

Vegetation Analysis of Protected Common Lands



PREPARED BY

Foundation for Ecological Security

SOUTH ASIA

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Vegetation Analysis of Protected Common Lands

Annexure to Document 21

**“Common Land Development and Poor Livestock Keepers:
Experiences from Common Land Development in the States of
Rajasthan and Madhya Pradesh in India”**

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1. Introduction

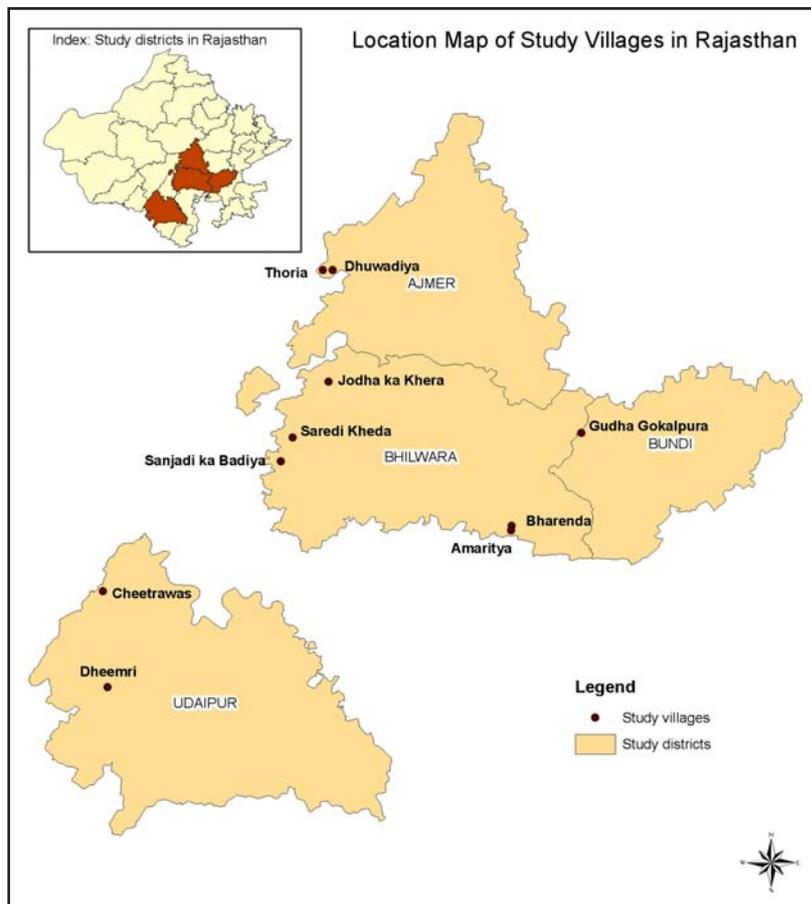
The state of vegetation not only depicts the health of the Commons but also determines the range of resources that it provisions and the composition of users that these resources are available to. A vegetation study assessing the nature and quantum of vegetation growth on the Commons which have received bio-physical support and have witnessed the setting up of institutional arrangements for governance of their resources is thus seen as an important part of any study on Common land Development that tries to understand its benefits to poor livestock keepers. This study is primarily aimed at estimating the increase in biomass, availability of palatable fodder and biodiversity emerging over a period of time that has seen community protection and governance of Common Property Resources.

The study looks into the work of two organizations- the Foundation for Ecological Security (FES) and BAIF Research Foundation, towards Common Land Development in the two States of Rajasthan and Madhya Pradesh. A representative sample of villages with different time-periods of engagement with governance of Commons, different topography and agro-climatic features, diverse social-cultural contexts and institutional arrangements for governing Common Property Resources, have been selected to understand the process of vegetative growth in different location specific contexts.

2. Study Area

The study was undertaken in two selected watersheds – namely the Ladwan watershed in Madhya Pradesh and the Thoria watershed in Rajasthan. The study also included certain select villages across different districts of Rajasthan and Madhya Pradesh. The villages of Cheetarawas and Dheemri fall in the Udaipur district; those of Amaritya, Saredi Kheda, Sanjadi ka Badiya and Jodha Ka Kheda in Bhilwara district; Gudha-Gokulpura in Bundi district of Rajasthan while Rojani, Rajakhedi and Jagatpura fall in the Shajapur district of Madhya Pradesh.

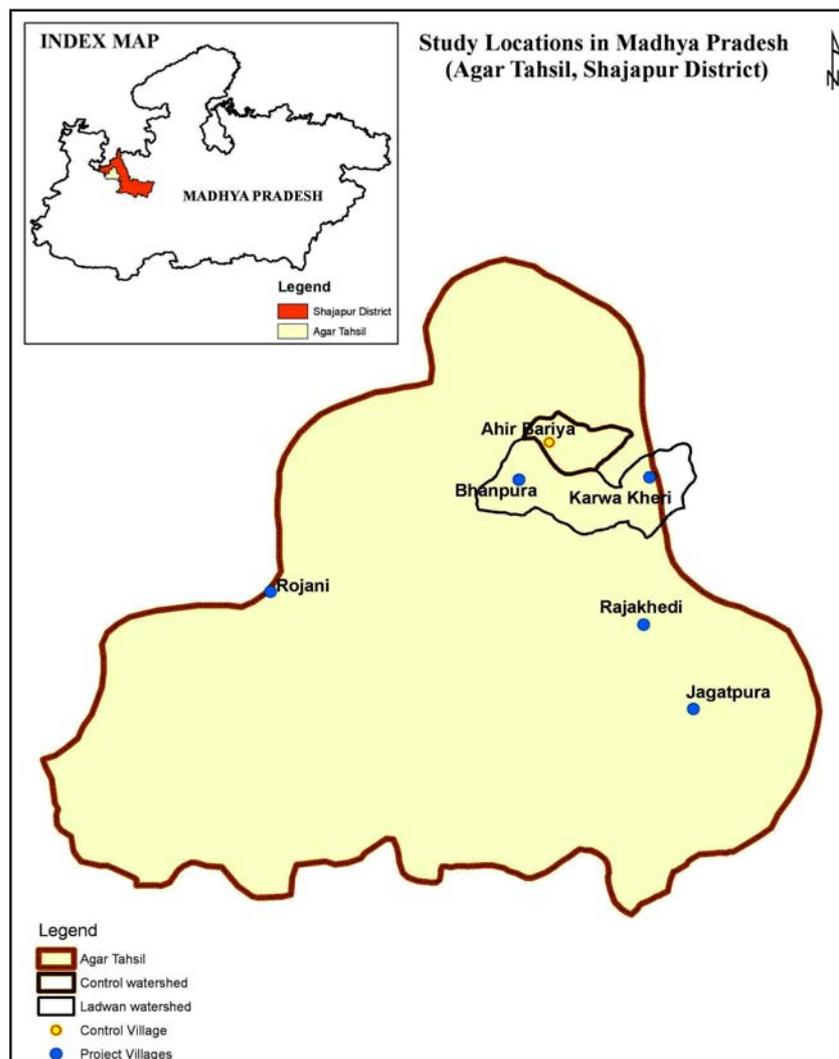
Fig 1: Location of the villages studied in Rajasthan



The Thoria watershed is located in the Pisangan *tehsil* of Ajmer district and shares a boundary with the Pali district towards the southwest. This watershed falls under the agro-ecological zone no. 4, which is classified as the Northern Plain and Central Highland of Aravalli, with a semi arid climate and alluvial derived soils. The annual rainfall varies from 400-600 mm and the temperature ranges from a minimum of 7°C to a maximum of 46°C.

The watershed falls under the macro watershed no. 19 and is further sub divided into 11 micro watersheds covering five revenue villages. The runoff is drained out mainly through two major *nalas*, which merge to form the river Lilri. The region is semi-arid, marked by acute soil erosion and a low hydrological table. This leads to low productivity and has even rendered large chunks of fields as uncultivable. The soil

Fig 2: Location of the villages studied in Madhya Pradesh



cover is shallow and the annual rainfall, which is often accompanied by heavy showers, is largely wasted in the form of runoff.

