



# Floristic Diversity, Distribution and Conservation Status in the Vicinity of Coal Mines of Kachchh District in Gujarat, India

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## Abstract

A study of floristic composition in various kinds of land use and habitat types plays a significant role in the environmental planning as plants are the primary producer of any ecosystem. The study of plant community structure and dynamics is an important aspect of forest ecology where various species contribute in determination of specific type of habitat. Such knowledge is very crucial to draw strategies for conservation and management of natural resources. The study area comprises tropical thorn forest, grassland, savannah, mangrove, saline desert and freshwater wetland as important habitats. During the study, we identified the various landcover and habitat types of western Kachchh and proposed some regional planning attributes for sustainable development in region. We surveyed the Panandhro, Matanamadh and Jadva mining complexes of region, for vegetation. We laid the sampling plot of specific dimension for various plant species in various landcovers and habitats to evaluate them for vegetation characters. During the survey a total of 326 plant species were recorded in which 14 were of conservation significance. To assess the impact of mining activities on floristic diversity, a circular zone of 2 km width was made around all the three sites. During the present study, it was observed that the species diversity decreases towards the mining site. The unfavourable habitat condition leads to reduce the regeneration capacity of various plant species. Furthermore, the dumping of contaminated soil leads to alter natural habitat and leads to growth of invasive alien species, i.e. *Prosopis juliflora*. The native tree species like *Acacia senegal*,

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*A. nilotica* and *Salvadora oleoides* face immense threats to extinction due to anthropogenic activities associated with mining. To minimize the impact on the vegetation, proper biodiversity conservation plan should be prepared to promote the plantation of native species. Along with that plant, some plant species which can improve the degraded habitat should be preferred.

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**Keywords**

Floral diversity · Land degradation · Coal mines · Soil conservation · Natural resources · Forest ecology

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## 7.1 Introduction

The study of floristic diversity plays very crucial role to understand plant community structure and function (Patel and Dabgar 2012). Further to that, such study also provides vital scientific information for various kinds of environmental planning because plants provide basic amenities that help to sustain life on earth. The study of plant community dynamics and species diversity is an important aspect of forest ecology, which entails the contribution of various species in determining structure of specific habitat type (Patel et al. 2012). To generate the information on diversity and distribution on tree and shrub species is of primary importance for developing the conservation and management strategies (Kumar et al. 2006).

Due to geographical situation and prevailing physio-climatic condition, this region supports the distinctive gene pool distributed in various habitats such as tropical thorn forest, grassland, savannah, mangrove, saline desert and freshwater wetland in the region of our interest, i.e. western Kachchh (Patel 2012). These forests are scattered throughout the district but predominantly recorded from the western part of Kachchh, i.e. Lakhpat and part of Nakhatrana talukas. Noticeably, a large portion of such forests, i.e. about 1185 km<sup>2</sup> area constituting 84% of thorn forest in western Kachchh, remains unprotected and thus not brought under management for maintaining vegetation cover or habitat improvement. Only 228 km<sup>2</sup> area of these forests is confined within the Narayan Sarovar Sanctuary and has got the legal protection.

In general, due to poor canopy formation, these forests form open canopy cover that is mainly constituted by *Acacia senegal* and *A. nilotica*. The occurrence and distribution of codominant species varied greatly within the study area due to high variability within soil taxonomy, moisture regimes and site-specific geological formations. Such species include *Euphorbia caducifolia*, *Grewia tenax*, *Cordia perrottetii*, *Salvadora oleoides*, *S. persica* and *Capparis decidua*. The invasion of *Prosopis juliflora* is very common in these forests, which has changed the floral composition and vegetation structure. Several species of conservation significance are also reported from this area (Patel and Dabgar 2018).

Mining is a major developmental activity in western Kachchh, which promotes several other economic activities and contributes substantially in local and regional economies. Such vigorous developmental activities are causing land and ecosystem damage, which leads to the loss of vegetation cover and loss of species diversity (Huang et al. 2015). Additionally, the overburdens of coal mines when dumped in unmined areas create mine spoils, which also affect the surrounding vegetation cover and plant species diversity (Alekseenko et al. 2018).

In the past very few studies have been conducted on floristic diversity of the region, and limited information is available about the plant community structure. The studies are mainly focused to fulfil legal requirement in the form of Environmental Impact Assessment studies. Gujarat Mineral Development Corporation (GMDC) (1995a, b, c) conducted rapid EIA/EMP studies for proposed Mata-no-Madh, Akrimota and Umarsar lignite mining complex and conducted surveys around these mining complexes to assess the status of biological (flora and fauna) components. Identification afforded recognition of 9 species of trees, 15 species of shrubs and 22 species of herbs from core zone, while 34 trees, 28 shrubs, 51 herbs, 12 climber species and 9 crop species were recorded from buffer zone. From the Umarsar mining site, 9 species of trees, 12 species of shrubs, 31 species of herbs and 8 species of climbers were recorded from core zone, while 26 species of trees, 20 species of shrubs, 41 species of herbs, 9 species of climbers and 11 crop varieties were recorded from buffer zone. In *Akrimota* mining site, 8 tree species, 12 shrubs, 36 herb species and 6 climber species were recorded from core zone, while 26 tree species, 18 shrubs, 43 herbs, 11 climber species and 11 crop varieties were recorded from buffer zone. Also, 10 species of plants that possess medicinal value have also been recorded from this site. Further to that, in 2006 GMDC conducted a Rapid Environmental Impact Assessment for Umarsar Lignite Mine and reported 81 floral species. In the past very few studies have been conducted on the correlation of vegetation and coal mining (Cornwell 1971; Fyles et al. 1985; Prasad and Pandey 1985; Singh and Jha 1987). Hence, present work deals with the community structure and diversity pattern in different zones around the three major mining complexes to assess the impact of mining on floristic diversity.

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## 7.2 Methodology

Floristic diversity assessment methods for various plant life forms such as trees, shrubs, climber, herbs and grasses varied greatly in terms of data collection, characterization, classification and identification (Bhatt 1993; Patel et al. 2012). Specific methods of sampling and data analysis used for evaluating different life forms of interest in the present chapter are as follows:

## 7.2.1 Sampling Design and Field Sampling

To understand the impact of mining on floral diversity, the diversity and distribution pattern of plant species was recorded in nine mine zones (referred to as Z1 to Z9 in present study) that represent the area under zones at the regular interval of 2 km from centre of the mining centres. After stratification, the entire area was divided into  $5 \times 5$  km grids using Survey of India's geo-referenced co-ordinate system. Those grid cells were further subdivided into  $1 \times 1$  km smaller grids, and a total of 180 transects (Fig. 7.1) were laid down in select grids chosen randomly using random number table (Table 7.1). Stratified random sampling was employed to lay down samples of 1.1 km ( $n = 180$  transects) different habitats. All transects were laid diagonally to randomly picked  $1 \times 1$  km grid. Care was taken to have adequate sampling in each of the topographical features across lateral and vertical gradients like altitudinal range and terrain and spatially within each habitat type.

## 7.2.2 Sampling and Data Collection

To carry out enumeration of the vegetation of the study area, a simple, systematic and predetermined technique was employed. Various habitats were surveyed using transect and quadrat methods as suggested by Misra (1968) and Mueller-Dombois and Ellenberg (1974) to record the various characteristics of tree, shrub and climber species. We used 1.1-km-long transect (180 no.) for vegetation survey (Table 7.1).

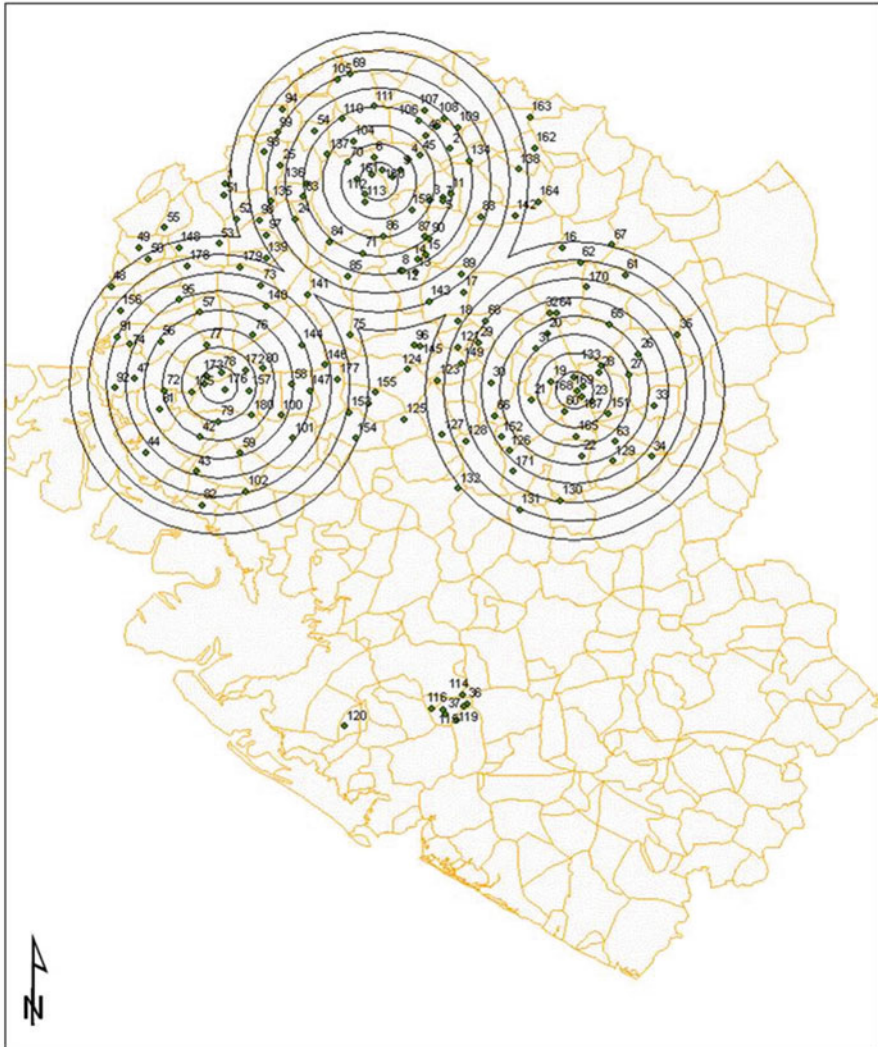
Flora of Gujarat State (Shah 1978), flora of the Indian Desert (Bhandari 1990) and the Bombay grasses (Blatter and McCann 1934) were used to identify various plant species collected from study area. Collected plant specimens were deposited in the herbarium section of Gujarat Institute of Desert Ecology, Bhuj. Secondary sources including published literature such as WCMC (1994) and *Red Data Book of Indian Plants* (Nayar and Sastry 1990) were used to identify the rare, endangered and threatened plant species.

