



Land Degradation Due to Wind Erosion in Arid Regions of India



Indian Council of Agricultural Research
New Delhi

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2026

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FOREWORD

Wind erosion remains a critical driver of soil degradation and declining land productivity in arid and semi-arid regions of India. In areas with high wind erosion, annual soil loss can range from 150 to 200 t ha⁻¹. The fine soil particles carried by wind are often nutrient-rich, meaning their loss directly depletes soil fertility. In highly eroded areas, the loss of essential nutrients such as nitrogen, phosphorus, and potassium can be two to three times greater than that in less affected regions. The loss of topsoil and associated nutrients can lead to a reduction in crop yields and further translates to economic losses, which may vary depending on the crop and severity of erosion.

The Indian Council of Agricultural Research (ICAR) has been continuously engaged in monitoring and assessing land degradation processes, including soil erosion by water and wind, soil salinity and soil acidity. It also promotes various strategies to mitigate these challenges. In 2010, ICAR published a book on “Degraded and Wastelands of India: Status and Spatial Distribution”, which served as a comprehensive land degradation atlas at the time. The publication provided data on extent of land degradation, highlighting its significant threat to agricultural productivity and food security in India.

ICAR-Central Arid Zone Research Institute (CAZRI), Jodhpur, has significantly contributed in monitoring and control of wind erosion process during the last few decades. Several technologies have been developed, and successfully adopted in the field to reduce wind erosion and stabilize active sand dunes. Notable among these are the checkerboard plantation method on sand dunes and the establishment of tree shelterbelts along canals, roads and field boundaries. There is a continuing need to periodically assess the effectiveness of these technologies to support the development of targeted strategies for further reducing land degradation.

In this context, the present study, which quantifies soil loss using the revised wind erosion equation (RWEQ) for both hot and cold arid regions of India, is highly relevant. The findings for the period 2020-2024 indicate that approximately 6% of the hot arid region falls under ‘severe’ category of annual soil loss ($\geq 150 \text{ t ha}^{-1} \text{ yr}^{-1}$), equivalent to loss of about 10 mm top soil annually. These severely affected areas are primarily located in the western parts of Barmer and Jaisalmer districts. In contrast, the northern part of hot arid region, including Sri Ganganagar, Hanumangarh and adjoining areas of southern Punjab and western Haryana, experience relatively low soil loss



($\leq 2 \text{ t ha}^{-1} \text{ yr}^{-1}$). Compared to the hot arid region, soil loss rates in the cold arid region are generally low, with most areas also recording $\leq 2 \text{ t ha}^{-1} \text{ yr}^{-1}$. The spatial maps developed in this study provide a benchmark for future assessments of land degradation.

I appreciate the dedicated efforts of the scientific team of ICAR-CAZRI, Jodhpur, for their work in quantifying and mapping spatial map of soil loss due to wind erosion. This publication will serve as an important resource for policymakers, planners, researchers, and development practitioners working towards monitoring and control of wind erosion and the promotion of sustainable land management.

(Dr Mangi Lal Jat)

March 17, 2026
New Delhi

Secretary, Department of Agricultural Research and Education (DARE)
& Director General, Indian Council of Agricultural Research (ICAR)

MESSAGE

Wind erosion is the major causative factor of land degradation in arid and semi-arid areas of India. It not only threatens the food production but also adversely affects the lives and livelihoods of marginalized groups of farmers and local communities. The western part of Rajasthan, which accounts for about 62% of the country's hot arid region, is highly vulnerable to wind erosion. Other states like Haryana, Gujarat, and Punjab and cold arid regions of Ladakh and Himachal Pradesh also experience wind erosion. Areas with predominantly sandy soils along the coast are also affected *e.g.* coastal region of Gujarat near Rann of Kutch.

