Research Paper E-ISSN NO : 2455-295X | VOLUME : 10 | ISSUE : 12 | DECEMBER 2024

DESERTIFICATION AND LIVELIHOOD CHALLENGES IN THE THAR REGION

DR. PARDEEP RATHEE [1]

ABSTRACT:

Desertification in the Indian Thar Desert presents severe challenges to the socio-economic structure and environmental equilibrium of the region. The arid desert, with vulnerable ecosystems, is becoming highly vulnerable to land degradation from unsustainable agriculture, overgrazing, forest degradation, and climate fluctuation. With increasing desertification, the land's ability to sustain subsistence farming and pastoralism decreases, resulting in food insecurity, water shortages, migration, and socio-economic instability. The rural poor are specifically impacted, especially women and marginalized groups who depend intensively on natural resources. This paper discusses the geographical, climatic, and anthropogenic drivers of desertification in the Thar Desert and explores its multi-dimensional consequences on human livelihoods. It also discusses community-led adaptive strategies, sustainable land management, and policy interventions for desertification mitigation and improving resilience. Scientific innovation, traditional wisdom, and participatory governance need to be integrated to achieve sustainable development in the Thar region.

KEYWORDS:

THAR DESERT, DESERTIFICATION, LAND DEGRADATION, RURAL LIVELIHOODS, CLIMATE RESILIENCE.

PAPER ACCEPTED DATE:	PAPER PUBLISHED DATE:
28th December 2024	31st December 2024

INTRODUCTION

The Thar Desert, or the Great Indian Desert, is South Asia's most visible arid region. In the north-western region of India, it covers about 200,000 square kilometers, mainly in western Rajasthan, but also into the bordering areas of Gujarat, Punjab, and Haryana. The desert is a natural boundary between India and Pakistan and flows into the Cholistan Desert on the Pakistani side. The central desert districts in India are Jaisalmer, Barmer, Bikaner, Jodhpur, Nagaur, and parts of Pali, Jalore, and Sirohi. In spite of the hostile climate, this area is one of the most densely populated deserts in the world and is inhabited by over 30 million people. The Thar Desert has very high temperature fluctuations, from sub-zero temperatures during winter to more than 50°C during the hot summer months, and low and unpredictable annual rainfall of about 100 to 400 mm. The landscape consists of mobile sand dunes, rocky outcrops, gravel plains, and scattered vegetation. Livestock farming and farming are principal sources of livelihood with the boost of rain-fed subsistence farming and open-range grazing. The region is also culturally affluent, with strong traditions, diversified communities such as the Bishnoi's, Rajputs, Meghwal's, and Raikas, and a heritage of music, crafts, and folklore. Apart from its strength, the Thar region is also becoming increasingly subject to environmental degradation, primarily in the form of desertification, as the United Nations Convention to Combat Desertification (UNCCD) determines, i.e., land degradation in arid, semi-arid, and dry sub-humid areas due to various factors, including climatic changes and human interventions. Thar desertification results primarily due to a combination of ecological vulnerability and anthropogenic forces. These include such activities as overgrazing due to growing livestock herds, deforestation for fuel and grazing, groundwater over extraction, irrigation through canals that leads to secondary salinisation, and uncontrolled farming on poor soils. Furthermore, successive droughts and volatile monsoons—compounded by climate change—have heightened people's and land's vulnerability to desertification.

Thar desertification arises mainly as a result of a mix of ecological susceptibility and human-induced factors. These consist of such practices as overgrazing as a result of increasing herds of livestock, forestry loss for firewood and grazing, overexploitation of groundwater, irrigation by canals that causes secondary salinisation, and unregulated agriculture on weak soils. Additionally, repeated droughts and erratic monsoons—combined with climate change—have increased the vulnerability of people and land to desertification.