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## 7.3 Data Analysis

### 7.3.1 Species Composition, Distribution and Diversity

Quantitative community characteristics such as density, abundance, % frequency, basal area and important value index (IVI) of each species were determined by following the methods as outlined by Misra (1968) and Mueller-Dombois and Ellenberg (1974). Distribution pattern was analysed using the value of abundance and % frequency. High frequency and low abundance of a species indicate the regular distribution; however, low frequency and high abundance indicate the contagious distribution of species (Misra 1968).



**Fig. 7.1** Sampling point location in and around coal mines of Kachhh, Gujrat

The % frequency of each species was calculated and placed into their respective frequency classes as suggested by Raunkiaer (1934). Further, species diversity and similarity indices were calculated using the following formulae:

(A) *Shannon-Wiener diversity index* ( $H'$ )  $H' = \sum pi \times \ln (pi)$

Where:

$H$  = index of species diversity

$pi$  = proportion of total sample belonging to the  $i$ th species

$\ln$  = natural log1

**Table 7.1** Distribution of samples in study area

Mining zone	# of transects
Z1	12
Z2	16
Z3	15
Z4	26
Z5	29
Z6	22
Z7	19
Z8	18
Z9	23
<b>Total</b>	<b>180</b>

(B) *Simpson diversity index (D)*:

$D = 1 - \text{Dominance}$ . Measure 'evenness' of the community from 0 to 1

(C) *Menhinick richness index* – the ratio of the number of taxa to the square root of sample size

(D) *Margalef's richness index (Rl)*

$$Rl = S - 1 / \ln(n)$$

(E) *Dominance*:

1 – Simpson index. Ranges from 0 (all taxa are equally present) to 1 species dominant to the community.

$D = \text{sum}((ni/n)^2)$  where  $ni$  is number of individuals of species  $i$ .

(F) *Equitability (Ei or J')*: Shannon diversity divided by the logarithm of number of taxa.

This measures the evenness with which individuals are divided among the taxa present.  $J' = H' / \ln(S)$

where  $n$  = total number of individuals and  $S$  = total number of species

(G) Buzas and Gibson's evenness:  $e^{H'/S}$

The rarefaction analysis was performed using Biodiversity Pro software (Biodiversity 1997 NHM and SAMS, <http://www.nhm.ac.uk/zoology/bdpro>) to cope up with the problem in comparing diversity among various zones evaluated during the present study.

### 7.3.2 Community Characteristics

Similarity indices: Jaccard's similarity coefficient ( $S_j$ ) is used to assess similarity of sites and uses presence/absence data. As it, Sorenson's similarity index (SI), also looks at the similarity of pairs of habitats in terms of presence of species but gives

greater preference to the species, those are common to the sites compared to those found on unique sites. Formula for calculating both of these indices are as below:

$$S_j = a/(a + b + c) \text{ and } S_s = 2a/(2a + b + c).$$

Where  $S_j$  = Jaccard's similarity coefficient and  $S_s$  = Sorenson's similarity coefficient,  $a$  = number of species common to (shared by) sites,  $b$  = number of species unique to the first site and  $c$  = number of species unique to the second site.

Further, cluster analysis, which is a hierarchical, agglomerative and polythetic technique of clustering, was used to quantify the resemblance among plant communities inhabiting various mine zones. Cluster analysis was performed on plant species abundance data obtained from transect survey using minimum variance technique, also known as Ward's method, which has been recognized as best way to classify the ecological communities and to identify community structure (Ludwig and Reynolds 1988). The cluster analysis generated a dendrogram providing hierarchically nested groups or clusters representing distinct plant communities, which were represented by subclusters.

### 7.3.3 Floristic Diversity and Distribution

Results are presented in the form of the impact of mining on vegetation communities. In order to achieve the objective, the entire study area was stratified into 2 km circular zones around each mining site.

### 7.3.4 Overall Floristic Composition

Kachchh district falls under arid to semiarid climate which demarcated by the xerophytes or majority of annual plant species. During the present study, a total of 326 plant species (including 1 Gymnosperm, i.e. *Ephedra foliata*) belonging to 63 families and 210 genera were recorded (Table 7.2). Out of them 14 species are of conservation significance that include above-mentioned gymnosperm species (Table 7.3). Poaceae family was the most dominant with 45 species followed by Fabaceae and Convolvulaceae with 24 and 20 species. Twenty-four families were recorded with 24 species while 27 families for single species. Dicotyledonous plants were represented with 81% ( $n = 264$  species) with 7% of tree/small tree, 15% of shrub/under shrub and 12% of climber/twiner/parasite and 50% of herbs, whereas monocotyledonous group was represented by 19% of species of grasses and sedges. Abundance and % frequency ratio reveal that all species were contagiously distributed, while overall plant community was heterogeneous in nature, which was revealed from the frequency diagram. *Acacia senegal* and *Salvadora oleoides* were the most dominant species with high IVI value (76.60). The mean  $\pm$  SD numbers of tree, shrub and climber species were  $4.18 \pm 0.14$ ,  $9.12 \pm 0.30$  and  $3.37 \pm 0.17$ , respectively. Mean density  $\pm$  SD for tree, shrub and climber were

**Table 7.2** List of plant species reported from study area

S. no.	Plant species	Local name	Habit
	<b>Acanthaceae</b>		
1.	<i>Barleria acanthoides</i> Vahl	Kandhari, Kasedo	Herb
2.	<i>Barleria prionitis</i> L. var. <i>Prionitis</i>	Kanta Aserio	Herb
3.	<i>Blepharis linariaefolia</i> Pers.	Kandhero Gokharu,	Herb
4.	<i>Blepharis maderaspatensis</i> (L.) Roth	Uti Gan, Vado Kandho	Herb
5.	<i>Blepharis repens</i> (Vahl) Roth	Nadho Chopad kandho,	Herb
6.	<i>Blepharis sindica</i> T. Anders.	Kandhero Gokharu	Herb
7.	<i>Dipteracanthus patulus</i> (Jacq.) Nees	–	Herb
8.	<i>Dipteracanthus prostratus</i> Hassk.	–	Herb
9.	<i>Ipomoea batatas</i> (L.) Lam.	Shakkariyu	Herb
10.	<i>Justicia gendarussa</i> Burm. f.	Tui, Que, Tue	Herb
11.	<i>Justicia procumbens</i> L.	Kari Anhedhi	Herb
12.	<i>Justicia simplex</i> Don	Kari Anhedhi	Herb
13.	<i>Lepidagathis trinervis</i> Wall.	Tran Kantho, Tran Ga	Herb
14.	<i>Peristrophe bicalyculata</i> (Retz.) Nees	Lasi Adhedi, Kari Adhedi	Herb
	<b>Aizoaceae</b>		
15.	<i>Corbichonia decumbens</i> (Forsk.) Jack. ex Exell	–	Herb
16.	<i>Trianthema triquetra</i> Rottl. & Willd.	Satodi	Herb
	<b>Amaranthaceae</b>		
17.	<i>Achyranthes aspera</i> L. var. <i>argentea</i> Hook. f.	Agado, Kandhero	Herb
18.	<i>Achyranthes aspera</i> L. var. <i>porphyristachya</i> Hk. f.	Vado Anhdado	Herb
19.	<i>Aerva lanata</i> (L.) Juss.	Sani Buu, Gorkhadi	Shrub
20.	<i>Aerva persica</i> (Burm. f.) Merrill	Bou, Bour	Shrub
21.	<i>Aerva pseudotomentosa</i> Blatt. & Hallb.	Sane Panjo Bur, Bur	Herb
22.	<i>Alternanthera sessilis</i> (L.) DC.	Jar Bhaji, Jar Bhangaro	Herb
23.	<i>Amaranthus spinosus</i> L.	Jangali tandaljo	Herb
24.	<i>Amaranthus viridis</i> L.	Adbau Rajgaro, Rajgaro	Herb
25.	<i>Celosia argentea</i> L.	Lampadi	Herb
26.	<i>Dicoma tomentosa</i> Cass	Ashi Kandheri	Herb
27.	<i>Digera muricata</i> (L.) Mart.	Lolar	Herb
28.	<i>Gomphrena globosa</i> L.	–	Herb
29.	<i>Pupalia lappacea</i> (L.) Juss.	Gadar Bhurat	Shrub
	<b>Anacardiaceae</b>		
30.	<i>Rhus mysurensis</i> Heyne ex W. & A.	Dasarni, Dasan	Tree
	<b>Apocynaceae</b>		
31.	<i>Catharanthus roseus</i> (L.) G. Don	Asi Sada Suvagan	Herb
	<b>Aristolochiaceae</b>		
32.	<i>Aristolochia bracteolata</i> Lamk.	Kida Mari	Herb
	<b>Asclepiadaceae</b>		
33.	<i>Calotropis procera</i> (Ait.) R. Br.	Akado, Aak	Shrub

(continued)