The removal of fine topsoil by wind erosion leaves behind a coarse, less fertile substrate, often referred to as skeletal soil, with poor nutrient status. Studies have shown significant losses of essential nutrients, like carbon and nitrogen, through wind erosion (45 kg C ha^{-1} and 4.3 kg N ha^{-1} during a cropping season). Wind erosion reduces crop productivity through direct damage like abrasion and burial of seedlings, and indirectly by diminishing soil fertility. Studies in western Rajasthan, a severely wind erosion affected area, show that yield losses can reach hundreds of kilograms per hectare for crops like pearl millet and groundnut. The associated economic losses are significant, with one study reporting losses between ₹36-₹2294 per hectare for pearl millet and up to ₹12,465 per hectare for clusterbean, depending on the erosion severity.

Sustaining agricultural productivity in India's arid regions requires the implementation of effective control measures to mitigate wind erosion. In this context, high-resolution mapping of soil loss potential at a very fine spatial resolution is essential to adopt suitable control measures at farmers' field level. The present work represents a first attempt to map soil loss potential for a recent period (2020-2024), covering both hot and cold arid regions of India. These maps may serve as a baseline to monitor the past trends and to assess future changes in wind erosion severity in the region, particularly in the context of climate change.

I commend the efforts of the scientists and institutions involved in producing this comprehensive assessment and mapping of soil loss potential due to wind erosion.



This work will support policymakers, planners, researchers, and field practitioners working towards monitoring and control of wind erosion process for sustainable land management and in achieving the goals of Land Degradation Neutrality.

(Dr Amaresh Kumar Nayak)

Deputy Director General (Natural Resource Management),
Indian Council of Agricultural Research (ICAR)

March 18, 2026
New Delhi

PREFACE

ICAR-Central Arid Zone Research Institute (ICAR-CAZRI), Jodhpur is a leader in undertaking research related to the assessment of land degradation in both the hot and cold arid regions of the country. ICAR-CAZRI has published two documents earlier in the years 2000 and 2016 on wind erosion in western Rajasthan and its control. However, considering the problems of land degradation and the need for recent estimates and updated status, a national-level committee was formulated by the Indian Council of Agricultural Research (ICAR), New Delhi. As a part of the committee, responsibility was given to ICAR-CAZRI, Jodhpur to map the status of land degradation due to wind erosion by adopting scientific methods. The task has been completed by amalgamating the basic and theoretical equations for wind erosion assessment with advanced and modern approaches suggested in recent literature. An extensive literature survey on the topic of geospatial mapping of soil erosion (or land degradation) due to wind erosion indicated that parameters/variables essential for soil loss prediction need to be computed through the Revised Wind Erosion Equation (RWEQ). With advancements in computing technologies and the availability of satellite images and other resources on several digital platforms, the geospatial analysis and estimates of soil erosion have been improved. Considering these vast improvements in computational intelligence, it was realized that a standard document is needed to cover all aspects comprehensively for employing the RWEQ model for soil loss predictions.

This publication presents extent, processes, and impacts of wind erosion in arid regions of the country covering both hot and cold arid agroecological regions. The bulletin briefs about the methodology and results of soil loss estimation due to wind erosion by applying the RWEQ model. The soil loss estimation was done for 24 fortnights of a year. Finally, the soil loss estimations were aggregated for four seasons: January-March, April-June, July-September, and October-December. The annual soil loss estimation maps were obtained and illustrated in the document and the major findings from the soil loss maps are summarized in conclusions.

The authors of this technical bulletin want to express sincere gratitude to Honourable Director General, ICAR, Dr M.L. Jat, and Deputy Director General (DDG), Natural Resource Management, ICAR, Dr A.K. Nayak for their guidance, inspiration, and motivation provided during the entire course of development of this technical bulletin. The authors are grateful to the Director, ICAR-CAZRI, Jodhpur for providing



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his constant support and supervision while carrying out the work and writing this bulletin. The authors are thankful to the Project Director, DKMA, ICAR, and Dr Adul Islam, Principal Scientist, NRM Division, ICAR for their critical observations and suggestions to further improve the quality of the bulletin. The support extended by all scientists of the Division of Natural Resources, ICAR-CAZRI, Jodhpur is acknowledged.