The effects of desertification are far-reaching in this area. Poor soil fertility and lack of water decrease crop production and restrict pasture development. This has a direct impact on the food and incomes security of the local people, resulting in worsening poverty, malnutrition, and rural distress. With unsustainable traditional livelihoods, there is high rural-urban migration, erosion of traditional

knowledge systems, and social fragmentation. The impacts of these are borne by women and marginal groups, since they have limited access to resources and decision-making structures. The research here sets out to conduct a spatial and socio-economic analysis of desertification in the Thar desert. Through analysis of regional land degradation patterns, the delineation of vulnerable areas, and an investigation of ecological stress and livelihood issues, the paper endeavors to make an informed explanation of the desertification phenomenon. It makes use of secondary sources of data such as the Desertification and Land Degradation Atlas of India (ISRO, 2021), climate data sets, census data, and government and non-governmental organization reports.

In addition, the research examines current policy responses—e.g., the Desert Development Programme (DDP), Integrated Watershed Management Programme (IWMP), and Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA)—on their ability to reverse degradation as well as benefit vulnerable communities. The research is driven by an effort to diagnose gaps in policy design and implementation, particularly in terms of community participation, ecological sustainability, and long-term resilience. Considering the immediacy of the issue and the special ecological and socio-cultural processes of the Thar Desert, the paper supports a region-specific and integrated strategy against desertification. Special focus is accorded to sustainable management of land and water, livelihood diversification, agroecological practice promotion, and community-based governance system strengthening. By targeting both human and environmental aspects, such measures are likely to not only rehabilitate lost land but also ensure the future of millions who are dependent on it.

GEOGRAPHY AND CLIMATE OF THE THAR DESERT

The Great Indian Desert, or Thar Desert, covers an area of over 200,000 km^2, with over 60% in western Rajasthan and spilling over into areas of Gujarat, Haryana, and Punjab. It covers an area of extreme environmental extremes, characterized by challenging climate and terrain conditions.

SOILS AND VEGETATION

The area is mainly composed of aeolian sandy soils, such as desertic regosols, lithosols, and salt depressions, with coarse texture, calcareous mineral composition, and low fertility. The vegetation is also mostly xerophytic, consisting of Prosopis cineraria, Tecomella undulata, and drought-tolerant grasses. Coverage rises marginally towards the east, which has slightly higher rainfall.

RAINFALL PATTERNS

Summer rainfall is limited and irregular, ranging from 100 mm in western Jaisalmer district to 400–500 mm in the eastern parts of Nagaur and Sikar. Around 90% of the rainfall is concentrated during the short southwest monsoon (July–September). Extreme spatial and temporal variability makes the region vulnerable to repeated droughts, compromising its agricultural stability.

TEMPERATURE EXTREMES

Thar has extreme temperature variations. Summer temperatures often touch 45–50 °C, and the records of 49 °C in Jaisalmer and Bikaner are unparalleled. Winters are cold, with nights dipping below 0 °C, especially in the areas of Bikaner, Churu, Pilani, and Sikar. The diurnal temperature range of the region can go above 30 °C, causing stress to crops and pastoral systems.

WIND AND EROSION

Pre-monsoon winds often reach 40–60 km/h, with dust storms sometimes exceeding 140 km/h, causing severe sand dune migration and wind erosion. Erosion rates near Bikaner can exceed 273 kg/ha/day, demonstrating the soil's extreme vulnerability.

GEOGRAPHIC AND ADMINISTRATIVE SCOPE

Main Thar districts are Jaisalmer, Barmer, Bikaner, Jodhpur, and Nagaur, with thorn forests, stabilised dunes, and sandy plains dominating these regions. Nagaur receives an average annual rainfall of 361.6 mm, with temperature ranges from 0 °C to 47.2 °C. The Luni River, the largest desert river in Rajasthan, is highly silted and acts to check the eastward extension of sand over Nagaur.

DESERTIFICATION AND LAND DEGRADATION

Over 67% of Rajasthan's geographic area is degraded due to desertification, with wind erosion accounting for over 44% of land loss. Factors include sand dune encroachment, water logging, salinization in canal-irrigated areas, and vegetation loss. Such processes endanger soil productivity, water security, and ecological stability. Rajasthan government and central reports paint the Thar Desert as an extreme and ecologically vulnerable environment with sandy barren soils, intense temperatures, uncertain rainfall, strong winds, and high desertification risk. Such conditions highlight the need for prompt climate-resilient land-management, ecological stabilization, and sustainable development approaches to ensure the future of the region.

