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Biodiversity in Thar Desert and its Role in Sustainable Agriculture

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ABSTRACT

The country has both hot and cold deserts. The *Thar* Desert, seventh largest desert in the world, harbors several species that have adapted themselves to survive in the harsh desert conditions. The floral diversity includes 682 species (63 introduced species), belonging to 352 genera and 87 families. The degree of endemism of plant species in the *Thar* Desert is 6.4 percent, which is relatively higher than the degree of endemism in the world famous Sahara desert. The faunal diversity represents 755 invertebrate and 440 vertebrate species, including 140 bird and 41 mammalian species and the only known population of the Asiatic wild ass. It is highlighted that sustainable use and management of this biodiversity is necessary to support human and livestock needs besides conservation. The strategy should be such that it is supported by public.

Figure : 01 References : 68 Tables : 08
KEY WORDS : Desert ecosystem, Forests, Grasslands, Livestock, Management, Wildlife

Introduction

India is having a critical blend of tradition and modernity. Apart from being one of the oldest civilizations in the world, it is one of the fastest growing economies (based on 2017-18 projections), supports second highest population (1.33 billion) and is the seventh largest in area (329 million hectares) in the world. Although well over half of the country's workforce (50 %) is still employed in the agriculture sector; it is having the unique geo-morphological position as its mainland is separated from the rest of Asia by the Himalayas. The country has an astounding spectrum of habitats and ecosystems, existing over a wide range of latitudes and longitudes, confluence of three global centers of origin of life (biogeographic Realms) and an extremely enriched flora and fauna. The unique mosaic of ecosystems and habitats in different bio-geographic zones of India has created a number of biodiversity-rich landscapes and the desert is one of that.

The term biodiversity, coined in 1986 is most commonly used to define species diversity and species richness. Biologists most often define biodiversity as the totality of genes, species and ecosystems of a region. The Convention on Biological Diversity (CBD) defines biodiversity as the variability among living organisms from all sources and the ecological complexes of which they are a part- including diversity within species, between species and of ecosystems[66].

Sustainable development is one that meets the needs of the present without compromising the ability of future generations to meet their requirements. It is now well understood that if biodiversity is well-managed, sustainable pathway for economic development is very likely. Biodiversity provides goods and services that help in sustainable development at different levels[59]. It underpins the functioning of ecosystems on which humanity depends for a range of essential services – provisioning, regulating, cultural and supporting. Although, the demand for these services is likely to go up in the coming years as a result of the rapidly expanding global economy and increase in human population, which is expected to reach nine billion by 2050; loss in biodiversity is in five key factors *viz.,* habitat loss; unsustainable use and overexploitation; pollution; invasive alien species and climate change[41].

The Millennium Ecosystem Assessment (MEA)[64] estimated that over the past few centuries, humans have increased extinction rates of species by as much as a thousand times as compared to extinction rates by natural processes. Species in all taxonomic groups with known

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TABLE-1: Bio-geographic zones of India

Zone No.	Name	Area (km)	Percent of Country's land area
1	Trans-Himalaya	184823	5.62
2	Himalaya	210662	6.41
3	Desert	215757	6.56
4	Semiarid	545850	16.60
5	Western Ghats	132606	4.03
6	Deccan Peninsula	1380380	41.99
7	Gangetic Plain	354782	10.79
8	Coasts	82813	2.52
9	Northeast	171341	5.21
10	Islands	8240	0.25
Total	3287263	100	
Source[49]			

trends are, on average, being driven closer to extinction, with amphibians and warm water reef-building corals being particularly vulnerable[66]. Nearly a quarter of all plant species is believed to be threatened. Some authors have even compared the present scenario to mass extinction events that have occurred a few times during the history of life on Earth[35]. Not only is the number of species on the decline, their populations and the ecosystems where they are nestled are also vanishing at a rapid pace. The population size or range (or both) of a majority of species is diminishing across a number of taxonomic groups[64]. The Global Living Planet Index, which monitors populations of selected vertebrate species, has fallen by over 30 percent since 1970; suggesting that, on average, vertebrate populations have declined by nearly one-third during this period[67].

Deserts are the very unique and important ecosystem harboring wider spectrum of biodiversity cut cross our planet along two fringes parallel to the equator, at 25°–35° latitude in both the northern and southern hemispheres. The Desert Biome is defined climatologically as the sum of all the arid and hyper-arid areas of globe; biologically, as the eco-region that contains plants and animals adapted for survival in arid environments. Desert ecosystem is characterized by very low rainfall (< 400 mm), aridity, and very sparse presence of vegetation. Though appearing to be lifeless at first glance, deserts can harbor an astonishing and unique diversity of species, and biological communities of high conservation value. They provide migratory corridors for many species. Non-desert birds on cross-desert migration across the Sahara compete increasingly with the human population of the region for rare oases that cover only two percent of the area. The desert locust (*Schistocera gregaria*) is normally found in 25 countries of the Sahel and the Arabian Peninsula, but during epidemic outbreaks can spread over upto 65 countries, consuming 100000 tons of vegetation a day, from India to Morocco and even crossing the Atlantic to the Caribbean and Venezuela[20].

Deserts have provided trade corridors from times immemorial through which goods and cultures travelled. Because of their warm climate, deserts also export agricultural products, produced under irrigation, to non-desert areas. Agriculture and horticulture are already profitable in many deserts, as in Israel and Tunisia, and have great potential in *Thar*. A new non-conventional desert export is derived from aquaculture, which paradoxically, can be more efficient in water use than desert plants, and can take advantage of the deserts' mild winter temperatures and low cost of land. Biologically-derived valuable chemicals, produced by micro-algae as well as medicinal plants, are also manufactured in deserts, capitalizing on their high year-round solar radiation, and exported to global markets. Besides the ongoing export of wild plant products from deserts to non-deserts, there is a pharmaceutical potential in desert plants which is yet to be tapped. Here lies the trichotomy of the biodiversity, desert and sustainable development and it may be envisaged philosophically towards Castri's three legs of sustainability to derive a kaleidoscopic view on the potential of the Indian *Thar* Desert[18,31].

The Indian *Thar* Desert

In India, the *Thar*, the smallest desert in the world, occupies nearly 385,000 km^2 and about 9 per cent of the area of the country[29,38]. The only river that crosses through region is Luni, joining the Arabian Sea through the *Rann of Kutch* in Gujarat. It extends from Punjab through Haryana and Rajasthan to Gujarat. The Aravalli Mountains, starting from northern Gujarat and extending up to Delhi state, form the eastern boundary of the *Thar*. In the west it joins with the *Thar* Desert of Pakistan and in the south it extends into the *Kutch* of Gujarat (Fig. 1). This Desert is the eastern extension of the vast Persio-Arabian desert, which joins the great Sahara

deserts[29,30,47]. It is the most populous desert in the world, with human density of around 84 persons per km^2. Population growth is also very high. For instance, between 1901 and 2011 decadal population growth in whole of India was 17.70 per cent; it was 23.56 per cent in the *Thar*[23,36]. More than 80 per cent of the people live in villages or scattered settlements called *dhanis*, but urbanization is increasing fast.