**Table 7.2** (continued)

S. no.	Plant species	Local name	Habit
34.	<i>Ceropegia bulbosa</i> Roxb.	–	Climber
35.	<i>Leptadenia pyrotechnica</i> (Forsk.) Decne.	Khip	Shrub
36.	<i>Oxystelma secamone</i> ( <i>O. esculentum</i> ) Linn.	Jal- dudhi	Climber
37.	<i>Pentatropis capensis</i> (L. f.) Bullock	Dhodhiyal, Dhodheji Val	Climber
38.	<i>Pentatropis spiralis</i> (Forsk.) Decne	Dhodhiyal, Dhodheji Val	Climber
39.	<i>Pergularia daemia</i> (Forsk.) Chiov.	Dudhariyal, Dudhar Val	Climber
40.	<i>Sarcostemma acidum</i> (Roxb.) Voigt	Chhirval, Chirval	Shrub
41.	<i>Calotropis gigantea</i> (L.) R. Br.	Vado Akad, Dholo Akad	Shrub
	<b>Asteraceae</b>		
42.	<i>Blainvillea acmella</i> (L.) Philip.	Aso Bhangaro,	Herb
43.	<i>Blumea bovei</i> (DC.)Vatke	–	Herb
44.	<i>Eclipta prostrata</i> (L.) L. Mant.	Bhangaro, Kakrodha	Herb
45.	<i>Helichrysum cutchicum</i> (C.B.Cl.) Rolla Rao et Des.	Dholu Fuladu	Herb
46.	<i>Launaea procumbens</i> (Roxb.) Ram. & Raj.	Vadi Gurval, Vadi Gemar	Herb
47.	<i>Launaea resedifolia</i> (L.) Druce	Dhariyai Gurval	Herb
48.	<i>Oligochaeta ramosa</i> (Roxb.) Wagenitz	Kandhari, Nandhi Uth Kandhari	Herb
49.	<i>Pluchea arguta</i> Boiss.	–	Herb
50.	<i>Pulicaria angustifolia</i> DC.	–	Herb
51.	<i>Pulicaria wightiana</i> (DC.) Cl.	Son Fuladi	Herb
52.	<i>Sonchus asper</i> Hill.	–	Herb
53.	<i>Spergula fallax</i> (Lowe) Krause	Vekar	Herb
54.	<i>Sphaeranthus senegalensis</i> DC.	Gorakhval	Herb
55.	<i>Tridax procumbens</i> L.	Vilayati Bhangro	Herb
56.	<i>Vernonia cinerascens</i> Sch.Bip.	Tatadio, Gandhi Ghenradi	Shrub
57.	<i>Xanthium strumarium</i> L.	Kantaru Zadvu, Gokhru	Herb
	<b>Aizoaceae</b>		
58.	<i>Trianthema portulacastrum</i> L.	Satodo	Herb
	<b>Balanitaceae</b>		
59.	<i>Balanites aegyptiaca</i> (L.) Del.	Hingor, Hingod	Tree
	<b>Bombacaceae</b>		
60.	<i>Bombax malabaricum</i> DC.	Rato Shamaro	Tree
	<b>Boraginaceae</b>		
61.	<i>Arnebia hispidissima</i> DC.	–	Herb
62.	<i>Coldenia procumbens</i> L.	Ukharad	Herb
63.	<i>Heliotropium bacciferum</i> Forsk. var. <i>bacciferum</i>	–	Herb
64.	<i>Heliotropium bacciferum</i> Forsk. var. <i>suberosum</i> (Clarke) Bhandari	–	Herb
65.	<i>Heliotropium curassavicum</i> L.	–	Herb
66.	<i>Heliotropium indicum</i> L.	Agio Kharsan, Morandhi	Herb

(continued)

**Table 7.2** (continued)

S. no.	Plant species	Local name	Habit
67.	<i>Heliotropium marifolium</i> Koen. ex Retz. var. <i>marifolium</i>	Dungario Agio, Zinko Okharad	Herb
68.	<i>Heliotropium ovalifolium</i> Forsk.	Ogiar	Herb
69.	<i>Heliotropium rariflorum</i> Stocks	Jakhau	Herb
70.	<i>Heliotropium strigosum</i> Willd.	–	Herb
71.	<i>Heliotropium subulatum</i> Hochst.	Piro Kharsan	Herb
72.	<i>Heliotropium supinum</i> L.	Ghedio Kharsan	Herb
73.	<i>Trichodesma amplexicaule</i> Roth	Undh Fuli	Herb
	<b>Brassicaceae</b>		
74.	<i>Farsetia hamiltonii</i> Royle	Sedha Asario, Adbau Rai	Herb
	<b>Burseraceae</b>		
75.	<i>Commiphora wightii</i> (Arn.) Bhandari	Gugar, Gugariya, Gugar Jo Zadvo	Tree
	<b>Cactaceae</b>		
76.	<i>Opuntia elatior</i> Mill.	Nag Phan	Herb
	<b>Caesalpinaceae</b>		
77.	<i>Bauhinia racemosa</i> Lam.	Zinj, Zanj, Zinji	Tree
78.	<i>Cassia pumila</i> Lam.	Rato Chon, Choniyo, Nidhechor	Herb
79.	<i>Cassia tora</i> L.	Punvar, Povario, Dadhar Jo Zad	Herb
80.	<i>Tamarindus indica</i> L.	Ambali Jo Zad, Ambali, Emali	Tree
81.	<i>Cassia auriculata</i> L.	Avar	Shrub
	<b>Capparaceae</b>		
82.	<i>Cadaba fruticosa</i> (L.) Flem.	Karo Pijaro	Shrub
83.	<i>Capparis cartilaginea</i> Decne.	Kawari, Karpatrai, Karpatirai, Parvati Rai	Shrub
84.	<i>Capparis decidua</i> (Forsk.) Edgew.	Kerado, Dora Kera, Kar Jo Zad	Shrub
85.	<i>Capparis grandis</i> L. f.	Dumaro, Dumar Jo Zad	Tree
86.	<i>Cleome gynandra</i> L. var. <i>gynandra</i>	Bidhro, Asso Bidharo, Vado bidharo	Herb
87.	<i>Cleome vahliana</i> Fresen.	–	Herb
88.	<i>Cleome viscosa</i> L.	Beddhro, Prlobidhro, Badhod	Herb
89.	<i>Crateva nurvala</i> Buch-Ham. var. <i>nurvala</i>	Tarapan, Tripan Jo Zad	Tree
90.	<i>Maerua oblongifolia</i> (Foeak.) A. Rich.	Pinjolo, Accho Pinjolo	Shrub
	<b>Chenopodiaceae</b>		
91.	<i>Atriplex hortensis</i> L.	Palakh Ni Bhaji	Herb
92.	<i>Chenopodium album</i> L.	Chir, Chir Ji Bhaji	Herb
93.	<i>Suaeda fruticosa</i> (L.) Forsk. ex Gmel.	Khario Luno, Lano, Luno	Shrub
	<b>Commelinaceae</b>		
94.	<i>Commelina benghalensis</i> L.	Sis Muriyu	Herb
95.	<i>Commelina diffusa</i> Burm. f.	–	Herb

(continued)

**Table 7.2** (continued)

S. no.	Plant species	Local name	Habit
	<b>Convolvulaceae</b>		
96.	<i>Argyrea nervosa</i> (Burm. f.) Boj.	Samandharsos Ji Val, Vardharo	Climber
97.	<i>Convolvulus arvensis</i> L.	Neri Val, Neri	Herb
98.	<i>Convolvulus auricomus</i> (A. Rich.) Bhandari var. <i>auricomus</i>	Rushad Neri Val	Herb
99.	<i>Convolvulus microphyllus</i> (Roth) Sieb. ex Spr.	Mankhani, Makhan Val, Ashi/ Bethi Sankh Val	Herb
100.	<i>Convolvulus stocksii</i> Boiss.	–	Herb
101.	<i>Cressa cretica</i> L.	Oin, Bukan, Gun, Lun, Un Bakano	Herb
102.	<i>Evolvulus alsinoides</i> (L.) L. var. <i>alsinoides</i>	Kari Sankhval, Sani Buti, Kari Buti	Herb
103.	<i>Ipomoea aquatica</i> Forsk.	Nari Val, Pani Ji Val	Herb
104.	<i>Convolvulus auricomus</i> (A. Rich.) Bhandari var. <i>auricomus</i>	Rushad Neri Val	Climber
105.	<i>Ipomoea kotschyana</i> Hoc. ex Choisy	Bhoyan Fotiyargi Val	Herb
106.	<i>Ipomoea nil</i> (L.) Roth	Trikhuni Potiyar, Kari Potiyar	Climber
107.	<i>Ipomoea obscura</i> (L.) Ker-Gawl	Gumadiyar, Satari Val, Gumdiyul	Climber
108.	<i>Ipomoea pes-caprae</i> (L.) Sw.	Dhariya Val, Ravar patri	Herb
109.	<i>Ipomoea pes-tigridis</i> L.	Fotiyal, Fotiyar	Climber
110.	<i>Merremia aegyptia</i> (L.) Urb.	Fisuaal Val, Panjapani Potiyal	Climber
111.	<i>Merremia emarginata</i> (Burm. f.) Hall. f.	Undarkani	Climber
112.	<i>Merremia tridentata</i> (L.) Hall. f. subsp. <i>tridentata</i>	Topriyal, Toprahal, Jamar Val	Climber
113.	<i>Rivea hypocrateriformis</i> Choisy	Fang val	Climber
114.	<i>Seddera latifolia</i> Hochst. & Steud.	–	Shrub
	<b>Cucurbitaceae</b>		
115.	<i>Citrullus colocynthis</i> (L.) Soland.	Truja Val, Tru Val, Tru Deda	Climber
116.	<i>Citrullus fistulosus</i> Stocks	Karengla	Climber
117.	<i>Coccinia grandis</i> (L.) Voigt	Tindora, Ghiloda	Climber
118.	<i>Corallocarpus conocarpus</i> (D. & G.) Cl.	Navi Val	Climber
119.	<i>Corallocarpus epigaeus</i> (Rottl. & Willd.) Cl.	Navi Val, Naigi Val, Ajapad	Climber
120.	<i>Ctenolepis cerasiformis</i> (Stocks) Hk. f.	Dod Val, Aankh Futamna	Climber
121.	<i>Cucumis callosus</i> (Rottl.) Cogn.	Kotimbda vel, Nindhatri, Kotimbiyal	Climber
122.	<i>Cucumis prophetarum</i> L.	Indriyal, Kandhari Indriyan	Climber
123.	<i>Dactyliandra welwitschii</i> Hk. f.	Dod Val, Aankh Futamna	Climber
124.	<i>Luffa acutangula</i> (L.) Roxb. var. <i>acutangula</i>	Adbau Gisodi, Vad Gisodi	Climber
125.	<i>Mukia maderespatensis</i> (L.) M. Roem.	Ankhfutmani	Climber

(continued)