PROCESSES AND PATTERNS OF DESERTIFICATION

The Thar Desert is an active arid environment, yet its delicate balance is under mounting attack by desertification—a process characterized by a reduction in land productivity and ecological integrity. Natural as well as human factors contribute significantly to the aggravation of such land degradation in the area. As per the Indian Space Research Organisation (ISRO)'s Desertification and Land Degradation Atlas (2021), nearly 38 percent of Rajasthan's geographical area is influenced by some level of desertification, with severe degradation in Barmer, Jaisalmer, and Bikaner districts.

NATURAL CAUSES

Climatic fluctuations have traditionally defined the ecological toughness of the Thar Desert. Yet these recent changes in rainfall patterns, drought intensification, and

regimes of temperature have upset this sensitive balance. Persistent droughts, more common as a result of climate change, have caused soil desiccation, groundwater depletion, and overall crop loss. The rainfall in the area is not only low (between 100 and 400 mm per year) but also irregular in terms of time and pattern. Impromptu cloudbursts or late monsoons lead to either flash floods or extended dry periods, both of which contribute to water stress and topsoil erosion.

Wind erosion is also a prevailing natural process in the Thar. Pre-monsoon seasonal winds with speeds of more than 40 km/h mobilize vast volumes of loose sand, causing dune migration and deposition on arable land. The low vegetation cover does not stabilize the soil; hence large areas are susceptible to wind-blown degradation. The natural forces together decrease the organic content, water-holding capacity, and fertility of the soil—initiating a cycle of productivity decline and ecological degradation.

HUMAN-INDUCED ACCELERATORS

Although natural factors trigger and perpetuate desertification, human activities drastically increase the extent and severity of land degradation. Overgrazing is a serious problem, particularly under open grazing systems prevalent in western Rajasthan. The livestock population has increased exponentially as a result of rural livelihood reliance and government subsidies for animal husbandry. Population growth has overtaken the recuperation potential of grasslands, which is resulting in trampling, compaction, and ground cover loss. Deforestation, caused by requirements for firewood, grazing, and building materials, further subjects the land to erosion. Indigenous trees like Prosopis cineraria (khejri), which previously stabilized soils and increased biodiversity, are being cut down in large numbers in most desert districts.

Water mismanagement has also led to desertification. The introduction of canal irrigation systems, especially from the Indira Gandhi Canal Project, resulted in short-term gains in agriculture but long-term costs in ecology. Misapplication of irrigation methods resulted in waterlogging and salinization of once productive soils. At the same time, uncontrolled groundwater pumping has drained aquifers, impacting irrigation as well as drinking water security. Farm expansion into marginal lands has put extra pressure. Mono-cropping, chemical intensive inputs, and tillage of sandy soils speed up the cycle of degradation. Incompatible crop selection and omission of fallow periods further decrease soil biodiversity and health. The Thar Desert degradation is caused by an intricate interaction of natural variability and human pressures. Desertification must be addressed by a holistic appreciation of both sets of drivers and by an integrated approach, integrating ecological restoration, sustainable land management, and community-based governance of resources.

LIVELIHOOD CHALLENGES IN THE THAR REGION

The Thar Desert, in its arid and harsh ecological setting, is home to vast numbers of people whose means of livelihood are heavily dependent on the land. The double leverage of environmental degradation and socio-economic stress has, however, made such livelihoods increasingly precarious. Farming, livestock husbandry, and water availability—the three crucial pillars of survival in this domain—are all under pressure, increasing rural susceptibility.

AGRICULTURE IN DISTRESS

Agricultural production in the Thar is predominantly rain-fed and monsoon-based and on low-fertility sandy soils. The mean annual rainfall in regions such as Jaisalmer and Barmer is less than 200 mm, and rain is both irregular and sparse. A single weak monsoon can result in large-scale crop failure. Ancient drought-resistant crops like millet (bajra), green gram (moong), cluster bean (guar), and moth bean are usually sown, but there is no regular yield due to variability of rainfall and persistent dry spells. Moreover, the dominance of a single cropping season (kharif) contributes to the risk. Without any reliable rabi crop, farmers have no alternative source, and persistent food insecurity and uncertainty of income follow.

