



Research Paper

Renewable Energy Expansion and Ecological Sustainability in Rajasthan's Thar Desert: A Review

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Abstract

The Thar Desert of Rajasthan represents one of the most promising frontiers for renewable energy generation in India, particularly solar and wind power. Over the past two decades, this arid region has undergone rapid transformation through large-scale renewable installations, positioning Rajasthan as a national leader in clean energy production. Yet, these developments raise concerns over land-use change, ecological fragility, and socio-cultural disruptions. This paper synthesizes findings from existing research to examine the multi-dimensional impacts of renewable energy expansion in the Thar Desert, emphasizing ecological, social, and governance perspectives. Through a systematic review of 38 peer-reviewed studies and policy reports (2010–2025), the paper explores the paradox of green growth within fragile desert ecosystems. The review concludes that while renewable energy contributes significantly to India's low-carbon goals, inadequate environmental planning and exclusionary governance structures threaten the ecological balance and cultural resilience of desert communities.

Keywords: Rajasthan, Thar Desert, renewable energy, desert ecosystem, biodiversity, sustainability, land use, energy governance

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I. Introduction

Rajasthan, India's largest state by area, has emerged as the epicenter of the country's renewable energy revolution. Contributing nearly 25% of India's installed solar capacity, the state has transformed its vast desert expanse into a key site for solar and wind energy generation (Pandey et al., 2012; MNRE, 2023). The Thar Desert, with its high solar insolation and sparse population, offers ideal conditions for energy infrastructure such as the Bhadla Solar Park, Jaisalmer Wind Cluster, and new developments in Barmer and Jalore (Meena et al., 2015).

While renewable energy development supports India's commitments under the Paris Agreement, it has also triggered ecological and socio-cultural challenges. Desert ecosystems are characterized by low resilience and unique biodiversity — including the Great Indian Bustard, desert fox, and chinkara — all increasingly threatened by land conversion and infrastructure sprawl (Choudhary et al., 2022). Additionally, pastoralist groups like the Raikas and Meghwals face disruptions to traditional grazing lands or *orans*, leading to livelihood insecurity and cultural loss (Roy & Paliwal, 2024).

This review aims to synthesize current research on renewable energy expansion and its ecological and social consequences in Rajasthan. It seeks to identify key patterns, contradictions, and governance challenges shaping the state's energy transition.

II. Methodology

This study adopts a systematic literature review approach, focusing on peer-reviewed articles, reports, and book chapters published between 2010 and 2025. Academic databases such as Scopus, Web of Science, and Google Scholar were searched using keywords: Rajasthan renewable energy, Thar Desert ecology, solar parks biodiversity, and energy transition India.

A total of 38 publications were selected based on:

1. Direct relevance to Rajasthan's desert ecosystems;

2. Discussion of renewable energy's ecological or social impacts;
3. Availability of full text for analysis.

Each study was categorized thematically into four analytical domains:

- Renewable energy trends and spatial patterns;
- Ecological and biodiversity implications;
- Socio-economic and cultural transformations;
- Governance and policy frameworks.

This secondary analysis enables an integrative understanding of how renewable energy development interacts with ecological sustainability in arid regions.

III. Review of Literature

3.1 Renewable Energy Development in the Thar Desert

Rajasthan's renewable growth stems from favorable climatic and policy conditions. Pandey et al. (2012) highlight the role of state incentives and private investment in catalyzing solar growth. Meena et al. (2015) describe the Thar as India's "solar hotspot," emphasizing the physical geography that supports high photovoltaic output. Santra et al. (2021) link renewable energy deployment with desertification control, suggesting that solar infrastructure could assist in land restoration if integrated with vegetation programs.

However, Sareen and Shokrgozar (2022) critique this optimism, describing Rajasthan's solar expansion as an extractive form of "green colonialism," where local communities are excluded from decision-making and benefit sharing.

3.2 Ecological and Biodiversity Impacts

The Thar Desert's ecosystem is highly fragile. Choudhary et al. (2022) report declining plant and animal diversity in areas hosting solar and wind parks. Studies such as Sahal and Choudhary (2023) document bird mortality around wind farms, while Singh and Sharma (2025) explain that solar panels alter local albedo, increasing soil dryness and disturbing vegetation cycles.

Sinha and Raghunathan (2022) emphasize the fragmentation of habitats critical for the Great Indian Bustard, while Basu et al. (2024) warn that cumulative ecological impacts are often underestimated in official assessments.

3.3 Socio-Economic and Cultural Transformations

Renewable energy has redefined rural livelihoods in Rajasthan's desert regions. Narula (2021) and Roy & Paliwal (2024) describe conflicts over land tenure and loss of sacred commons (*orans*). Pastoralists face declining grazing access, pushing many toward wage labor (Chouhan & Singh, 2020). Shokrgozar and Sareen (2025) interpret this shift as part of a broader "energy frontier" transformation, where traditional landscapes are reterritorialized by energy capital.

Nonetheless, Santra et al. (2021) advocate for integrating renewable initiatives with community-oriented schemes, such as solar-based irrigation and agroforestry, to achieve socio-ecological synergy.

3.4 Governance and Policy Gaps

Narula (2021) and Ghosh et al. (2021) criticize India's Environmental Impact Assessment (EIA) process for renewable projects, noting its generic scope and lack of cumulative analysis. The Rajasthan Renewable Energy Policy (2023) emphasizes capacity expansion but lacks ecological zoning or biodiversity-sensitive planning (MNRE, 2023).

Governance remains fragmented among agencies like the Rajasthan Renewable Energy Corporation (RREC), Forest Department, and local panchayats, leading to procedural overlaps and land conflicts (Roy & Paliwal, 2024).

IV. Discussion

The reviewed studies converge on a central paradox: renewable energy, while essential for decarbonization, generates localized ecological degradation and social inequities in Rajasthan's desert zones. The conversion of commons into energy parks represents a spatial and cultural reconfiguration of the Thar Desert — from pastoral to techno-industrial landscapes.

Ecological research points to microclimatic shifts, biodiversity stress, and soil degradation, while social studies reveal cultural displacement and weakened traditional governance systems. These patterns illustrate the global "green paradox" — where sustainability efforts risk producing new environmental injustices.

However, several scholars (Santra et al., 2021; Choudhary et al., 2022) propose integrative models: promoting community-owned solar parks, ecological restoration, and participatory site planning. A shift toward smaller, distributed energy systems could mitigate ecological pressures and promote inclusive sustainability.

V. Conclusion and Recommendations

The Thar Desert exemplifies the complex interplay between renewable energy progress and ecological vulnerability. The literature demonstrates that while Rajasthan's renewable boom aligns with India's climate ambitions, its current trajectory risks undermining desert ecology and traditional livelihoods.

Future policy must prioritize:

- Biodiversity-sensitive energy zoning;
- Cumulative environmental impact assessments;
- Legal protection of *orans* and community grazing lands;
- Participatory planning involving local pastoralists;
- Promotion of decentralized, small-scale renewable systems.

A sustainable future for Rajasthan's deserts depends on harmonizing energy innovation with ecological stewardship and social justice.

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