March 18, 2026
Jodhpur

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ICAR-Central Arid Zone Research Institute

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1. Extent, Processes, and Impacts of Wind Erosion in Arid Regions

Wind erosion affects approximately 41% of the world's total geographical area, causing severe land degradation in arid and semi-arid regions (Lal 1990). In India, it impacts about 13.5% of the country's total land area (Sehgal and Abrol 1994). In the arid agroecological regions, wind erosion leads to several major problems, such as the suspension of fine particles into the atmosphere, the loss of nutrient-rich topsoil from agricultural fields, and the deposition of eroded sediments on irrigation canals, roads, railway tracks and other infrastructure. Additional impacts on crops include physical damage to plants from sand blasting of tender stems and leaves, and burial of crops due to deposition of wind-blown sediments.

Arid regions possess climatic and landform characteristics that strongly favour the occurrence of wind erosion. The process is initiated when wind speed exceeds the threshold value of 5 m s^{-1} at a height of 2 m above the ground surface (Schwab *et al.* 1993). Among the land-related factors, plant cover, soil aggregate size, surface roughness, soil moisture, and the extent of open and exposed field surface play critical roles in determining the severity of wind erosion. Additionally, uncontrolled grazing further reduces vegetative cover, leaving the land more exposed and increasingly susceptible to wind erosion.

Suspended particulate matter, particularly dust particles smaller than $60 \mu\text{m}$, generated during wind erosion events, can remain in the atmosphere for extended periods. These particles pose severe health risks by affecting human respiratory and cardiovascular systems (Santra and Mertia 2006). Moreover, eroded soil carries significant amounts of carbon and nutrients, leading to a decline in soil fertility at the source areas while causing nutrient





enrichment in unintended locations through dust deposition, such as in water bodies (Santra *et al.* 2006, 2013; Soni *et al.* 2013).

Apart from dust hazards in atmosphere created by dust storm events, the accumulation of eroded dust on roads, railway tracks, and irrigation canals necessitates regular cleaning operations, which impose significant economic costs. Therefore, addressing wind erosion effectively requires prioritizing areas based on the severity of the problem to develop appropriate policies and management strategies. Hence, to classify such an extensive desert region accurately, field measurements of wind erosion across different land-use systems are essential, as they provide critical data for assessing severity and validating process-based wind erosion models.

•

2. Arid Regions in India

The arid region of India falls within two of the 20 agro-ecological regions (AERs): (i) the Western Himalayas, cold arid eco-region (A13E1) and (ii) Western Plains, Kutch and part of Kathiawar Peninsula, hot arid eco-region (M9E1). Together, these regions cover approximately 47.2 million hectares (mha), accounting for about 14.34% of the total geographical area of India. The agro-ecological regions of the country were delineated based on four key parameters: soil, physiography, length of growing period (LGP) and bioclimatic parameters (Sehgal *et al.* 1992).

The hot arid agro-ecological region is primarily located in the western part of Rajasthan and the north-western part of Gujarat, with extensions into adjoining areas of Haryana and Punjab (Fig. 1). Geographically, it lies between 21°17'-31°12' N and 68°8'-76°20' E, covering roughly 32 mha (Gajbhiye and Mandal 2000). Rajasthan accounts for the largest share with 21.8 mha, distributed across the districts of Barmer, Bikaner, Jalore, Jodhpur, Nagaur, Churu, Sikar, Jhunjhunu, Hanumangarh, Sri Ganganagar, Pali and Jaisalmer.