Soil erosion also comes into play. Years of unsustainable agriculture, such as excessive ploughing and dependence on chemical fertilizers where water allows, has compromised soil structure, depleted organic matter, and augmented erosion. The absence of agricultural extension in far-flung regions restricts exposure to climate-resilient methods and better crop varieties, further worsening the issue.

LIVESTOCK CHALLENGES

Livestock farming has long been an important livelihood strategy, especially for pastoral communities such as the Raika, Rebari, and Meghwal. This source of livelihood is however under threat from fodder shortages, declining water availability, and animal diseases. Pastures for grazing are being reduced by desertification and land use conversion, while intense heat and unpredictable rainfall discourage the natural regrowth of fodder grasses. Animals, especially sheep and goats, experience stress, lower milk production, and higher mortality rates during years of drought.

Availability of veterinary care is still limited in desert villages. Absence of early intervention means occasional disease outbreaks, such as foot-and-mouth or anthrax, can decimate entire herds. In addition, financial rewards from livestock decreased, rendering it less viable as a single livelihood. Water shortage is maybe the most severe issue in the Thar Desert. Groundwater is usually salty, at deep levels, and costly to pump. Borewells produce brackish water unfit for drinking or agriculture in most villages. Surface water exists only in small talabs and ephemeral streams, which evaporate rapidly during drought years. India's longest irrigation canal, Indira Gandhi Canal, supplied water to the desert regions, including tracts of Ganganagar, Hanumangarh, and Bikaner. While it facilitated irrigation and crop diversification, secondary

salinization, waterlogging, and land degradation in low-lying areas also crept in. This has decreased agricultural sustainability in some regions and established new ecological issues.

MIGRATION AND GENDERED BURDENS

As productivity declines and incomes become uncertain, seasonal and permanent migration has become prevalent. More men migrate to places like Jaipur, Delhi, and Mumbai for work, leaving women to handle farms, cattle, and homes. Feminization of agriculture is happening without equivalent access to resources, training, or institutions. Women experience enhanced drudgery, isolation, and restricted decision-making opportunities. The livelihoods of rural residents in the Thar are severely at risk as a result of converging crises in agriculture, water, and jobs. A shift towards sustainable agriculture, better water management, livestock support services, and migration-inclusive policies is urgently needed in order to stabilize rural economies and safeguard the socio-ecological integrity of the region.

IMPACTS ON MARGINALIZED COMMUNITIES

Desertification in the Thar Desert is not just an environmental issue—it is a very social one that disproportionately affects the poorest and most vulnerable sections of society. Women, Scheduled Castes (SCs), Scheduled Tribes (STs), and nomadic pastoralists are more burdened with less access to land, institutional support, and adaptation resources. Women, especially, carry the brunt of environmental degradation. Since desertification decreases water and biomass availability, women have to spend most of their time collecting water and firewood, sometimes from far, poor-quality sources. All this effort, day in and day out, takes away valuable time and energy that could have been spent learning, earning money, or getting involved in community life. Despite their core position in household land and water management, women are often not owners of agricultural land and are systematically left out of decision-making structures and extension services. Incomplete access to credit, education, and climate-resilient technologies further limits their ability to respond.

Marginalized caste and tribal communities are more likely to inhabit ecologically fragile zones prone to drought, wind erosion, and soil degradation. These groups often rely on marginal landholdings and communal grazing resources, both of which are shrinking due to desertification and land use change. Mobile pastoralists, who previously prospered under seasonal movement, nowadays have limited grazing paths, legal uncertainties, and informal status, rendering their survival even more vulnerable. In addition, government drought relief, soil conservation, and watershed development policies discriminate against such communities due to structural inequality and bureaucratic exclusion. Without deliberate measures to reach out to these communities, the desertification process will widen existing large socio-economic gaps. Thus, a gender-responsive and equitable desertification response must incorporate gender-sensitive planning, secure tenure and resource rights, and ensure equal access to climate adaptation options for everyone.