The Ladwan watershed of the project area in Agar lies in the uplands of the Lakhunder which is a tributary of the Choti Kali Sindh, the main perennial stream in the region. It falls in the semi arid zone within the Malwa plateau and is characterized by deep medium black soils and an average annual rainfall in the range of 800-1200 mm. Agriculture and animal husbandry are the predominant livelihoods in the region. The region falls in the *cotton-jowar* crop zone and used to be the seat of the textile industry in producing cotton and yarn. However, the area under cotton has been on the decline since the past few years and soyabean is now the main *kharif* crop. The other important crops include *jowar*, *maize*, *wheat* and *channa*. The majority of land holdings are small with about 65% of all land holdings less than 2 ha.

3. Methodology

3.1 SAMPLING

For the purpose of carrying out the sampling process, the watershed was divided into a grid of unit 100m x 100m. Based on the proportion of each landscape type viz. open scrub, dense scrub etc., the grids were selected randomly with the help of the GIS (Geographic Information System) software and the points of the grids noted down in the GPS (Global Positioning System). These points were tracked in the field and the required data and samples collected from them.. Necessary care was taken to include all landscapes in justifiable proportions while collecting the samples. Other selected villages were sampled by taking random samples inside the protected plots and outside land area selected as a control area.

3.2 VEGETATION DIVERSITY

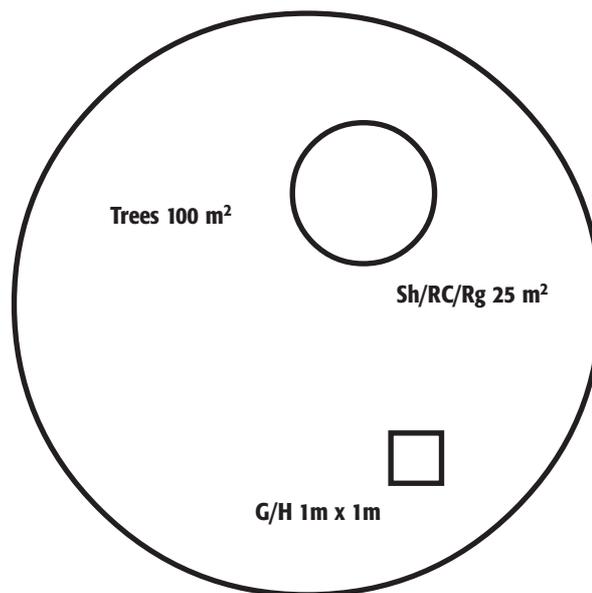
The sample plot size was set to 100 m² for trees having a girth above 5 cm at breast height (GBH). A subplot of 25 m² was nestled within this sample plot to gather information on shrubs, seedlings and saplings (below 5 cm GBH) whereas an additional 1m x 1m subplot was set up for collecting data on grasses and herbaceous species (Modified Whittaker Method). The watershed was searched intensively for the range of plant species and a checklist prepared enlisting all of them.

3.3 BIOMASS STUDIES

A sample plot of 10m x 10m size was taken from each microhabitat for estimating the above-ground tree biomass with the use of non-destructive methods. For this purpose, the GBH (girth at breast height), DSH (diameter at stump height), and height in meters of all the tree species within the plot were noted and then extrapolated for the entire study area. The equations developed by Brown *et al* (1997) were used for calculating the biomass for the tree species.

Within the 10m x 10m plots, a 5m x 5m plot was marked and the length, breadth, and height of shrubs within it were calculated for arriving at an estimate of volume (LxBxH). A unit volume (1ft. x 1ft. x 1ft.) of the shrubs was harvested and the wet weight was measured in order to derive the volume-mass multipliers. While harvesting, multiples of each shrub species covering all the habitat types were considered and averaged to arrive at the unit volume of biomass.

Fig 3: The layout of the sample plots in Thoria watershed



For assessment of the ground flora, the 10m x 10m plots were subdivided into quadrat plots of size 1m x 1m and all the plant species to be found within these quadrat plots were recorded, harvested above ground, oven-dried and weighed.

3.4 PHYTOSOCIOLOGICAL STUDIES

Phytosociology is the study of the characteristics, classification, relationships, and distribution of plant communities. Various measures of phytosociology of the area like density, abundance, frequency, dominance, diversity indices etc. were studied.

4. Results

4.1 THORIA WATERSHED

4.1.1 Vegetation Composition

A total of 187 species of plants were reported from within the watershed. The tree flora of the area is found to be dominated by a mixture of species like *Acacia leucophloea*, *Acacia nilotica*, *Acacia Senegal*, *Azadirachta indica* etc. Though other species like *Holoptelia Integrifolia*, *Ficus Religiosa*, *Ficus Benghalensis* etc. do occur in the watershed, they were not reported from the grids that were selected for sampling.

The understorey is represented by shrub species like *Euphorbia Caducifolia*, *Maytenus Emarginatus*, *Calotropis Procera*, *Prosopis Juliflora* etc. The area is abundant with various grass and herb species like *Aristida spp.*, *Sporobulus sp.*, *Evolvulus sp.* etc. Among the grasses, *Aristida* is found to dominate in terms of the area occupied on the common lands. A herb species called *Tephrosia Purpurea* dominates all others in most of the watershed areas. Other important herb species include *Evolvulus Alsinoides*, *Fagonia Indica*, *Xanthium Strumarium*, *Indigofera Linnaei*, *Indigofera Cordifolia* etc.

There is a fair amount of plant biodiversity in the Thoria watershed with 187 plant species, 20 tree species, 49 shrubs/climbers species and 118 grasses/herb species. A total of 52 families of flowering plants were reported from the study area in the watershed. Of these, 49 families are from the class of dicotyledons and three from that of monocotyledons. *Poaceae*, *Fabaceae*, *Asteraceae* etc. are some of the important families abundant in the area.

Table 1: No. of species in different categories in Thoria watershed

S.No.	Category	No. of Species
1	Tree	20
2	Shrub/Climbers	49
3	Grasses/Herbs	118

Table 2: Plant Families of Thoria with number of species within each

Family	Number of species	Family	Number of species
Acanthaceae	7	Meliaceae	1
Aizoaceae	1	Menispermaceae	3
Amaranthaceae	8	Mimosaceae	8
Ancardiaceae	1	Moraceae	2
Asclepiadaceae	3	Moringaceae	1
Asteraceae	12	Nyctaginaceae	3
Balanitaceae	1	Oxalidaceae	1
Brassicaceae	1	Papaverceae	1
Burseraceae	2	Periplocaceae	1
Caesalpiniaceae	5	Polygalaceae	1
Capparaceae	3	Polygonaceae	1
Celastreaceae	1	Portulacaceae	1
Chenopodiaceae	1	Rhamnaceae	2
Combretaceae	1	Rubiaceae	3
Convolvulaceae	7	Sapindaceae	1
Cucurbitaceae	12	Scrophulariaceae	3
Cuscutaceae	1	Simaroubaceae	1
Elatinaceae	1	Solanaceae	4
Euphorbiaceae	9	Sterculiaceae	1
Fabaceae	15	Tiliaceae	6
Gentianaceae	1	Ulmaceae	1
Lamiaceae	2	Verbenaceae	1
Liliaceae	2	Vitaceae	2
Lythraceae	1	Zygophyllaceae	2
Malvaceae	5	Cyperaceae	5
Poaceae	27	Commelinaceae	3

The vegetation in the sampling grids was noted down in data sheets and analysed for various phytosociological parameters such as density, abundance, frequency etc. Their Importance Value Index (IVI) was then calculated and tabulated. While all the tree species show a contagious pattern of distribution, *Acacia Nilotica*, *Acacia Leucophloea* and *Acacia Senegal* were found to be the most important tree species in the area. The following table gives various parameters for the tree species found in the Thoria watershed.