This is an important bio-region of Rajasthan comprising about 61 percent of the state's total geographical area. It is one of the most biologically and culturally diverse Deserts of the world and houses distinct and unique ecosystems, landscapes and species of plants and animals. It is characterized by geomorphic forms and landscapes such as dunes, *magras*, *dhands* and *bhakars*, each with a distinct ecology of its own. This Desert results from the dryness of the prevailing monsoon winds, which do not bring sufficient rain to keep the region moist. The sand cover is of early Pre-Cambrian gneiss (granite-like metamorphic rocks formed in the oldest geologic era, which began 3.8 billion years ago), sedimentary rocks from about 2.5 billion to 570 million years old, and more recent material deposited by rivers (alluvium). The surface sand is aeolian (wind deposited) sand of the Quaternary Period (the most recent geologic period, which began about 1.6 million years ago). The desert presents an undulating surface, with high and low sand dunes separated by sandy plains and low, barren hills, or *bhakars*, which rise abruptly from the surrounding plains. The dunes are in continual motion and take on varying shapes and sizes. Older dunes, however, are in a semi-stabilized or stabilized condition, and many rise to a height of almost 500 feet (150 m). Several saline lakes, locally known as *dhands*, are scattered throughout the region[5,19,26,37,39,56]. Comprehensive studies on faunal diversity in the *Thar* Desert have been documented[68]. Three types of major terrestrial habitats are recognized in the Indian desert in relation to flora and fauna[7,8,9,54] .

Sandy: The sandy habitat occupies the largest area of the desert. Depending upon the soil type and topography, it can be further subdivided into (i) Younger alluvial plain, (ii) Older alluvial flat plains, (iii) Older alluvial hummocky plains, (iv) Saline flats, and, (v) Sand dunes. Mixed xeromorphic vegetation with trees such as *Tecommela undulata*, *Prosopis cineraria*, *Acacia nilotica* and *Salvadora oleoides*; shrubs like *Calligonum polygonoides* and *Haloxylon salicornicum*; forbs like *Tephrosia purpurea*, *Indigofera* spp., *Crotalaria burhia*, *Aerva tomentosa*, *Aerva persica* and grasses like *Cenchrus biflorus* and *Crotalaria ciliaris*, *Aristida spp.,*

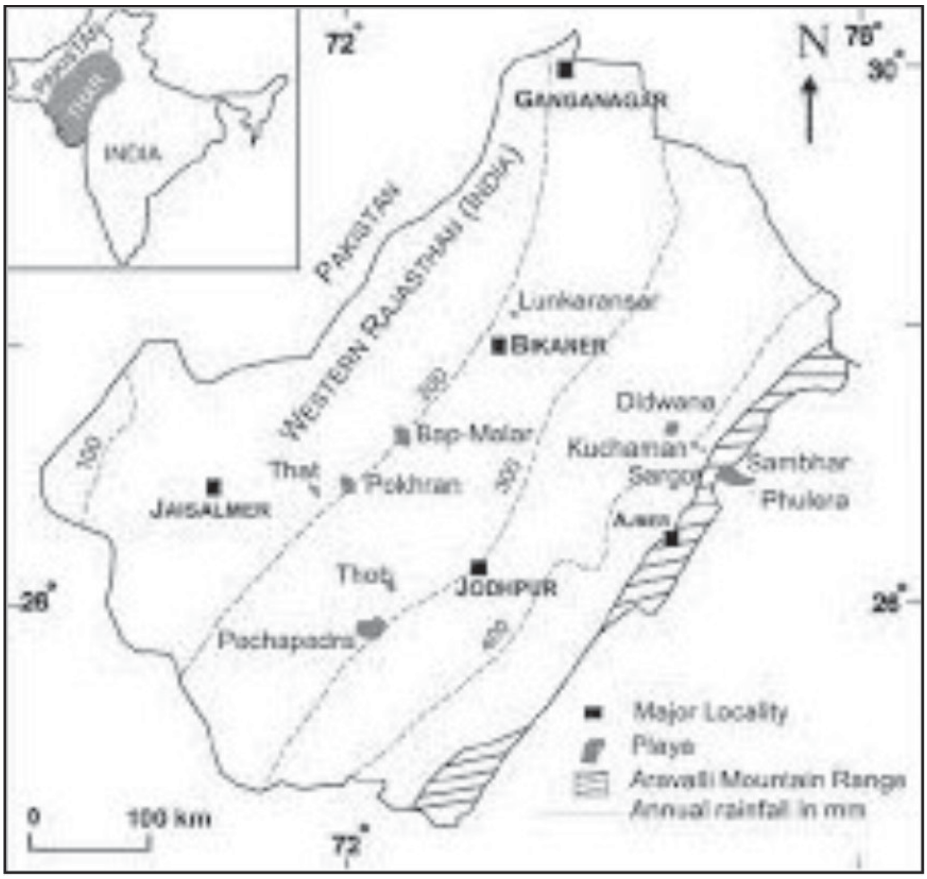

Fig. 1 : Map of *Thar* Desert of India

are common.

Hills and Rocky Outcrops: Such outcrops are scattered all over the desert region. *Anogeissus pendula*, *Acacia senegal*, *Euphorbia caducifolia*, *Maytenus emarginatus*, *Commiphora wightii* and *Cordia garaf* are common trees, and *Sehima nervosum*, *Cymbopogon jawarancusa*, *Hackelochloa granularis*, and *Dichanthium annulatum* constitute the ground flora.

Ruderal: This habitat is associated with villages which are scattered all over the desert, over rocky outcrops, sandy plains, sand dunes, saline flats and river banks. The luxuriant trees such as *Azadirachta indica*, *Tamarindus indica*, *Prosopis cineraria*, *Acacia* spp. *Ficus* spp. and *Salvadora oleoides* are the major species found in these regions.

Biological Diversity

The future of biodiversity and the very foundations of life on earth depend on this. Life on Earth is believed to

