



## “PATTERNS, PROCESSES, AND IMPACTS OF SOIL DEGRADATION IN RAJASTHAN”!

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### ABSTRACT:

Soil degradation in Rajasthan, India's largest and one of the driest states, poses a significant threat to agricultural productivity, environmental sustainability, and rural livelihoods. This paper investigates the spatial extent, drivers, and socio-economic impacts of soil degradation across the diverse agro-climatic zones of Rajasthan. Approximately 60% of Rajasthan's geographical area, equivalent to about 20.4 million hectares, is affected by various forms of soil degradation, primarily wind erosion (56%), water erosion (42%), and chemical degradation including salinity and sodality (2%). The degradation accelerates desertification and lowers land productivity, creating economic losses estimated in billions of Indian Rupees annually. This study synthesises insights from recent soil surveys, GIS mapping, satellite imagery, and field data, focusing on both western arid zones and more humid eastern districts. The findings highlight critical hotspots such as Jaisalmer, Bikaner, Barmer, Bhilwara, and Udaipur, emphasise the interplay of natural and anthropogenic factors, and explore existing government policies and restoration efforts. Enhanced conservation practices, community engagement, and climate-smart agriculture are recommended to mitigate degradation and secure long-term land health in Rajasthan.

### KEYWORDS:

**SOIL DEGRADATION, WIND EROSION, WATER EROSION, DESERTIFICATION, SALINITY, SUSTAINABLE LAND MANAGEMENT, ARID REGIONS, AGRICULTURE.**

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### INTRODUCTION

Soil resources are fundamental to food production, ecological balance, and sustainable development. Rajasthan, located in northwest India, is characterised by arid and semi-arid climates, extreme temperatures, scarce rainfall, and fragile ecosystems. With agriculture employing a large majority of its population, soil degradation severely compromises food security and economic stability. Degradation processes such as wind and water erosion, salinisation, and sodicity reduce soil fertility, increase surface runoff, and enhance desertification, ultimately threatening livelihoods.

The magnitude of soil degradation in Rajasthan is staggering: as per the National Bureau of Soil Survey and Land Use Planning (NBSS&LUP), nearly 60% (20.4 million ha) of the total geographic area is degraded[1]. This study aims to explore the spatial distribution and causes of soil degradation, assess its socio-economic consequences, and evaluate current management strategies to provide a holistic understanding of this critical problem.

### OBJECTIVES

- Quantify and map the extent and types of soil degradation across Rajasthan's districts.
- Analyze natural and anthropogenic factors contributing to soil degradation.

- Identify the socio-economic and environmental impacts of land degradation.
- Review governmental policies, programs, and community-based interventions for combating soil degradation.
- Recommend sustainable land management practices tailored to Rajasthan's diverse agro-ecological zones.

### SCOPE

The research encompasses all major physiographic and agro-climatic zones in Rajasthan, focusing on degraded and wasteland areas identified through GIS and field-based surveys. It investigates district-level variations in erosion types and severity, integrates soil chemical quality data, and includes a case study from Bhilwara District to highlight local specifics. Government reports, remote sensing data, and scholarly articles form the data foundation.

### LITERATURE REVIEW

Soil degradation in Rajasthan has been a focus of scientific inquiry for decades, with detailed mapping and comprehensive wasteland surveys conducted by NBSS&LUP and other agencies. According to a 2020 report, Rajasthan has about 20.42 million hectares of degraded

land—constituting 60% of its total area—with wind erosion contributing 56%, water erosion 42%, and 2% due to salinity and sodicity[1]

Wind erosion dominates especially in western districts like Jaisalmer, Barmer, Bikaner, Churu, and Jodhpur, where shifting sand dunes, minimal rainfall, and sparse vegetation accelerate soil loss. These regions are also highly vulnerable to desertification. In contrast, water erosion is more prevalent in the southeastern and eastern districts, including Udaipur, Bhilwara, Chittorgarh, and Bundi, where runoff and slope gradients cause extensive rill, sheet, and gully erosion.