Table 3: Phytosociological analysis of tree species in Thoria watershed

Species	R.Freq.	R.Dom.	R.Dens.	IVI	Abundance	A/F Ratio	Distribution	Plants/ha
<i>Acacia nilotica</i>	41.27	36.93	46.87	125.08	1.73	0.07	Contagious	45
<i>Acacia leucophloea</i>	12.70	17.56	13.54	43.80	1.63	0.20	Contagious	13
<i>Acacia senegal</i>	17.46	9.11	16.67	43.24	1.45	0.13	Contagious	16
<i>Azadirachta indica</i>	4.76	22.84	3.12	30.73	1.00	0.33	Contagious	3
<i>Balanites aegyptiaca</i>	7.94	2.53	6.25	16.72	1.20	0.24	Contagious	6
<i>Acacia tortilis</i>	6.35	3.28	5.21	14.84	1.25	0.31	Contagious	5
<i>Prosopis cineraria</i>	4.76	4.36	3.12	12.24	1.00	0.33	Contagious	3
<i>Ailanthus excelsa</i>	3.17	3.05	4.17	10.39	2.00	0.99	Contagious	4
<i>Anogeissus pendula</i>	1.59	0.34	1.04	2.97	1.00	0.99	Contagious	1

The analysis of the shrub species in the watershed reveals that the most important species of the area are *Euphorbia Caducifolia*, *Maytenus Emarginatus* and *Zizyphus Nummularia*.

Table 4: Phytosociological analysis of top 10 shrub species

Species	R.Freq.	Rel.Dom.	R.Dens.	IVI	Abundance	A/F Ratio	Distribution	Plants/ha
<i>Euphorbia caducifolia</i>	9.82	42.86	9.92	62.61	1.14	0.05	Random	101
<i>Prosopis juliflora</i>	16.96	28.98	15.87	61.81	1.05	0.03	Regular	162
<i>Maytenus emarginatus</i>	8.04	2.25	8.33	18.62	1.17	0.06	Contagious	85
<i>Zizyphus nummularia</i>	6.25	3.16	7.14	16.55	1.29	0.09	Contagious	73
<i>Cucumis sativus</i>	6.25	0.06	5.56	11.87	1.00	0.07	Random	57
<i>Grewia tenax</i>	4.02	2.31	4.37	10.69	1.22	0.13	Contagious	44
<i>Calotropis procera</i>	4.91	0.11	5.16	10.18	1.18	0.11	Contagious	53
<i>Capparis decidua</i>	3.57	1.68	3.17	8.43	1.00	0.12	Contagious	32
<i>Leptadenia pyrotechnica</i>	2.68	0.23	2.38	5.29	1.00	0.17	Contagious	24
<i>Ipomoea eriocarpa</i>	2.68	0.03	2.38	5.09	1.00	0.17	Contagious	24

The TGCS plots show a change in the composition of tree species over time. Here, individuals of *Prosopis Cineraria* were also to be found, though less in number. *Acacia Nilotica* is the dominant tree species, with other important species being *Balanites Aegyptiaca*, *Ailanthus Excelsa*, and *Acacia Senegal*. Amongst the shrubs, *Euphorbia Caducifolia*, *Maytenus Emarginatus*, *Zizyphus Nummularia* and *Capparis Decidua* are the species present in abundance.

The grass species were sampled using the diagonal point intercept method to assess the percentage of grass cover. The percentage importance was calculated based on the numerical strength of the species encountered through this method. The analysis

reveals that *Aristida Funiculata*, *Tephrosia Purpurea*, *Indigofera Cordifolia*, *Eragrostis Major* and *Melanocenchrus Jacquemontii* are the most important grass/herb species in the area.

The following table gives the number of woody plants per hectare for the watershed, TGCS and control area. It is clear that the TGCS areas are faring better than both - the watershed and the control areas, in all categories.

Table 5: Top ten grass/herb species of Thoria watershed

S.No.	Species	% Importance
1	<i>Aristida funiculata</i>	21.33
2	<i>Tephrosia purpurea</i>	13.27
3	<i>Indigofera cordifolia</i>	11.37
4	<i>Eragrostis major</i>	8.77
5	<i>Melanocenchris jacquemontii</i>	6.87
6	<i>Digitaria sp</i>	6.16
7	<i>Cynodon dactylon</i>	5.92
8	<i>Bothriochloa pertusa</i>	4.74
9	<i>Cenchrus setigerus</i>	2.84
10	<i>Justicia simplex</i>	1.90

Table 6: No. of plants per ha in Thoria watershed

Watershed			TGCS			Control		
Tree	Regeneration	Shrub	Tree	Regeneration	Shrub	Tree	Regeneration	Shrub
97	214	804	256	275	950	29	286	571

The diversity indices show that in case of the trees, the Shannon-Weiner's diversity index value of the watershed ($H'=1.76$) is slightly more than that of the TGCS plots ($H'=1.47$). The diversity of shrub species is also higher for the watershed ($H'=2.73$) than TGCS ($H'=2.16$). The value for the index is lowest for the control area in the case of both trees as well as shrubs. The values of the Simpson's index show a dominance of tree species in both the watershed as well as the TGCS plots. This tendency is not seen in control plots or in the case of shrubs, in either of the areas.

The values of the Pielou's evenness index show that the tree species across the sample points in the watershed and TGCS plots are evenly distributed while those in the control microwatershed show an uneven distribution.

Table 7: Diversity Indices of woody species in Thoria watershed

		Shannon-Weiner Index	Simpson's Index	Pielou Index
Watershed	Trees	1.76	0.23	0.80
	Shrubs	2.73	0.11	0.79
TGCS	Trees	1.47	0.30	0.82
	Shrubs	2.16	0.13	0.94
Control	Trees	0.00	1.00	0.00
	Shrubs	1.93	0.17	0.93

4.1.2 Biomass and Grass Cover

The results of the estimation of biomass show that in the overall watershed, tree biomass is 9.03 tonnes per hectare (t/ha), shrub biomass is 3.49 t/ha and grass biomass is 1.97 t/ha. This gives a total of 14.5 t/ha phytomass for the overall watershed. On the other hand, in the TGCS plots, the tree biomass is as high as 9.48 t/ha while shrub biomass is 5.24 t/ha and grass biomass is 1.26 t/ha. In the adjacent microwatershed studied for the purpose of comparison, the total biomass is 3.14 t/ha, which is much less than either Thoria watershed, or the TGCS plots within it.

The grass cover values reveal similar trends for the three categories. The TGCS plots have the highest grass cover value of 89.58 percent followed by that in the Thoria watershed at 84.81 percent and trailed by that of the control micro watershed with only 78.57 percent.

Table 8: Biomass (t/ha) and grass cover in the Thoria watershed

	Tree	Shrub	Grass	Total	Biomass Carbon	Grass cover %
Watershed	9.03	3.49	1.97	14.50	7.25	84.81
TGCS	9.48	5.24	1.26	15.98	7.99	89.58
Control	0.83	1.60	0.71	3.14	1.57	78.57

4.1.3 Species wise biomass

Among the six species that were reported in the species-wise analysis of biomass for the overall watershed, *Acacia Nilotica*, *Acacia Senegal* and *Acacia Leucophloea* are found to be the species contributing a maximum of tree biomass. The total tree biomass for this watershed is 5.18 t/ha. In the shrubs/regeneration category with a standing biomass of 4.11 t/ha, the most important species are *Euphorbia Caducifolia*, *Prosopis Juliflora*, *Acacia Senegal* and *Acacia Leucophloea*. The total number of the species in this category is 30.

Among the six species reported in the TGCS plots of Thoria watershed, *Acacia Nilotica*, *Ailanthus Excelsa* and *Balanites Agyptiaca* are seen to contribute the maximum to tree biomass. The

Table 9: Species wise biomass of woody species in Thoria watershed

S.No.	Species	Biomass
TREES		
1	<i>Acacia nilotica</i>	2.55
2	<i>Acacia senegal</i>	1.05
3	<i>Acacia leucophloea</i>	1.02
4	<i>Acacia tortilis</i>	0.38
5	<i>Azadirachta indica</i>	0.15
6	<i>Anogeissus pendula</i>	0.04
SHRUBS (TOP SPECIES)		
1	<i>Euphorbia caducifolia</i>	1.25
2	<i>Prosopis juliflora</i>	0.53
3	<i>Capparis decidua</i>	0.15
4	<i>Grewia hypodermis</i>	0.15
5	<i>Grewia tenax</i>	0.15
6	<i>Rhus mysorensis</i>	0.15
7	<i>Zizyphus nummularia</i>	0.13

total tree biomass for these plots is 9.48 t/ha. In the shrubs/regeneration category with 5.24 t/ha standing biomass, the most important species are *Euphorbia Caducifolia*, *Prosopis Juliflora*, *Acacia Senegal* and *Zizyphus Nummularia*. There are a total of 10 species in this category.