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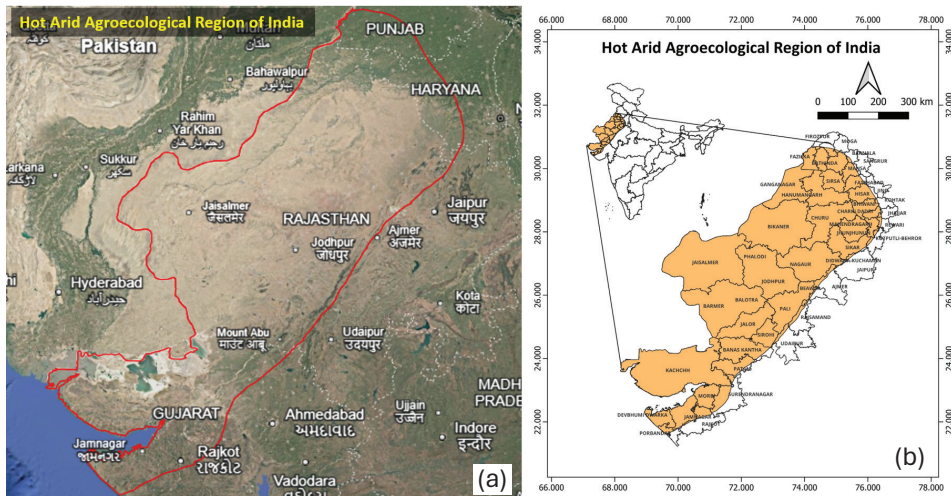


Fig. 1. Hot arid agro-ecological region of India

a) Google Earth image, b) boundary of study area along with administration units

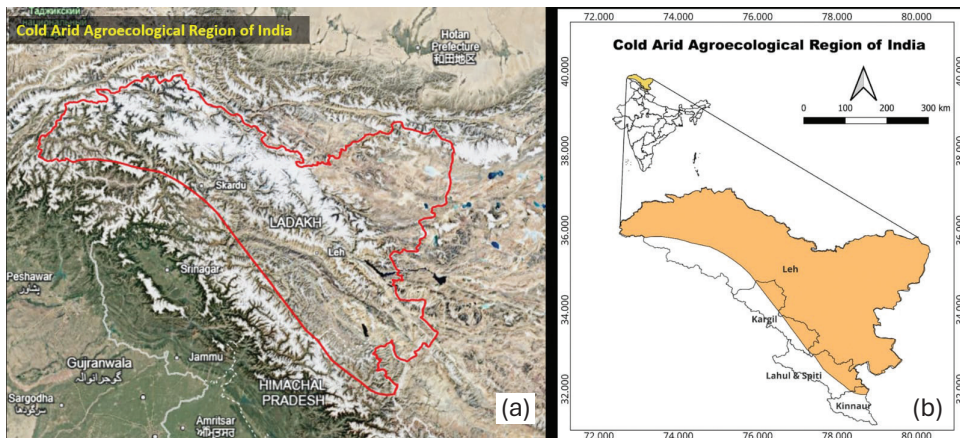


Fig. 2: Cold arid agro-ecological region of India:

a) Google Earth image, b) boundary of study area along with administration units

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In Punjab, the hot arid region spans about 1.2 mha, covering districts including Bathinda, Faridkot, Firozpur, Mansa, Moga, Muktsar and Sangrur. Haryana contributes 1.7 mha, including districts such as Bhiwani, Fatehabad, Hisar, Jhajjar, Jind, Mahendragarh, Rewari, Rohtak and Sirsa. In Gujarat, around 7.6 mha fall under hot arid conditions, notably within Banaskantha, Jamnagar, Kutch, Patan, Porbandar, Rajkot, Sabarkantha and Surendranagar.

In contrast, India's cold arid region extends over approximately 15 mha, located in Union Territory of Ladakh (Leh and Kargil) and parts of Himachal Pradesh (Lahul & Spiti and Kinnaur) (Fig. 2). It lies between 31.86°-37.07° N and 72.52°-80.34° E, covering an area of 15.13 mha (Gajbhiye and Mandal 2000). Ladakh (Leh, Kargil) and Himachal Pradesh (Lahaul & Spiti), together account for 14.4 mha, while the Kinnaur district of Himachal Pradesh makes up the remaining 0.6 mha.



