



Ecology of Arid Zone Plants with Special Reference to North Eastern Region of Rajasthan and Methods to Conserve Them

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To Cite this Article

Dr. Prashant Kumar Sharma. Ecology of Arid Zone Plants with Special Reference to North Eastern Region of Rajasthan and Methods to Conserve Them. *International Journal for Modern Trends in Science and Technology* 2021, 7, pp. 162-171. <https://doi.org/10.46501/IJMTST0711027>.

Article Info

Received: 11 October 2021; Accepted: 19 November 2021; Published: 23 November 2021

ABSTRACT

A region is arid when it is characterized by a severe lack of available water, to the extent of hindering or preventing the growth and development of plant and animal life. Environments subject to arid climates tend to lack vegetation and are called xeric or desertic. Most "arid" climates straddle the Equator.

Rajasthan has arid zone is situated in the north-western part of India between 23°03' and 30°12' N. latitude and 69°30' and 78°17' E. longitude, occupying an area of about 3,42,274 sq km. The elevation of land surface varies from 214 to 1375 m. In shape, it is an irregular rhomb with north-south and east-west diagonals, the former about 784 km and the latter 850 km long. The western and north-western boundaries are marked by Pakistan. In the north and north-east, it is bounded by Punjab, Haryana and Uttar Pradesh, in the east and south-east by Madhya Pradesh and in the south-west by Gujarat states of India. The present state of Rajasthan is the product of successive merger of nineteen princely states between 1948-1956. Rajasthan state has been divided into 27 administrative units/districts, namely Ganganagar, Bikaner, Jaisalmer, Barmer, Jodhpur, Churu, Nagaur, Pali, Jalore, Jhunjhunu, Sikar, Ajmer, Sirohi, Alwar, Bharatpur, Dholpur, Jaipur, Tonk, Sawaimadhopur, Bhilwara, Bundi, Kota, Jhalawar, Chittorgarh, Udaipur, Dungarpur and Banswara.

The eastern part of Sirohi, the major part of Udaipur and the entire Dungarpur district fall under "Bhorat Plateau", with an average elevation of 1225 m. The river Ban Ganga rises in Jaipur and flows eastwards through Bharatpur and Dholpur to join Yamuna in Uttar Pradesh. Its beds are sandy and dry up after rains. The river Mahi originates in Madhya Pradesh and enters Banswara district from the east. It flows in northerly, westerly and south-westerly directions in Banswara district forming a natural boundary between Banswara and Dungarpur districts. Ultimately, it falls in the Arabian Sea passing through Gujarat state.

Keywords: ecology, arid, zone, plants, Rajasthan, conserve, methods

INTRODUCTION

Arid environments are extremely diverse in terms of their land forms, soils, fauna, flora, water balances, and human activities. Because of this diversity, no practical definition of arid environments can be derived. However, the one binding element to all arid regions is

aridity. Aridity is usually expressed as a function of rainfall and temperature. A useful "representation" of aridity [1]

is the following climatic aridity index: P/ETP

Where

P = precipitation

ETP = potential evapotranspiration, calculated by method of Penman, taking into account atmospheric humidity, solar radiation, and wind.[2,3]

Three arid zones can be delineated by this index: namely, hyper-arid, arid and semi-arid. The hyper-arid zone (arid index 0.03) comprises dryland areas without vegetation, with the exception of a few scattered shrubs. True nomadic pastoralism is frequently practiced. Annual rainfall is low, rarely exceeding 100 millimeters. The rains are infrequent and irregular, sometimes with no rain during long periods of several years.

The arid zone (arid index 0.03-0.20) is characterized by pastoralism and no farming except with irrigation. For the most part, the native vegetation is sparse, being comprised of annual and perennial grasses and other herbaceous vegetation, and shrubs and small trees. There is high rainfall variability, with annual amounts ranging between 100 and 300 millimeters. The semi-arid zone (arid index 0.20-0.50) can support rain-fed agriculture with more or less sustained levels of production. Sedentary livestock production also occurs. Native vegetation is represented by a variety of species, such as grasses and grass-like plants, forbes and half-shrubs, and shrubs and trees. Annual precipitation varies from 300-600 to 700-800 millimeters, with summer rains, and from 200-250 to 450-500 millimeters with winter rains.[4,5]

Aridity results from the presence of dry, descending air. Therefore, aridity is found mostly in places where anticyclonic conditions are persistent, as is the case in the regions lying under the anticyclones of the subtropics. The influence of subtropical anticyclones on rainfall increases with the presence of cool surfaces. Arid conditions also occur in the lee of major mountain ranges that disrupt the structure of cyclones passing over them, creating "rain shadow" effects. Rainfall is also hindered by the presence of greatly heated land surfaces; as a consequence, large areas of dry climate exist far from the sea.[6,7]

The vegetation cover in arid zones is scarce. Nevertheless, three plant forms can be distinguished:

- Ephemeral annuals.
- Succulent perennials.
- Nonsucculent perennials.

