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Brief Report

Harnessing ecosystem services for climate adaptation and mitigation: Evidence from drylands, restored landscapes and coastal wetlands

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Climate change poses unprecedented challenges to both natural ecosystems and human societies, intensifying droughts, floods, sea-level rise and biodiversity loss. Ecosystem services-the benefits that humans derive from nature-offer powerful, nature-based solutions for both climate adaptation and mitigation. Drylands, restored terrestrial landscapes and coastal wetlands are increasingly recognized as critical systems that, despite their vulnerability, play outsized roles in regulating climate, sequestering carbon, buffering extreme events and sustaining livelihoods. This article synthesizes evidence from these ecosystems to demonstrate how ecosystem services can be harnessed to address climate change. It highlights key mechanisms underpinning climate regulation, resilience and human well-being, emphasizing the integration of ecological processes with land management and policy. By examining multiscale interactions across diverse landscapes, the article underscores the importance of ecosystem-based approaches as cost-effective, resilient and socially inclusive strategies for climate adaptation and mitigation.

Keywords: Ecosystem services, Climate adaptation, Climate mitigation, Drylands, Ecological restoration, Coastal wetlands, Nature-based solutions, Carbon sequestration.

Introduction

Climate change is reshaping Earth's ecosystems through rising temperatures, altered precipitation patterns, intensifying extreme events and accelerating sea-level rise. These changes threaten food security, water availability, biodiversity and human health. Conventional climate responses have focused largely on technological and infrastructural solutions, such as engineered flood defenses or carbon capture technologies. While essential, these approaches are often costly, inflexible and limited in their capacity to address complex socio-ecological challenges. Ecosystem services provide a complementary and increasingly vital pathway for climate adaptation and mitigation (Narayan S., et al. 2017). Natural and managed ecosystems regulate climate through carbon sequestration, influence hydrological cycles, reduce disaster risks and support human well-being. When conserved, restored, or sustainably managed, ecosystems function as nature-based solutions that can simultaneously mitigate greenhouse gas emissions and enhance societal resilience to climate impacts. Among the most significant yet often undervalued ecosystems in this context are drylands, restored landscapes and coastal wetlands. Drylands cover over 40% of the terrestrial surface and strongly influence global carbon and productivity dynamics. Restored landscapes demonstrate the potential of ecological recovery to reverse degradation and enhance climate resilience.

Description

Ecosystem services relevant to climate change fall broadly into regulating, provisioning and cultural categories. Regulating services-such as carbon sequestration, temperature regulation, flood control and erosion prevention-are particularly central to climate mitigation and adaptation. Provisioning services, including food, fiber and medicinal resources, support livelihoods under climate stress, while cultural services enhance psychological resilience and social cohesion (Xu C., et al. 2021). Ecosystem-based approaches differ from engineered solutions in that they rely on self-organizing ecological processes, often providing multiple co-benefits. Importantly, ecosystem services operate across scales, from microbial processes in soils to landscape-level hydrological regulation, making them especially suited to addressing the multifaceted nature of climate change.

Drylands are characterized by low and variable rainfall, sparse vegetation and high climatic variability. Historically viewed as marginal systems, drylands are now recognized as major contributors to interannual variability in the global carbon cycle. Periodic rainfall events can trigger rapid vegetation growth and carbon uptake, demonstrating the dynamic role of drylands in climate regulation (Ebi KL., et al. 2008). Soil processes play a central role in dryland ecosystem services. Soil organic carbon, stabilized by biological crusts, plant roots and microbial communities, contributes to long-term carbon storage. Vegetation cover reduces surface albedo and moderates local temperatures, while root systems stabilize soils and reduce erosion under extreme weather. Dryland ecosystems support climate adaptation by sustaining livelihoods through grazing, dryland farming and non-timber forest products. Healthy drylands enhance water infiltration, reduce dust storms and buffer communities against drought impacts. Conversely, degradation through overgrazing, deforestation and unsustainable land use reduces ecosystem services and increases vulnerability to climate extremes.

Ecological restoration aims to recover ecosystem structure, function and services in degraded landscapes. Reforestation, afforestation, grassland restoration and wetland recovery have been widely implemented as climate mitigation strategies due to their carbon sequestration potential (Sterk A., et al. 2016). Restored forests and grasslands accumulate carbon in biomass and soils, contributing to national and global climate mitigation goals. Importantly, restoration also improves ecosystem stability, reducing vulnerability to climate stressors such as drought, heatwaves and intense rainfall. Beyond carbon storage, restored landscapes provide multiple adaptation benefits. Vegetation cover reduces flood risk by slowing runoff, enhances groundwater recharge and stabilizes slopes prone to landslides. Biodiversity recovery increases functional redundancy, enhancing ecosystem resilience to climate variability. Restoration also delivers socio-economic benefits, including improved agricultural productivity, livelihood diversification and enhanced cultural values (Lu F., et al. 2018). Community-based restoration initiatives often strengthen social capital, which is critical for adaptive capacity under climate change.

Conclusion

Ecosystem services offer powerful, multifunctional pathways for addressing climate change through both adaptation and mitigation. Evidence from drylands, restored landscapes and coastal wetlands demonstrates that nature-based solutions can regulate climate, buffer extreme events, support livelihoods and enhance resilience across diverse socio-ecological contexts. As climate change accelerates, harnessing ecosystem services will require a shift toward integrated, ecosystem-based approaches that recognize the value of biodiversity, ecological processes and human–nature relationships. Protecting and restoring ecosystems is not merely an environmental imperative but a foundational strategy for sustainable climate action and human well-being in a changing world. Harnessing ecosystem services for climate adaptation and mitigation requires integration across ecological, social and governance scales. Effective strategies depend on sound ecological science, inclusive decision-making and supportive policy frameworks. Key challenges include trade-offs among ecosystem services, land-use competition and unequal distribution of benefits. For example, afforestation for carbon sequestration must be balanced against water availability and biodiversity conservation. Similarly, coastal wetland restoration must consider local livelihoods and land tenure.

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Conflict of Interest

The authors declare no conflict of interest.

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