Table 10: Species wise biomass of woody species on Protected Common lands in Thoria watershed

S.No.	Species	Biomass
TREES		
1	<i>Acacia nilotica</i>	4.82
2	<i>Acacia senegal</i>	2.02
3	<i>Ailanthus excelsa</i>	0.98
4	<i>Balanites aegyptiaca</i>	0.82
5	<i>Prosopis cineraria</i>	0.43
6	<i>Acacia leucophloea</i>	0.42
Total		9.48
SHRUBS (TOP SPECIES)		
1	<i>Euphorbia caducifolia</i>	2.89
2	<i>Prosopis juliflora</i>	0.56
3	<i>Zizyphus nummularia</i>	0.38
4	<i>Maytenus emarginatus</i>	0.34
5	<i>Capparis decidua</i>	0.18

4.2 LADWAN WATERSHED

4.2.1 Vegetation composition

A total of 161 plant species were reported from the Ladwan watershed. The tree flora of this area is dominated by a mixture of species like *Acacia Leucophloea*, *Butea Monosperma*, *Azadirachta Indica*, *Acacia Catechu* etc. The understorey is represented by shrub species such as *Maytenus Emarginatus*, *Carassia Carundus*, *Lantana Camara*, *Zizyphus Nummularia*, *Annona Squamosa* etc. The area is abundant with various grass and herb species like those of *Aristida Adscensionis*, *Indigofera Cordifolia*, *Apluda Mutica* etc. Among the grasses, *Aristida* is found to be dominating in terms of total area occupied on the common lands. Other important herb species are *Evolvulus Alsinoides*, *Fagonia Indica*, *Xanthium Strumarium*, *Indigofera Linnaei* etc.

Table 11: Number of plant species in different categories in the watershed

S.No.	Category	No. of species
1	Tree	30
2	Shrub/Climbers	32
3	Grasses/Herbs	99

In all, a total of 53 families of flowering plants were reported from the study area in the watershed, of which 47 families are dicotyledons and six are monocotyledons. The flowering families of *Poaceae*, *Fabaceae*, *Asteraceae* etc. are some of the important ones present abundantly in the area. *Butea Monosperma*, *Acacia Leucophloea* and *Azadirachta Indica* are the most important tree species found in the area. All the tree species show contagious patterns of distribution, except *Acacia Leucophloea* which has a random distribution pattern. The following table gives various parameters for the tree species found in the Thoria watershed.

Table 12: Families of Ladwan watershed with number of species

S.No.	Family	Species	S.No.	Family	Species
1	Acanthaceae	8	28	Linaceae	1
2	Agavaceae	1	29	Lyrthaceae	1
3	Amaranthaceae	5	30	Malvaceae	5
4	Annonaceae	1	31	Martyniaceae	1
5	Apocynaceae	1	32	Meliaceae	2
6	Arecaceae	1	33	Menispermaceae	2
7	Asclepiadaceae	1	34	Mimosaceae	7
8	Asteraceae	13	35	Moraceae	2
9	Bignoniaceae	1	36	Moringaceae	1
10	Bombacaceae	1	37	Myrtaceae	1
11	Burseraceae	1	38	Plumbaginaceae	1
12	Cactaceae	1	39	Poaceae	22
13	Caesalpiniaceae	10	40	Polygalaceae	1
14	Capparaceae	2	41	Portulacaceae	1
15	Caryophyllaceae	1	42	Rhamnaceae	2
16	Celastraceae	1	43	Rubiaceae	3
17	Combretaceae	3	44	Rutaceae	1
18	Commelinaceae	2	45	Santalaceae	1
19	Convolvulaceae	5	46	Sapindaceae	1
20	Cucurbitaceae	5	47	Sapotaceae	1
21	Cyperaceae	6	48	Scrophulariaceae	1
22	Elatinaceae	1	49	Simaroubaceae	1
23	Euphorbiaceae	7	50	Solanaceae	3
24	Fabaceae	12	51	Tiliaceae	3
25	Gentianaceae	1	52	Ulmaceae	1
26	Lamiaceae	1	53	Verbenaceae	1
27	Liliaceae	2			

Table 13: Phytosociological analysis of tree species in Ladwan watershed

Species	R. Freq.	Rel. Dom.	R. Dens.	IVI	Abundance	A/F Ratio	Distribution	Plants/ha
<i>Acacia leucophloea</i>	35.55	44.96	30.91	111.43	1.06	0.04	Random	29
<i>Butea monosperma</i>	31.11	19.05	27.27	77.43	1.07	0.04	Contagious	26
<i>Azadirachta indica</i>	8.89	22.00	9.09	39.98	1.25	0.18	Contagious	9
<i>Acacia catechu</i>	6.67	9.32	16.36	32.35	3.00	0.58	Contagious	16
<i>Jatropha curcas</i>	4.44	2.03	5.45	11.93	1.50	0.44	Contagious	5
<i>Diospyros melanoxylon</i>	4.44	0.69	3.64	8.77	1.00	0.29	Contagious	3
<i>Santalum album</i>	4.44	0.49	3.64	8.57	1.00	0.29	Contagious	3
<i>Cassia sp.</i>	2.22	0.83	1.82	4.87	1.00	0.58	Contagious	2
<i>Acacia nilotica</i>	2.22	0.64	1.82	4.68	1.00	0.58	Contagious	2

The analysis of the shrub species in the watershed reveals that the most important shrub species of the area are *Maytenus Emarginatus*, *Carissa Carandas*, *Zizyphus Nummularia* etc.

Table 14: Phytosociological analysis of top 10 shrubs in Ladwan watershed

SPECIES	R. Freq.	Rel. Dom.	R. Dens.	IVI	Abundance	A/F Ratio	Distribution	Plants/ha
<i>Maytenus emarginatus</i>	16.56	27.30	13.35	57.22	1.89	0.04	Random	352
<i>Carissa carandas</i>	10.43	25.42	15.97	51.82	3.59	0.12	Contagious	421
<i>Lantana camara</i>	19.02	0.32	31.15	50.49	3.84	0.07	Contagious	821
<i>Zizyphus nummularia</i>	6.14	1.37	4.71	12.21	1.80	0.10	Contagious	124
<i>Annona squamosa</i>	1.23	1.87	1.83	4.93	3.50	1.02	Contagious	48
<i>Cocculus hirsutus</i>	3.07	0.01	1.57	4.65	1.20	0.14	Contagious	41
<i>Xanthium stromarium</i>	1.84	0.07	1.05	2.95	1.33	0.26	Contagious	28
<i>Comipohora wightii</i>	1.23	0.27	0.79	2.28	1.50	0.44	Contagious	21
<i>Grewia tenax</i>	1.23	0.11	0.52	1.86	1.00	0.29	Contagious	14
<i>Rhus mysurensis</i>	1.23	0.09	0.52	1.84	1.00	0.29	Contagious	14

In the protected areas of the Ladwan watershed, the dominating species of trees are *Acacia Leucophloea*, *Butea Monosperma* and *Acacia Catechu*. The shrub species dominant in these areas are *Butea Monosperma*, *Carissa Carandas*, *Maytenus Emarginatus* and *Lantana Camara*.

In the control grids studied near the Ladwan watershed, the tree species category was represented by a few individuals of *Azadirachta Indica*. The shrubs were represented by a total of eight species of which the regenerations of *Carissa Carandas*,

Maytenus Emarginatus and *Diospyros Melanoxylon* regenerations dominate the landscape.