Ephemeral annuals, which appear after rains, complete their life cycle during a short season (\pm 8 weeks). Their growth is restricted to a short wet period. Ephemerals do not have the xeromorphic features of perennials. In general, ephemerals are small in size, have shallow roots, and their physiological adaptation consists of their active growth. Ephemerals live through the dry season, which may last a number of years, in the

form of seeds. At times, ephemerals can form dense stands and provide some forage.[8,9]

Succulent perennials are able to accumulate and store water (that may be consumed during periods of drought); this is because of the proliferation and enlargement of the parenchymal tissue of the stems and leaves and their physiological feature of low rates of transpiration. Cacti are typical succulent perennials.

Nonsucculent perennials comprise the majority of plants in the arid zone. These are hardy plants, including grasses, woody herbs, shrubs and trees that withstand the stress of the arid zone environment. Many nonsucculent perennials have "hard" seeds that do not readily germinate; these seeds often must be treated (by soaking in water or acid) before they will germinate. Three growth forms of nonsucculent perennials can be distinguished:[10]

- Evergreen - biologically active throughout the year.
- Drought-deciduous - biologically dormant during the dry season.
- Cold-deciduous - biologically dormant during the cold season.

Ephemerals are drought-escaping species and, in general, are not considered true xerophytes; succulent and nonsucculent perennials are drought-enduring and drought-resisting species and are true xerophytes. Xerophytism refers to adaptive attributes of plants which can subsist with small amounts of moisture. Some of the features of xerophytic plants are:

- Development of an extensive root system - the main growth of the roots can be vertical, horizontal, or both, and seems to depend on the site conditions. Roots penetrating 10 to 15 meters in depth are not unusual; horizontally extending roots are common in shallow soils. Some xerophytic species produce "rain roots" below the soil surface, in response to light rainfall or during periods of dew formation., Shoots not as large as their roots - shoot-to-root ratios of 1:3.5 to 1:6 are frequent, Reduction of the transpiring surface - transpiring surfaces reduced by shedding of foliage and rolling of leaves, Seasonal reduction of the transpiring surface of the plant this feature results in a reduction of the water loss during the dry season, Special adaptations in "evergreen" species lessen transpiration their leaves are leathery and often heavily wax-coated; these plants are referred to as sclerophylls.[11,12]

Other distinguishing anatomical characteristics associated with xerophytism are:

- Cuticularization - the formation of a surface plaster-like layer of cutin.

- Cutinization - the impregnation of the cell wall with cutin, which forms a watertight layer with abundant hairs.

- Special arrangements of the stomata in recesses and grooves which provide protection from the arid atmosphere.

North east Rajasthan Forests located have vegetation of mixed deciduous type dominated by *Anogeissus pendula*, associated with *Acacia senegal*, *Bauhinia racemosa*, *Boswellia serrata*, *Capparis sepiaria*, *Cassia fistula*, *Dichrostachys cinerea*, *Diospyros melanoxylon*, *Lannea coromandelica*, *Wrightia tinctoria* etc. There is no significant elevational effect on the vegetation of Banas basin except that *Boswellia serrata* becomes more abundant at the summit of the hills and *Butea monospema* and *Cassia auriculata* on the outskirts, and *Ampelocissus latifolia*, *Bombax ceiba*, *Carissa congesta*, *Cayratia trifolia*, *Cissus repanda*, *Cordia dichotoma*, *Ficus virens*, *Hiptage benghalensis*, *Ixora arborea*, *Mangifera indica*, *Pueraria tuberosa*, *Schleichera oleosa*, *Syzygium cumini*, *Terminalia arjuna*, *Vandat Usellata* etc. Many ferns, aquatic and shade loving spermatophytes grow in this forest fed by a perennial stream. *Acacia leucophloea*, *A. nilotica*, *Anogeissus pendula*, *Balanites aegyptiaca*, *Kirganelia reticulata*, *Maytenus emarginatus*, *Prosopis juliflora*, *Salvadora oleoides*, *S. persica* etc North-eastern hilly region (ZAI- tuwar district) is traversed in the north and north-east to south and outeast by a number of parallel outliers of Aravallis rising up to 800 m. This region is open towards north-west and south-west with flat plains at 300- 400 m above m.s.l. The Jaipur district is situated between 75-77°E longitudes and 26-28° latitudes in the North eastern part of Rajasthan. It is bisected lengthwise by 76°E and across its width by 27° latitude. Topographically, the area consists of hilly regions, plains, depressions, rivulets and reservoirs. [13,14]

The hill slopes are excessively stony and the vegetation shows three distinct elevation zones, dominated by *Boswellia serrata*, associated with *Crateva nunala*, *Euphorbia nerifolia*, *Holoptelea integrifolia*, *Mallotus philippensis*, *Terminalia bellerica* etc. at higher elevations. The middle zone is dominated by *Anogeissus pendula*, associated with *Commiphora wightii*, *Lannea coromandelica*, *Wrightia tinctoria* etc. In the basal zone *Acacia nilotica*, *Dichrostachys cinerea*, *Butea monospema*, *Tecomella undulata* etc. grow almost in equal proportions. In the cool and shady valley *Colebrookea oppositifolia*, *Dendrocalamus strictus*, *Mitrauna panifolia*, *Balanites aegyptiaca*, *Butea monospema*, *Cordia dichotoma*, *michandrone falcata*, *Ficus benghalensis*, *F. religiosa*, *Mangifera indica*, *Phoenix sylvestris*, *Pithecellobium dulce*,

Prosopis cineraria, *Salvadora persica*, *Ziziphus mauriliana* etc.

