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Ecological Importance of Bio-fencing in Biodiversity Conservation in the South West region of the Thar Desert, India

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ABSTRACT

This study aims to highlight the ecological importance of bio-fencing as a practical alternative to electric and metallic barriers. Its goals include assessing its potential for soil and habitat restoration, examining its role in conserving biodiversity, and emphasizing the importance of integrating traditional ecological knowledge into contemporary land management practices in the Thar Desert.

One of India's most ecologically delicate arid regions, the Thar Desert, is home to distinctive plant and animal communities that have adapted to the harsh temperatures and little rainfall. However, due to the disruption of natural habitats caused by rapid agricultural expansion and the increased use of barbed and electric fencing, species like *Herpestesedwardsii* (Mongoose), *Vulpes vulpes pusilla* (Desert Fox), and *Gazella bennettii* (Chinkara) have suffered injuries and died. This study investigates the ecological significance of bio-fencing, a sustainable alternative that utilizes native desert trees and shrubs, such as *Acacia nilotica* (Babool), *Euphorbia caducifolia* (Thor), *Leptadenia pyrotechnica* (Kheep), and *Capparis decidua* (Ker). In addition to protecting farmlands, these living barriers also serve as microhabitats, promoting soil conservation and controlling local humidity and temperature. Bio-fencing reduces the adverse effects of artificial fencing while enhancing the resilience of desert ecosystems by encouraging native vegetation. Therefore, the Thar Desert's biodiversity conservation and sustainable land management may greatly benefit from the adoption of bio-fencing through community involvement and policy incentives.

Figures : 00 References : 13 Tables : 05
KEY WORDS : Arid Ecosystem, Bio-fencing, Biodiversity Conservation, Habitat Protection, Thar Desert, Traditional Practices.

Introduction

One of the world's most distinctive and delicate arid ecosystems is the Thar Desert, which is in northwest India. The area is home to a diverse range of plants and animals that have developed amazing physiological and behavioural adaptations to withstand the harsh environmental conditions, including high temperatures and limited water supplies. The desert vegetation, composed mainly of xerophytic and thorny species such as *Euphorbia caducifolia* (Thor), *Capparis decidua* (Ker), *Leptadenia pyrotechnica* (Kheep), and *Prosopis juliflora* (Babool), *Clerodendrum phlomidis* (Arni), *Maytenus emarginata*(Kankera)plays a vital role in stabilizing dunes, conserving soil moisture, and providing habitats for a wide range of desert fauna including *Gazella bennettii* (Chinkara), *Vulpes vulpespusilla* (Desert Fox), and numerous reptilian and avian species[5,10] highlight the ecological significance of canal-based habitats in enhancing bird diversity and emphasize their role in biodiversity conservation in the Thar landscapes. It was reported that Rufous Treepie (*Dendrocitta vagabunda*) exhibits seasonal variations in behaviour and habitat use in semi-arid Rajasthan, contributing to seed dispersal and vegetation dynamics. The study highlights its indirect role in supporting plant regeneration, relevant to the sustainability of bio-fencing systems.

However, the ecosystem of the Thar Desert faces increasing anthropogenic and climatic challenges. In addition to low and irregular rainfall, which averages only 200 to 300 mm annually, the area experiences extreme heat, with temperatures often rising above 45°C. Land use patterns have changed significantly in recent decades due to the expansion of agriculture through groundwater irrigation. Farmers are increasingly

TABLE -1 : The dominant biofencing species recorded during the study

S. No.	Common Name (Local)	Scientific Name	Ecological Role
1.	Thor	*Euphorbia caducifolia*	Acts as a dense, thorny barrier; provides nesting sites for small birds.
2.	Kheep *pyrotechnica*	*Leptadenia*	Controls wind erosion and stabilizes sandy soils.
3.	Ker	*Capparis decidua*	Produces edible fruits; attracts pollinators and birds.
4.	Babool	*Acacia nilotica*	Improves soil nitrogen; offers shade and nesting habitat.
5.	Babool (Vilayati Babool)	*Prosopis juliflora*	Improves soil nitrogen; offers shade and nesting habitat.
6.	Rohida	*Tecomella undulata*	Important timber and shelter species; supports insect diversity.
7.	Ber	*Ziziphus nummularia*	Provides food for birds and mammals; prevents soil erosion.
8.	Phog *polygonoides*	*Calligonum*	Grows on sand dunes; helps stabilize loose sand.
9.	Arni	*(Clerodendrum phlomidis)*	Grows on sand dunes; helps stabilize loose sand and medicinal use.
10.	Kankera	*Maytenus emarginata*	Provides food for birds and mammals; prevents soil erosion
11.	Aak	*Calotropis procera*	Grows on sand dunes; helps stabilize loose sand.
12.	Bui	*Crotalaria burhia*	Grows on sand dunes; helps stabilize loose sand.
13.	Khejri	*Prosopis cineraria*	Provides food for birds and mammals; prevents soil erosion.
14.	Kumat	*Acacia senegal*	Provides food for birds and mammals; prevents soil erosion. Production of Gum and Seed (Kumtiya)