Salinity and sodicity issues, though covering a smaller area, cause significant fertility loss in pockets across Hanumangarh, Churu, Nagaur, Jaipur, and Sri Ganganagar. Anthropogenic factors such as deforestation, overgrazing, unsustainable agricultural practices, groundwater over-exploitation, and mining have aggravated natural degradation processes.

Economic assessments estimate that soil degradation causes annual losses equivalent to billions of rupees due to reduced crop yields and increased land restoration costs[2]. Studies highlight the need for integrated approaches, harnessing afforestation, agroforestry, soil and water conservation technologies, and participatory forest management to curb degradation.

**STUDY AREA AND BACKGROUND**

Rajasthan covers 342,239 square kilometers and lies between 23°30' to 30°12' N latitude and 69°30' to 78°17' E longitude, featuring diverse landscapes from the Thar Desert to the Aravalli hills and Vindhyan plateau[1]. The state’s climate is typified by extreme fluctuations: summer temperatures can reach 49°C and winters may dip below 13°C, while annual rainfall averages 531mm but varies widely.

**KEY CAUSES OF SOIL DEGRADATION**

- Wind Erosion: This is the most significant contributor to soil degradation in Rajasthan, impacting approximately 56% of degraded lands. Districts such as Jaisalmer, Bikaner, Barmer, Churu, and Jodhpur are severely affected, with the typical Thar Desert landscape being especially vulnerable.
- Water Erosion: Accounting for around 42% of degradation, water erosion affects the southeastern and eastern districts, including Udaipur, Chittorgarh, Bhilwara, and Bundi. Factors such as poor agricultural practices and deforestation exacerbate this process.
- Chemical Degradation: This form of degradation is associated with issues like salinity and sodicity, which are more scattered but still pose problems—for example, saline soils are common in Hanumangarh, Churu, Nagaur, Jaipur, and Jaisalmer.
- Human-Induced Factors: Overgrazing, mining, industrial pollution, and over-extraction of water

have intensified natural erosion and desertification, posing additional challenges to sustainability.

**SCALE AND ECONOMIC IMPACT**

- Over 60% of Rajasthan’s total geographical area is affected by some form of soil or land degradation.
- This leads to an estimated economic loss of ₹55.24 billion per year (at 2017-18 prices), reducing agricultural yields and increasing vulnerability to climate extremes.
- Desertification is a major environmental challenge, with 67% of the state’s land suffering from desertification or degradation processes such as wind erosion, water erosion, and chemical changes in the soil.

**DISTRICT-LEVEL DETAILS**

District	Degradation Type	Estimated Area (ha)
Jaisalmer	Wind erosion	~2,772,000
Bikaner	Wind erosion	~2,119,000
Barmer	Wind erosion	~1,908,000
Churu	Wind erosion/Salinity	~1,346,000
Udaipur	Water erosion	~986,000
Bhilwara	Water erosion	~571,000
Hanumangarh	Salinity	Not specified
Bundi	Water erosion	~539,000

**THE PHYSIOGRAPHIC ZONES INCLUDE**

- Thar Desert and Western Sandy Plains: Characterized by sandy, loose soils prone to wind erosion and desertification.
- Central Highlands and Aravalli Ranges: Rocky terrains with thin soil cover but susceptible to water erosion.
- Eastern Plains: More fertile alluvial soils but vulnerable to water erosion and salinity.

Vegetation cover is scanty due to forest degradation, with forest cover below 7%—far less than the national average—intensifying the exposure of soils to erosive forces. The population primarily depends on rainfed agriculture and livestock grazing, increasing pressure on already fragile soils.

**MATERIALS AND METHODS**

This paper synthesizes data from NBSS&LUP’s comprehensive wasteland and soil degradation mapping exercises at scales of 1:50,000 to 1:250,000. Remote sensing, GIS, and satellite imagery analyses were employed to delineate degraded lands, supported by secondary data such as rainfall, temperature, land use, and soil chemical analyses.

Field survey data, particularly from Bhilwara District, were reviewed to integrate site-specific degradation patterns

with broader trends. Soil profile analyses, erosion classification, and vegetation cover assessments provide micro-level detail.