OBSERVATIONS

Leguminosae are the second largest family for this State, represented by 277 species belonging to 81 genera. Of these 54 spp. are trees, 60 spp. are shrubs, 145 spp. are herbs and 18 spp. are climbers / lianas/twiners. Within the family, Faboideae are the largest sub-family with 203 species belonging to 61 genera while Caesalpinioideae and Mimosoideae are represented by 41 species belongs 7 genera and 33 species belongs 8 genera respectively. Dominant genera are *Crotalaria* (22 spp.), *Desmodium* (10 spp.), *Indigofera* (22spp.) and *Tephrosia* (13 spp.) of sub-family Faboideae, *Cassia* (12 spp.) of sub-family Caesalpinioideae and *Acacia* (16 spp.) of sub-family Mimosoideae.[15,16]



Prosopis juliflora



Calotropis procera



Echinopsis pachanoi

Succulent Xerophytes with Fleshy Leaves



Aloe

Agave

Haworthia



Bryophyllum

Peperomia

Kalanchoe

Succulent Xerophytes with Fleshy Stem



Opuntia Sps.

Echinocactus Sps.

Euphorbia royleana

Non-succulent Xerophytes



Nerium

Pinus

Casuarina



Equisetum

Calotropis

Ephedra

Most of Rajasthan's population consist of Indians of various social, occupational, and religious backgrounds. The Rajputs (various clans of landowning rulers and their descendants), though representing only a small

percentage of Rajasthan's residents, are perhaps the most notable section of the population; indeed, the state draws its name from this community. In terms of caste structure, the Brahmans (highest caste) are subdivided into many gotras (lineages), while the Mahajans (trading caste) are subdivided into a bewildering number of groups. In the north and west the Jats (peasant caste) and Gujars (herding caste) are among the largest agricultural communities. Aboriginal (tribal) peoples constitute more than one-tenth of the population of Rajasthan. In the eastern part of the state, these groups include the Mina (and the related Meo), most of whom are farmers; the Banjara, [17,18] who have been known as traveling tradesmen and artisans; and the Gadia Lohar, another historically itinerant tribe, who traditionally have made and repaired agricultural and household implements. The Bhil, one of the oldest communities in India, generally inhabit southern Rajasthan and have a history of possessing great skill in archery. The Grasia and Kathodi also largely live in the south, mostly in the Mewar region. Sahariya communities are found in the southeast, and the Rabari, who traditionally are cattle breeders, live to the west of the Aravallis in west-central Rajasthan.[19,20]

The typical dance of Rajasthan is the ghoomar, which is performed on festive occasions only by women. Other well-known dances include the geer, which is performed by men and women; the panihari, a graceful dance for women; and the kacchi ghorri, in which male dancers ride dummy horses. Performances of khyal, a type of dance-drama composed in verse with celebratory, historical, or romantic themes, also is widely popular.[21]



Ghoomar dance

DISCUSSION

Commicarpus boissieri (Heimerl) Cufod. in Bulletin du Jardin Botanique National de Belgique 39 (Suppl.): xxi. 1969. (Nyctaginaceae).

Type: Baluchistan: Chuttok, S. Kalat, 1350 m, Stocks s.n. (K!).

Synonyms: *Boerhavia boissieri* Heimerl ex Vierh.; *Boerhavia plumbaginea* var. *viscosa* Asch. & Schweinf.; *Boerhavia verticillata* Poir.; *Commicarpus stellatus* (Wight) Berhaut

A decumbent to straggling perennial herb; stem and braches glabrous. Leaves ovate, subcordate to suborbiculate at base, 2–6 x 1–6 cm, obtuse, retuse or cuspidate at apex, often repand or sinuate, fleshy; petiole 0.7–2 cm long. Flowers 3–5 per node, c. 6.5mm long, in superposed umbels, campanulate. Involucral bracts 2–3 mm long, linear-lanceolate, puberulous, deciduous. Pedicel 0.5–1.2 cm long, slender. Perianth pink, violet or white, 2.5–4 mm long, lower part 1.5mm long, raphides present. Stamens (2-)3, sub-exserted; filament 5–5.5 mm long, slender. Ovary less than 1mm long, subglobose to ovoid; style as long as or longer than the filaments; stigma capitate. Anthocarp 5–7 mm long, turbinate, nodding, with a ring of large wart-like glands around the apex.[22]

Specimen examined: 117468 (FRLH), 19.viii.2014, Shri Jogi Mataji Temple, Barmer, Rajasthan, 25°44'26.5"N & 071°23'8.9"E, 281.6m, coll. K. Ravikumar, N. Balachandran and Umeshkumar Tiwari.