surrounding fields with electric fencing and metal barbed wire to protect their crops. The desert's biodiversity is severely threatened by these human-made barriers, which, while effective in discouraging livestock, have unintentionally caused wildlife injuries, deaths, and habitat fragmentation[11].

In the past, local communities have protected agricultural lands using environment friendly bio-fencing techniques made from native trees and shrubs. These living fences prevented wind erosion, maintained microclimatic balance, and gave animals food and

shelter, among other ecological purposes. Due to modernization and a lack of legislative support, these long-standing customs are quickly vanishing despite their sustainability.

Objectives of the Study

The present study focuses on understanding the ecological significance of bio-fencing in the conservation of biodiversity within the Thar Desert region of Rajasthan. The specific objectives are as follows:

1. **To identify traditional plant species used in bio-fencing in Barmer district:**

   To document and classify native plant species that have been historically used by local communities for fencing agricultural fields. Species such as *Euphorbia caducifolia* (Thor), *Capparis decidua* (Ker), *Leptadenia pyrotechnica* (Kheep), *Acacia Senegal* (Kumat),*Prosopis juliflora* (Babool), *Ziziphus nummularia* and *Tecomella undulata* (Rohida) are among the commonly utilized species that contribute to natural boundary formation and ecological resilience.

2. **To assess their ecological role in conserving biodiversity:**

   This objective seeks to evaluate how bio-fencing supports habitat diversity by providing nesting sites, food resources, and shelter for desert fauna including *Gazella bennettii* (Chinkara), *Vulpesvulpes pusilla* (Desert Fox), *Herpestese dwardsii* (Mongoose), reptiles, and native bird species. It also examines their role in soil stabilization, microclimate regulation, and moisture conservation.

3. To suggest sustainable conservation tactics by promoting bio-fencing: The goal is to suggest environmentally responsible and socially acceptable tactics that support the reintroduction and advancement of bio-fencing techniques. To guarantee sustainable land use and biodiversity preservation in the Thar Desert, this involves fusing traditional ecological knowledge with contemporary conservation regulations.

Study Area

The present study was conducted in the south-west region of the Thar Desert, including Sanchore (Jalore district) and Barmer district of Rajasthan, which lie in the western part of India and forms a core portion of the Indian Thar Desert. Geographically, Barmer is situated between 24°582 N to 26°322 N latitude and 70°052 E and 72°522 E longitude, covering an area of approximately 28,387 km². The district shares its western boundary with Pakistan and is characterized by extensive dunes, sparse vegetation, and an arid to semi-arid climate.

For the present investigation, six villages representing typical desert agro-ecosystems were selected: Lunu, Genhu, Tirsingari, Sedva, Lalji ki Dungri and Sanvlor. These villages were chosen based on the presence of traditional agricultural practices, variation in fencing types (bio-fencing and metal fencing), and proximity to natural desert habitats.

Methodology

The study employed both primary and secondary data collection methods to examine the ecological importance of bio-fencing and its relationship with biodiversity conservation in the Barmerdistrict of Rajasthan.Primary data were collected through field observations, local interviews, and photographic documentation conducted across six selected villages-Lunu, Genhu, Tirsingari, Sedva, Lalji ki Dungri and Sanvlor. Observations focused on identifying traditional plant species used in bio-fencing and assessing the associated fauna dependent on these habitats. We collected data through using point count, line transect and direct observation methods and techniques. Data were collected between 2021 and 2025 through random fieldwork.Secondary data were obtained from Forest Department records, non-governmental organizations (NGOs), and local wildlife protection groups.

Sampling

A random sampling method was adopted to ensure representative coverage across the study area. In each of the six villages, households were randomly selected. The households were chosen based on their engagement in agricultural activities and the type of fencing systems implemented around their fields (bio-fencing or metal/electric fencing).

Parameters Recorded

Field surveys recorded both ecological and management-related parameters. These included :

- Type of fencing used (bio-fencing, barbed wire, or electric fencing).
- Composition and density of plant species used in bio-fencing (scientific and local names).
- Presence and diversity of associated fauna, including mammals, reptiles, and avian species.