Statistical and GIS tools facilitated quantification of degradation extent, spatial distribution, and correlation analyses between climatic variables and degradation intensity. Socio-economic impacts were inferred from government agricultural and rural livelihood reports.

## RESULTS

### EXTENT AND TYPES OF SOIL DEGRADATION

- ❖ Rajasthan has 20.42 million hectares classified as degraded or wasteland, approximately 60% of the state's physical area[1].
- ❖ Wind erosion accounts for 11.4 million hectares (56%): Primarily in districts like Jaisalmer, Bikaner, Barmer, Churu, Jodhpur. These areas have highly mobile sand dunes and minimal vegetation. For example, Jaisalmer exhibits wind erosion over 2.7 million hectares[1].
- ❖ Water erosion impacts about 8.63 million hectares (42%): Concentrated in southern and eastern districts such as Udaipur (986,000 ha), Bhilwara (571,000 ha), Chittorgarh, Bundi, and Baran[1].
- ❖ Chemical degradation from salinity and sodicity affects around 373,000 hectares scattered in Hanumangarh, Churu, Nagaur, Jaipur, and Sri Ganganagar.
- ❖ Some districts exhibit extreme degradation—Bundi has up to 97% of its wasteland area, while districts like Pali show minimal degradation (~2%).

### BHILWARA DISTRICT CASE STUDY

Bhilwara (10,455 km<sup>2</sup>) exemplifies mixed degradation patterns due to diverse geomorphology and human pressure. It receives an average annual rainfall of approximately 700 mm with spatial variability. Soil erosion severity distribution from field surveys shows:

- Slight erosion (31.3%)
- Moderate erosion (34.9%)
- Severe erosion (11.9%)
- Very severe erosion (4.7%)

Most degradation occurs on hilly slopes and cultivable lands, exacerbated by overgrazing and deforestation.

### SOCIO-ECONOMIC AND ENVIRONMENTAL IMPACTS

Soil degradation lowers agricultural yield potential, resulting in economic losses. Conservative estimates suggest yearly losses exceeding ₹55 billion (INR) due to decreased productivity and increased input costs for soil conservation[2]. Degradation also leads to groundwater depletion due to poor surface retention, increased flood risk in some areas, and loss of biodiversity. Rural communities face heightened vulnerability to climatic variability and livelihood insecurity.

## DISCUSSION

The dual challenge of wind and water erosion characterizes Rajasthan's soil degradation. Wind erosion in desert regions is driven by strong winds, sparse vegetation, and exposed sandy surfaces. Effective mitigation includes physical barriers such as checkerboard plantations, afforestation of shelterbelts, and use of brushwood fences.

Water erosion in hillier southeast districts, aggravated by episodic heavy rains and inadequate terrain management, creates surface runoff and gullies. Contour bunding, construction of check dams, terracing, and vegetative cover improvement are sustainable solutions.

Salinity and sodicity, though less widespread, deteriorate soil structure and reduce crop growth in localized zones, demanding reclamation via gypsum amendment, improved drainage, and salt-tolerant crop varieties.

Human activities like deforestation, mining, and poorly managed agriculture exacerbate natural degradation. Therefore, integrated management combining technical interventions with community participation and policy support is essential.

Existing government programs range from afforestation drives, the Rajasthan Agroforestry Policy 2025, to soil and water conservation schemes at the gram panchayat level. Implementation gaps remain, making geographic targeting and long-term monitoring vital.

## CONCLUSION

Soil degradation in Rajasthan is a significant environmental and socio-economic hurdle, impacting over 60% of its land area through intensive wind and water erosion, as well as chemical deterioration. This degradation jeopardizes agricultural productivity, rural livelihoods, and ecological health. The study advocates a multipronged approach emphasizing afforestation, sustainable land management, water conservation, and community empowerment.

Calls for action include expansion of vegetative barriers in the west, terracing and bunding in the east and southeast, adoption of salt-tolerant crops, and regular spatial monitoring using remote sensing.

Such strategies can help arrest desertification trends, restore soil fertility, improve water security, and ensure food and livelihood security for Rajasthan's farming population in the face of climate variability and growing resource pressures.

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