TABLE-2 : Tannins yielding plants of Indian *Thar*

Local Name	Botanical Name	Family	Part used	Other uses
Babul	*Acacia nilotica*	Mimosaceae	Bark	Medicine, Gum
Arunj	*Acacia leucophloea*	Mimosaceae	Bark	Fiber, Gum
Sadad	*Terminalia alata*	Combretaceae	Bark	Medicine
Arjuna	*Terminalia arjuna*	Combretaceae	Bark	Medicine, Silk Worm Host
Amaltas	*Cassia fistula*	Caesalpiniaceae	Bark	Medicine
Anwal	*Cassia auriculata*	Caesalpiniaceae	Bark	Medicine
Godal	*Lannea coromandelica*	Anacardiaceae	Bark	Gum, Resin, Dye
Dansara	*Rhus mysurensis*	Anacardiaceae	Bark	Fruit
Farash	*Tamarix aphylla*	Tamaricaceae	Bark	Medicine
Jangaljalbi	*Pithecellobium dulce*	Mimosaceae	Bark	Timber
Khair	*Acacia catechu*	Mimosaceae	Bark	Dye, Medicine, Gum
Ghatbor	*Zizyphus glaberrima*	Rhamnaceae	Fruit	Fruit
Baheda	*Terminalia bellirica*	Combretaceae	Fruit	Medicine
Anonla	*Emblica officinalis*	Euphorbiaceae	Fruit	Fruit, Medicine
Dhokra	*Anogeissus pendla*	Combretaceae	Leaves	Medicine
Dhawra	*Anogeissus latifolia*	Combretaceae	Leaves	Gum, Medicine
Karaunda	*Carissa carandas*	Apocynaceae	Leaves	Fruit
Mehandi	*Lawsonia inermis*	Lytharaceae	Leaves	Dye, Medicine
Khejari	*Prosopis cineraria*	Mimosaceae	Leaves	Fruit, Gum
Karpata	*Garuga pinnata*	Burseraceae	Leaves	Medicine

have originated around 3.5 billion years ago. Over time, it evolved into myriad fascinating forms through the process of speciation. Some of these life forms were, however, lost along the way through extinction. The current stock of species is a product of these two processes occurring simultaneously over a long period of time. At present, approximately 1.75 million species have been formally identified. While estimates of the total numbers vary widely, some scientists believe that there may be as many as 13 million species living on earth[33,34,64].

India, with 2.4% of the world's area, has over 8% of the world's total biodiversity, making it one of the 12 mega-diversity countries in the world. This status is based on the species richness and levels of endemism recorded in a wide range of taxa of both plants and animals. This diversity can be attributed to the vast variety of landforms and climates, resulting in habitats ranging from tropical to temperate and from alpine to desert. Adding to this is a very high diversity of human-influenced ecosystems, including agricultural and pasture lands, and a diversity of domesticated plants and animals. India is also considered as one of the world's eight centers of origin of cultivated plants. Being a predominantly agricultural country, India also has a mix of wild and cultivated habitats, giving rise to very specialized biodiversity, which is specific to the confluence of two or more habitats.

The tendency to classify ecological regions and plant and animal groupings, according to their geographical distribution and their essential similarities and differences, is not new. Traditional human communities did this on the basis of their own understanding, though their knowledge was necessarily somewhat restricted in its geographical spread[4,28]. Unfortunately, this aspect of traditional community knowledge is not receiving due attention presently. In modern times, bio-geographical classification, started in the latter half of the 19th century, is based on distribution of animals and plants[21]. An attempt to synthesize the two approaches on the combination of plant and animal distribution, is very recent, and has been prompted by the need to use such zonation in fixing conservation priorities[49]. Workers[50] recognized ten bio-geographic zones divided into twenty-six biotic provinces in India (Table-1).

Due to the diversified habitat and ecosystem, the vegetation, human culture and animal life in this arid region is very rich in contrast to the other deserts of the world. About 23 species of lizard and 25 species of snakes are found here and several of them are endemic to the region. The plant biodiversity (Tables 2-7) of *Thar* Desert is having great economic value which includes categories like plants yielding fibers, tannins, dyes, gum and resins, extraction and distillation products, plants for lac worm hosts, plant for silkworm hosts, *biri* leaves, soap substitutes *etc.* which can be broadly classified in the following categories[3,14,27].

Trees: *Acacia leucophloea*; *Acacia nilotica*; *Acacia senegal*; *Acacia tortilis*; *Azadirachta indica*; *Ailanthus excelsa*; *Balanites aegyptiaca*; *Dichrostachys cinerea*; *Ficus benghalensis*; *Ficus religiosa*; *Holoptelea integrifolia*; *Prosopis cineraria*; *Prosopis juliflora*; *Tecomella undulata*; *Ziziphus mauritiana*; *Maytenus emarginata*; *Phoenix sylvestris*; *Riccinus communis*; *Terminalia alata*; *Terminalia arjuna*; *Cassia fistula*; *Cassia auriculata*; *Tamarix aphylla*; *Pithecellobium dulce*; *Acacia catechu*; *Zizyphus glaberrima*; *Terminalia bellirica*; *Emblica officinalis*; *Anogeissus pendula*; *Anogeissus latifolia*; *Prosopis cineraria*; *Garuga pinnata*; *Madhuca indica*; *Pongamia pinnata*; *Salvadora oleoides*; *Salvadora persica; Jatropha curcas*; *Balanites aegyptiaca*; *Sapindus emarginatus; Mimusops elengi; Aegle marmelos*; *Bauhinia racemosa*; *Boswellia serrata; Bombax ceiba; Buchnania latifolia; Butea monosperma*; *Leucaena leucocephala*; *Lannea coromandelica*; *Moringa oleifera*; *Mangiferaindica*; *Miliusa tomentosa*; *Pterocarpus marsupium*; *Sterculia urens*; *Nyctanthes arbortristis*; *Wrightia tinctoria*; *Morinda tinctoria*; *Helicteres isora*; *Cordia gharf*; *Erythrina suberosa*; *Phoenix sylvestre*; *Cordia oblique*; *Ficus religiosa*; *Morusalba*; *Diospryos melanoxylon*; *Diospryos tomentosa*; *Diospryos montana*; *Santalum album.*

Shrubs: *Carissa carandas*; *Punica granatum*; *Lawsonia inermis*; *Rhus mysurensis*; *Mallotus philiphinensis*; *Capparis deciduas*; *Abutilon indicum*; *Sida cordifolia*; *Waltheria indica*; *Commiphara wightii*; *Hibiscus ovalifolius*; *Ziziphus nummularia*; *Acacia jacqumontii*; *Crotalaria burhia*; *Grewia tenax*; *Crotalaria medicaginia*; *Verbesina encelioides*; *Xanthium strumarium*; *Calotropis procera*; *Leptadenia pyrotechnica* (Forsk.) Decne.; *Sericostoma pauciflorum*; *Withania somnifera*; *Lantana indica*; *Aerva tomentosa*; *Salsola baryosoma*; *Suaeda maritime*.

Perennial herbs: *Tephrosia hamiltonii*; *Tephrosia purpurea*; *Farsetia hamiltonii*; *Indigofera linnaei* Ali.; *Trianthema portulacastrum*; *Zaleya govindia*; *Borreria articularis*; *Echinopsechinatus*; *Launaea resedifolia*; *Launaea procumbens*; *Oligochaeta ramose*; *Pulicaria crispa*; *Catharanthus roseus*; *Convolvulus microphyllous*; *Datura metal*; *Solanum nigrum*; *Solanum surattense*; *Lepidagathis trinervis*; *Boerhavia diffusa*; *Achyranthes aspera*; *Amaranthus caudatus*; *Pupalia lappacea*; *Croton bonplandianum*.; *Euphorbia hirta*.