The grass cover of the Ladwan watershed is dominated by a mixture of grass species with *Aristida Adscensionis* and *Indigofera Cordifolia* present in maximum strength. Based on their numerical strength, the following table provides a listing of the top ten species of herb/grass to be found in this watershed.

Table 15: Top 10 grass/herb species of Ladwan watershed

S.No.	Species	% Importance
1	<i>Aristida adscensionis</i>	11.14
2	<i>Indigofera cordifolia</i>	8.43
3	<i>Apluda mutica</i>	6.78
4	<i>Iseilema laxum</i>	6.63
5	<i>Brachiaria raptans</i>	4.82
6	<i>Eragrostis major</i>	4.82
7	<i>Borreria cristata</i>	3.92
8	<i>Chloris barbata</i>	3.61
9	<i>Indigofera linifolia</i>	3.61
10	<i>Merremia sp.</i>	3.31

Table 16: Diversity Indices in Ladwan watershed

		Shannon-Weiner Index	Simpson's Index	Pielou Index
Watershed	Trees	1.38	0.29	0.86
	Shrubs	2.30	0.14	0.81
PAs	Trees	1.77	0.22	0.81
	Shrubs	2.21	0.15	0.74
Control	Trees	0.00	1.00	0.00
	Shrubs	1.67	0.23	0.80

The diversity indices indicate that in case of the trees, the Shannon-Weiner's diversity index value is highest for the Protected Areas ($H'=1.77$) and lower for the watershed ($H'=1.38$), while the diversity of shrub species is higher for the watershed ($H'=2.30$) and lower in the Protected Areas ($H'=2.21$). The value for the index in the case of both – trees and shrubs, is lowest for the control watershed. The values of the Simpson's index show a dominance of tree species in the watershed, a tendency not displayed in the control watershed or in the shrub species in either of the areas. The values of the Pielou's evenness index show uneven distribution of all species across the sample points in the watershed and the TGCS. The distribution of tree species in the control watershed is, however, uneven.

4.2.2 Biomass and Grass cover

The results of biomass estimation for the watershed show the tree biomass at 5.28 tonnes/hectare, shrub biomass at 5.81 t/ha and grass biomass at 4.54 t/ha, giving a total of 15.63 t/ha phytomass for the overall watershed. On the other hand, the tree biomass for the protected plots is slightly higher at 5.47 t/ha, while shrub biomass is 5.87 t/ha and grass biomass is 4.95 t/ha, giving a total of 16.29 t/ha, which is higher

than that for the overall watershed. In the nearby micro watershed studied for the purpose of comparison, the total biomass is 6.64 t/ha, which is much less than the Ladwan watershed.

The grass cover values show that the protected areas have the highest value of grass cover (at 97.73 percent), followed by the watershed (at 95.39 percent) and trailed by the control micro watershed (at 79.05 percent).

Table 17: Biomass (t/ha) and grass cover in the Ladwan watershed

	Tree	Shrub	Grass	Total	Biomass Carbon	Grass cover %
Watershed	5.28	5.81	4.54	15.63	7.82	95.39
PAs	5.47	5.87	4.95	16.29	8.14	97.73
Control	0.35	5.07	1.21	6.64	3.32	79.05

The following table gives the number of woody plants per hectare for the watershed area, the TGCS plots and the control site. It is evident that the watershed and the protected areas are faring better than the control site in all categories.

Table 18: No. of plants per ha in Ladwan watershed

Watershed			PAs			Control		
Tree	Regeneration	Shrub	Tree	Regeneration	Shrub	Tree	Regeneration	Shrub
95	662	1972	86	698	1990	14	1143	1371

4.2.3 Species wise biomass

Amongst the five species that were reported in the analysis of species-wise biomass for the watershed, those of *Acacia Leucophloea*, *Azadiracta Indica* and *Butea Monosperma* were found to be contributing a maximum of tree biomass. The total tree biomass for the watershed is 4.75 t/ha. In the category of shrubs/regeneration with a standing biomass of 5.62 t/ha, the most important species were listed as *Maytenus Emarginatus*, *Carassia Carundus* and *Zizyphus Numularia*. The total number of species in this category is 17.

Among the nine species of trees reported in the protected plots of the Ladwan watershed,

Table 19: Species wise biomass of woody species in ladwan watershed

S.No.	Species	Biomass
TREES		
1	<i>Acacia leucophloea</i>	2.19
2	<i>Azadiracta indica</i>	1.56
3	<i>Butea monosperma</i>	0.60
4	<i>Acacia catechu</i>	0.37
5	<i>Santalum album</i>	0.03
SHRUBS (TOP SPECIES)		
1	<i>Maytenus emarginatus</i>	1.93
2	<i>Carassia carundus</i>	0.96
3	<i>Zizyphus nummularia</i>	0.10
4	<i>Lantana camara</i>	0.03
5	<i>Rhus mysurensis</i>	0.03

, *Acacia Leucophloea*, *Butea Monosperma* and *Azadirachta Indica* were found to contribute the maximum of tree biomass. The total tree biomass for the watershed is 5.47 t/ha. In the category of shrubs/regeneration with standing biomass of 5.87 t/ha, the most important species are *Carassia Carundus*, *Maytenus Emarginatus* and *Butea Monosperma*. The total number of species in this category is 20.

Table 20: Species wise biomass of woody species on Protected Common lands in Thoria watershed

S.No.	Species	Biomass
TREES		
1	<i>Acacia leucophloea</i>	2.20
2	<i>Butea monosperma</i>	1.29
3	<i>Azadirachta indica</i>	1.00
4	<i>Acacia catechu</i>	0.57
5	<i>Jatropha curcas</i>	0.19
6	<i>Cassia sp.</i>	0.08
7	<i>Diospyros melanoxylon</i>	0.06
8	<i>Acacia nilotica</i>	0.06
9	<i>Santalum album</i>	0.02
	Total	5.47
SHRUBS (TOP SPECIES)		
1	<i>Carassia carundus</i>	2.17
2	<i>Maytenus emarginatus</i>	1.52
4	<i>Zizyphus nummularia</i>	0.28
5	<i>Annona squamosa</i>	0.25
6	<i>Jatropha curcas</i>	0.08

4.3 SELECTED VILLAGES IN RAJASTHAN AND MADHYA PRADESH

The following section provides an analysis of biomass and vegetational composition of the study villages in Rajasthan and M.P, based on a pattern similar to that used for the analysis of the watersheds discussed above.

4.3.1 Biomass and Grass Cover

The results of biomass estimation for the villages indicate that the highest values of tree, shrub and grass biomass are to be found in the TGCS plots. The values of grass cover also display similar trends for all the three categories of land across the villages, save for those of Amritiya and Bharenda. Both these villages have a dense growth of *Anogeissus Pendula*, the shade of which does not favour good undergrowth. Elsewhere in Udaipur, the pasture plot developed with the help of the local village communities

shows a grass cover greater than that of the VFPMC plot, but with low tree density, which subsequently enhances the grass cover in similar conditions.