Data Analysis

Descriptive and comparative statistical methods were used to analyse the collected data. To ascertain the relative ecological impacts of metal/electric-fenced and bio-fenced farmlands, the biodiversity status and wildlife activity were compared. To evaluate local

TABLE -2 :Several Faunal species used in the Biofencing Vegetarian

S. No.	Local Plant (Hindi Name)	Scientific Name (Plant)	Benefited Faunal Species (Common Name)	Scientific Name (Animal)	Ecological Benefits
1	Thor	*Euphorbia caducifolia*	Desert Fox, Mongoose	*Vulpes vulpes pusilla*, *Herpestes edwardsii*	Dense shrubs provide shelter and prevent soil erosion.
2	Kheep	*Leptadenia pyrotechnica*	Desert Hare, Indian Desert Gerbil	*Lepus nigricollis dayanus*, *Meriones hurrianae*	Stabilizes sand dunes and conserves soil moisture.
3	Phog	*Calligonum polygonoides*	Lizard, Sand Boa, Francolin	*Trapelus agilis*, *Eryx johnii*, *Francolinus pondicerianus*	Creates microhabitats by providing shade and humidity in desert conditions.
4	Babool	*Acacia nilotica*	Peacock, Kite, Parakeet, Mongoose	*Pavo cristatus*, *Milvus migrans*, *Psittacula krameri*, *Herpestes edwardsii*	Nitrogen fixation, suitable for bird nesting sites.
5	Ker	*Capparis decidua*	Chinkara, Camel, Sparrow	*Gazella bennettii*, *Camelus dromedarius*, *Passer domesticus*	Fruits and flowers serve as food sources and aid in pollination.
6	Kankera	*Maytenus emarginata*	Reptiles	*Ophisops jerdonii*	Shrub structure provides nesting and hiding shelter.
7	Arani	*Clerodendrum phlomidis*	Insectivorous Birds	*Acridotheres tristis*, *Dicrurus macrocercus*	Supports insect control, pollination, and bird habitation.
8	Rohida	*Tecomella undulata*	Parakeet, Squirrel, Honeybee	*Psittacula krameri*, *Funambulus pennantii*, *Apis dorsata*	Native tree, biodiversity hotspot, provides wood and nectar.
9	Ber	*Ziziphus nummularia*	Fox, Sparrow	*Vulpes pusilla*, *Passer domesticus*	Fruits serve as food; branches provide safe nesting habitat.
10	Aakra (Aakda)	*Calotropis procera*	Butterflies, Honeybees	*Danaus chrysippus*, *Apis florea*	Important for pollination; has medicinal significance.

perceptions, traditional ecological knowledge, and attitudes toward the adoption of bio-fencing, qualitative data from interviews were subjected to thematic analysis.

Results

1. Dominant Plant Species Used in Bio-fencing

Field observations conducted across six villages of the south-west region of Rajasthan revealed that local farmers continue to use several native thorny and drought-resistant plant species for traditional bio-fencing. These species are well adapted to the desert environment and serve both protective and ecological functions.

The dominant bio-fencing species recorded during the study are listed below :

These species form dense, living barriers that not only protect crops but also provide habitats for desert fauna, thereby promoting biodiversity at the microhabitat level.

2. Wildlife Species Associated with Bio-fencing

- It was noted that several faunal species used the bio-fencing vegetation as a place to hide, nest, or feed. Among these were:
- *Gazella bennettii* (Chinkara), which seeks refuge and feeds on surrounding plants.
- Desert Fox (*Vulpes vulpes pusilla)*, burrows close to thick bushes for cover.
- The Indian Mongoose, *Herpestese dwardsii*, nests in prickly hedges.
- The Indian Hare (*Lepus nigricollis*)seeks cover in areas with a lot of vegetation.
- Among the hedges are the nests of ground-nesting birds, such as *Francolinus pondicerianus* (Grey Francolin) and *Ammomanes phoenicura* (Rufous-tailed Lark).
- Some reptiles were also seen utilizing bio-fenced areas, such as *Calotes versicolor* (Garden Lizard) and *Varanus bengalensis* (Monitor Lizard).

3. Comparative Biodiversity between Bio-fenced and Metal-fenced Areas

A comparative analysis indicated that bio-fenced farmlands support significantly higher biodiversity than those enclosed by metallic or electric fences.In contrast, electric and barbed wire fences contributed to habitat fragmentation, restricted wildlife movement, and increased mortality rates.