Annual herbs: *Argemone mexicana*; *Fumaria indica*; *Sismbrium irio*; *Portulaca oleracea*; *Portulaca*

suffruticosa; *Alysicarpus monilifer*; *Medicago laciniata* , *Melilotus indica*; *Fagonia cretica*; *Trigonella. polycerata*; *Trianthema triquetra*; *Acanthospermum hispidum*; *Artemisia scoparia*; *Gnaphalium indicum*; *Pulicaria angustifolia*; *Sonchus asper*; *Vernonia cinerea*; *Anagallis arvensis*; *Arnebia hispidissima*; *Heliotropium ellipticum*; *Heliotropium marifolium; Heliotropium subulatum*; *Datura innoxia*; *Leucas aspera*; *Gomphrena celosiodies; Indigofera cordifolia*; *Indigofera hochstetteri*; *Tephrosia strigosa*; *Ocimum canum*; *Chenopodium album*; *Chenopodium murale*; *Phyllanthus asperulatus*.

Ephemerals: *Cleome gynandra*; *Cleome viscose*; *Polygala erioptera*; *Polygala irregularis*; *Indigofera astragalina*; *Polycarpaea corymbosa*; *Sida ovata*; *Corchorus tridens*; *Triumfetta pentandra*; *Tribulus terrestris*; *Cassia tora*; *Cassia occidentalis*; *Alysicarpus vaginalis*; *Indigofera linifolia*; *Indigofera sessiliflora*; *Gisekia pharnaceoides*; *Mollugo cerviana*; *Mollugo nudicaulis*; *Bidens biternata*; *Blainvilleaacmella*; *Trichodesma indicum*; *Evolvulus alsinoides*; *Physalis minima*; *Pedalium murex*; *Sesamum indicum*; *Martynia annua*; *Peristrophe bicalyculata*; *Rostellularia procumbens*; *Anisomeles indica*; *Amaranthus spinosus*; *Digeramuricata*; *Euphorbia prostrata*; *Commelina benghalensis*; *Commelina forskalaei*.

Climbers and twiners: *Cocculus pendulus*; *Celastrus paniculata*; *Tinospora cordifolia*; *Blastania fimbristipula*; *Citrulluscolocynthis*; *Cucumis callosus*; *Mukia maderaspatana*; *Pergularia daemia*; *Ipomoea eriocarpa*; *Ipomoea pes-tigridis*.

Grasses: *Bulbostylis barbata*; *Cyperus arenarius; Cyperus bulbosus*; *Cyperus triceps*; *Aristida funiculata*; *Brachiariaramose*; *Brachiaria reptans*; *Cenchrus biflorus*; *Cenchrus ciliaris*; *Cenchrus pennisetiformis*; *Chloris virgata*; *Dactyloctenium sindicum*; *Vetiveria zizanioides*; *Typha elephantine*; *Eragrostis ciliaris*; *Eragrostispilosa*; *Eragrostis tremula*; *Saccharum bengalense*.

Production Systems and Biodiversity

Thar is one of most heavily populated desert areas in the world and the main occupations of people living here are agriculture and animal husbandry. Agriculture is

TABLE-3 : Nonedible oil yielding plants of Indian *Thar*

Local Name	Botanical Name	Family	Part use	Other use
Arundi	*Riccinus communis*	Euphorbiacae	Seed	Medicine
Mahuwa	*Madhuca indica*	Sapotaceae	Seed	Fruit
Karanj	*Pongamia pinnata*	Fabaceae	Seed	Medicine
Neem	*Azadirachta indica*	Meliaceae	Seed	Medicine
Tumba	*Citrullus colocynthis*	Cucurbitaceae	Seed	Medicine
Pil-hulhul	*Cleome viscose*	Capparaceae	Seed	Medicine
Satyanashi	*Argemone maxicana*	Papaveraceae	Seed	Medicine
Pilu	*Salvadora oleoides*	Salvadoraceae	Seed	Medicine
Kharajal	*Salvadora persica*	Salvadoraceae	Seed	Medicine
Ratanjot	*Jatropha curcas*	Euphorbiaceae	Seed	Medicine, Dye
Hingot	*Balanites aegyptiaca*	Simaroubaceae	Seed	Medicine
Aritha	*Sapindus emarginatus*	Sapindaceae	Seed	Soap substitute
Maulsiri	*Mimusops elengi*	Sapotaceae	Seed	Medicine
Malkangini	*Celastrus paniculata*	Celastraceae	Seed	Medicine

not a dependable proposition in this area—after the rainy season, at least 33% of crops fail. Animal husbandry, trees and grasses, intercropped with vegetables or fruit trees, is the most viable model for arid, drought-prone regions. The region faces frequent droughts. Overgrazing due to high animal populations, wind and water erosion,

TABLE- 4 : Gums and Resins yielding plants in *Thar*

Local Name	Botanical Name	Family	Other uses
Babul	*Acacia nilotica*	Mimosaceae	Tannin, Medicine
Kumta	*Acacia senegal*	Mimosaceae	Tannin, Medicine
Baonli	*Acacia jacquemontii*	Mimosaceae	Medicine
Arunj	*Acacia leucophloea*	Mimosaceae	Medicine, Tannin
Dhawra	*Anogeissus latifolia*	Combretaceae	Tannin, Medicine
Dhokra	*Anogeissus pendula*	Combretaceae	Medicine
Bel	*Aegle marmelos*	Rutaceae	Medicine, Fruit
Neem	*Azadirachta indica*	Meliaceae	Oil, Medicine
Jhinjha	*Bauhinia racemosa*	Caesalpiniaceae	Medicine
Salar	*Boswellia serrata*	Burse raceae	Medicine
Semal	Bombax ceiba	Bombacaceae	Fiber
Chironji	*Buchnania latifolia*	Anacardiaceae	Edible seed
Palas	*Butea manosperma*	Fabaceae	Dye, Medicine
Ganiara	*Cochlospermum religiosum*	Cochlospermaceae	Fiber, Oil
Gugal	*Commiphara wightii*	Burseraceae	Medicine
Subabool	*Leucaena leucocephala*	Mimosaceae	Firewood, Charcoal
Godal	*Lannea coromandelica*	Anacardiaceae	Dye, Timber, Tannin
Sainjana	*Moringa oleifera*	Caesalpiniaceae	Fruit
Aam	*Mangifera indica*	Anacardiaceae	Fruit
Umb	*Miliusa tomentosa*	Anonaceae	Timber
Bijasal	*Pterocarpus marsupium*	Fabaceae	Medicine
Katria	*Sterculia urens*	Sterculiaceae	Oil, Medicine
Rohan	*Soymida febrifuga*	Meliaceae	Medicine
Khair	*Acacia catechu*	Mimosaceae	Dye, Medicine, Tannin

mining and other industries result in serious land degradation[22].