Flowering: August; Fruiting: September–October.

Distribution: Southern Iran, Pakistan and India.

Note: This species has been reported from western Panjab, Konkan, Sindh, Gujarat, Mysore and Hyderabad, Travancore and Carnatic (Hooker 1885). In Rajasthan this species was observed to be common in and around Shri Jogi Mataji Temple, Barmer under the shade of *Prosopis juliflora* (Sw.) DC. forest. *Commicarpus boissieri* (Heimerl) Cufod. is closely related to *Commicarpus verticillatus* (Poir.) Standl. (syn. *Boerhavia verticillata* Poir.), from which it differs in the flowers that are 5–7 mm long in verticils of 4–7; stamens rarely more than 3.[23,24]



Image 1. *Commicarpus boissieri* (Heimerl) Cufod. A - Leaf; B - Voucher specimen; C - Flowers; D - Fruits

Geodorum recurvum (Roxb.) Alston (Image 2) in H. Trimen, Handb. Fl. Ceylon. 6: 276. 1931. (Orchidaceae).

Type: India, Circars, Roxburgh sine loc. (Corom Pl. t 39) (Iconotype).

Synonyms: *Limodorum recurvum* Roxb.; *Geodorum dilatatum* R. Brown.

Plants up to 30cm tall. Pseudobulbs tuberous, ovoid, borne on a short rhizome and sometimes forming clusters, up to 2.5cm in diam., few noded, usually partially covered in fibrous sheaths. Leaves up to 3, well developed at anthesis, elliptic-oblong to elliptic, 13–30 x 5–10 cm, apex acute or shortly acuminate; petiole-like stalk enclosed in several sheaths and forming a pseudostem 8–18 cm. Inflorescence 10–20 cm, much shorter than leaves; peduncle with 2 or 3 tubular, membranous sheaths; rachis pendulous, 3–4 cm, densely 8–20 flowered; floral bracts linear-lanceolate, membranous, apex acute. Flowers not opening widely, white, lip with purplish streaks and a yellowish callus at center. Sepals narrowly oblong, apex acuminate; lateral sepals slightly wider than dorsal sepal. Petals obovate-oblong, 9–11 x ca. 3.5mm, apex obtuse or acute; lip broadly oblong-ovate, unlobed, lateral margins erect, apical margins slightly crisped, apex obtuse and usually slightly emarginate; disk with a central callus composed of 2 or 3 fleshy, crest like longitudinal ridges extending from midway along lip almost to apex. Column 3–3.5 mm, with a short column foot.[25,26]

Specimen examined: 117519 (FRLH!), 23.viii.2014, Rajasthan- Near Valmiki Ashram, Sitamata Wildlife Sanctuary, Pratapgarh 27°04'4.4"N & 074°25'11.5"E, 357m, Umeshkumar Tiwari & S.K. Sharma.

Flowering: August; Fruiting: September.

Distribution: Tropical and subtropical Asia (India, Cambodia, China, Myanmar, Thailand, Vietnam)



Image 2. *Geodorum recurvum* (Roxb.) Alston A - Habit with flowers; B - Voucher specimen

Maytenus senegalensis (Lam.) (Image 3)

Exell. Boletim da Sociedade Broteriana, sér. 2 26: 223. 1952. (Bol. Soc. Brot., sér. 2). (Celastraceae).

Type: Angola, BM000838871 (BM!)

Synonyms: *Catha montana* (Roth ex Roemer & Schultes) G. Don; *Celastrus montanus* Roth ex Roemer & Schultes; *Celastrus senegalensis* Lam.; *Gymnosporia montana* (Roth ex Roemer & Schultes) Benth.; *Gymnosporia senegalensis* (Lam.) Loes.[27,28]

A small tree; young branches often spiny, bearing leaves and flowers. Leaves grey, coriaceous, glabrous, very variable, obovate, oblanceolate or linear-spathulate, obtuse, entire or crenulate, decurrent at the base, 0.5–4.5 x 0.4–2 cm; petioles c. 3mm long. Flower small in axillary, dichotomous or fasciculate cymes on short branchlets, often forming terminal, elongate panicles. Pedicels filiform; bracts small, lanceolate, acute. Calyx lobes broadly elliptic-oblong, ciliate. Petals oblong. Disc fleshy, many lobed. Ovary glabrous, orbicular; style deeply 2–3-cleft. Capsules globose, 4–5 mm broad, bivalved, purple. Seeds chestnut brown; arillode orange.[29]

Specimen examined: 117402 (FRLH!), 15.viii.2014, Rajasthan- Naval-ghar, Jhunjunu 27°26'0.4"N & 075°14'0.5"E, 418m, coll. K. Ravikumar, N. Balachandran and Umeshkumar Tiwari. Flowering: August; Fruiting: October. Distribution: Tropical and subtropical Africa and Asia. Note: In India Genus *Maytenus* is represented by 18 species. This is very common in dryer areas.[30]



Image 3. *Maytenus senegalensis* (Lam.) Exell. A - Inflorescence stalk with leaves; B - Voucher specimen; C - Close up of flowers.