3. Mapping Soil Loss due to Wind Erosion

To assess the spatial distribution of soil loss caused by wind erosion, datasets on key climatic parameters such as wind speed, maximum and minimum temperature, rainfall, and solar radiation, were compiled along with soil attributes, including sand, silt, and clay fractions, organic matter content, and calcium carbonate content. In addition, fortnightly vegetation parameters, namely normalized difference vegetation index (NDVI), vegetation cover, and combined crop factor, were obtained. A digital elevation model (DEM) was also used to represent terrain characteristics. All datasets were generated for spatially distributed grids/points and covered a five-year period (2020–2024) to facilitate the assessment of potential soil loss rates across the arid regions of India under recent conditions.

The potential soil loss rate due to wind erosion is computed using the Revised Wind Erosion Equation (RWEQ) model, expressed as follows (Fryrear *et al.* 1998).

$$SL = \frac{2x}{S^2} Q_{\max} e^{-\left(\frac{x}{S}\right)^2} \quad (1)$$

where, SL = potential soil loss rate (kg m^{-2}); x = distance from non-erodible border (m), and S = critical field length (m).

The critical field length and maximum transport capacity are computed using the following expressions (Fryrear *et al.* 2001).

$$S = 150.7(WF \times EF \times SCF \times K' \times COG)^{-0.3711} \quad (2)$$

$$Q_{\max} = 109.8(WF \times EF \times SCF \times K' \times COG) \quad (3)$$

where, S = critical field length (m) and $Q_{\max}$ = maximum transport capacity (kg m^{-1}), WF = weather factor, EF = soil erodibility factor, SCF = soil crust factor, K' = soil roughness factor and COG = combined crop factor.

4. Soil Loss Rate due to Wind Erosion

The computed spatial maps of soil loss rate were aggregated on a quarterly basis to estimate seasonal soil loss for four periods: January-March (winter), April-June (summer), July-September (rainy) and October-December (post-rainy). Across all seasons, a clear gradient in soil loss rate is observed, increasing from the south-western and southern parts of the region towards the eastern direction.

- » Annual potential soil loss rate in hot arid agro-ecological region of India was 0-650 $\text{t ha}^{-1} \text{yr}^{-1}$
- » Only 6% area of hot arid region lies under severe category of soil loss rate, and 30% area lies under moderate to extremely intense erosion category
- » Annual soil loss was higher ($> 80 \text{ t ha}^{-1} \text{yr}^{-1}$) in Jaisalmer and Barmer districts of Rajasthan and Kutch, Jamnagar, Devbhumi Dwarka and Rajkot districts of Gujarat than other parts of hot arid region

Soil loss was negligible (i.e., close to zero) over more than 99% of the area during the winter season. In contrast, during the summer season (April-June), soil loss rates





ranged from 0 to 45 kg m⁻². Higher seasonal soil loss rates (>8 kg m⁻²) were recorded in the western and south-western parts of the region than rest, particularly in the districts of Jaisalmer and Barmer in Rajasthan and coastal portion of Kutch. During the rainy season (July–September), soil loss rates declined, ranging between 0 and 22 kg m⁻² across the study area.

All seasonal maps were aggregated to estimate the annual soil loss rate, and the corresponding spatial distribution is presented in Fig. 3. The annual soil loss rate in the area ranged from 0 to 65 kg m⁻² yr⁻¹ (equivalent to 0-650 t ha⁻¹ yr⁻¹). Similar to the seasonal maps of the soil erosion patterns,

- » Annual potential soil loss rate in cold arid agro-ecological region of India was 0-33 t ha⁻¹ yr⁻¹.
- » Erosion was highest during July–September as compared to other seasons
- » Soil loss rate was comparatively low in cold arid region (≤ 20 t ha⁻¹ yr⁻¹), except small pockets nearby Nubra Valley

