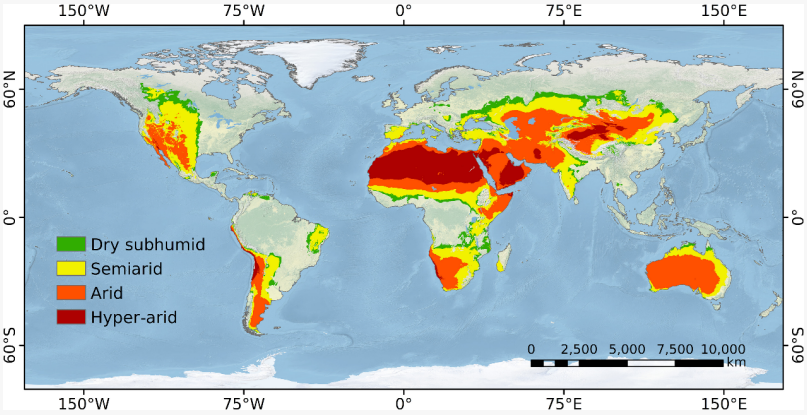
Human activities drive global dryland greening

GA, UNITED STATES, January 27, 2026 /EINPresswire.com/ -- A new global dryland assessment using long-term satellite observations reveals widespread vegetation greening over the past two decades, reversing long-held expectations of accelerating desertification. Using satellite-based productivity data, researchers quantified where greening occurred, at what speed, what forces contributed to it, and how much was driven by agricultural expansion rather than climate or CO fertilization alone. The findings reshape our understanding of dryland ecosystems and highlight the strong influence of human land-use practices.



Spatial distribution of global drylands and aridity classification map.

Drylands cover more than 40% of the global land surface and support over three billion people while maintaining essential ecological functions, including carbon cycling, food production, and biodiversity. Yet these fragile ecosystems face increasing aridity, groundwater stress, drought, and land-use intensification under rapid climate change. Previous global analyses suggested greening in many dryland regions, mainly attributed to rising atmospheric CO. However, the relative influence of climate factors, management practices, and agricultural expansion remains disputed, leading to uncertainty in future dryland sustainability assessments. Based on these challenges, there is a critical need to evaluate long-term greening patterns and attribute them to key driving factors.

Scientists from Lanzhou University and collaborating institutions published their findings on November 27, 2025, in Journal of Remote Sensing, presenting a 24-year global evaluation of vegetation productivity trends using satellite-derived gross primary productivity (GPP) data. The work analyzes drylands across continents to determine where greening is most pronounced and how natural and human drivers shape this change. Their results offer new clarity on the mechanisms behind greening and highlight the underestimated role of farming, irrigation, and fertilization in sustaining productivity in water-limited regions.

The study shows that 29.2% of global drylands have significantly greened from 2001–2024, while only 4.9% experienced significant browning. Drylands gained a net increase of 1,899 teragrams

of carbon, with Asia contributing nearly half. Human-related land cover—mainly croplands—accounted for 773 Tg of carbon gain, despite only covering about 12% of dryland area. Statistical attribution revealed human activities have more than twice the impact of CO□ fertilization and far exceed the effects of climate alone. However, current Dynamic Global Vegetation Models significantly underestimated greening trends and misattributed changes largely to CO□ and climate factors, highlighting the need to incorporate realistic land-use dynamics into Earth system simulations.

The research team combined satellite-derived GPP datasets with land-cover maps, atmospheric CO□ trends, climate records, and agricultural input datasets to evaluate ecological change over time. They examined vegetation responses across croplands, shrublands, grasslands, forests, and aridity zones ranging from hyper-arid deserts to dry subhumid regions. Over two decades, cropland areas expanded by 22.31×10^4 km², especially in semi-arid belts. Productivity surged most strongly in intensively managed agricultural regions of Asia, northern India, eastern China, and parts of Africa. Partial Least Squares Regression identified cropland area (0.34), nitrogen fertilizer use (0.30), and CO□ (0.33) as dominant greening drivers, while climate factors had minor influence (0.03). When comparing remote-sensing observations with TRENDY vegetation models, 86.98% of greening regions were underestimated, especially where cropland intensity was highest. This evidence confirms that anthropogenic land management—not climate alone—is reshaping dryland ecologies at a global scale.

"Our findings challenge the traditional view that global dryland greening is primarily driven by CO□ fertilization effect," the authors note. "Anthropogenic agricultural activity—fertilizer use, irrigation, and land expansion—plays a far greater role than previously recognized. Incorporating realistic land-use and land management processes into vegetation and climate models will be crucial for predicting dryland ecosystem resilience and sustainability under future warming."

The study used multi-source remote sensing datasets including MODIS-based GPP products (2001–2024), ERA5-Land climate reanalysis, GLC_FCS30D global land-cover maps, irrigation water use records, and nitrogen fertilization datasets. Vegetation trends were derived using the Sen slope estimator with Mann–Kendall significance testing. Attribution was performed via Partial Least Squares Regression to separate the effects of climate, CO□, and human land management. Satellite-observed results were compared with TRENDY v12 dynamic global vegetation models.

The work signals the need for improved agricultural water management and sustainable cropping strategies as freshwater stress intensifies. Enhanced integration of planting patterns, irrigation practices, and land-cover transitions into Earth system models will enable more accurate predictions of dryland carbon balance. The authors emphasize that greening is not inherently positive—unchecked irrigation and groundwater extraction could lead to long-term ecological degradation, further jeopardize the stability of human societies. Future research will focus on high-resolution and long-term consistent monitoring of land management, biodiversity responses, and policy-driven restoration approaches to ensure dryland resilience.

References
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Lucy Wang
BioDesign Research
email us here