Premna resinosa (Hochst.)

Schauer subsp. *resinosa* (Image 4) in A.DC., Prodr. 11:367. 1847. (Verbenaceae).

Type: Sudan-Mt. Cordofani Arasch-Cool, Kotschy, 21/10/1839, 198 (Iso-syntype, K!).

Synonyms: *Holochiloma resinisum* Hochst. Fl. 24:371. 1841.

Undershrub, 1–1.5 m tall, woody at base. Leaves ovate or ovate-elliptic, obtuse or acute at apex, older leaves entire at margin, young or flowering twig leaves crenate; young braches sometime villous. Inflorescence

of small peduculate corymbose panicles or few flowered cymes; peduncle ca. 1cm long, bract linear or subulate, 1–2 mm long, pubescent. Flower very small; pedicels 1–2 mm long or subsessile. Calyx cupular, faintly five toothed or entire, ca. 2x3 mm, pubescent outside. Carolla infundibular, tube barbate, ca. 5x2 mm, 2-lipped, four lobed, cream coloured; lobes unequal. Stamen 4, didynamous; filiform, glabrous, included. Drup obovate or subglobose, ca. 3x2 mm, orange red when mature.[31,32]

Flowering: August; Fruiting: September–October.

Specimen examined: 117498 (FRLH!), 20.viii.2014, Rajasthan-Sirohi, on way to Jodhpur from Raniwada, 24°45'36"N & 072°09'30.7"E, 139m, coll. K. Ravikumar, N. Balachandran and Umeshkumar Tiwari; 7822 (BLAT!), s.d., Gujarat-Barda forest, Santapau.

Note: In India Genus *Premna* is represented by 31 species .



Image 4. *Premna resinosa* (Hochst.) Schauer subsp. *resinosa* A - Inflorescence stalk with leaves; B - Voucher specimen

Solanum elaeagnifolium Cav. (Image 5)

Iconeset Descriptiones Plantarum 3: 22–23, pl. 243. 1794 [1795]. (Solanaceae).

Type: Cult. In hortu bot. Matrit.ex America (MA!).

A perennial branched herb up to 1m tall. Stem and branches dense stellate-tomentose, prickly. Prickles sparse, acicular, 2–5 mm long, yellow. Leaves alternate, 1.5–11x3.0 cm, ovate-lanceolate to lanceolate, repand-sinuate, base cuneate to oblique. Flowers 1–5 in number, violet-blue to purplish, in extra-axillary cymes. Pedicel up to 20 mm long. Calyx ± 5 mm long deeply 5-lobed, enlarging in fruit. Corolla 20-25 mm broad. Anthers yellow. Filaments 3 mm long. Berry globose, 11-12 mm broad, yellow. Seed sub-reniform, c. 3 mm long.[33,34]

Fl. & Fr.: July–August.

Distribution: Native to temperate America, naturalised in India.

Specimen examined: 117404 (FRLH!), 15.08.2014, Rajasthan-Jhunjhunu, 28°06'5.50"N & 075°22'39.1"E, 339m, coll. K. Ravikumar, N. Balachandran and Umeshkumar Tiwari.

Note: *Solanum*, a member of family Solaneaceae, is a large and diverse genus of annual and perennial plants containing nearly 2000 species of which 37 are native to Asia. In India Genus *Solanum* is represented by 45 species. *Solanum elaeagnifolium* is native to northeastern Mexico and southwestern USA. [37,38]



Image 3. *Solanum elaeagnifolium* Cav.
A - Habit with flowers; B - Voucher specimen

RESULTS

Humans and animals in Rajasthan also dependent on plants for their survival. Many modern pharmaceuticals are based on chemicals that are derived from Rajasthan plants. In the developing world 80% of people rely on herbs, barks, fruits and roots of Rajasthan plants for their natural medicines. Increasingly moreover science is looking to biofuels as a future replacement to fossil fuels, such as oil, coal and gas. Conservation of plants in north east of Rajasthan, is very essential and done by following ways:

***In Situ* Conservation Methods**

In-situ conservation, the conservation of species in their natural habitats, is considered the most appropriate way of conserving biodiversity.[39,40]

Conserving the areas where populations of species exist naturally is an underlying condition for the conservation of biodiversity. That's why protected areas form a central element of any national strategy to conserve biodiversity.