**Table 7.2** (continued)

S. no.	Plant species	Local name	Habit
	<b>Cuscutaceae</b>		
126.	<i>Cuscuta hyalina</i> Roth	Sani Piri Val	Climber
127.	<i>Cuscuta reflexa</i> Roxb.	Makani, Makaniyal, Makan Val	Climber
	<b>Cyperaceae</b>		
128.	<i>Cyperus alopecuroides</i> Rottb.	–	Sedge
129.	<i>Cyperus bulbosus</i> Vahl	–	Sedge
130.	<i>Cyperus compressus</i> L.	–	Sedge
131.	<i>Cyperus difformis</i> L.	Chiyo	Sedge
132.	<i>Cyperus haspan</i> L.	Chiyo, Nidan moth	Sedge
133.	<i>Cyperus iria</i> L. var. <i>iria</i>	–	Sedge
134.	<i>Cyperus rotundus</i> L. subsp. <i>rotundus</i>	Kaluro, Mutha, Moth	Sedge
135.	<i>Cyperus triceps</i> (Rottb.) Endl.	–	Sedge
136.	<i>Fimbristylis miliacea</i> (L.) Vahl	–	Sedge
137.	<i>Scirpus affinis</i> Roth.	–	Sedge
	<b>Ehretiaceae</b>		
138.	<i>Cordia perrottetii</i> Wt.	Adbau Gundi, Jangli Gundi	Shrub
	<b>Elatinaceae</b>		
139.	<i>Bergia ammannioides</i> Roxb. ex Roth	Jal Ukharad	Herb
140.	<i>Bergia capensis</i> L.	Rapatri	Herb
141.	<i>Bergia suffruticosa</i> (Del.) Fenzl	Jal jambu	Herb
	<b>Ephedraceae</b>		
142.	<i>Ephedra foliata</i> Boiss. & Kotschy ex Boiss.	Andhoi Khip	Shrub
	<b>Euphorbiaceae</b>		
143.	<i>Acalypha indica</i> L.	Dadar Jo Zad	Herb
144.	<i>Dalechampia scandens</i> L. var. <i>cordofana</i>	Char Val, Khaj Val	Climber
145.	<i>Euphorbia caducifolia</i> Hains.	Thor	Shrub
146.	<i>Euphorbia heterophylla</i> L.	Lal Pati	Herb
147.	<i>Euphorbia hirta</i> L.	Vadi Dudheli	Herb
148.	<i>Euphorbia milii</i> Ch.	–	Herb
149.	<i>Phyllanthus fraternus</i> Webst.	Pat Amari, Amari	Herb
150.	<i>Phyllanthus maderaspatensis</i> L.	Amario	Herb
151.	<i>Securinega leucopyrus</i> (Willd.) Muell.-Arg.	Shini	Shrub
152.	<i>Securinega virosa</i> (Roxb. ex Willd.) Pax & Hoffm	Shini	Shrub
	<b>Fabaceae</b>		
153.	<i>Abrus precatorius</i> L.	Chanothi Ji Val	Climber
154.	<i>Alysicarpus longifolius</i> (Rottl. ex Spr.) W. & A.	Vado Sanervo	Herb
155.	<i>Alysicarpus monilifer</i> (L.) DC. var. <i>monilifer</i>	–	Herb
156.	<i>Arachis hypogaea</i> L.	Mung Fali	Herb

(continued)

**Table 7.2** (continued)

S. no.	Plant species	Local name	Habit
157.	<i>Butea monosperma</i> (Lam.) Taub.	Kesudijo Zad, Khkhar, Khakharo	Tree
158.	<i>Clitoria ternatea</i> L.	Gaeni, Kari Koagi Val	Climber
159.	<i>Crotalaria burhia</i> Buch-Ham. ex Bth	Khirasani, Khadasani, Sangiro, Achhi Khadasani	Shrub
160.	<i>Crotalaria evolvuloides</i> Wt. ex W.& A.	Val Fatakdi	Herb
161.	<i>Derris indica</i> (Lam.) Bennet	Karanj Jo Zad	Tree
162.	<i>Desmodium dichotomum</i> (Klein ex Willd.) DC	Trapani Samervo	Herb
163.	<i>Goniogyna hirta</i> (Willd.) Ali	Undarkani	Herb
164.	<i>Indigofera caerulea</i> Roxb. var. <i>monosperma</i> (Sant.) Sant.	Rangagi Gari	Herb
165.	<i>Indigofera cordifolia</i> Heyne ex Willd.	Gadar Gari, Ridha Gari	Herb
166.	<i>Indigofera linifolia</i> Retz. var. <i>linifolia</i>	Sani Gari	Herb
167.	<i>Indigofera linnaei</i> Ali.	Pat Gari, Bhojan Gari	Herb
168.	<i>Indigofera tinctoria</i> L.	Nili Gari, Gudi, Gari Jo Zad	Shrub
169.	<i>Rhynchosia minima</i> (L.) DC. var. <i>minima</i>	Mogariyal, Sanari, Mungariyal	Climber
170.	<i>Sesbania sesban</i> (L.) Meer. subsp. <i>sesban</i> var. <i>sesban</i>	Ekad	Shrub
171.	<i>Taverniera cuneifolia</i> (Roth) Arn.	Jathi madh	Herb
172.	<i>Tephrosia falciformis</i> Ramaswami	Sarpankho	Shrub
173.	<i>Tephrosia purpurea</i> (L.) Pers.	Sarpankho, Vado Sarpankho, Bikanjo Zad	Herb
174.	<i>Tephrosia strigosa</i> (Dalz.) Sant. & Mahesh	Sani Sarpankhi, Asmani Sarpankho, Sanero Sarpankho	Herb
175.	<i>Tephrosia uniflora</i> Pers. subsp. <i>petrosa</i>	Sarpankhi	Herb
176.	<i>Tephrosia villosa</i> (L.) Pers.	Rushad Sirpankho, Kinojo Zad	Herb
	<b>Gentianaceae</b>		
177.	<i>Enicostema axillare</i> (Lamk.) Roynal	Mamecho, Mamej, Kadvi Bhaji	Herb
	<b>Hydrocharitaceae</b>		
178.	<i>Hydrilla verticillata</i> (L. f.) Royle	Paniji Sevar	Herb
	<b>Lamiaceae</b>		
179.	<i>Leucas aspera</i> (Willd.) Spr.	Gumu	Herb
180.	<i>Ocimum gratissimum</i> L.	Vadi Tulsi, Mara Tulsi	Herb
181.	<i>Ocimum sanctum</i> L.	Tulsi	Herb
	<b>Lemnaceae</b>		
182.	<i>Lemna gibba</i> L.	Paniji Sevar	Herb
	<b>Liliaceae</b>		
183.	<i>Asparagus dumosus</i> Baker	–	Shrub
184.	<i>Asparagus racemosus</i> Willd. var. <i>javanicus</i> (Kunth) Baker	Akal Kandha Ni Val, Chini Ji val	Shrub
185.	<i>Chlorophytum tuberosum</i> (Roxb.) Baker	Karli, Karliji Bhaji	Herb

(continued)

**Table 7.2** (continued)

S. no.	Plant species	Local name	Habit
	<b>Lythraceae</b>		
186.	<i>Ammannia baccifera</i> L.	Rato Jal Agio	Herb
	<b>Malvaceae</b>		
187.	<i>Abutilon fruticosum</i> Guill. var. <i>fruticosum</i>	Saneri Dabariar	Shrub
188.	<i>Abutilon indicum</i> (L.) Sw. subsp. <i>guineense</i> (Schum.) Borss.	Khapato, Dabaliar	Shrub
189.	<i>Abutilon ramosum</i> Guill.	–	Shrub
190.	<i>Althea rosea</i> (L.) Cav.	–	Herb
191.	<i>Hibiscus ovalifolius</i> (Forsk.) Vahl	San Bhindo, Kurad Val	Shrub
192.	<i>Pavonia arabica</i> Steud. var. <i>Arabica</i>	Rato Balbuwaro	Herb
193.	<i>Pavonia zeylanica</i> Cav.	–	Herb
194.	<i>Sida acuta</i> Burm. f.	Adbau Balbuwaro, Vado Balbuwaro	Herb
195.	<i>Sida alba</i> L.	Bal Buvaro, Kharanto, Kandharo	Herb
196.	<i>Sida cordata</i> (Burm. f.) Borss	Pat balbuwaro, Nidhi Dhatuval	Herb
197.	<i>Sida cordifolia</i> L.	Barabovaro, Bal Bunwero, Bal Bunwarejo Zad	Herb
198.	<i>Sida ovata</i> Forsk.	–	Herb
199.	<i>Sida retusa</i> L.	Khetrau Barbuwaro	Herb
200.	<i>Sida tiagii</i> Bhandari	Bulbuwaro	Herb
	<b>Meliaceae</b>		
201.	<i>Azadirachta indica</i> A. Juss.	Limbdo, Neem	Tree
	<b>Menispermaceae</b>		
202.	<i>Cocculus hirsutus</i> (L.) Diels	Vegai, Vagval, Asipal	Climber
203.	<i>Cocculus pendulus</i> (Forst.) Diels	Karipat, Karipad	Climber
204.	<i>Cyclea peltata</i> (lam) Hk. F.&Th	–	Climber
205.	<i>Tinospora cordifolia</i> Roxb.	Guddaval, Gadu, Gaduji Val	Climber
	<b>Mimosaceae</b>		
206.	<i>Acacia</i> sp.	Acacia binosa	Shrub
207.	<i>Acacia leucophloea</i> (Roxb.) Willd.	Hirmo, Haramu	Tree
208.	<i>Acacia nilotica</i> (L.) Del. subsp. <i>indica</i> (Bth.) Brenan	Deshi Baval, Bavar	Tree
209.	<i>Acacia senegal</i> (L.) Willd.	Kher, Gorad	Tree
210.	<i>Acacia tortilis</i> (Forssk.) Hayne.	Israil Baval	Tree
211.	<i>Albizia amara</i> Boivin var. <i>amara</i>	Aso Sarsado	Tree
212.	<i>Mimosa hamata</i> Willd.	Kai bavari, Kai, Zanjani, Zinjani	Shrub
213.	<i>Prosopis cineraria</i> (L.) Druce	Kandhi, Khajdo, Kando	Tree
214.	<i>Prosopis juliflora</i> SW (DC.)	Vilayati Baval	Shrub
215.	<i>Acacia jacquemontii</i> Bth.	Harmo Baval	Shrub
	<b>Molluginaceae</b>		
216.	<i>Gisekia pharnaceoides</i> L. var. <i>pharnaceoides</i>	–	Herb

(continued)