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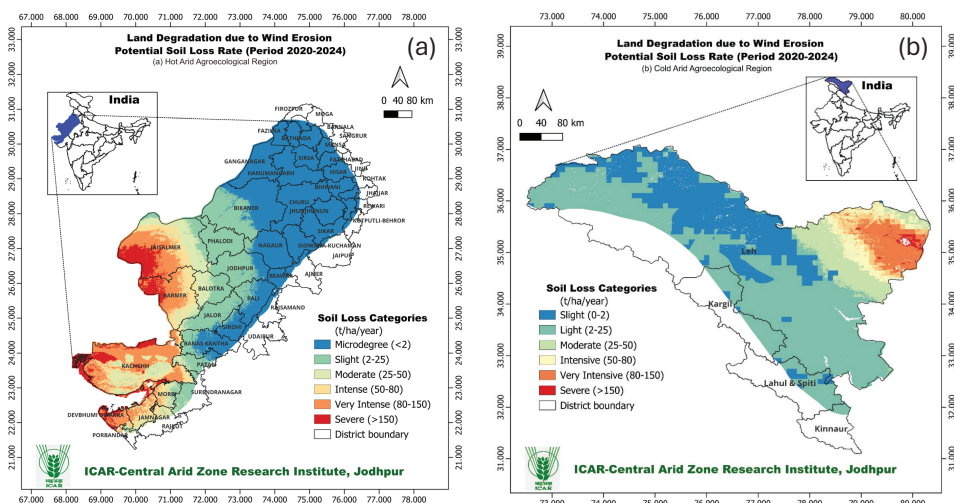


Fig. 3: Spatial maps of the potential annual soil loss rate due to wind erosion in arid regions of India (2020-2024): (a) hot arid agro-ecological region and (b) cold arid agro-ecological region

a distinct gradient in annual soil loss is observed, increasing from the south-west towards the northeast.

Based on severity classes, the area under severe ($> 15 \text{ kg m}^{-2} \text{ yr}^{-1}$), extremely intense ($8-15 \text{ kg m}^{-2} \text{ yr}^{-1}$), intense ($5-8 \text{ kg m}^{-2} \text{ yr}^{-1}$), moderate ($2.5-5 \text{ kg m}^{-2} \text{ yr}^{-1}$), slight ($0.2-2.5 \text{ kg m}^{-2} \text{ yr}^{-1}$) and micro-degree ($0-0.2 \text{ kg m}^{-2} \text{ yr}^{-1}$) erosion categories cover 2.088, 4.246, 2.726, 2.783, 6.839 and 13.883 mha, respectively. A substantial proportion of the arid agro-ecological region falls under slight ($\approx 21\%$) and micro-degree ($\approx 43\%$) categories. However, nearly 30% of the area experiences moderate to extremely intense erosion, while severe erosion affects about 6% of the total area. Higher soil loss rates ($> 5 \text{ kg m}^{-2} \text{ yr}^{-1}$) are predominantly observed in the districts of Jaisalmer and Barmer in Rajasthan, and Kutch, Jamnagar and Rajkot in Gujarat.

The seasonal soil loss rate in cold arid agro-ecological region lies in the range of $0-14 \text{ kg m}^{-2}$ in all the seasons, except July-September period. As depicted in Fig. 3, the annual soil loss rate is the highest in the northeastern part of Leh district. However, it largely falls within the micro-degree ($0-0.2 \text{ kg m}^{-2}$), slight ($0.2-2.5 \text{ kg m}^{-2}$), and moderate ($2.5-5.0 \text{ kg m}^{-2}$) categories, covering approximately 11.933, 1.212, and 0.595 mha, respectively.