***Ex Situ* Conservation Methods**

Ex-situ conservation is the preservation of components of biological diversity outside their natural habitats. This involves conservation of genetic resources, as well as wild and cultivated or species, and draws on a diverse body of techniques and facilities. Some of these include:

- Gene banks, e.g. seed banks, sperm and ova banks, field banks;
- In vitro plant tissue and microbial culture collections;
- Captive breeding of animals and artificial propagation of plants, with possible reintroduction into the wild; and

- Collecting living organisms for zoos, aquaria, and botanic gardens for research and public awareness.[41,42]

Ex-situ conservation measures can be complementary to in-situ methods as they provide an "insurance policy" against extinction. These measures also have a valuable role to play in recovery programmes for endangered species. The Kew Seed Bank in England has 1.5 per cent of the world's flora - about 4,000 species - on deposit.

In agriculture, ex-situ conservation measures maintain domesticated plants which cannot survive in nature unaided. Ex-situ conservation provides excellent research opportunities on the components of biological diversity. Some of these institutions also play a central role in public education and awareness raising by bringing members of the public into contact with plants and animals they may not normally come in contact with. It is estimated that worldwide, over 600 million people visit zoos every year.[43]

Ex situ conservation measures should support in-situ conservation measures (in-situ conservation should be the primary objective). The role of *Protected Areas* in maintaining biodiversity

A protected area is a geographically defined area that is designated or regulated and managed to achieve specific conservation objectives. It may be set aside for the protection of biological diversity, and of natural and associated cultural resources and is managed through legal or other effective means. This includes national parks and nature reserves, sustainable use reserves, wilderness areas and heritage sites[44]

Protected areas (Pas) have been widely used as a conservation tool in order to maintain a representative sample of unaltered species and eco-systems for the future, and to limit the potential for environmental degradation through human mismanagement of resources. At present, approximately 8,500 PAs exist throughout the world in 169 countries. This covers about 750 million hectares of marine and terrestrial ecosystems, which amounts to 5.2 % of the Earth's land surface.

The World Conservation Union (IUCN) has a key role in promoting the establishment of protected areas throughout the world. Since 1948, IUCN has developed standards and guidelines for PA management. Protected areas have been established following the categories defined by the IUCN.

(It should be noted that strict protection categories (categories I – III) have mostly been applied in the developing countries, whereas categories V and VI are the most commonly used in the developed world).

Category I Strict Protection. Sometimes called strict nature reserve/wilderness areas. Protected areas managed mainly for science or wilderness protection. Generally smaller areas where the preservation of important natural values with minimum human disturbance are emphasized.

Category II Ecosystem Conservation and Tourism. Sometimes called national parks. Generally larger areas with a range of outstanding features and ecosystems that people may visit for education, recreation, and inspiration as long as they do not threaten the area's values.

Category III Conservation of Natural Features. Sometimes called natural monuments. Similar to National Parks, but usually smaller areas protecting a single spectacular natural feature or historic site.

Category IV Conservation through Active Management. Sometimes called habitat and wildlife (species) management areas. Areas managed to protect and utilise wildlife species.

Category V Landscape/Seascape Conservation and Recreation. Sometimes called protected landscapes/seascapes.[45]

Category VI Sustainable Use of Natural Ecosystems. Sometimes called managed resource protected areas. Protected areas managed mainly for the sustainable use of natural ecosystems.

In the past, it was assumed that the best way to preserve biodiversity was to conserve it through protected areas by reducing human activities or completely excluding humans. Population growth and poverty were seen as main causes of environmental degradation; people were regarded as a problem from which the environment needed protecting. Accordingly, protected areas and parks were fenced off from local people, traditional practices were prohibited, and people were held under penalties of fines or imprisonments for utilising park resources. However, there are very controversial scientific and social problems with this approach, which was characterized by serious conflicts between local communities and the state.[45]

National Parks and Sanctuaries in Rajasthan

No	Name of National Parks/ Wild Life Sanctuary	District	Area(Sq .km.)
National Parks			
1	Keoladeo National Park	Bharatpur	28.73
2	Ranthambore National Park	Sawai Madhopur	392.50
	Sub Total		421.23
Sanctuaries			
1	Bandh Baratha WL Sanctuary	Bharatpur	199.50