Agriculture: In past few decades the development of canals, tube wells *etc.* has changed crop pattern. Now the desert districts in Rajasthan have started producing *rabi* crops like wheat, mustard, cumin seed *etc.* The people have started to grow cash crops too. Pearl millet (*Pennisetum typhoides*) is the main monsoonal crop. The other common crops are *Mong* (*Phaseolus radiates*), *Moth* (*Vigna aconitifolia*), *Guar* (*Cyamopsis tetragonoloba*) and *Til* (*Sesamum indicum*). In the Indira Gandhi *Nahar* (canal) Project (IGNP) common areas, these traditional crops are being replaced by cash crops such as groundnut (*Arachis hypogea*), cotton (*Gossypium* spp.), rice (*Oryza sativa*), sugarcane (*Saccharum officinarum*), wheat (*Triticum sativum*) and barley (*Hordeum vulgare*)[15,29]. This region is also the main opium producer and consumer area. During good rainfall years, vast areas in Jodhpur, Bikaner, Nagpur, Pali, Churu and Sri Ganganagar are being brought under cultivation. However, the irrigated area in the *Thar* is limited to 14% of the total crop area. Nearly 54% of the total irrigated area is fed by canals, 45% by wells and tube wells, and only about 1% by tanks[16]. However, with the development of IGNP the picture is changing[29,30,46,52]. Arrival of water in this region has opened up land for colonization in the Sri Ganganagar district and certain other parts of Rajasthan. The increase in population is due to immigration, especially in the Sri Ganganagar and Bikaner districts has taken place because of the newly irrigated areas and also higher population growth rates there. The IGNP has also brought tremendous changes in the crop pattern from subsistence farming to commercial farming[29,30,43,45]. A great extent of the marginal land has been brought under cultivation. In the canal-irrigated areas, the groundwater table is rising due to seepage from the canals, field channels and irrigated fields[15]. Moreover, owing to leakages in the channels and bad maintenance of the canals, in many places inter dune reservoirs have been formed where the vegetation cover has changed from xerophytic and psammophytic to hydrophytic and mesophytic plants. Many wetlands are covered by aquatic vegetation such as *Typha angustata, Arundo donax, Eichhornia crassipes, Imperata cylindrica, Phragmites* and *Saccharum spontaneum*. The Government of India has started a centrally sponsored scheme under the title of Desert Development Program (DDP) based on watershed management with the objective to check spreading of desert and improve the living condition of people in desert.

Livestock: Livestock production and agriculture are intrinsically linked, each being dependent on the other, and both crucial for overall food security. According to estimates of the Central Statistics Office (CSO), the value of output from livestock sector at current prices was about ₹4,59,051crore during 2011-12 which is about 24.8 per cent of the value of output from total agricultural and allied sector at current price and 25.6 percent at constant prices (2004-05). The value of output of milk was 3,05,484 crore in 2011-12, which is higher than the value of output of paddy and wheat. The value of output from meat group as per the estimates at current prices in 2011-12 was 83,641 crore. The value of output from eggs and wool group is 17,803 crore and 318 crore respectively for 2011-12[24].

In the last 15–20 years, the Rajasthan desert has seen many changes, including a manifold increase in animal population. Animal husbandry has become popular due to the difficult farming conditions. At present, there are ten times more animals per person in Rajasthan than the national average, and overgrazing is also a factor affecting climatic and drought conditions. A large number of farmers in *Thar* Desert depend on animal husbandry for their livelihood. Cow, buffalo, sheep, goats, camel, and ox consist of major cattle population. Buffalo are also found along the IGNP. Barmer district has the highest cattle population out of which sheep and goats are in majority. Some of the best breeds of bullocks such as *Kankrej* (*Sanchori*) and *Nagauri* are from desert region. This region has one of the largest livestock densities in the world. Historically, the forage supply and demand scenario in this region indicates supply shortage of 62%, varying from a deficit of 30.9% in Zone IV to 71% in Zone III. Similar shortages were observed during the 1997–2003 field surveys due to an increase in the livestock numbers. The density of livestock varies from 42 in Jaisalmer district to 226 km^2 in Sikar district[16,44]. Livestock density is directly proportional (positive correlation) to rainfall. This region is the biggest wool-producing area in India. *Chokla*, *Marwari*, *Jaisalmeri*, *Magra*, *Malpuri*, *Sonadi*, *Nali* and *Pungal* breeds of sheep are found in the region. Of the total wool production in India, 40-50% comes from Rajasthan. The sheep-wool from Rajasthan is considered best for carpet making industry in the world. The wool of *Chokla* breed of sheep is considered of superior quality. The breeding centers have been developed for *Karakul* and *Merino* sheep at Suratgarh, Jaitsar and Bikaner. Some important mills for making Woolen thread established in desert area are: Jodhpur Woolen Mill, Jodhpur; Rajasthan Woolen Mill, Bikaner and India Woolen Mill, Bikaner. Bikaner is the biggest *mandi* (market place) of wool in Asia.

Most of the livestock are dependent on grazing on

common lands in and around villages[13,17,63]. During famine years in the desert the nomadic *Rebari* people move with large herds of sheep and camel to the forest areas of south Rajasthan or nearby states like Madhya Pradesh for grazing the cattle. The importance of animal husbandry can be understood from the organization of large number of cattle fairs in the region. Cattle fairs are normally named after the folk-deities. Some of major cattle fairs held are *Ramdevji* cattle fair at Manasar in Nagaur district, *Tejaji* cattle fair at Parbatsar in Nagaur district, *Baldeo* cattle fair at Merta city in Nagaur district, *Mallinath* cattle fair at Tilwara in Barmer district.

Agroforestry: Forestry has an important part to play in the amelioration of the conditions in semi-arid and arid lands. If properly planned, forestry can make an important contribution to the general welfare of the people living in desert areas. The living standard of the people in the desert is low. Many still cannot afford other fuels like gas, kerosene *etc* and fire wood constitute a major fuel. The forest area is mainly in southern districts of Rajasthan like Udaipur and Chittorgarh. The minimum forest area is in Churu district only 80 km^2. Thus, the forest is insufficient to fulfill the needs of firewood and grazing in desert districts. This diverts the much needed cattle dung from the field to the hearth. This in turn results into the decrease in agricultural production. Agroforestry model is best suited to the people of desert [2,51]. The most important tree species in terms of providing a livelihood in this region is *Prosopis cineraria*.