**Table 7.2** (continued)

S. no.	Plant species	Local name	Habit
217.	<i>Glinus lotoides</i> L.	Aso Okharad	Herb
218.	<i>Mollugo pentaphylla</i> L.	–	Herb
	<b>Moraceae</b>		
219.	<i>Ficus benghalensis</i> L. var. <i>benghalensis</i>	Vad Jo Zad	Tree
	<b>Moringaceae</b>		
220.	<i>Moringa concanensis</i> Nimmo	Kharo Saragvo, Kadvi Saragvo, Dungar Jo Sargave Jo Zad	Tree
	<b>Nyctaginaceae</b>		
221.	<i>Boerhavia diffusa</i> L.	Sunny Dhokariaur	Herb
222.	<i>Commicarpus verticillatus</i> (Poir.) Standl.	Dhokariyar	Herb
	<b>Papaverceae</b>		
223.	<i>Argemone mexicana</i> L.	Darudi, Uzar Kandho, Piri Aakandho	Herb
	<b>Pedaliaceae</b>		
224.	<i>Pedaliium murex</i> L.	Ubhera Gokhru, Kadua Gokhru	Herb
225.	<i>Senra incana</i> Cav.	Jangli kala, Aadbau Kapas	Shrub
226.	<i>Sesamum laciniatum</i> Klein ex Willd.	Adbau Tal, Vagdau Tir, Kag Tir	Herb
	<b>Plumbaginaceae</b>		
227.	<i>Plumbago zeylanica</i> L.	Vara Val, Gadar Zipto	Herb
	<b>Poaceae</b>		
228.	<i>Acrachne racemosa</i> (Heyne ex R. & S.) Oswi	Chinkhiyu	Grass
229.	<i>Aeluropus lagopoides</i> (L.) Trin. ex Thw.	Khario Ga, Kharo Ga	Grass
230.	<i>Apluda mutica</i> L.	Bhungario Ga, Fulari Ga	Grass
231.	<i>Aristida adscensionis</i> L. subsp. <i>adscensionis</i>	Jandhar Lambha Ga, Lampdo	Grass
232.	<i>Aristida funiculata</i> Trin. & Rupr.	Laso Lambh	Grass
233.	<i>Bothriochloa glabra</i> (Roxb.) A. Camus	Dharfo	Grass
234.	<i>Cenchrus biflorus</i> auct.	Dhaman Gha, Anajaniyo	Grass
235.	<i>Cenchrus ciliaris</i> L.	Dhaman Gha	Grass
236.	<i>Cenchrus setigerus</i> Vahl	Dhaman Gha	Grass
237.	<i>Chloris barbata</i> Sw.	Rusad Gha, Punjaniu Ga	Grass
238.	<i>Chrysopogon fulvus</i> (Spr.) Shiov.	Khad Sundhiyu Ga	Grass
239.	<i>Cymbopogon jwarancusa</i> (Jones) Schult.	–	Grass
240.	<i>Cymbopogon martinii</i> (Roxb.) Wats	Rosha Gha	Grass
241.	<i>Cynodon dactylon</i> (L.) Pers.	Chhabbar Gha	Grass
242.	<i>Dactyloctenium aegyptium</i> (L.) P. Beauv.	Kagatango Gha, Vado Mandanu	Grass
243.	<i>Dactyloctenium indicum</i> Boiss.	Chund Gha, Sano Madanu, Nindho Madanu	Grass
244.	<i>Desmostachya bipinnata</i> (L.) Stapf	Darab, Gha, Dab	Grass

(continued)

**Table 7.2** (continued)

S. no.	Plant species	Local name	Habit
245.	<i>Dichanthium annulatum</i> (Forssk.) Stapf	Dunuhi gha, Jinjavo	Grass
246.	<i>Digitaria pennata</i> (Hochst.) Cooke	–	Grass
247.	<i>Dinebra retroflexa</i> (Vahl) Panz	–	Grass
248.	<i>Echinochloa colonum</i> (L.) Link	Sanvadhau Sau, Samu	Grass
249.	<i>Eleusine compressa</i> (Forsk.) Aschers. & Schweinf.	Gandhiro Gha, Mandanu Gha, Gaantharo, Mandanu	Grass
250.	<i>Eleusine indica</i> (L.) Gaertn.	Adbau Madanu	Grass
251.	<i>Elyonurus royleanus</i> Nees ex A. Rich.	–	Grass
252.	<i>Eragrostis ciliaris</i> (L.) R. Br. var. <i>ciliaris</i>	Fuliyu Gah	Grass
253.	<i>Eragrostis pilosa</i> (L.) P. Beauv.	–	Grass
254.	<i>Eragrostis tenella</i> (L.) P. Beauv. ex R. & S.	Limor, Kalavo	Grass
255.	<i>Halopyrum mucronatum</i> (L.) Stapf	Dariyai Kans, Sari Ga, Kans	Grass
256.	<i>Heteropogon contortus</i> (L.) P. Beauv. ex R. & S.	Dungar Gha, Surianadha, Chhuro	Grass
257.	<i>Melanocenchrus jacquemontii</i> J. & S.	Vekar	Grass
258.	<i>Panicum antidotale</i> Retz.	Gum Gha, Dham Gha	Grass
259.	<i>Pennisetum typhoides</i> A. Rich.	Bajri	Grass
260.	<i>Phragmites karka</i> (Retz.) Trin. Ex Steud.	Anchi, Nadi	Grass
261.	<i>Saccharum bengalense</i> Retz.	Munj	Grass
262.	<i>Setaria glauca</i> (L.) P. Beauv.	Sani Bhichdi, Sani Zipti	Grass
263.	<i>Sorghum halepense</i> (L.) Pers.	Baru Gha	Grass
264.	<i>Sporobolus coromandelianus</i> (Retz.) Kunth	Khariyu Ga	Grass
265.	<i>Sporobolus fertilis</i> (Steud.) Clayton	Ganthiar, Khari Ga, Palangi	Grass
266.	<i>Sporobolus helvolus</i> (Trin.) Th. Dur. et Sch	Khevai	Grass
267.	<i>Sporobolus maderaspatensis</i> Bor	Khevai Ga	Grass
268.	<i>Sporobolus marginatus</i> Hochst. ex A. Rich.	Khevai Ga	Grass
269.	<i>Tragus biflorus</i> (Roxb.) Schult.	Gah	Grass
270.	<i>Triticum aestivum</i> L.	Gahu, Gaun	Grass
271.	<i>Urochondra setulosus</i> (Trin.) Hubb	Kkariyu Gah	Grass
272.	<i>Zea mays</i> L.	Makai	Grass
	<b>Polygalaceae</b>		
273.	<i>Polycarpha corymbosa</i> (L.) Lam.	Jangali soa, Rupa phali	Herb
274.	<i>Polygala chinensis</i> L.	Piri Patsan	Herb
275.	<i>Polygala erioptera</i> DC. var. <i>erioptera</i>	Patsan	Herb
276.	<i>Polygala irregularis</i> Boiss.	Patsan	Herb
	<b>Polygonaceae</b>		
277.	<i>Antigonon leptopus</i> Hk. & Arn.	Icecream Val	Climber
278.	<i>Polygonum plebeium</i> R. Br. var. <i>indica</i> (Heyne ex Roth) Hook.	Ratanjyot	Herb

(continued)



**Table 7.2** (continued)

S. no.	Plant species	Local name	Habit
	<b>Portulacaceae</b>		
279.	<i>Portulaca oleracea</i> L.	Lakha Luni, Vadiluni, Kunbo	Herb
	<b>Periplocaceae</b>		
280.	<i>Periploca aphylla</i> Decne	Rati Khip, Siriyar Khip, Shingadiyo	Shrub
	<b>Rhamnaceae</b>		
281.	<i>Zizyphus nummularia</i> (Burm. F.) W. & A.	Bordi, Boedi, Chania Bor	Shrub
	<b>Rubiaceae</b>		
282.	<i>Borreria articularis</i> (L.f.) F.N. Will.	Bikan, Baakan Jo Zad	Herb
283.	<i>Borreria pusilla</i> (Wall.) DC.	Bikan	Herb
284.	<i>Oldenlandia corymbosa</i> L.	–	Herb
	<b>Salvadoraceae</b>		
285.	<i>Salvadora oleoides</i> Decne.	Mithi Zar, Mithi Pilujo Zad	Tree
286.	<i>Salvadora persica</i> L.	Khari Zar, Pailu	Tree
	<b>Sapindaceae</b>		
287.	<i>Cardiospermum halicacabum</i> L.	Bkan Fofti, Tridhari Val, Popti	Climber
	<b>Scrophulariaceae</b>		
288.	<i>Bacopa monnieri</i> (L.) Pennell	Kadvi Naveri, Naveri	Herb
289.	<i>Campylanthus ramosissimus</i> Wt.	–	Shrub
290.	<i>Kickxia ramosissima</i> (Wall.) Janch.	Bhit Val, Bhi Chatti	Herb
291.	<i>Srigna angustifolia</i> (D. Don) Saldhana	Kunvario	Herb
	<b>Solanaceae</b>		
292.	<i>Lindenbergia muraria</i> (Roxb. Ex D. Don) P. Bruehl	Piri Sadedi, Zamar Val	Herb
293.	<i>Lycium barbarum</i> L.	Garothi, Gerati, Gerothi, Khareti	Shrub
294.	<i>Physalis longifolia</i> Nutt.	Fofati, Fad, Fotaji Val	Herb
295.	<i>Physalis minima</i> L.	Fofati, Fad, Fotaji Val	Herb
296.	<i>Solanum albicaule</i> Kotschy ex Dunal	–	Shrub
297.	<i>Solanum indicum</i> L.	Vad Ringni, Mot Ringni	Herb
298.	<i>Solanum nigrum</i> L.	Kamperu	Herb
299.	<i>Solanum surattense</i> Burm. f.	Jangali Ringani, Pat Ringani	Herb
	<b>Sterculiaceae</b>		
300.	<i>Melhania futteyporensis</i> Munro ex Masters var. <i>major</i> (Blatt. & Hallb.) Santapau	Adbau Khapat	Herb
301.	<i>Vernonia cinerea</i> (L.) Less.	Sadodi, Kadu Kariyato, Sap Val	Herb
302.	<i>Waltheria indica</i> L.	Pilu Fulaju Zadvu	Shrub
303.	<i>Melhania futteyporensis</i> Munro ex Masters var. <i>futteyporensis</i>	Adbau Khapat	Shrub
304.	<i>Helicteres isora</i> L.	Aatadi, Anati Maeda, Singi	Shrub

(continued)

**Table 7.2** (continued)

S. no.	Plant species	Local name	Habit
	<b>Tamaricaceae</b>		
305.	<i>Tamarix aphylla</i> (L.) Karst.	Lai	Tree
306.	<i>Tamarix ericoides</i> Rottl.	Lai Jo Zad	Shrub
307.	<i>Tamarix troupii</i> Hole	Lai, Ratilai	Shrub
	<b>Tiliaceae</b>		
308.	<i>Corchorus aestuans</i> L.	Kag Gisodi, Kag Kela	Herb
309.	<i>Corchorus depressus</i> (L.) Stocks	Munderi, Munderi	Herb
310.	<i>Corchorus olitorius</i> L.	Kag Gisoda, Gunpat	Herb
311.	<i>Corchorus tridens</i> L.	–	Herb
312.	<i>Corchorus urticaefolius</i> W.&A.	Khetau Surval	Herb
313.	<i>Grewia tenax</i> (Forsk.) Fiori	Gangati, Gangi, Gangni	Shrub
314.	<i>Grewia villosa</i> Willd.	Luo, Luejo Zad, Luskejo Zad	Shrub
315.	<i>Triumfetta rhomboidea</i> Jacq.	Bhurati, Zepati	Herb
	<b>Typhaceae</b>		
316.	<i>Typha angustata</i> Bory & Chaub	Gha Bajariu	Herb
	<b>Verbenaceae</b>		
317.	<i>Clerodendrum phlomidis</i> L.	Tankaro, Arani	Shrub
318.	<i>Phyla nodiflora</i> (L.) Greene	Rato Ukharar, Ratval	Herb
319.	<i>Premna resinosa</i> Schau	Nidhi Kundher	Shrub
	<b>Vitaceae</b>		
320.	<i>Cayratia carnosa</i> (Lam.) Gagnep.	Khatumbadi Ji Val	Climber
	<b>Zygophyllaceae</b>		
321.	<i>Fagonia bruguieri</i> DC. var. <i>bruguieri</i>	Dhramau, Dhamaso, Kandhera	Herb
322.	<i>Fagonia schweinfurthii</i> (Hadidi) Hadidi	Dhramau, Dhamaso, Kandhera	Herb
323.	<i>Tribulus rajasthanensis</i> Bhandari et Sharma	Akanthi, Mitha Gokharu	Herb
324.	<i>Tribulus terrestris</i> L.	Akanthi, Mitha Gokharu	Herb
325.	<i>Zornia gibbosa</i> Span	Bepani	Herb
326.	<i>Zygophyllum simplex</i> L.	Pat Lani	Herb

122.58 ± 5.75, 285 ± 8.97 and 56.32 ± 3.72, respectively. Shannon diversity index values for tree, shrub and climber are with mean ± SD of 1.01 ± 0.03, 1.71 ± 0.05 and 0.88 ± 0.05, respectively. Species richness index (Menhinick index) values of tree, shrub and climber are with mean ± SD of 0.91 ± 0.029, 1.21 ± 0.03 and 1.00 ± 0.032, respectively. Species evenness for tree, shrub and climber are with mean ± SD 0.75 ± 0.01, 0.71 ± 0.01 and 0.88 ± 0.007, respectively.