5. Changes in Land Degradation Status Over Past and its Impact

The average annual soil loss rate due to wind erosion during the period 2020-2024 indicates that approximately 9.058 mha fall under the severe, extremely intense and intense categories, with soil loss rates exceeding $5 \text{ t ha}^{-1} \text{ yr}^{-1}$ (equivalent to loss of 0.33 mm top soil annually). According to ICAR report published in 2010, approximately 12.4 mha in India was affected by wind erosion (ICAR 2010). A comparison of the present estimates with earlier reports suggests a notable reduction in the magnitude of soil loss due to wind erosion over time. For example, Gupta and Aggarwal (1980) reported a soil loss of $1,449 \text{ t ha}^{-1}$ during April-June period in the Bikaner region, whereas the present study estimates soil loss in the same region to be in the range of $2\text{--}25 \text{ t ha}^{-1} \text{ yr}^{-1}$, indicating a several folds reduction in soil loss rate over the past four decades. Similarly, Kar (1988) documented extremely high soil loss ($3,128\text{--}3,754 \text{ t ha}^{-1}$) during a single dust storm event in 1985 at Chandan. In contrast, current estimates (2020-2024) suggest an annual soil loss rate of about $80\text{--}150 \text{ t ha}^{-1} \text{ yr}^{-1}$ in the same region. These comparisons clearly indicate a declining trend in wind erosion-induced soil loss over recent decades.

The observed decline in the severity of wind erosion can be largely attributed to the adoption of appropriate soil conservation measures, increased uptake of sustainable agricultural practices, and a reduction in the intensity of natural drivers of degradation. For instance, sand dune stabilization technologies, particularly the use of vegetative windbreaks (checkerboard patterns), have contributed to the stabilization of dunes over approximately 0.4 million hectares in arid Rajasthan. Similarly, the establishment



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of shelterbelt plantations along state highways (~200 km), railway tracks (~100 km), tube-well-irrigated areas (~167 km), and the Indira Gandhi Nahar Pariyojana (IGNP) command area (~250 km) has significantly reduced the impact of high-velocity winds.

Agricultural intensification has also played a key role. The average cropping intensity in western Rajasthan increased from 123% in 2010 to 147% in 2020. In highly affected districts such as Jaisalmer, cropping intensity rose from 115% to 147%, while in Hanumangarh it reached as high as 176%. Over the same period, the area under drought-tolerant kharif crops—such as moth bean, green gram, and clusterbean—expanded across most districts of western Rajasthan.



Irrigation development has further strengthened land productivity and resilience. The net irrigated area in the region increased substantially from 2.61 million hectares in 2010 to 4.23 million hectares in 2020, largely due to major projects such as the Indira Gandhi Nahar Pariyojana (IGNP) and the Narmada Canal Project (NCP). In Jaisalmer district alone, the net irrigated area has been almost doubled, increasing from 0.08 million hectares in 2010 to 0.196 million hectares in 2020.

In addition to these anthropogenic interventions, there has been a measurable decline in the intensity of natural factors contributing to wind erosion. For example, annual rainfall increased by about 14%, from an average of 342 mm during 1961–1990 to 389 mm during 1991–2020 (CAZRI Report, 2024). Decadal analysis of mean annual wind speed shows a clear long-term decreasing trend, with values of 8.9, 7.7, 4.7, 5.3, and 4.2 km h⁻¹ for the periods 1971–1980, 1981–1990, 1991–2000, 2001–2010, and 2011–2020, respectively (CAZRI Report, 2022).

As a result of the reduced severity of land degradation due to wind erosion, the region has witnessed an increase in both human and livestock population densities. Human population density rose from 28.19 persons km⁻² in 1951 to 130 persons km⁻² in 2011, while livestock density increased from 64 to 100 animals km⁻² between 1956 and 2019.

6. Summary

The assessment of annual soil loss due to wind erosion in the hot arid region of India for the period 2020–2024 indicates that about 6% of the area falls under the severe category ($\geq 150 \text{ t ha}^{-1} \text{ yr}^{-1}$), which is equivalent to the loss of approximately 10 mm of topsoil in a single year. These severely affected areas are predominantly located in the western parts of Barmer and Jaisalmer districts. In contrast, the northern part of the hot arid region—covering Sri Ganganagar, Hanumangarh, and adjoining areas of southern Punjab and western Haryana—exhibits micro-degree soil loss ($\leq 2 \text{ t ha}^{-1} \text{ yr}^{-1}$). Compared to the hot arid region, the cold arid region experiences relatively lower soil loss rates, with most areas recording $\leq 2 \text{ t ha}^{-1} \text{ yr}^{-1}$. However, a few localized pockets in the north-eastern portion of Leh district fall under the moderate to intense category ($25\text{--}80 \text{ t ha}^{-1} \text{ yr}^{-1}$).