Prosopis cineraria provides wood of construction class. It is used for house-building, chiefly as rafters, posts scantlings, doors and windows, upright posts of Persian wheels, agricultural implements and shafts, spokes, fellows and yoke of carts. It can also be used for small turning work and tool-handles. Container manufacturing is another important wood-based industry, which depends heavily on desert-grown trees. It is a valuable fodder as well. The trees are heavily lopped particularly during winter months when no other green fodder is available in the dry tracts. There is a popular saying that death will not visit a man, even at the time of a famine, if he has a *Prosopis cineraria*, a goat and a camel, since the three together are somewhat said to sustain a man even under the most trying condition. The forage yield per tree varies a great deal. On an average, the yield of green forage from a full grown tree is expected to be about 60 kg with complete lopping having only the central leading shoot, 30 kg when the lower two third crown is lopped and 20 kg when the lower one third crown is lopped. The leaves (*Loong*) are of high nutritive value. Feeding of the leaves during winter when no other green fodder is generally available in rain-fed areas is thus

TABLE- 5 : Dyes yielding plants in *Thar*

Local Name	Botanical Name	Family	Part use	Other use
Khair	*Acacia catechu*	Mimosaceae	Wood	Tannin, Medicine
Sadad	*Terminalia alata*	Combertaceae	Bark	Medicine
Maulsiri	*Mimusops elengi*	Sapotaceae	Bark	Fruit
Godal	*Lannea coromandelica*	Anacardiaceae	Bark	Dye, Gum, Resin
Kamala	*Mallotus philiphinensis*	Euphorbiaceae	Fruit	Non-edible oil
Palas	*Butea monosperma*	Fabaceae	Flower	Medicine, Gum
Harsinghar	*Nyctanthes arbortristis*	Oleaceae	Flower	Essential oil
Khirni	*Wrightia tinctoria*	Apocynaceae	Flower	Medicine
Aal	*Morinda tinctoria*	Rubiaceae	Root	Medicine
Anar	*Punica granatum*	Punicaceae	Root	Fruit
Mehandi	*Lawsonia inermis*	Lytharaceae	Leaves	Medicine

profitable. The pods (*Sangar* or *Sangri*) have a sweetish pulp and are also used as fodder for all categories of livestock viz., cattle, sheep, goat and camel. The dried pods (*Kho-Kha*) are also fodder. They are also used as famine food and known even to prehistoric man. Even the bark, having an astringent bitter taste, was reportedly

TABLE- 6 : Fibers yielding plants in *Thar*

Local Name	Botanical Name	Family	Part use	Other use
Palas	*Butea monosperma*	Fabaceae	Bark	Dye, Medicine
Karaya	*Sterculia urens*	Sterculiaceae	Bark	Gum, Resin
Mororphali	*Helicteres isora*	Sterculiaceae	Bark	Medicine
Sandan	*Ougeinia oojeinesis*	Fabaceae	Bark	Poisonous Plant
Kewra	*Pandanus tectorius*	Pandanaceae	Leaves	Medicine
Aira	*Typha elephantine*	Typhaceae	Leaves	Wasteland colonizer
Jhinjha	*Bauhinia racemosa*	Caesalpiniaceae	Bark	Medicine
Aak	*Calotropis procera*	Asclepiadaceae	Bark	Medicine
Semal	*Bombax ceiba*	Bombacaceae	Fruit & Flower	Ornamental
Arunj	*Acacia leucophloea*	Mimosaceae	Bark	Tannin, Gum, Resin
Gondi	*Cordia gharf*	Ehretiaceae	Bark	Medicine
Gadha Palas	*Erythrina suberosa*	Fabaceae	Bark	Medicine
Gangan	*Grewia tenax*	Tiliaceae	Bark	Medicine
Khimp	*Leptadenia pyrotechnica*	Asclepiadaceae	Stem	Medicine, Fruit
Khajur	*Phoenix sylvestre*	Arecaceae	Leaves	Fruit
Tad	*Borassus flabellifer*	Areacaceae	Fruit & Flower	Edible seed
Dudhi	*Wrightia tinctoria*	Apocynaceae	Fruit & Flower	Medicine
Ganiara	*Cochlospermum religiosum*	Cochlosperma-ceae	Fruit & Flower	Gum, Resin
Rambans	*Agave Americana*	Agavaceae	Leaves	Medicine
Senia	*Crotalaria burhia*	Fabaceae	Stem	Wasteland colonizer
Gonda	*Cordia oblique*	Ehretiaceae	Bark	Medicine

eaten during the severe famine of 1899 and 1939.

Pod yield is nearly 1400 kg ha^{-1} with a variation of 10.7% in dry locations. *Prosopis cineraria* wood is reported to contain high calorific value and provide high quality fuel wood. The lopped branches are good as fencing material. Its roots encourage nitrogen fixation leading to higher crop yields. Quite a number of health benefits of this tree are also reported[47].

Tecomella undulata is another important tree species, locally known as *Rohida*, which is found in this region, northwest and western parts. It is a medium sized tree of great value in agroforestry that produces quality timber and is the main source of timber amongst the indigenous tree species of desert regions. The trade name of the tree species is Desert teak or *Marwar* teak. Its wood is strong, tough and durable. It takes a fine finish. Heartwood contains quinoid. The wood is excellent for firewood and charcoal. Camels, goats and sheep consume leaves, flowers and pods. It acts as a soil-binding tree by spreading a network of lateral roots on the top surface of the soil. It also acts as a windbreak and helps in stabilizing shifting sand dunes. It is considered as the home of birds and provides shelter for other desert wildlife. Shade of tree crown is shelter for the cattle, goats and sheep during summer days[2]. It has medicinal properties as well. The bark obtained from the stem is used as a remedy for syphilis. It is also used in curing urinary disorders, enlargement of spleen, gonorrhea, leucoderma and liver diseases. Seeds are used against abscess.

Wildlife and Protected Areas: Some wildlife species, which are fast vanishing in other parts of India, are found in the desert in large numbers such as the blackbuck (*Antilope cervicapra*), chinkara (*Gazella bennettii*) and Indian wild ass (*Equus hemionus khur*) in the *Rann* of Kutch. Other mammals in this region include a subspecies of red fox (*Vulpes vulpes pusilla*) and a wild cat, the caracal. The region is a heaven for 141 species of migratory and resident birds of the desert. There are eagles, harriers, falcons, buzzards, kestrel and vultures, short-toed eagles (*Circaetus gallicus*), tawny eagles (*Aquila rapax*), greater spotted eagles (*Aquila clanga*), laggar falcons (*Falco jugger*) and kestrels. The Indian Peafowl is a resident breeder in the Indian subcontinent particularly Thar region. The region has a number of reptiles as well[48]. The protected and closed areas in the *Thar* Desert and presence of keystone species are depicted in Table 8.

Among all the bio-geographic zones of India, the desert biome has the lowest number of protected areas (PA). This Desert has only about 0.9% of its area under the PA system[49]. Out of the 26 PAs of Rajasthan, three were prioritized based on the above process; Desert National Park (DNP) (3162 km^2), Gajner Wildlife Sanctuary (24 km^2) and Tal Chhapar Wildlife Sanctuary (7 km^2). Fragmented grasslands such as Sultana in the DNP are extremely important for the Great Indian Bustard and other globally threatened species; however, they are not scientifically managed. The Forest Department has developed several large core areas (enclosures), consisting of 400 to 700 ha, where grazing or any other type of human disturbance is not allowed. Some of the well-known enclosures are Sam (1100 ha, in two parts), Sudasari (1750 ha, in four parts), Miyajlar (500 ha), Sundra (700 ha), Phulia (400 ha) and Barsiala (400 ha). The degree of protection varies from enclosure to enclosure, depending upon the staff posted there and the interest taken by the higher authorities. In terms of management and protection, the best protected enclosures are Sam, Sudasari and Miyajlar. Besides the enclosures present inside the boundary of the DNP there are six enclosures, which are outside the DNP boundary called satellite conservation areas. They are as follows: Ramdevera (875 ha, in three parts), Ujlan (250 ha) and Rasla (600 in two parts). These enclosures are protected by the local people and partly by the Forest Department.