Table 21: Biomass and Grass cover in the scattered villages

Village	District	Land use	Tree	Shrub	Grass	Total	Grass Cover%	Biomass C
FES SUPPORTED VILLAGES								
Bharenda	Bhilwara	Plot	16.90	20.74	0.31	37.95	28.10	18.97
		Control	0.96	12.84	0.62	14.42	43.33	7.21
Amaritya	Bhilwara	Plot	12.43	8.73	0.83	21.99	40.00	10.99
		Control	7.35	1.03	0.72	9.11	32.00	4.55
Sanjadi Ka Badiya	Bhilwara	Plot	11.70	5.10	1.89	18.69	73.85	9.34
		Control	1.02	3.66	1.18	5.85	58.75	2.93
Saredi kheda	Bhilwara	Plot	20.49	2.67	1.40	24.57	80.74	12.28
		Control	0.00	3.53	0.50	4.03	67.78	2.02
		Panchayat	21.97	0.88	0.74	23.59	60.00	11.79
Dheemri	Udaipur	Plot	65.39	4.21	8.50	78.11	98.33	39.05
		Control	0.00	2.49	0.29	2.78	60.00	1.39
Cheetrawas	Udaipur	Plot	282.82	13.16	5.63	301.62	92.17	150.81
		Pasture	148.17	9.42	7.92	165.51	98.33	82.75
		Control	140.43	3.00	0.26	143.68	25.33	71.84
Rajakhedi	Agar	Plot	15.76	2.10	1.92	19.78	76.67	9.89
Rojani	Agar	Plot	7.63	4.40	2.51	14.55	92.00	7.27
Jagatpura	Agar	Plot	5.80	2.22	3.16	11.19	88.67	5.59
BAIF SUPPORTED VILLAGES								
Jodha Ka Kheda	Bhilwara	Plot	14.09	2.36	0.60	17.04	43.39	8.52
		Control	4.11	0.41	0.49	5.01	33.66	2.51
Gudha Gokulpura	Bundi	Plot	10.02	1.09	0.81	11.92	68.50	5.96
		Control	0.00	2.56	0.03	2.59	56.21	1.29

*All values in t/ha except grass cover %

4.3.2 Species wise biomass

4.3.2.1 Bharenda village (Bhilwara)

TGCS Plot

The two species reported in the analysis of species wise biomass in the TGCS plot were *Acacia Leucophloea* and *Azadirachta Indica*. The total tree biomass of the plot is 16.9 t/ha, of which *Acacia Leucophloea* contributes 10.67 t/ha and *Azadirachta Indica* contributes 6.23 t/ha. The plot features *Anogeissus Pendula*, with a standing biomass 20.4 t/ha, as the main species in category of shrubs/regeneration.. The other species of this category are *Acacia Leucophloea* (0.07 t/ha) and *Azadirachta Indica* (0.26 t/ha).

Control

The single tree species that was reported in the sampling grids of the unprotected common lands in Bharenda village was *Acacia Leucophloea* with a biomass of 0.96 t/ha. The area has *Anogeissus Pendula* as the main species in the shrubs/regeneration category, with a standing biomass of at 12.67 t/ha, which is however, low in comparison to the protected plot. Almost all the regenerations of *Anogeissus Pendula* were reported to be stunted in growth, with heavy signs of browsing by cattle and goats. The other species in this category is *Zizyphus Nummularia* with a standing biomass of 0.17 t/ha, thus totalling the biomass in the category of shrubs/regeneration to 12.84 t/ha.

4.3.2.2 Amaritya (Bhilwara)

Protected Plot

The analysis of species wise biomass in the protected plot shows the decreasing order of abundance of species as *Butea Monosperma*> *Anogeissus Pendula*> *Acacia Leucophloea*> *Azadirachta Indica*> *Acacia Catechu*. The total tree biomass for this plot is 12.43 t/ha. The plot features *Anogeissus Pendula* as the main species in the category of shrubs/regeneration, with a standing biomass of 8.41 t/ha. The other species of this category are *Cassia sp.* (0.29 t/ha) and *Zizyphus Nummularia* (0.2 t/ha), thus totalling the biomass of this category to 8.73 t/ha shrubs.

Control

The predominant tree species in the unprotected common lands in Amritiya village are *Anogeissus Pendula* with 5.88 t/ha biomass and *Acacia Leucophloea* with 1.47 t/ha biomass. The area has *Anogeissus Pendula* as the main species in the category of shrubs/regeneration, with standing biomass of 0.98 t/ha. Almost all the regenerations of *Anogeissus Pendula* regenerations were reported to be stunted in growth, with heavy signs of browsing by cattle and goats. The other species of this category is *Zizyphus Nummularia* with biomass of 0.05 t/ha, thus totalling the biomass in the shrubs/regeneration category to 1.03 t/ha..

4.3.2.3 Sanjadi ka badiya (Bhilwara)

Protected Plot

The biomass analysis of Sanjadi ka Badiya village reported the occurrence of four species of trees in the sampling grids of the protected plots, in the decreasing order of abundance of: *Acacia Nilotica* (6.87 t/ha)> *Prosopis Cineraria* (2.49 t/ha)> *Acacia Leucophloea* (1.75 t/ha)> *Azadirachta Indica* (0.60 t/ha). The total tree biomass is 11.7 t/

ha. The plot has 10 species falling in the shrubs and regeneration category, the important ones being *Balanites Aegyptiaca*, *Acacia Nilotica*, *Acacia Leucophloea* etc. The total shrub biomass is 5.10 t/ha for this area.

Control

Only two species of trees were reported from the sampling grids in the Control area (Unprotected common land) of the village, namely *Acacia Leucophloea* (0.62 t/ha) and *Acacia Nilotica* (0.40 t/ha). A total of 11 species were reported from the shrub/regeneration category, with important species being those of *Prosopis Juliflora*, *Rhus Mysorensis*, *Acacia Nilotica*, *Balanites Aegyptiaca* etc. The total biomass in this category was calculated as 3.66 t/ha.

4.3.2.4 Saredi kheda (Bhilwara)

TGCS Plot

In the TGCS plot of Saredi Kheda village, a total of four species of trees were reported viz. *Acacia Nilotica* (10.72 t/ha), *Acacia Leucophloea* (4.38 t/ha) *Capparis Decidua* (3.80 t/ha) and *Prosopis Cineraria* (1.59 t/ha). The total tree biomass was 20.49 t/ha. The plot has a total of eight species in the shrubs/regeneration category, with a total standing biomass of 2.67 t/ha.

The village communities have also traditionally protected certain areas in the village. Some sample grids were studied from within these areas too. The analysis of species-wise biomass reported the presence of two species viz. *Acacia Leucophloea* (6.02 t/ha) and *Acacia Nilotica* (15.95 t/ha) in these areas. The total tree biomass for this area was 21.97 t/ha. Five species were reported in the category of shrubs/regeneration, with a total biomass of 0.88 t/ha.

Control

No trees were reported from the sampling grids of the unprotected area of the village. The area has nine species in the category of shrubs/regeneration, with a total of 3.53 t/ha biomass. The important species in this category are *Acacia Nilotica*, *Acacia Leucophloea*, *Prosopis Juliflora* etc.

4.3.2.5 Dhemri (Udaipur)

Plot

The analysis of species-wise biomass for the VFPMC plot of Dhemri village shows the presence of nine species of trees and a total tree biomass of 65.39 t/ha, of which

Tamarindus Indica (39.32 t/ha), *Eucalyptus sp.* (10.91 t/ha), *Diospyros Melanoxyton* (3.71 t/ha) and *Butea Monosperma* (3.55 t/ha) are the main tree species. The plot has 17 species in shrubs/regeneration category, with 4.21 t/ha biomass. The main species in this category are *Acacia LLeucophloea* (1.08 t/ha), *Dendrocalamus Strictus* (0.72 t/ha), *Carissa Carandas* (0.65 t/ha) and *Diospyros Melanoxyton* (0.45 t/ha).

Control

No trees were reported from the sampling grids in the unprotected area of the village. The area has four species in the shrubs/regeneration category, with a total of 2.49 t/ha biomass. The main species in this category are *Jatropha Curcas*, *Acacia Leucophloea*, *Butea Monosperma* and *HolopteliaIntegrifolia*, with *Jatropha Curcas* showing a maximum biomass of 1.90 t/ha.

4.3.2.6 Cheetrawas (Udaipur)

Plot

The analysis of species-wise biomass in the VFPMC plot shows a total of 11 tree species, with a total tree biomass of 282.82 t/ha. Trees contributing a maximum to the biomass are *Lannea Grandis*, *Boswellia Serrata*, *Butea Monosperma*, *Ficus Benghalensis* and *Sterculia Urens*. The plot has 29 species in the shrubs/regeneration category, with 13.16 t/ha biomass. The important species in this category are *Phoenix Sylvestris*, *Sterculia Urens* and *Annona Squamosa*.