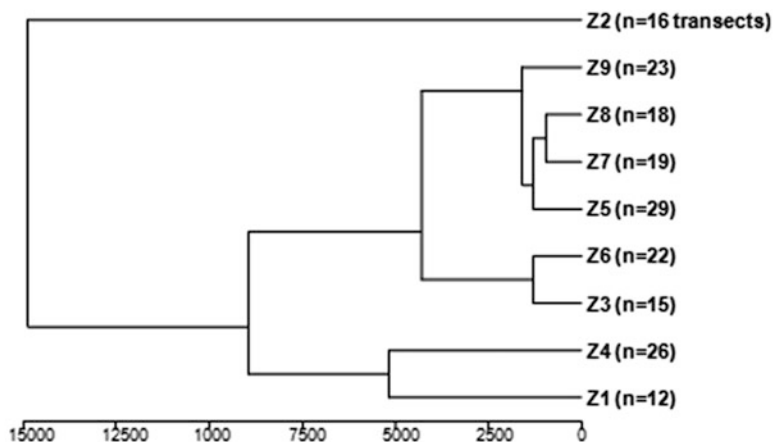
**Table 7.3** Plant species with conservation significance

Sr. no.	Conservation significance species	Local name	Habit	Family
1.	<i>Campylanthus ramosissimus</i> Wt.	–	Shrub	Scrophulariaceae
2.	<i>Citrullus colocynthis</i> (L.) Soland.	Truja Val	Climber	Cucurbitaceae
3.	<i>Commiphora wightii</i> (Arn.) Bhandari	Gugar	Tree	Burseraceae
4.	<i>Convolvulus stocksii</i> Boiss.	–	Herb	Convolvulaceae
5.	<i>Corallocarpus conocarpus</i> (D. & G.) Cl.	Navi Val	Climber	Cucurbitaceae
6.	<i>Dactyliandra welwitschii</i> Hk. f.	Aankh Futamna	Climber	Cucurbitaceae
7.	<i>Ephedra foliata</i> Boiss. & Kotschy ex Boiss.	Andhoi Khip	Shrub	Ephedraceae
8.	<i>Helichrysum cutchicum</i> (C.B.Cl.) Rolla Rao et Des.	Dholu Fuladu	Herb	Asteraceae
9.	<i>Heliotropium bacciferum</i> Forsk. var. <i>suberosum</i> (Clarke) Bhandari	–	Herb	Boraginaceae
10.	<i>Heliotropium rariflorum</i> Stocks	Jakhau	Herb	Boraginaceae
11.	<i>Indigofera caerulea</i> Roxb. var. <i>monosperma</i> (Sant.) Sant.	Rangagi Gari	Herb	Fabaceae
12.	<i>Ipomoea kotschyana</i> Hoc. ex Choisy	Bhoyan Fotiyargi Val	Herb	Convolvulaceae
13.	<i>Sida tiagii</i> Bhandari	Bulbuwaro	Herb	Malvaceae
14.	<i>Tribulus rajasthanensis</i> Bhandari et Sharma	Akanthi, Mitha Gokharu	Herb	Zygophyllaceae

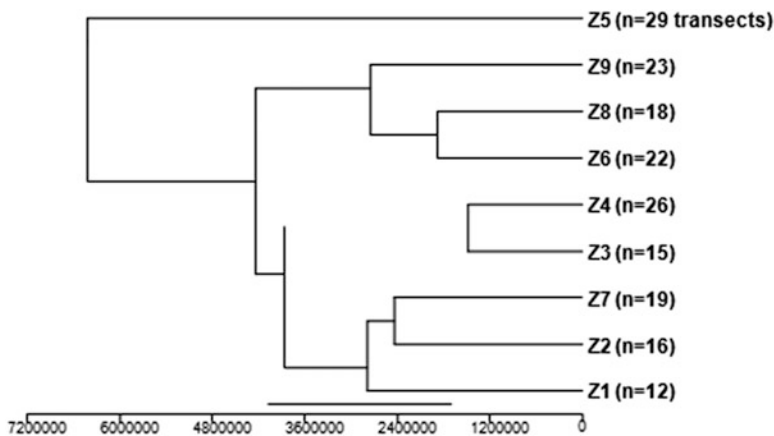
## 7.4 Impact of Mining Activities on Plant Community Structure

### 7.4.1 Overall Description of Impact of Mining

Around the mining area, major *Prosopis* forest was found because of the high tolerance value of *Prosopis juliflora* against the extreme edaphic condition and some patches of *Euphorbia-Salvadora* and *Acacia* forest, but they were confronted of the tremendous pressure of extinction. *Campylanthus ramosissimus*, *Commiphora wightii*, *Dactyliandra welwitschii*, *Helichrysum cutchicum*, *Heliotropium bacciferum* var. *suberosum*, *H. rariflorum*, etc. are conservation significant plant species found around the mining area. Including mining activities, other disturbance was also occurring which causes the impact on the biodiversity. ANOVA results reveal that there was no significant difference in plant communities between nine zones in terms of various diversity indices, viz. number of species, density, Shannon diversity, Menhinick and Margalef species richness, evenness, etc.



**Fig. 7.2** Zone-wise clustering of tree species



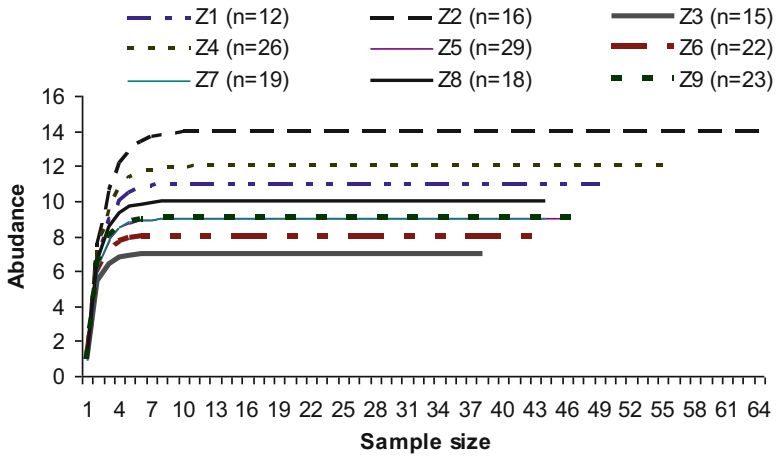
**Fig. 7.3** Zone-wise clustering of shrub species

Cluster analysis reveals that the greater similarity among sampling points belongs to the same kind of habitat. Four distinct groups (Z2, Z9:Z8:Z7:Z5, Z6:Z3, Z1:Z4) were clearly identified from abundance data of tree species, while on the basis of shrub species, four distinct groups (Z5, Z9:Z8:Z6, Z4:Z3, Z7:Z2:Z1) were clearly identified also (Figs. 7.2, 7.3 and 7.4).

#### 7.4.1.1 Zone-Wise Description of Floristic Diversity

##### Zone One (Z1)

A total of 147 plant species were recorded from the zone one (Z1) including 12 trees, 26 shrubs, 15 climbers, 74 herbs and 20 grasses. Abundance and % frequency ratio reveals that all tree, shrub and climber species were contagiously distributed within