Tal Chhapar was designated in 1962 for the protection of Blackbuck and Demoiselle Cranes (*Anthropoides virgo*). The sanctuary is a treeless depression which can get inundated with water during high rainfall years. However, as the district falls in the arid zone, rainfall is generally insufficient to inundate the sanctuary. Therefore, for most of the year, the depression or *taal* remains dry. The surrounding areas are under human occupation but cultivation is marginal and wholly dependent on monsoon rains. This is a pure grassland sanctuary but it suffers from illegal grazing and spread of *Prosopis juliflora*. *P. juliflora* is considered as a weed that was introduced in the *Thar* by the Forest Department to have more trees in the desert, but this plant quickly dominated the environment and even the livestock avoid eating it. Also it is not considered good for fuel-wood as it gives off too much smoke.

Gajner Wildlife Sanctuary was the hunting ground for the former Maharajas of Bikaner and since India's independence and abolition of privy purses and privileges, this sanctuary has been under litigation. The Forest Department is in charge of wildlife but the land belongs to the Maharajah's family. This duel charge has resulted in a peculiar situation, the result of which is that the sanctuary is totally neglected by the Forest Department. As the sanctuary is covered with trees, mainly *Prosopis juliflora*, the habitat is not very suitable for the Houbara

Bustard. The animal is sometimes seen just outside the boundary of the protected area. A wetland is present in the sanctuary, which was at one time famous for Imperial Sandgrouse shoots[30,43,46]. Owing to the development of the IGNP and resultant seepage causing wetlands, the importance of the Gajner tank as a drinking place for Imperial Sandgrouse has diminished. However it still attracts 6000–10,000 birds in a winter. It is also an important wetland for waterfowl.

Assessing Biodiversity Loss

Various biodiversity fora have highlighted the need to achieve a significant reduction in current rate of biodiversity loss at global, regional and national levels. Until recently, there was little quantitative data available on recent changes in species abundance and most studies relied extensively on expert or qualitative judgments[53]. Species richness has been found to be an insufficient indicator. On the one hand, it is hard to monitor the number of species in an area, but, more importantly, it may sometimes increase as original species are gradually replaced by the new human-introduced invasive ones. Consequently the CBD has chosen a limited set of indicators to track this degradation process, selecting,

TABLE- 7 : Other economically important plants in Thar

Local Name	Botanical Name	Family	Other use
Ber	*Zizyphus mauritiana*	Rhamnaceae	Lac worm host
Ghatbor	Zizyphus glaberrima	Rhamnaceae	
Palas	*Butea monosperma*	Fabaceae	
Pipal	*Ficus religiosa*	Moraceae	
Shahtut	*Morus alba*	Moraceae	Silk worm host
Arjuna	*Terminalia arjuna*	Combretaceae	
Arundi	*Riccinus communis*	Euphorbiaceae	
Timru	*Diospryos melanoxylon*	Ebenaceae	*Biri* leaves
Tendu	*Diospryos tomentosa*	Ebenaceae	
Chikon	*Diospryos montana*	Ebenaceae	
Jhinjha	*Bauhinia racemosa*	Caesalpiniaceae	
Aritha	*Sapindus emarginatus*	Sapindaceae	Soap substitute
Hingot	*Balanites aegyptiaca*	Simaroubaceae	
Khus	*Vetiveria zizanioides*	Poaceae	Extraction and Distillation products
Khair	*Acacia catechu*	Mimosaceae	
Mahuwa	*Madhuca indica*	Sapotaceae	
Rosha	*Cymbopogon martini*	Poaceae	
Chandan	*Santalum album*	Santalacease	

among others, the "change in abundance of selected species"[65]. It simulates the rate and extent of biodiversity loss by estimating abundance of selected species, projections of change in landscape, infrastructure development, climate and pollution. The GLOBIO 3.0 model was developed specifically to estimate this indicator. Biodiversity loss is here expressed as the percentage of original species abundance as found in undisturbed controls or information about the diversity in the original state of the land use category in question[55]. Currently, the desert biome holds an average abundance of original species of 68 percent. Most of it is concentrated in hotspots or in transition zones between arid rangelands and true deserts. In 1700, mean abundance of original species was approximately 93 per cent (range 89–96%), dropping to 87 percent in 1900 (range 83–91%). Given a proportional decline in abundance with either (a) population growth or (b) change in cropland, the rate of loss in original species abundance has been about 0.17 percent per year (range 0.13–0.21%) in the last century in deserts. This compares to the decline of 0.8–2.4 percent of intact wilderness ecosystems per year. Declines are greatest in desert margins and mountainous areas within deserts. Future loss scenario of biodiversity in deserts shows that the rate of biodiversity loss in deserts may be as much as double in the coming decades. These results are fairly similar compared to the global regime[65]. All four scenarios project a further decline in mean original species abundance from about 65 percent in deserts in 2000 to a mean of 62.8 percent by 2030 (range 60–65%) and 58.3 percent by 2050 (range 53–62%). Over a period of 50 years, the current global desert species abundance may thus drop by as much as 15 percent - a dramatic decline given the relatively short time-span. The projected decline in biodiversity varies greatly among the scenarios. Remarkably, even a slowing of the rate of biodiversity loss to that of the middle of 20th century would still mean a continued decline in the abundance of wildlife in desert regions. As for the scenarios in which the effect of land use and infrastructure development is modelled, the degree of decline varies greatly among and within the regions[32].

Agriculture and human land use already accounted for 41% of the biodiversity loss by the year 2000. Fragmentation associated with infrastructure comes in at a close second (40%). The relative share of the different factors varies among the scenarios, with climate change being the only one increasing in share for all four scenarios, from 6 percent in 2000 to up to 14 percent by 2050[57], compared to a range of the share of 37-44 percent for agriculture and 33-45 percent for infrastructure. In deserts, infrastructure appears to play a major role in biodiversity losses, simply because it accelerates and facilitates human access to scattered and patchy hotspots of biodiversity where water is available and because it increases fragmentation, which has been shown to have cascading adverse effects on ecosystems.

Modeling Biodiversity Change

Numerous models have been developed across the last decade to assess biodiversity change[42,53]. In 2004, several major global models merged in the creation of the GLOBIO 3.0 model. The individual components of the GLOBIO 3.0 model have been used to generate global scenarios[60], scenarios for the Arctic[1,40], rainforest habitat for great apes in Asia and Africa[12] and mountain regions[10] The model results can be presented by using a definition of the desert biome that is, an area of particular aridity, eco-regional and land-cover attributes. By using the SRES scenarios, which have previously been used to describe the implications of different socio-economic developments for climate change, different biodiversity scenarios can be developed for the *Thar* Desert biome. The present overall scenario assumes that market forces will continue to be the main drivers of natural resource use, but that globalization is likely to reach a limit, giving way to renewed emphasis on local economies. We may run the simulations for this scenario on our desert biome. The results of the other alternative scenarios can be derived as a range to provide an indication of the level of uncertainty. It is also important to emphasize that because of the time lag for measures to control environmental degradation to take effect, all scenarios, even those with outstanding new efforts, will slow but not stop the rate of biodiversity loss.