After 2017, barbed wire fencing replaced bio-fencing in the Barmer District, causing open desert ecosystems to become fragmented, important herbivores like *Gazella bennettii* to become less mobile, and smaller fauna to be at higher risk of dying. A dramatic drop in Indian Gazelle from 2364 (2017) to 1196 (2020) suggests that wire fencing is limiting movement. Free movement across community pastures (Gochar and Oran lands) is essential for open-range species like *Gazella bennettii* and *Antilope cervicapra*. Physical barriers erected by barbed fencing led to:

- Local populations are being isolated;
- Injuries or entanglement deaths.
- There is less genetic interchange between herds.
- The biting of feral dogs

4. The Advantages of Bio-fencing for the Environment

- Soil Fertility: Organic matter and nitrogen fixation from native plants like *Tecomella undulata* and *Acacia nilotica* increase soil productivity.
- Pollinator Support: By drawing bees, butterflies, and other pollinators, flowering plants like *Capparis decidua* and *Ziziphus nummularia* increase crop yield.
- Moisture Retention: By lowering evapotranspiration and wind desiccation, dense plant cover helps to maintain soil moisture.
- Microclimate Regulation: By lowering local temperature swings and wind speed, vegetative fencing makes the agricultural environment more stable.
- Habitat Connectivity: By serving as ecological corridors, bio-fences allow small fauna to move safely between fragmented habitats.

The findings show that, in addition to providing field protection, bio-fencing is a multipurpose ecological tool that supports habitat resilience, biodiversity, and soil conservation in the Thar Desert ecosystem.

Discussion

1. The Most Common Plant Species for Bio-fencing:

Several native thorny and drought-resistant plant species are still used by local farmers for traditional bio-fencing, according to field observations made in ten villages in the Barmer district. These species have ecological and protective roles and are well-suited to the desert environment.

These species create thick, living barriers that support biodiversity at the microhabitat level by protecting crops and serving as habitats for desert fauna. Habitat characteristics affect the abundance and diversity of bird

TABLE -3 : Biodiversity of Biofenced areas

S. No.	Species Local Name	Species Scientific Name	Lal ji Ki Dungri 24.905, 71.433	Sedva (24.905, 71.433)	Sanvlor (25.587, 71.221)	Total
1.	Indian Gazelle (Chinkara)	*Gazella bennettii*	37	34	30	101
2.	Desert Fox	*Vulpes vulpes pusilla*	21	17	09	47
3.	Nilgai (Blue Bull)	*Boselaphus tragocamelus*	23	12	07	42
4.	Blackbuck	*Antilope cervicapra*	11	0	0	11
5.	Desert Hare (Indian Hare)	Lepus nigricollis dayanus	13	11	09	33
6.	Sehi (Indian Crested Porcupine)	*Hystrix indica*	21	0	0	21
7.	Peacock	*Pavo cristatus*	51	42	35	128
8.	Common Mangoose	*Herpestes edwardsii*	15	13	11	39
9.	Monitor Lizard	*Varanus bengalensis*	19	21	20	60
10.	Golden Jackal (Devli ke Dhore)	*Canis aureus indicus*	06	0	0	06

populations[4-6].

2. Species of Wildlife Linked to Bio-fencing:

It was noted that several faunal species used the bio-fencing vegetation as a place to hide, nest, or feed. Among these were:

- *Gazella bennettii* (Chinkara), which seeks refuge and feeds on surrounding plants.
- Desert Fox (*Vulpes pusilla)*, burrows close to thick bushes for cover.
- The Indian Mongoose (*Herpestese dwardsii)* nests in prickly hedges.
- The Indian Hare (*Lepus nigricollis)* seeks cover in areas with a lot of vegetation.
- Among the hedges are the nests of ground-nesting birds, such as *Francolinus pondicerianus* (Grey Francolin) and *Ammomanes phoenicura* (Rufous-tailed Lark).
- Some reptiles were also seen utilizing bio-fenced areas, such as *Calotes versicolor* (Garden Lizard) and *Varanus bengalensis* (Monitor Lizard).

The type of vegetation and the availability of food resources influence the feeding behaviours and diversity of avian species[7].