POLICY RESPONSES AND GAPS

The government has launched a number of programmes to reduce desertification in the Thar Desert. The major programmes are Integrated Watershed Management Programme (IWMP), Desert Development Programme (DDP), National Afforestation Programme and Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA). These schemes have contributed towards the recovery of ecological balance, conservation of soil and water, and generation of rural employment in drought-prone regions. IWMP is focusing on integrated development of watersheds to enhance the harvesting of water, recharge groundwater, and enhance agriculture output. DDP, one of the first schemes for arid areas, focuses on stabilising sand dunes, afforestation, and pastureland improvements. MGNREGA, though a programme geared towards rural employment, has indirectly assisted in land and water conservation efforts through measures such as pond desilting, bund creation, and plantation drives. In isolated areas of Rajasthan, these programs have enhanced water retention, restricted erosion, and provided temporary livelihood benefits.

However, despite these successes, the overall contribution of these programs has fallen short of their maximum potential due to structural and administrative failures. One of the main issues has been poor coordination among implementing agencies, which has resulted in the duplication of efforts and wasteful resource deployment. Citizen participation, essential for sustainable provision, has typically been absent or tokenistic, and thus levels of ownership have been low and assets poorly maintained. The repeated project cycles of most schemes cannot capture the long-term nature of desertification. Moreover, monitoring and evaluation systems are weak, with little use of satellite imagery or ground verification to ascertain actual progress. Isolated policy-making and policy incoherence among central and state initiatives also dent results. An integrated, community-orientated, data-informed strategy with improved institutional support, long-term investment, and climate-resilient planning responsive to the region's natural conditions is necessary to close these gaps.

STRATEGIES FOR SUSTAINABLE DEVELOPMENT

Mitigating desertification in the Thar Desert requires a holistic, integrated and locally based strategy that reduces wasteland and enables villagers to sustain their livelihoods. Since the region is ecologically sensitive and socio-economically deprived, the measures should be environmentally friendly as well as socially acceptable. Promoting water-efficient crops, agro forestry and organic farming are measures that can help prevent soil degradation. Traditional crops like bajra, moong, guar and moth are naturally adapted to the arid conditions of the Thar and can grow even in less water. Cultivation of these

crops needs to be promoted through seed banks, farmer training and better market linkages. Growing khejri trees along with crops can reduce soil erosion, and increase soil fertility.

Recovering pasturelands must be accomplished to support the pastoral economy of the nation. Creating fodder development areas, seeding native grasses, and implementing controlled grazing systems can prevent overgrazing and allow degraded commons to heal. These steps will not merely assist in maintaining the health of livestock but will also support the income of pastoralist communities. Water shortage, a defining problem of the Thar, calls for the return to ancient water harvesting systems in the form of tankas, khadins, and Nadis. Ancient techniques, when brought back into use and coupled with modern micro-irrigation technology, such as drip and sprinkler systems, can significantly enhance efficiency in the use of water. Watershed planning and participatory water budgeting can make it equitably and sustainably distributed. To decongest the land, diversified and alternative livelihood sources must be promoted actively. The Thar has a rich tradition of weavers' handicrafts, leather crafts, and earthenware, which can be tapped for domestic and foreign markets. Small-scale enterprises and ecotourism ventures, when planned well, can provide non-agricultural jobs while celebrating the cultural and ecological diversity of the region.

Empowering grassroots institutions is critical for long-term effect. Self-help groups (SHGs), Panchayati Raj Institutions, and women's cooperatives can be made champions of participatory conservation planning and implementation. These institutions need to be empowered with technical skills training, financial inclusion tools, and representation in decision-making bodies on issues related to land, water, and development. Finally, the institutionalization of GIS-based monitoring systems and climate-resilient planning frameworks should be implemented. Satellite imaging and spatial analysis can be employed to monitor land degradation, water supply, and vegetation patterns in real-time. This information can be used to drive anticipatory land-use planning and targeted intervention, so that interventions are context-sensitive and responsive to evolving climatic conditions.