In 2005, the final report of the United Nations MEA warned that if current patterns of biodiversity loss continue to increase, then future generations of humanity may be at risk[58]. It estimated that current species extinction rates may be a thousand times greater than normal in nature, and that 12% of bird species and 23% of mammalian species are threatened with extinction. Some evolutionary and ecological processes may also be endangered. Accordingly, the extinction crisis is one of the most critical challenges for the 21st century[11]. A symbiotic relationship exists between biological diversity and cultural diversity, and this relationship constitutes a determining factor in ensuring sustainable human development[6]. Religious beliefs and rituals (such an invariable part of the cultural milieu) are very much inter-linked and intimately related to management of the ecosystems. Religion forwards the conservation of natural biodiversity in several different ways. The first is by providing ethical and social models for living respectfully with nature[62].

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Options for Action

The future of deserts, as natural and cultural landscapes, depends on our ability to develop their potential as providers of goods and services without degrading their ecological value in the face of increasing human pressures and possible climatic deterioration. Desired outcomes of action can be subsumed under two closely related concepts - human well-being and environmental sustainability. The MEA defined human well-being on the basis of five dimensions: the provision of the basic materials needed to sustain life, freedom and choice, health, good social relations and personal security. Human well-being in deserts is generally below the global average. Desert regions are characterized by comparatively high infant mortality rates and low economic performance, as expressed in their per capita gross domestic product[64]. Not surprisingly, livelihood options in deserts are limited primarily by the scarcity of water, which, when coupled with poor infrastructure and social and political marginalization, negatively affects health and food security. Environmental sustainability is a concept that emerged as part of the sustainable development discussion triggered by the World Commission on Environment and Development[61]. It implies that we should not deplete environmental goods and services, or at least that we should safeguard them[25]. This must be compatible with qualitative improvements in human well-being rather than quantitative growth in production and consumption - particularly in deserts, given the heavy resource consumption of all desert development and the vulnerability of those resources.

Biodiversity and Agricultural Sustainability

Sustainable development of Deserts needs to reflect social and ecological realities and provision of a framework against which policies and investments can be assessed. Such a vision should include at least four components based on the intersection between sustainable land management and biodiversity conservation viz., adapting green economic growth to the desert; conservation and sustainable management of desert biodiversity with special emphasis on agro-biodiversity in particular; land health as the basis for secure food and water provision; resilience and risk management in uncertain environments.

Green economic growth in the deserts can play a prominent role in ensuring that ecosystems are protected as the foundation of life and prosperity, but green growth strategies need to be tailored to the environmental conditions of desert. The ecologically-sensitive farming practices, such as agroforestry, pastoralism or conservation agriculture should be promoted in a way that incorporates indigenous knowledge and participation of local institutions and public.

Resilience is at the heart of desert livelihoods but is poorly reflected in public decision making or development investment. A greater understanding of resilience in desert social-ecosystems is needed to inform policy making and institutions need to be strengthened to provide the foundation for resilience. To realize such an ambitious vision in the desert requires a strategic and broad suite of actions and investment to strengthen innovation, science, knowledge and collaboration. .Research and investment need to be more responsive to new and evolving understanding of desert ecology and there is need for greater consensus on how to protect and regenerate soil through land management. Greater investment is needed in extension services that provide relevant technical advice to land users in the desert.

Incentives and investment are required to promote sustainable land management and biodiversity conservation in the desert and this includes significant multi-sectorial investments to establish conditions for sustainable growth. Policies that favor less sustainable land use options need to be revised. Payments for ecosystem services and other incentives for environmental custodianship have an important role to play in conserving desert biodiversity.

Governance, from local to international levels, needs strengthening in desert in order to enable sustainable growth and conservation. Role of Community Conserved Areas (ICCAs) is particularly important in conserving desert biodiversity. However, conservation strategies are needed to combine a variety of protected area approaches so that exclusionary forms of protection are complemented by widespread community-conserved areas like ICCAs.

Conclusion

Human well-being depends on biological diversity and ecosystems and the goods and services they provide. Unprecedented loss of biodiversity and degradation of ecosystems over the past few decades pose new and urgent challenges. Addressing these challenges necessitates the strengthening of existing models of biodiversity governance and formulating new ones. The strategic goals like preventing the extinction of endangered species, halving the loss of forests and natural habitats and also reclaim 15 per cent of degraded lands, move from conservation to restoration as well.

The desert region is considered more sensitive to changing climate. A concerted effort is required to mainstream desert biodiversity and coordinate actions

between all government sectors. The practices related to conservation, restoration and sustainable use with a blend of traditional knowledge and modern scientific interventions will lead to sustainable agriculture in the region. Some of the larger grasslands and *Orans* in this region should be put under multiple use protected areas

TABLE- 8 : The protected and closed areas in the *Thar* Desert and the associated keystone species

Name	District	Size (km^2)	Great Indian bustard *Ardeotis nigriceps*	Asian Houbara bustard *Chlamydotis macqueenii*	Chinkara (Indian gazelle) *Gazella bennettii*	Blackbuck *Antilope cervicapra*	Stoliczka's bushchat *Saxicola macro-rhyncha*
Guda-Vishnoian	Jodhpur	424	+	+	+	+	+
Dhawa-Doli	Jodhpur	424	?	+	+	+	+
Lohawat	Jodhpur	1242	?	+	+		+
Jambeshwar	Jodhpur	3500	?	+	+		+
Dechu	Jodhpur	2000	?	+	+		+
Sathin	Jodhpur	244	?	+	+		+
Diyatra	Bikaner	50	+	+	+		+
Bajju	Bikaner	100		+	+		+
Jodbeer	Bikaner	75	?	+	+		+
Deshnok	Bikaner	25		+	+		+
Mokam	Bikaner	170	?	+	+		+
Sawantsar	Churu	7.09	?	?	+		+
Ujalan	Jaisalmer	3000	?	+	+		+
Ramdeora	Jaisalmer	3000	+	+	+		+
Dhorimanna	Barmer	70		?	+	+	+
Sanchor	Jalore	1813		?	+		+
Desert National Park	Jaisalmer	3162	+	+	+	+	+
Gajner Wild Sanctuar	Gajner	24	+	+			+
Tal Chhapar Wildlife Sanctuary	Churru	7	+	+	+	+	+

Note: + = present or formerly recorded; = absent so far as known; ? = status unknown.

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alongwith traditional but controlled grazing and avoiding canal irrigation to these areas will be required for sustainable agriculture in future as well. The better deployment of agricultural biodiversity in this region will be essential to improve productivity, enhance ecosystem functions and adaptability.

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