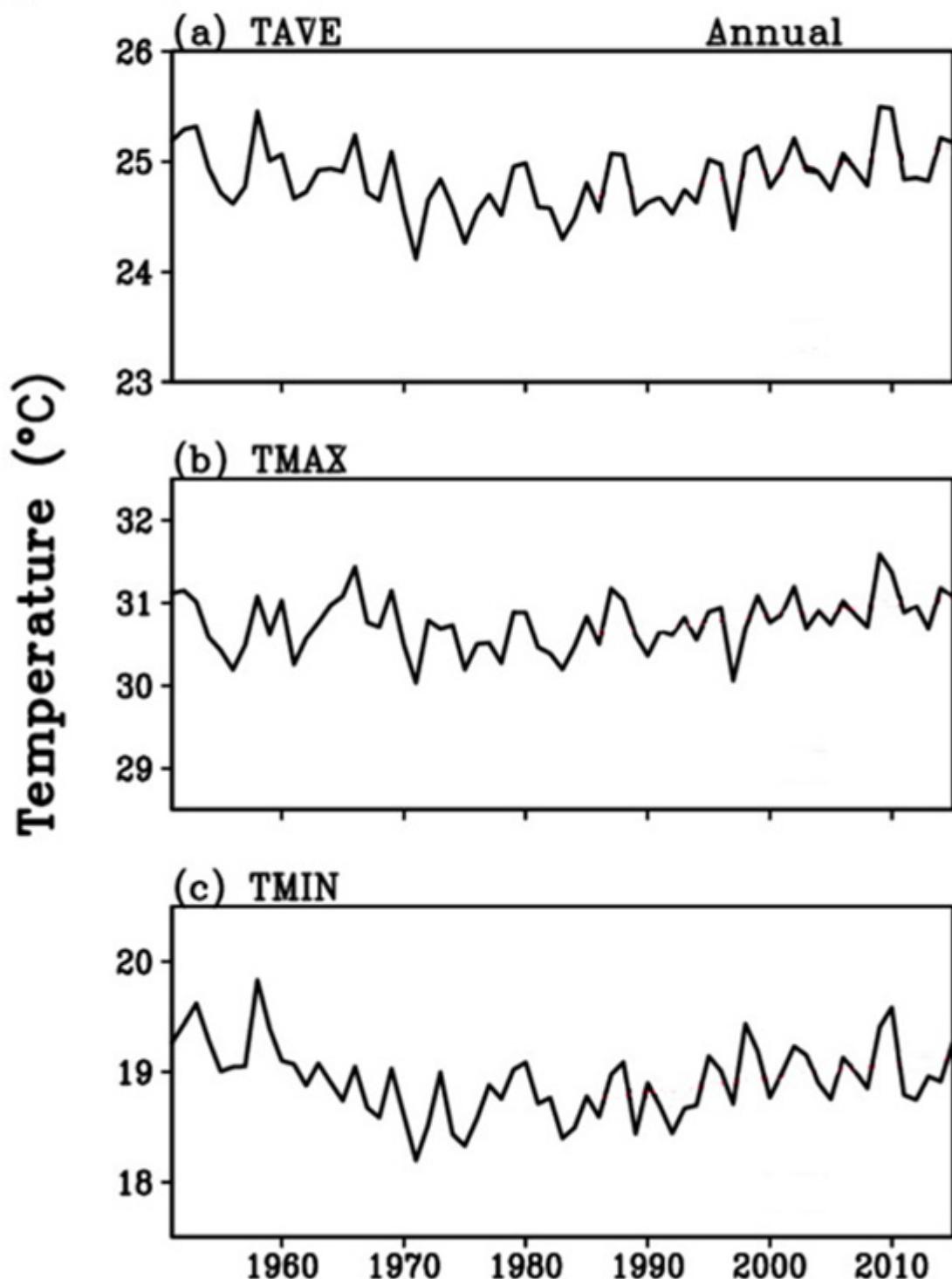


Abbildung 5. Jährliches TMEAN (b) über Indien im Zeitraum 2001-2024, abgeleitet aus MERRA-2-Daten. Jährliches TMEAN Mittlere jährliche Lufttemperatur



Temperature Changes in India

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Link:

[https://notrickszone.com/2026/01/26/new-study-affirms-rising-CO₂s-greening-impact-across-india-a-region-with-no-net-warming-in-75-years/](https://notrickszone.com/2026/01/26/new-study-affirms-rising-CO2s-greening-impact-across-india-a-region-with-no-net-warming-in-75-years/)

Übersetzt von Christian Freuer für das EIKE