CASE EXAMPLES

In Barmer district, effective watershed development under the Integrated Watershed Management Program (IWMP) has greatly increased water availability and checked seasonal migration. Under Rajasthan Forest Department records, community-built farm ponds and percolation tanks have increased groundwater recharge by over 25%, enabling families to sustain livelihoods without migrating during drought years. In Pokhran, agro forestry systems involving native tree species like khejri (Prosopis cineraria) and ber (Ziziphus mauritiana) have led to impressive ecological and socio-economic enrichment. Based on a report in 2021 from the Zonal Arid Research Institute (CAZRI), alley-cropping methods have stabilized sand dunes, increased soil moisture levels, and minimized wind erosion. These tree species in the area not only retain soil but also increase local biodiversity and drought resistance. The khejri tree also nitrogen-fixes in soils, while the ber trees provide healthy fruits that bring variety to family diets. Incorporating trees within the farm fields has also increased the quantity of livestock fodder, especially during dry spells. Consequently, up to 30% yield increments in crops, as well as improved food and fodder security, have been witnessed by farmers. This example from Pokaran agro forestry illustrates the importance of combining indigenous ecological knowledge and arid region-compatible sustainable land management practices.

In Bikaner, salinization due to canal irrigation was a serious threat to soil health in the Indira Gandhi Canal-irrigated command areas. This led to the installation of subsurface drainage systems, such as tile drains under government-funded salinity control programs. CSSRI studies point to their efficiency in reducing the water table and ridding the land of salt accumulation, reclaiming lands for productive farming, and protecting livelihoods in canal command areas. These projects demonstrate the promise of site-specific, integrated measures in combating desertification threats. Barmer's watershed schemes provide water security and economic resilience; Pokaran's agroforestry improves soil quality and livestock support; and Bikaner's drainage system presents an exemplary model for recuperating salinity-affected areas. Collectively, they provide useful case studies for replicating sustainable interventions throughout the Thar Desert.

CONCLUSION

Thar desertification is not just an ecological issue—it is a multidimensional, multifaceted problem with long-term repercussions for land productivity, water resources, economic stability, and social equity. The arid terrain of western Rajasthan and neigh boring areas of Gujarat, Haryana, and Punjab confronts growing land degradation as a result of interrelated climatic extremes and non-sustainable human activities. As soil quality decreases, water supplies reduce, and biodiversity is lost, the foundation of rural livelihoods—mainly agriculture and livestock—is eroded.

The conventional rain-fed agriculture and open grazing systems are becoming more and more susceptible to unpredictable rainfall, increased temperatures, and extended droughts. As access to fertile land and forage dwindles, pastoralists and farmers are exposed to economic insecurity. The effects are most draconian for women, Scheduled Castes and Scheduled Tribes, and nomadic peoples who are reliant on marginal resources, don't enjoy legal titles to land, and have limited access to state support mechanisms. These communities are most affected by the ecological crisis and least able to adapt or respond.

To tackle this, there has to be a sustainable and inclusive strategy—one that not only revives ecological well-being but also fortifies the socio-economic fabric of the region. Ecological restoration activities must focus on

drought-tolerant varieties of crops, native agro forestry models, and rehabilitation of common lands. Rejuvenation of traditional water harvesting systems such as tankas, khadins, and nadis, combined with modern irrigation practices, can enhance water efficiency and decrease reliance on groundwater.

Livelihood diversification is also essential. Encouraging alternate sources of income like handicrafts, value-added dairy products, eco-tourism, and renewable energy employment can also minimize excessive dependence on land-based jobs. Particular attention needs to be given to empowering women and marginalized groups through skill building, credit provision, and market exposure.

Strengthening institutions is the other pillar. Panchayati Raj Institutions, local cooperatives, and Self-Help Groups have to be strengthened to play an active role in planning, implementation, and monitoring land management programs. Government policies need to be harmonized across departments and states to provide convergence and long-term commitment. In addition, incorporating climate-resilient development planning with GIS-based monitoring systems can ensure more effective targeting of interventions and adjusting strategies to evolving environmental realities.

Lastly, any sustainable intervention has to be based on community ownership and participation. Local knowledge systems, if acknowledged and accommodated, can provide useful information on land management. Participation also facilitates accountability, transparency, and maintenance of long-term assets.

In summary, as challenging as desertification is in the Thar region, it also represents a chance to reformulate and remake development processes. Using a comprehensive, inclusive, and resilience-based approach, the region can embark upon ecological rehabilitation and socio-economic rejuvenation. The experience of Thar can be used as a model for development in other arid and semi-arid areas beset by similar challenges globally.

REFERENCES

1. Kar, A., Moharana, P. C., Raina, P., Kumar, M., Soni, M. L., Santra, P., ... &Dhinwa, P. S. (2009). Desertification and its control measures. *Trends in arid zone research in India*, 1-47.