Pasture

There are certain areas of the Commons that have been developed by the villagers as pasturelands. These areas show a very good growth of grass, with a total grass production of 7.92 t/ha at the time of sampling. The species-wise biomass analysis for this plot revealed a total of four tree species viz *Boswellia Serrata*, *Wrightia Tinctoria*, *Butea Monosperma* and *Terminalia Bellerica*. The total tree biomass is 148.17 t/ha, lower than that of the VFPMC plot. The plot has *Annona Squamosa*, *Holarrehena Antidysentrica* and *Phoenix Sylvestris* as the main shrub species, with 9.42 t/ha standing biomass.

Control

A total of three species of trees were reported in the sampling grids studied in the unprotected common lands of the villages, with the total tree biomass estimated as 140.43 t/ha. The area has *Annona Squamosa* and *Phoenix Sylvestris* as the main species in the shrubs/regeneration category, with an estimated biomass of 3.0 t/ha.

4.3.2.7 Rajakhedi (Agar, Madhya Pradesh)

The species-wise biomass analysis of the sample plot in Rajakhedi village reveals the occurrence of just one tree species in the plot (*Acacia Leucophloea*), with a total tree biomass of 15.76 t/ha. In the shrubs/regeneration category, with a total of six reported species, the total biomass was estimated to be 2.10 t/ha.

4.3.2.8 Rojani (Agar, Madhya Pradesh)

In the village of Rojani, the species-wise biomass analysis shows *Butea Monosperma* as the main tree species, with a biomass of 6.40 t/ha. The total tree biomass for the area is 7.63 t/ha. The plot has seven species of shrubs of which *Maytenus Emarginatus* is the main species alongside *Jatropha Curcas*. The total biomass of this category is 4.4 t/ha.

4.3.2.9 Jagatpura (Agar, Madhya Pradesh)

In the village of Jagatpura, the species-wise biomass analysis indicates *Acacia Leucophloea* as the main tree species, with a biomass of 4.56 t/ha. The total tree biomass is 5.80 t/ha. The plot has 10 species in the shrubs category of which *Butea Monosperma*, *Maytenus Emarginatus* and *Carissa Carandas* are the main species. The total biomass of this category is 2.22 t/ha.

4.3.2.10 Jodha Ka Kheda (Bhilwara, BAIF)

Plot

In the village of Jodha Ka Kheda, which is a project location of BAIF, the species wise biomass analysis shows *Acacia Leucophloea* as the main tree species with a biomass of 5.93 t/ha. The other tree species found in the sampling grids were *Acacia Nilotica* with 3.82 t/ha, *Acacia Senegal* with 0.44 t/ha and *Butea Monosperma* with 3.90 t/ha biomass. The total tree biomass of the area is 14.09 t/ha. The plot has nine species in the shrubs/regeneration category of which *Rhus Mysorensis*, *Prosopis Juliflora* and *Balanites Aegyptiaca* are the main species. The total biomass of this category is 2.36 t/ha.

Control

The species-wise biomass analysis in the unprotected areas of the Jodha Ka Kheda village highlights *Acacia Leucophloea* as the only tree species found in the sample plots, with a total biomass of 4.11 t/ha. The plot has seven species in the shrubs/regeneration category of which *Acacia Leucophloea*, *Prosopis Juliflora* and *Rhus Mysorensis* are dominant. The total biomass of this category is 0.41 t/ha.

4.3.2.11 Gudha Gokulpura (Bundi_BAIF)

In the village of Gudha Gokulpura, the analysis of species-wise biomass highlights *Acacia Leucophloea* as the main tree species, with a biomass of 8.25 t/ha. Other important species of trees are *Azadirachta Indica*, *Boswellia Serrata* and *Leucaena Leucocephala*. The total tree biomass for this area is 10.02 t/ha. The plot has seven species in the shrubs/ regeneration category. The total biomass of this category is 2.22 t/ha.

Control

In the unprotected areas of Gudha Gokulpura village, the species-wise biomass analysis revealed no species of trees inside the sample plots. The total biomass of the shrub/ regeneration category is 2.56 t/ha.

4.3.3 Plant Density

The data pertaining to the number/variety of plants per hectare shows a greater number of plants in all categories in the protected plots. This shows an improvement in the vegetational composition of these areas over time.

Table 22: Number of trees, shrubs and regeneration in the selected villages

Village	District	Landuse	Tree	Regn.	Shrub
FES SUPPORTED VILLAGES					
Bharenda	Bhilwara	Plot	114	5600	0
		Control	40	3600	480
Amaritya	Bhilwara	Plot	175	2400	50
		Control	80	1840	80
Sanjadi Ka Badiya	Bhilwara	Plot	154	831	1046
		Control	25	300	1050
Saredi kheda	Bhilwara	Plot	289	533	311
		Control	0	433	200
		Panchayat	175	800	200
Dheemri	Udaipur	Plot	150	2050	1350
		Control	0	933	534
Cheetrawas	Udaipur	Plot	205	1720	1640
		Pasture	133	667	1933
		Control	80	0	640
Rajakhedi	Agar	Plot	120	720	480
Rojani	Agar	Plot	100	880	1760
Jagatpura	Agar	Plot	120	960	2000
BAIF SUPPORTED VILLAGES					
Jodha Ka Kheda	Bhilwara	Plot	100	360	400
		Control	33	533	533
Gudha Gokulpura	Bundi	Plot	170	320	440
		Control	0	800	200

4.3.4 Phytosociology

The diversity indices indicate that the Shannon-Weiner's diversity index value for trees as well as for shrubs/regenerations show higher values for the protected plots in comparison to unprotected plots and other areas. It can therefore be concluded that the protected areas are more diverse in terms of plant species.

The values of the Simpson's index indicate a dominance of both tree as well as shrub species in the protected plots and the common lands of the villages. [*Dominance tendency was assumed when $C > 0.25$ (Stone & Pence, 1978; Yanez & Canaris, 1988)]

The values of the Pielou's evenness index show a largely even distribution of species across the sample points in the protected and unprotected plots. (The Pielou index is defined between 0 and 1, where 1 represents a community with perfect evenness, and decreases to zero as the relative abundances of the species diverge from evenness)

Table 23: Diversity Indices of woody species in selected villages

Village	Landuse	Plant Category	Shannon-Weiner Index	Simpson's Index	Pielou Index
FES SUPPORTED VILLAGES					
Bharenda	Plot	Tree	0.69	0.50	0.99
		Shrub	0.37	0.83	0.34
	Control	Tree	0.00	1.00	–
		Shrub	0.32	0.82	0.47
Amaritya	Plot	Tree	1.47	0.26	0.92
		Shrub	0.37	0.83	0.34
	Control	Tree	0.68	0.51	0.99
		Shrub	0.29	0.84	0.42
Sanjadi Ka Badiya	Plot	Tree	1.15	0.38	0.83
		Shrub	2.13	0.14	0.92
	Control	Tree	0.69	0.50	0.99
		Shrub	2.05	0.17	0.85
Saredi kheda	Plot	Tree	1.08	0.42	0.78
		Shrub	1.80	0.20	0.86
	Control	Tree	–	–	–
		Shrub	2.00	0.16	0.91
	Panchayat	Tree	0.63	0.56	0.90
		Shrub	1.36	0.32	0.85
	Control	Tree	–	–	–
		Shrub	1.23	0.33	0.88
Dheemri	Plot	Tree	2.01	0.16	0.92
		Shrub	2.55	0.10	0.90
Cheetrawas	Plot	Tree	2.09	0.15	0.87
		Shrub	2.74	0.11	0.81

Table 23: Diversity Indices of woody species in selected villages

Village	Landuse	Plant Category	Shannon-Weiner Index	Simpson's Index	Pielou Index
	Pasture	Tree	1.20	0.35	0.87
		Shrub	2.32	0.14	0.86
	Control	Tree	1.00	0.40	0.91
		Shrub	1.17	0.37	0.84
Rajakhedi	Plot	Tree	0.00	1.00	–
Shrub		1.59	0.24	0.89	
Rojani	Plot	Tree	0.48	0.70	0.69
Shrub		1.73	0.20	0.89	
Jagatpura	Plot	Tree	0.62	0.57	0.89
		Shrub	1.88	0.20	0.82
BAIF SUPPORTED VILLAGES					
Jodha Ka Kheda	Plot	Tree	1.24	0.32	0.89
		Shrub	2.01	0.16	0.91
	Control	Tree	0.00	1.00	–
		Shrub	1.89	0.16	0.97
Gudha Gokulpura	Plot	Tree	0.81	0.59	0.58
		Shrub	1.79	0.19	0.92
	Control	Tree	–	–	–
		Shrub	0.63	0.56	0.91

The table below shows the number of species that are found in different vegetation categories across the village landscapes. The maximum diversity in species is seen in the VFPMC plot of the village of Cheetrawas.