TABLE -4 : Biodiversity of Metal-fenced fencing areas

S. No.	Species Local Name	Species Scientific Name	Lunu (25.8155, 71.326)	Genhu (25.78, 71.35)	Tirsingari 25.8621, 71.2286	Total
1.	Indian Gazelle (Chinkara)	*Gazella bennettii*	35	22	30	87
2.	Desert Fox	*Vulpes vulpes pusilla*	10	04	08	22
3.	Nilgai (Blue Bull)	*Boselaphus tragocamelus*	05	25	03	33
4.	Blackbuck	*Antilope cervicapra*	0	0	0	0
5.	Desert Hare (Indian Hare)	Lepus nigricollis dayanus	15	11	07	33
6.	Sehi (Indian Crested Porcupine)	*Hystrix indica*	0	04	0	04
7.	Peacock	*Pavo cristatus*	28	24	15	67
8.	Common Mangoose	*Herpestes edwardsii*	16	15	14	45
9.	Monitor Lizard	*Varanus bengalensis*	21	22	20	63
10.	Golden Jackal (Devli ke Dhore)	*Canis aureus indicus*	0	0	0	0

3. Biodiversity Comparison of Metal-Fenced and Bio-Fenced Areas:

Compared to farmlands surrounded by electric or metallic fences, bio-fenced farmlands support a significantly higher level of biodiversity, according to a comparative analysis. On the other hand, barbed wire and electric fences increased mortality rates, limited wildlife movement, and fragmented habitat.

4. The Advantages of Bio-fencing for the Environment :

The study emphasized many ecosystem services that bio-fencing vegetation offers, including:

- Soil Fertility: Organic matter and nitrogen fixation from native plants like *Tecomella undulata* and *Acacia nilotica* increase soil productivity.
- Pollinator Support: By drawing bees, butterflies, and other pollinators, flowering plants like *Capparis decidua* and *Ziziphus nummularia* increase crop yield.
- Moisture Retention: By lowering evapotranspiration and wind desiccation, dense

TABLE -5 : Wildlife census data for Barmer (Forest Department Office, Barmer) district from 2010 to 2025

Year	Indian Gazelle	Black buck	Nilgai	Desert Fox
2010	2192	0	623	160
2011	1985	0	320	65
2012	1053	0	613	120
2013	1604	26	471	88
2014	2270	20	578	76
2015	2290	0	492	46
2016	1562	0	582	122
2017	2364	0	756	119
2018	2235	0	1176	72
2019	1732	0	766	31
2020	1196	0	643	68
2022	1355	11	593	73
2024	1548	17	868	93
2025	1618	19	1291	18

plant cover helps to maintain soil moisture.

- Microclimate Regulation: By lowering local temperature swings and wind speed, vegetative fencing makes the agricultural environment more stable.
- Habitat Connectivity: By serving as ecological corridors, bio-fences allow small fauna to move safely between fragmented habitats.

The findings show that, in addition to providing field protection, bio-fencing is a multipurpose ecological tool that supports habitat resilience, biodiversity, and soil conservation in the Thar Desert ecosystem.

Conclusion

The results of this study clearly show that, in the Thar Desert, bio-fencing is an economical, environmentally responsible, and sustainable substitute for contemporary metallic and electric fencing systems. Bio-fencing derived from native plant species improves agricultural productivity and ecosystem health in contrast to artificial barriers that fragment habitats and frequently result in wildlife mortality.

In addition to acting as efficient physical barriers, traditional bio-fencing species like *Ziziphus nummularia* (Ber), *Euphorbia caducifolia* (Thor), *Capparis decidua* (Ker), and *Acacia nilotica* (Babool) also offer a variety of ecological benefits. These consist of microclimate control, pollinator attraction, nitrogen fixation, and soil stabilization. According to the study, bio-fenced areas had greater faunal diversity and species richness than those encircled by barbed or electric wires, highlighting their function in promoting biodiversity and restoring habitat.

Additionally, bio-fencing improves soil fertility and

moisture retention, which supports sustainable agriculture over the long run. It increases desert agro-ecosystems' resistance to climatic stress by reducing wind erosion and creating shelterbelts. Thus, the revival of such traditional methods is highly compatible with contemporary ideas of community-based conservation, eco-restoration, and sustainable land management.

However, because of low awareness, slow native shrub growth rates, and a lack of institutional support, bio-fencing adoption is still restricted despite its demonstrated ecological advantages. Campaigns to raise awareness, educational initiatives, and government incentives that support bio-fencing under current agricultural and environmental programs are urgently needed. Similar to the subsidies and technical assistance offered for metal fencing, bio-fencing could be widely adopted by farmers and rural communities if it were made available.

To sum up, in arid regions like the Thar Desert, bio-fencing provides a practical and sustainable way to balance wildlife preservation with agricultural security. In one of India's most ecologically sensitive areas, its promotion through community involvement, policy integration, and scientific validation can guarantee both biodiversity preservation and sustainable rural development.

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