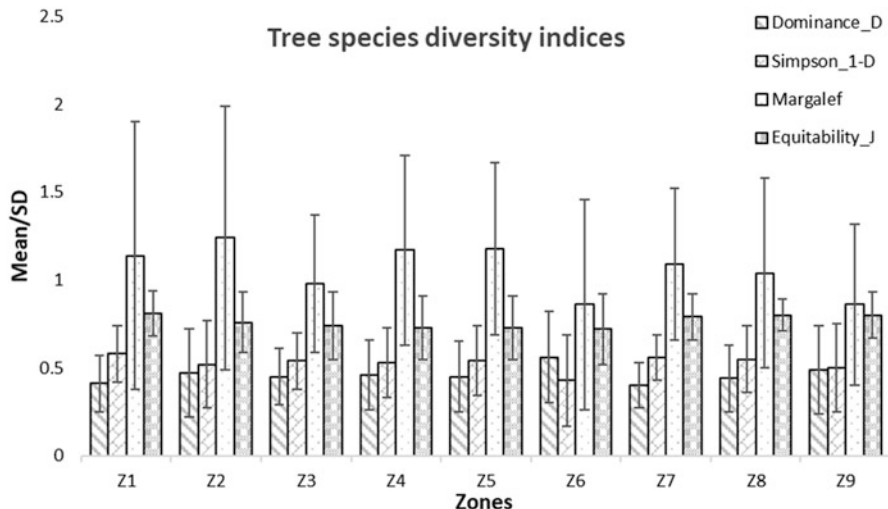


**Fig. 7.4** Rarefaction curve of various mining zones for tree species

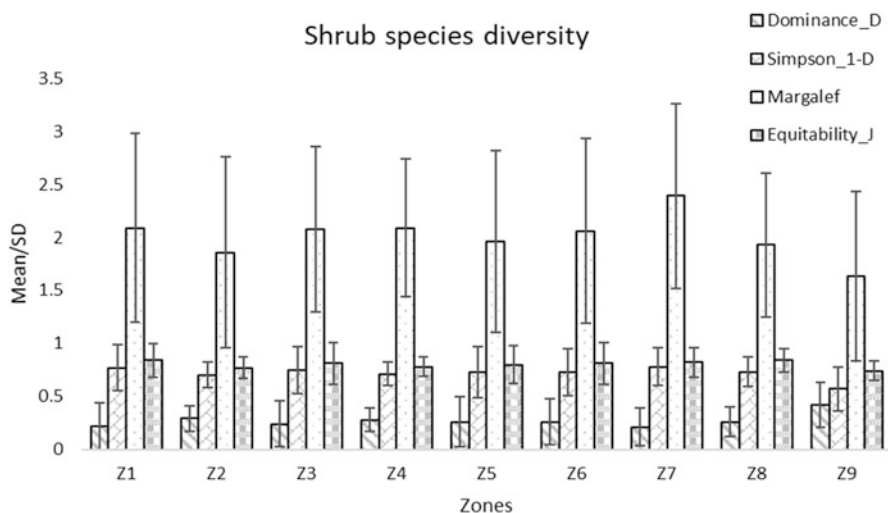
area. Important value index shows that the *Acacia senegal* was the most dominant species ( $IVI = 114.68$ ) followed by *A. nilotica* (101.50). Frequency diagram of the tree, shrub and climber reveals that the zone was heterogeneous in nature. Various diversity indices were obtained from the data of tree, shrub and climber. Mean  $\pm$  SD numbers of species occurring in transect were  $4.5 \pm 2.54$ ,  $9.26 \pm 4.04$  and  $2.66 \pm 1.66$  for tree, shrub and climber, respectively, while densities of the said habitat were  $118.75 \pm 76.10$ ,  $248.33 \pm 84.80$  and  $48.33 \pm 39.56$ . Shannon diversities of the tree, shrub and climber were in mean  $\pm$  SD,  $1.11 \pm 0.47$ ,  $1.82 \pm 0.53$  and  $0.71 \pm 0.60$ , respectively, while Menhinick species richness values with mean  $\pm$  SD were  $0.98 \pm 0.49$ ,  $1.29 \pm 0.43$  and  $0.93 \pm 0.30$  for tree, shrub and climber, respectively. Evenness values of tree, shrub and climber with mean  $\pm$  SD were  $0.78 \pm 0.14$ ,  $0.74 \pm 0.13$  and  $0.93 \pm 0.09$ , respectively (Figs. 7.5 and 7.6).

### Zone Two (Z2)

A total of 199 plant species were recorded from the zone two including 14 trees, 26 shrubs, 20 climbers, 112 herbs and 27 grasses. Tree, shrub and climber species were contagiously distributed within area, which was revealed from % frequency and abundance ratio. *Acacia nilotica* was the most dominant and ecologically successful species with high  $IVI$  value (142.05) followed by *A. senegal* (78.51). Frequency diagram of all habit tree, shrub and climber reveals that the community of the zone two was heterogeneous in nature. A number of species of tree, shrub and climber with mean  $\pm$  SD were  $4.81 \pm 2.88$ ,  $8.31 \pm 3.62$  and  $3.41 \pm 2.77$ , respectively, while densities with mean  $\pm$  SD were  $120.62 \pm 73.45$ ,  $250 \pm 96.64$  and  $69.16 \pm 64.87$  of tree, shrub and climber, respectively. Shannon diversities of tree, shrub and climber with mean  $\pm$  SD were  $1.05 \pm 0.54$ ,  $1.63 \pm 0.61$  and  $0.85 \pm 0.62$ , respectively, while Menhinick species richness values of tree, shrub and climber with mean  $\pm$  SD were  $1.02 \pm 0.41$ ,  $1.17 \pm 0.36$  and  $0.92 \pm 0.32$ , respectively.



**Fig. 7.5** Zone-wise diversity indices of tree species



**Fig. 7.6** Zone-wise diversity indices of shrub species

Species evenness values with mean  $\pm$  SD were  $0.75 \pm 0.20$ ,  $0.69 \pm 0.12$  and  $0.89 \pm 0.11$  of tree, shrub and climber, respectively (Figs. 7.5 and 7.6).

### Zone Three (Z3)

Two hundred and eight plant species were recorded from the mining zone three with 7 trees, 33 shrubs, 19 climbers, 117 herbs and 32 grasses. Abundance and % frequency ratio reveals the all tree, shrub and climber species were contagiously

distributed within area, while *Acacia nilotica* was ecologically successful and well-established species with high IVI value (126.90) followed by *A. senegal* (100.04). Comparative results with frequency diagram reveal that the plant community was heterogeneous in nature. Mean  $\pm$  SD numbers of species were  $4 \pm 1.55$ ,  $9.33 \pm 3.39$  and  $3.28 \pm 2.67$  of tree, shrub and climber respectively, while densities were  $130.66 \pm 85.70$ ,  $271 \pm 129.99$  and  $63.57 \pm 68.82$  for tree, shrub and climber, respectively. Shannon diversities of tree, shrub and climber with mean  $\pm$  SD were  $0.98 \pm 0.35$ ,  $1.77 \pm 0.40$  and  $0.81 \pm 0.70$ , respectively, while Menhinick species richness were  $0.87 \pm 0.29$ ,  $1.28 \pm 0.25$  and  $0.95 \pm 0.40$  of tree, shrub and climber, respectively. Species evenness values of tree, shrub and climber with mean  $\pm$  SD were  $0.74 \pm 0.15$ ,  $0.69 \pm 0.13$  and  $0.90 \pm 0.10$ , respectively (Figs. 7.5 and 7.6).

#### **Zone Four (Z4)**

A total of 219 higher plant species were recorded from zone four, in which there are 12 trees, 35 shrubs, 22 climbers, 124 herbs and 26 grasses. Abundance and frequency ratio of the tree, shrub and climber reveals that all species of the said habitat were contagiously distributed within area. Prepared frequency diagram compared with the normal frequency diagram reveals that the vegetation was heterogeneous in terms of nature. In that heterogeneous vegetation, the most dominant and ecologically successful tree species was *Acacia senegal* with high IVI value (106.25) followed by *Salvadora oleoides* (81.14) and *A. nilotica* (76.99). A number of species occurring during the transect were with mean  $\pm$  SD for tree, shrub and climber,  $4.42 \pm 1.64$ ,  $9.42 \pm 3.89$  and  $3.17 \pm 2.05$ , respectively, while densities of the tree, shrub and climber were  $108.46 \pm 63.25$ ,  $288.84 \pm 105.96$  and  $46.30 \pm 30.90$ , respectively. Shannon diversity index values with mean  $\pm$  SD of tree, shrub and climber were  $10.4 \pm 0.42$ ,  $1.72 \pm 0.65$  and  $0.84 \pm 0.65$ , respectively, while the Menhinick species richness index values were  $1.03 \pm 0.39$ ,  $1.26 \pm 0.44$  and  $1.07 \pm 0.45$ , respectively. Species evenness values of the tree, shrub and climber with mean  $\pm$  SD were  $0.71 \pm 0.17$ ,  $0.69 \pm 0.14$  and  $0.91 \pm 0.10$ , respectively (Figs. 7.5 and 7.6).

#### **Zone Five (Z5)**

A total of 251 plant species were recorded in which there were 9 trees, 38 shrubs, 26 climbers, 142 herbs and 36 grasses. Abundance and % frequency ratio of each species of the tree, shrub and climbers reveals that all species were contagiously distributed within area, while a comparison of the frequency diagram of the various species with normal frequency diagram reveals that the plant community was heterogeneous in terms of nature. Among the heterogeneous communities, *Acacia senegal* was the most dominant and well-established species with high IVI value (102.38) followed by *Salvadora oleoides* (101.08). Mean  $\pm$  SD numbers of species occurring during transect of tree, shrub and climber were  $4.5 \pm 1.64$ ,  $9 \pm 3.91$  and  $3.46 \pm 2.08$ , respectively, while densities with mean  $\pm$  SD were  $139.28 \pm 84.18$ ,  $290 \pm 3.91$  and  $56.15 \pm 37.26$  of tree, shrub and climber, respectively. Shannon diversity values of tree, shrub and climber with mean  $\pm$  SD were  $1.06 \pm 0.42$ ,  $1.75 \pm 0.65$  and  $0.92 \pm 0.60$ , respectively, while Menhinick species richness values

with mean  $\pm$  SD were  $0.97 \pm 0.40$ ,  $1.18 \pm 0.41$  and  $1.05 \pm 0.35$  of tree, shrub and climber, respectively. Species evenness values of tree, shrub and climber were  $0.71 \pm 0.20$ ,  $0.73 \pm 0.10$ ,  $0.87 \pm 0.09$ , respectively (Figs. 7.5 and 7.6).

### **Zone Six (Z6)**

Two hundred and forty-four total plant species were recorded from zone six including 8 trees, 39 shrubs, 27 climbers, 137 herbs and 33 grasses. Abundance and % frequency ratio reveals that all tree, shrub and climber species were contagiously distributed within area, while a comparative result of frequency diagram shows heterogeneous nature of community. The important value index (IVI) reveals that the *Acacia senegal* (93.78) was most dominant species followed by *Salvadora oleoides* (88.02). Mean  $\pm$  SD numbers of species of tree, shrub and climber were  $3.36 \pm 1.86$ ,  $9.45 \pm 4.47$  and  $4.09 \pm 3.08$ , respectively, while densities were  $115 \pm 73.58$ ,  $320.22 \pm 192.91$  and  $76.19 \pm 69.85$ , respectively. Shannon diversity index mean values of tree, shrub and climber were  $0.80 \pm 0.54$ ,  $1.75 \pm 0.65$  and  $1.03 \pm 0.63$ , respectively, while Menhinick species richness index values of tree, shrub and climber were  $0.81 \pm 0.45$ ,  $1.22 \pm 0.39$  and  $1.05 \pm 0.37$ , respectively. Species evenness means  $\pm$  SD value of tree, shrub and climber were  $0.79 \pm 0.26$ ,  $0.72 \pm 0.14$  and  $0.85 \pm 0.08$ , respectively (Figs. 7.5 and 7.6).