2. Chlachula, J. (2021). Between sand dunes and hamadas: environmental sustainability of the thar desert, west India. *Sustainability*, *13*(7), 3602.

3. Kashyap, R., Kuttippurath, J., & Patel, V. K. (2025). Agriculture intensification and moisture-induced Thar desert greening: implications for energy balance, socio-economy, and biodiversity. *GIScience& Remote Sensing*, *62*(1), 2483458.

4. Jain, S., Srivastava, A., Khadke, L., Chatterjee, U., &Elbeltagi, A. (2024). Global-scale water security and desertification management amidst climate change. *Environmental Science and Pollution Research*, *31*(49), 58720-58744.

5. Sanz, M. J., de Vente, J., Chotte, J. L., Bernoux, M., Kust, G., Ruiz, I., ... & Akhtar-Schuster, M. (2017). Sustainable land management contribution to successful land-based climate change adaptation and mitigation: A report of the science-policy interface. In *Bonn, Germany: United Nations Convention to Combat Desertification (UNCCD)*.

6. Sharma, G. (2013). A review on the Studies on Faunal diversity, status, threats and conservation of Thar Desert or Great Indian Desert Ecosystem. In *Biological Forum–An International Journal* (Vol. 5, No. 2, pp. 81-90). Citeseer.

7. Purohit, K. G. (1967). The Great Indian Desert. Perspectives in the ecology and physiology of small desert mammals.

8. Smith, P., Calvin, K., Nkem, J., Campbell, D., Cherubini, F., Grassi, G., ... & Arneth, A. (2020). Which practices co-deliver food security, climate change mitigation and adaptation, and combat land degradation and desertification? *Global Change Biology*, *26*(3), 1532-1575.

9. Sivakumar, M. V. (2007). Interactions between climate and desertification. *Agricultural and forest meteorology*, *142*(2-4), 143-155.

10. Dhir, R. P., & Singhvi, A. K. (2012). The Thar Desert and its antiquity. *Current Science*, 1001-1008.

11. Varghese, K. A. (2023). An Overview of World Deserts with Special Reference to Thar Desert. *Natural Resource Management in the Thar Desert Region of Rajasthan*, 1-24.

12. Ravi, S., & Huxman, T. E. (2009). Land degradation in the Thar Desert. *Frontiers in Ecology and the Environment*, *7*(10), 517-518.

13. Moharana, P. C. (2016). ICAR-central arid zone research institute, Jodhpur: erosion processes and desertification in the Thar Desert of India.

14. Kar, A. (2018). Desertification: causes and effects. In *Exploring natural hazards* (pp. 159-206). Chapman and Hall/CRC.

15. Ghai, R. (2021). Understanding 'culture 'of pastoralism and 'modern development 'in Thar: Muslim pastoralists of north-west Rajasthan, India. *Pastoralism*, *11*, 1-19.

16. Chauhan, S. S. (2003). Desertification control and management of land degradation in the Thar desert of India. *Environmentalist*, *23*, 219-227.

17. Tewari, V. P., & Arya, R. (2004). Degradation of arid rangelands in Thar Desert, India: A review. *Arid Land Research and Management*, *19*(1), 1-12.

18. Kumar, A., Kumar, S., Dubey, R., Das, A., & Chavan, S. (2025). Agroforestry and Climate Adaptation: Overcoming Drought and Heat Challenges. In *Drought and Heat Stress in Agriculture* (pp. 131-151). Springer, Singapore.

19. Tirado, R., & Cotter, J. (2010). Ecological farming: Drought-resistant agriculture. *Exeter, UK: Greenpeace Research Laboratories*.

20. Machiwal, D., Kar, A., Joshi, D. C., & Yadav, K. K. (2023). Land and water resource management in the Thar Desert region. In *Natural Resource Management in the Thar Desert Region of Rajasthan* (pp. 73-99). Cham: Springer International Publishing.

21. Devi, S., Kumar, S., Choyal, G., & Saran, R. K. TRADITIONAL PRACTICES IN WATER RESOURCES CONSERVATION IN THE THAR DESERT OF RAJASTHAN.