2	Bassi WL Sanctuary	Chittorgarh	138.69
3	Bhensrodgarh WL Sanctuary	Chittorgarh	229.14
4	Darrah Game Sanctuary	Kota, Jhalawar	274.41
5	Desert WL Sanctuary	Barmer, Jaisalmer	3,162.00
6	Fulwari ki Nal WL Sanctuary	Udaipur	492.68
7	Jaisamand WL Sanctuary	Udaipur	52.34
8	Jamwa Ramgarh WL Sanctuary	Jaipur	300.00
9	Jawahar Sagar WL Sanctuary	Kota	153.41
10	Keladevi WL Sanctuary	Karoli,Sawai Madhopur	676.40
11	Kesarbagh WL Sanctuary	Dholpur	14.76
12	Kumbalgarh WL Sanctuary	Udaipur,Rajsamand,Pa li	608.57
13	Mount Abu WL Sanctuary	Sirohi	112.98
14	Nahargarh WL Sanctuary	Jaipur	50.00
15	National Chambal WL Sanctuary	Kota, S.Madhopur, Bundi, Dholpur, Karauli	280.00
16	Ramgarh Vishdhari WL Sanctuary	Bundi	252.79
17	Ramsagar WL Sanctuary	Dholpur	34.40
18	Sajjangarh WL Sanctuary	Udaipur	5.19
19	Sariska WL Sanctuary	Alwar	557.50
20	Sawai Mansingh WL Sanctuary	Sawai Madhopur	127.76
21	Shergarh WL Sanctuary	Kota	98.70
22	Sitamata WL Sanctuary	Chittorgarh,Udaipur	422.94
23	Tal Chappar WL Sanctuary	Churu	7.19
24	Todagarh Rawali WLSanctuary	Ajmer,Pali,Rajsamand	463.03
25	Van Vihar WL Sanctuary	Dholpur	25.60
		Sub Total	8,739.98
		Grand Total	9,161.21

This therefore led to a transformation in thinking and the recognition that:

1. Local people understand their environment and have extensive knowledge of the resources within their local environment
2. The exclusion of local people from protected areas may actually lead to impoverishment of their biological diversity, with both ecological and social costs

3. Traditional practices enable people to live with nature in a mutually beneficial way. For example, instead of banning hunting altogether, a series of regulations could be put in place to regulate hunting, i.e., prohibitions on killing juveniles, or pregnant females
4. Many communities still do not see wildlife and the environment as their own property because they are not involved in decision-making and have little responsibility in conservation projects[43]
5. Revenues earned from PAs have not always been passed on to communities

PA management has taken on a more holistic approach to assessing biodiversity and environmental protection - it has to be effective in linking conservation with human needs. PA management must take into account the local people's realities, that is, policy formulation must be based on a more realistic understanding of the social and political dimensions of natural resources management. [44]

CONCLUSION

Conservation of biodiversity in natural heritage sites including sacred groves, protected areas and other biodiversity 'hotspots' is crucial for maintaining the resilience of ecosystems. Specific actions are included in the following existing programme for biodiversity conservation, which has climate change effect inbuilt:

- Study of the status of corals and lagoons and mangroves by the concerned government department[45]
- In-situ and ex-situ conservation of genetic resources, especially of threatened flora and fauna
- Creation of biodiversity registers (at national, district and local levels) for documenting genetic diversity and the associated traditional knowledge
- Management of non-biodegradable wastes, which is very crucial to check pollution
- Enforcement of laws
- Effective implementation of the Protected Area System under the Wildlife Conservation Act

Effective implementation of the National Biodiversity Conservation Act, 2001[45]