### **Zone Seven (Z7)**

A total of 236 plant species were recorded from the zone seven including 9 trees, 41 shrubs, 19 climbers, 133 herbs and 34 grasses. Distribution pattern of the tree, shrub and climber species within area was contagious as revealed by the ratio of abundance and % frequency, while comparative results of frequency diagram show that the plant community of this zone was heterogeneous in nature. Mean  $\pm$  SD numbers of species forming transect were  $4.36 \pm 1.30$ ,  $11 \pm 3.24$  and  $3.38 \pm 1.68$  of tree, shrub and climber, respectively, while densities were  $132 \pm 69.96$ ,  $325 \pm 95.81$  and  $64.72 \pm 47.04$ , of tree, shrub and climber, respectively. Shannon diversity index mean  $\pm$  SD values of tree, shrub and climber were  $1.11 \pm 0.30$ ,  $1.96 \pm 0.47$  and  $0.90 \pm 0.55$ , respectively, while Menhinick species richness index mean  $\pm$  SD values were  $0.93 \pm 0.34$ ,  $1.36 \pm 0.30$  and  $1.01 \pm 0.39$  of tree, shrub and climber, respectively. Species evenness mean  $\pm$  SD values of tree, shrub and climber were  $0.75 \pm 0.14$ ,  $0.69 \pm 0.13$  and  $0.85 \pm 0.10$ , respectively (Figs. 7.5 and 7.6).

### **Zone Eight (Z8)**

A total of 237 plant species were recorded from the community of zone eight (Z8) in which there are 10 trees, 33 shrubs, 18 climbers, 139 herbs and 37 grasses. All of the tree, shrub and climber species were contagiously distributed within area, which were results of abundance and % frequency ratio. The nature of community was heterogeneous, which was revealed by the comparison of frequency diagram to normal frequency diagram. Among this heterogeneous plant community, *Salvadora oleoides* was the dominant and ecologically successful species with high IVI value (92.97) followed by *Acacia senegal* (71.96). Mean  $\pm$  SD numbers of species of tree, shrub and climber were  $4.22 \pm 1.89$ ,  $8.72 \pm 3.56$  and  $3.16 \pm 1.85$ , respectively,



while densities of tree, shrub and climber were  $115.27 \pm 72.07$ ,  $276.38 \pm 113.05$  and  $40.83 \pm 31.63$ , respectively. Shannon diversity index mean values of tree, shrub and climber were  $1.05 \pm 0.46$ ,  $1.72 \pm 0.60$  and  $0.90 \pm 0.52$ , respectively, while Menhinick species richness index mean ( $\pm$ SD) values of tree, shrub and climber were  $0.93 \pm 0.31$ ,  $1.19 \pm 0.41$  and  $1.13 \pm 0.28$ , respectively. Species evenness mean  $\pm$  SD values of tree, shrub and climber were  $0.77 \pm 0.13$ ,  $0.69 \pm 0.13$  and  $0.90 \pm 0.07$ , respectively (Figs. 7.5 and 7.6).

### Zone Nine (Z9)

A total of 225 species were recorded from the plant community of zone nine in which there were 9 trees, 31 shrubs, 23 climbers, 129 herbs and 33 grasses. Abundance and % frequency ratio reveals that all tree, shrub and climber species were contagiously distributed within area, while the frequency diagram reveals that the plane community was heterogeneous in nature. Important value index reveals that the *Salvadora oleoides* (135.69) was the most dominant species followed by *Acacia senegal* (119.70) of that community. Mean  $\pm$  SD numbers of species of tree, shrub and climber were  $3.59 \pm 1.79$ ,  $7.78 \pm 5.59$  and  $3.36 \pm 2.05$ , respectively, while mean  $\pm$  SD density values of tree, shrub and climber were  $121.13 \pm 96.44$ ,  $270.65 \pm 110.10$  and  $46.59 \pm 34.37$ , respectively. Shannon diversity index mean ( $\pm$ SD) values of tree, shrub and climber were  $0.92 \pm 0.52$ ,  $1.35 \pm 0.89$  and  $0.89 \pm 0.60$ , respectively, while Menhinick species richness index mean  $\pm$  SD values of tree, shrub and climber were  $0.83 \pm 0.25$ ,  $0.99 \pm 0.60$  and  $1.11 \pm 0.39$ , respectively. Species evenness mean  $\pm$  SD values of tree, shrub and climber were  $0.82 \pm 0.12$ ,  $0.71 \pm 0.16$  and  $0.88 \pm 0.10$ , respectively (Figs. 7.5 and 7.6).

Vegetation of the study area is mainly composed of thorny plant species. Upper canopy consists of the most dominant plant species like *Acacia nilotica*, *A. senegal* and *Salvadora oleoides* while major component lower canopy mainly comprising shrubby vegetation are *Prosopis juliflora*, *Euphorbia caducifolia*, *Capparis decidua*, *Grewia tenax* and *G. villosa*. Higher species diversity, richness and evenness of shrubs suggest their dominance over tree community in our study area. Kachchh region has specific forest type called tropical thorn forest, which consists the thorny shrub species. Shrub vegetation is dominated by thorny shrub species, while open areas are dominated by the annual plants which are mainly supported by scanty rainfall during monsoon. Most of the species were contagiously distributed within area and create heterogeneous plant community in nature. A total of 326 plant species were recorded including trees, shrubs, climbers/twiners, herbs and grasses.

The results of impact assessment of mining activities on vegetation of the total nine circular zones were identified within 2 km width because mining causes massive damage to landscape and biological communities, creating unfavourable habitat condition for plant growth. It was found that there was more or less impact in the inner zones of mining impact areas delineated for the present study. The number of tree and shrub species drastically decreased in their number due to mining. The unfavourable habitat conditions prevailing the coal-mined area have reduced the chances of regeneration of species, thereby, reducing the number of species in the mined areas. Habitat was changed by dumping of the contaminated soil on the

natural habitat and by succession of extreme condition-tolerant plant species like *Prosopis juliflora* that occupies the landscape. Results of the study reveal that the positive impact on the vegetation of mining and associated activities creates the anthropogenic pressure on the local plant community structure and diversity. The main tree species like *Acacia senegal*, *A. nilotica* and *Salvadora oleoides* face heavy threats of extinction from the area. The present study led to the conclusions that phytosociological analysis can be used as important tools for predicting the suitability of mine-spoil habitats for plant growth, which would be helpful to revegetation of the mined areas. To minimize the impact of mining on the local vegetation, conservation strategies and extensive plantation drive of the local or native plant species in contaminated mining area are urgently required by long-term monitoring of the plantation.

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## 7.5 Conservation and Management Strategies

With the clear understanding of environmental, ecological and social component with respect to the vegetation formation in the western Kachchh and widely available management options, the following strategies are suggested as conservation measures for rare, endangered and threatened (RET) plants and ecologically sensitive areas (ESAs).

- A. In view of high floral diversity and increasing biotic pressures on vegetation, the following management strategies for NSS and LBS are suggested for the conservation of threatened floral species:
- A detailed status survey of threatened floral species needs to be done, and the habitats supporting high floral diversity should be identified and notified as mini-core areas (MCAs) of the sanctuary.
  - Strict protection should be given to these MCAs to prevent wood cutting, grazing and collection of other natural resources.
  - Degraded habitats should be restored through restoration programmes with threatened species and their associate species.
  - Herbaceous cover (including grass cover), of both dense and sparse grasslands, provides potential habitat for seven rare herbaceous species such as *Helichrysum cutchicum* (470 nos.), *Heliotropium bacciferum* (375), *Heliotropium rariflorum* (325), *Tribulus rajasthanensis* (95) and *Indigofera caerulea* (24). A detailed status survey of these herbaceous covers and identification of the location where there is very high abundance was recorded.
  - There are 26 villages with the population of 10,872 located in and around the sanctuary (recent survey part of this project), and they depend on the sanctuary area for grass, firewood, fodder and other nontimber forest produce. Based on the dependency level, few villages, i.e. Ratipar, Gugariyana, Midhiyari and Amiyu, should be considered for eco-development.

- Creation of village-level eco-development committees, distribution of fuel-efficient stoves, development of fodder and fuel wood plantation, restoration of grassland and creation of employment alternative for economically poor villagers should be included in management planning for the overall conservation of threatened biological diversity of NSS and LBS.
- B. Within the study area like Lifri, Guneri, Siyot, Haripar, Walka nana, Walka mota and Lakhapar, out of seven localities, eight species of threatened plants were recorded. Even though these RFs were under control, severe wood cutting and grazing pressures were reported from the neighbouring villages. Based on the abundance of threatened species and existing threats, the following management strategies are suggested:
- RFs like Gugaryani, Chakrai, Mindhiari, Kaniari, Maniyara and Khirsara RFs and adjoining forest stretches should be resurveyed for the complete status assessment of RET plants.
  - Within these RFs, the areas with the abundance of above-mentioned threatened species need to be identified.
  - The identified stretches should be protected by providing natural green fence by planting *Euphorbia caducifolia* and *Balanites aegyptiaca*.
  - Local villagers should be informed to avoid grazing and cutting of trees in the potential locations identified.
  - Apart from the protection measures, the concerned forest staff should be employed for monitoring these protected sites to assess and understand the productive potential of the threatened species.
  - These protected sites in RFs should be resorted with the threatened plants, and it can act as natural seed banks for the threatened species.
- C. Biodiversity is under varying degrees of protection in the protected and normal areas, but considerable proportion of biodiversity is manifested outside these areas and is existing without any protection. Realizing the limitation in declaring more areas as protected areas, and the need of participation of local communities in conservation efforts, the concept of ESAs is gaining popularity. During this study the following areas have been reported with diverse plant species and some threatened flora. Since these areas are not having any protected area status, they are under severe biotic pressures from the local villagers. (However for these areas reported for high floral diversity, area-specific floral richness is not discussed.)
- I. *Piper*: It is a hilly tract located close to Narayan Sarovar and provides high diversity of floral species. A total of 108 plant species were reported during this study. Further it has been found that this hilly area provides habitat for six threatened species.
  - II. *Kharai*: This area is dominated by thorn scrub forest holding 127 plant species. Out of these plant species, around 42 were medicinal plants and 5 of conservation significance.
  - III. *Punrajpur*: This unprotected area supports 106 plant species in which 5 are of conservation significance.

- IV. *Vayor and Vagoth*: This village area, i.e. hedges of agriculture and common grazing land, harboured the total five plant species of conservation significance including highly endangered plant species *Corallocarpus conocarpus*.
- Considering the high floral diversity of these village areas, it has been suggested that these microhabitats should be declared as ecologically sensitive areas (ESAs).
  - Villager's dependency on the identified hot spots for their natural resources like fodder and fuel wood collection should be identified.
  - Many government, nongovernment (Shrujan, Ashapura Foundation, Setu-Abhiyan, KMVS and VRTI) and research organizations are currently working with the villagers of proposed ESAs. In order to reduce the biotic pressures on the identified hot spot areas, the dependent villagers should be connected with these organizations to get socio-economic benefit.
  - All the identified hot spots should be strictly prohibited for grazing and wood cutting by providing alternate resources through the ongoing developmental programmes.
  - Creation of village-level forest and resources management committees and monitoring of the ESA are suggested.

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