This assessment represents the first national-level estimate of soil loss due to wind erosion and can serve as a benchmark for evaluating both historical trends and future changes in land degradation across arid regions. Furthermore, the estimates generated in this study provide a scientific basis for implementing targeted control measures at appropriate locations to achieve Land Degradation Neutrality (LDN) targets by 2030. These findings will also support ecosystem-based assessments of land degradation mitigation efforts. Extending this approach to past datasets could help establish linkages between climate change and land degradation, thereby contributing to the formulation of effective strategies for combating desertification in the region.



References

- CAZRI. 2022. Annual Report 2021-2022. ICAR–Central Arid Zone Research Institute, Jodhpur, Rajasthan, India.
- CAZRI. 2024. Annual Report 2023-2024. ICAR–Central Arid Zone Research Institute, Jodhpur, Rajasthan, India.
- Fryrear D W, Chen W and Lester C. 2001. Revised wind erosion equation. *Annals of Arid Zone* **40**(3): 265-79.
- Fryrear D W, Saleh A, Bilbro J D, Schomberg H M, Stout J E and Zobeck T M. 1998. *Revised Wind Erosion Equation (RWEQ)*. Technical Bulletin 1, Southern Plains Area Cropping Systems Research Laboratory, Wind Erosion and Water Conservation Research Unit, United States Department of Agriculture (USDA)-Agricultural Research Station (ARS), United States.
- Gajbhiye K S and Mandal C. 2000. Agro-Ecological Zones, their Soil Resource and Cropping Systems. In *Status of Farm Mechanization in India*, 1-32.
- Gupta J P and Aggarwal R K. 1980. Sand movement studies under different land use conditions of western Rajasthan. In *Arid Zone Research and Development* (Ed. Mann B S), pp. 109-14. Scientific Publishers, Jodhpur.
- ICAR. 2010. *Degraded and Wastelands of India: Status and Spatial Distribution*. National Academy of Agricultural Sciences (NAAS) and Indian Council of Agricultural Research (ICAR), New Delhi, India.
- Kar A. 1988. Evaluation of present day geomorphic processes in the Indian desert for assessing land degradation and natural hazards. In: *Geomorphology and Environment*, pp. 643-54, Singh S and Tiwari R C (Eds). Allahabad Geographical Society, Allahabad.
- Lal R. 1990. *Soil Erosion in the Tropics: Principles and Management*. McGraw-Hill, New York.
- Santra P and Mertia R S. 2006. Air pollution through particulate matter and its impact on human health. *Science Reporter* (June), pp 28-9.
- Santra P, Mertia R S and Narain P. 2006. Land degradation through wind erosion in Thar Desert-Issues and research priorities. *Indian Journal of Soil Conservation* **34**(3): 214-20.



- Santra P, Mertia R S, Kumawat R N, Sinha N K and Mahla H R. 2013. Loss of soil carbon and nitrogen through wind erosion in the Indian Thar Desert. *Journal of Agricultural Physics* **13**(1): 13-21.
- Schwab R O, Fangmeier D D, Elliot W J and Frevert R K. 1993. *Soil and Water Conservation Engineering*. John Wiley and Sons, New York.
- Sehgal J, Mandal D K, Mandal C and Vadivelu S. 1992. *Agro Ecological Regions of India*, 2nd edn. NBSS&LUP Publ. No. 24, National Bureau of Soil Survey and Land Use Planning, Nagpur, 130 p.
- Sehgal J L and Abrol I P. 1994. Soil degradation in India: status and impact. *Transactions of the International Congress of Soil Science*, **15**(Part): 188-212.
- Soni M L, Yadava N D, Beniwal R K, Singh J P, Sunil Kumar and Birbal. 2013. Grass based strip cropping systems for controlling soil erosion and enhancing system productivity under drought situations of arid western Rajasthan. *International Journal of Agricultural Statistics Science* **9**(2): 685-92.



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