REFERENCES

- [1] Bhandari M. M. 1978. Flora of the Indian Desert. Jodhpur, pp. 1-471 (Repr. pp. 1 – 575. 1990).
- [2] Blatter, E. & Hallberg, F. 1918 -21. The Flora of the Indian Desert (Jodhpur and Jaisalmer).
- [3] J. Bombay nat. Hist. Soc. 26: 218-246. tt. 1-12. 1918; 525-551. tt.13-25; 811-818. tt. 26-31. 1919; 968-987. 1920; 27: 40-47. 270-279. tt. 32-34. 1920; 506-519. tt.35-37.1921.
- [4] Cooke, T. 1901-08. The Flora of Presidency of Bombay. London, 1: 285-457 (Repr. 1: 304-486. 1958).
- [5] Duhie, J. F. 1902-29. Flora of the Upper Gangetic Plains. Calcutta, 1:194-322 (Repr. 1; 180-297. 1960).
- [6] Hooker, J. D. 1872-1897. The Flora of British India. London, 2(4): 56-240. 1876; 2(5): 241-306. 1878.
- [7] J. G. Baker. Jain, S. K. 1970. Floral Composition of Rajasthan- A Review. Bull. bot. Surv. India 12: 176-187 (Also in ROONWAL, M. L. ed. The Natural Resources of Rajasthan. 1:47- 64.1977, University of Jodhpur, Jodhpur.
- [8] Jain, S. K. 1980. A Style Manual for Flora of India. B. S. I., Howrah, pp.1-20. Johri, S. C. 1984. The genus Ipomoea L. in Rajasthan. J. Econ. Tax. Bot. 5(5): 1113 -1142.
- [9] Kanodia, K. C. & Nanda, P. C. 1968. The genus Aristida L. in Western Rajasthan. Indian For. 94: 296-306. Kulhari, O. P. 1988.
- [10] Flora of Jhunjhunu district, Rajasthan (Revisionary studies of). Ph. D. Thesis, University of Rajasthan, Jaipur. Maheshwari, J. K. 1963. The Flora of Delhi, pp.1-47.
- [11] Nair, N. C. 1978. Flora of the Punjab Plains. Rec. bot. Surv. India 21(1): 1-450.
- [12] Nair, N. C. & Koshy, T. 1963. A taxonomic study of the genus Indigofera L. in Rajasthan. J. Bombay nat. Hist. Soc. 60: 326-336.
- [13] Puri, G. S., Jain, S. K., Mukherjee, S. K., Kotwal, N. N. & Sarup, S. 1964. Flora of Rajasthan – West of Arawallis. Rec. bot. Surv. India. Vol. xix No. 1. New Delhi.
- [14] Ramdeo, K. D. 1969. Contribution to the Flora of Udaipur (S. E. Raj.). Udaipur 1-70.
- [15] Roy, G. P. 1976. The genus Eragrostis P. Beauv. in Rajasthan. Bull. bot. Surv. India 18: 102- 108.
- [16] Shah, G. L. 1978. Flora of Gujrat State. Vallabh Vidynagar, 1: 347-402.
- [17] Sharma, K. K. & Sharma, S. 1989. Flora of Rajasthan - Series Infaerae. Scientific Publishers, Jodhpur pp. 1-221.
- [18] Sharma, S. 1974. An enumeration of the Flora of Jaipur distt. (Rajasthan). University of Rajasthan studies in Botany, pp. 1-38.
- [19] Sharma, S. 1980. Floristic Studies in Rajasthan – in retrospect and prospect. J. Econ. Tax. Bot. 1: 55 -75.
- [20] Sharma, S. & Tyagi, B. 1979. Flora of North - East Rajasthan. New Delhi, pp. i-xx, 1-540.
- [21] Shetty, B. V. & Pandey, R. P. 1983. Flora of Tonk District, Rajasthan. Flora of India Ser. 3.
- [22] B. S. I. Howrah, pp. 1-253. Shetty, B. V. & Singh, V. 1987.
- [23] Flora of Rajasthan. Flora of India Ser. 2. B. S. I. Howrah, 1: 197-308.
- [24] Shringi, O. P. 1985. Flora of Jhalawar District, (S. E. Raj.). Ph. D. Thesis, University of Rajasthan, Jaipur
- [25] Singh, V. 1976. A taxonomic study of the genus Cassia L. in Rajasthan. Bull. bot. Surv. India 18: 85-101. Singh, V. 1983. Flora of Banswara District – Rajasthan. BSI. Howrah pp. 1-312.

- [26] Bhandari, M.M. (1990). *Flora of Indian Desert*. MPS. Reprints, Jodhpur, 435pp.
- [27] Deshpande, U.R. (1961). *Premna resinosa* Schau. (Verbenaceae) an addition to Indian flora. *Current Science* 30(1): 21–22.
- [28] Hooker, J. D. (1885). *Flora of British India*. Authority of the Secretary of State for India in Council, iv+229-710pp.
- [29] Rajendran, A. & P. Daniel (2002). *The Indian Verbenaceae (A taxonomic revision)*. Bishen Singh Mahendra Pal Singh, 278–279pp.
- [30] Shah, G.L. (1978). *Flora of Gujarat State*. Sardar Patel University, Vidyanagar, Gujarat, i+489–492pp.
- [31] Sharma, S. & B. Tiagi (1979). *Flora of North–East Rajasthan*. Kalyani Publishers, New Delhi, 540pp.
- [32] Sharma, S.K. & S.S. Katewa (2007). Addition to the flora of Rajasthan from Southern Aravallis. *Zoos' Print Journal* 22(10): 2867
- [33] Shetty, B.V. & R.P. Pandey (1983). *Flora of Tonk District*. Botanical Survey of India, Calcutta, 312pp.
- [34] Shetty, B.V. & V. Singh (1987). *Flora of Rajasthan*. Botanical Survey of India, Calcutta, 452pp.
- [35] Shetty, B.V. & V. Singh (1991). *Flora of Rajasthan*. Botanical Survey of India, Calcutta, 453–860pp.
- [36] Shetty, B.V. & V. Singh (1993). *Flora of Rajasthan*. Botanical Survey of India, Calcutta, 861–1246pp.
- [37] Singh, N.P., J.N. Vohra, P.K. Hajra & D.K. Singh (eds.) (2000). *Flora India*. Botanical Survey of India, Calcutta, 126–127pp.
- [38] Singh, V. (1983). *Flora of Banswara, Rajasthan*. Botanical Survey of India, Calcutta, 312pp.
- [39] Tiagi, Y.D. & N.C. Aery (2007). *Flora of Rajasthan (South & South East Region)*. Himanshu Publications, New Delhi, 725pp.
- [40] Tiwari U.L., A. Kotia, T. Mewada & G.S. Rawat (2009). New Distributional Record of an endemic Orchid, *Peristylus stocksii* (Hook.f) Kraenzl., from Rajasthan. *Indian Journal of Forestry* 32(1): 149–152.