Table 24: Number of plant species in the selected villages

Village	District	Landuse	Category	No. of species
FES SUPPORTED VILLAGES				
Bharenda	Bhilwara	Plot	Tree	2
			Shrub/Climbers	3
			Grasses/Herbs	7
		Control	Tree	1
			Shrub/Climbers	2
			Grasses/Herbs	9
Amaritya	Bhilwara	Plot	Tree	5
			Shrub/Climbers	3
			Grasses/Herbs	7
		Control	Tree	2
			Shrub/Climbers	2
			Grasses/Herbs	8
Sanjadi Ka Badiya	Bhilwara	Plot	Tree	4
			Shrub/Climbers	10
			Grasses/Herbs	12

Table 24: Number of plant species in the selected villages

Village	District	Landuse	Category	No. of species		
Saredi kheda	Bhilwara	Control	Tree	2		
			Shrub/Climbers	11		
			Grasses/Herbs	7		
		Plot	Tree	4		
				Shrub/Climbers	8	
				Grasses/Herbs	6	
			Control	Tree	0	
				Shrub/Climbers	9	
				Grasses/Herbs	5	
Dheemri	Udaipur	Panchayat	Tree	2		
			Shrub/Climbers	5		
			Grasses/Herbs	5		
		Plot	Tree	9		
				Shrub/Climbers	17	
				Grasses/Herbs	9	
			Control	Tree	0	
				Shrub/Climbers	4	
				Grasses/Herbs	8	
Cheetrawas	Udaipur	Plot	Tree	11		
			Shrub/Climbers	29		
			Grasses/Herbs	25		
			Pasture	Tree	4	
				Shrub/Climbers	15	
				Grasses/Herbs	16	
		Control	Tree	3		
			Shrub/Climbers	4		
			Grasses/Herbs	13		
		Rajakhedi	Agar	Plot	Tree	1
					Shrub/Climbers	6
					Grasses/Herbs	6
Rojani	Agar	Plot	Tree	2		
			Shrub/Climbers	7		
			Grasses/Herbs	6		
Jagatpura	Agar	Plot	Tree	2		
			Shrub/Climbers	10		
			Grasses/Herbs	8		
BAIF SUPPORTED VILLAGES						
Jodha Ka Kheda	Bhilwara	Plot	Tree	4		
			Shrub/Climbers	9		
		Control	Tree	1		
			Shrub/Climbers	7		
Gudha Gokulpura	Bundi	Plot	Tree	4		
			Shrub/Climbers	7		
		Control	Tree	0		
			Shrub/Climbers	2		

4.3.5 Composition of Grasses/herbs

The grass species were sampled by the diagonal point intercept method in order to assess the percentage of grass cover and the importance of different grass species.

4.3.5.1 Bharenda

The results show that *Aristida Adscensionis* (51.64%), *Sporobulus Coromadelianus* (22.13%), *Justicia Simplex* (9.02%) and *Eragrostis Major* (6.56%) are the most important grass/herb species in the area. Ten species of grasses/herbs were reported from the sampling grids.

4.3.5.2 Amaritya

The results for the village of Amaritya show that *Aristida Adscensionis* (60.42%), *Sporobulus Coromadelianus* (20.14%), *Justicia Simplex* (6.25%) and *Chloris Barbata* (4.17%) are the most important species of grass/herb in the area. Ten species of grass/herbs were reported from the sampling grids.

4.3.5.3 Sanjadi ka Badiya

The table below shows the results for the Sanjadi ka Badiya village. It can be seen that *Aristida Adscensionis* (59.81%), *Sporobulus Coromadelianus* (19.63%), *Justicia Simplex* (6.78%) and *Eragrostis Major* (4.44%) are the most important grass/herb species of the area. Ten species of grasses/herbs were reported from the sampling grids.

4.3.5.4 Saredi Kheda

In the Saredi kheda village, the analysis of grasses/herbs shows that *Aristida Adscensionis* (63.43%), *Sporobulus Coromadelianus* (20%), *Justicia Simplex* (6%) and *Eragrostis Major* (6%) are the most important species in the area. Six species of grasses/herbs were reported from the sampling grids.

4.3.5.5 Dheemri

The table below shows the results for the village of Dheemri in Udaipur. Here, *Heteropogon Contortus* (28.62%), *Apluda Mutica* (23.1%), *Themeda sp.* (22.07%) and *Aristida Adscensionis* (13.45%) are the most important grass/herb species in the area. Ten species of grasses/herbs were reported from the sampling grids.

4.3.5.6 Cheetrawas

In the village of Cheetrawas, it can be seen that *Heteropogon Contortus* (24.35%), *Apluda Mutica* (25.92%), *Themeda sp.* (23.95%) and *Aristida Adscensionis* (5.5%) are the most

important grass/herb species in the area. A total of ten species of grasses/herbs were reported from the sampling grids.

4.3.5.7 Rajakhedi

The table below shows the results for Rajakhedi village. It can be seen that *Aristida Adscensionis* (39.13%), *Heteropogon Contortus* (34.14%) and *Iseilema Laxum* (11.96%) are the most important grass/herb species in the area. A total of six species of grasses/herbs were reported from the sampling grids.

4.3.5.8 Rojani

The table below shows the results for the village of Rojani . It can be seen that *Aristida Adscensionis* (37.96%), *Heteropogon Contortus* (23.36%) and *Iseilema Laxum* (18.25%) are the most important grass/herb species in the area. Six species of grasses/herbs were reported from the sampling grids.

4.3.5.9 Jagatpura

In Jagatpura village, *Aristida Adscensionis* (46.72%), *Heteropogon Contortus* (35.25%) and *Melanocenchris Jaquemontii* (10.66%) are observed as the most important species of grasses/herbs. A total of six species of grasses/herbs were reported from the sampling grids.

4.4 PALATABILITY ANALYSIS

This section includes an analysis of the palatable biomass in order to get an idea of the total amount of palatable biomass that is available in these areas for livestock consumption.

Table 25: Category wise palatable biomass in the watersheds

	Trees	Shrubs	Grasses/Herbs	Total Palatable BM
Thoria TGCS	0.52	0.25	0.88	1.65
Thoria Watershed	0.28	0.22	1.38	1.88
Control	0.06	0.07	0.49	0.62
Ladwan TGCS	0.26	0.16	4.95	5.37
Ladwan Watershed	0.19	0.25	4.54	4.98
Control	0.02	0.08	0.85	0.95

* All values in t/ha

The data for the two watersheds pertaining to palatable biomass indicate an improved availability of the same in these areas as compared to the control micro-watersheds. The maximum palatable biomass in all cases is derived from the category of grasses/herbs.

Table 26: Category wise palatable biomass in the selected villages

Villages	Tree			Shrub			Grass/Herb			Total Palatable biomass	
	Plot	Control	Average	Plot	Control	Average	Plot	Control	Average	Plot	Control
FES SUPPORTED VILLAGES											
Bharenda	0.56	0.20	0.38	1.03	0.64	0.84	0.22	0.43	0.33	1.81	1.27
Amaritya	0.63	0.33	0.48	0.44	0.05	0.25	0.58	0.43	0.51	1.65	0.81
Sanjadi Ka Badiya	0.68	0.04	0.36	0.14	0.16	0.15	1.32	0.83	1.07	2.14	1.03
Saredi Kheda	0.97	0.00	0.49	0.14	0.19	0.17	0.98	0.35	0.67	2.09	0.54
Dheemri	0.54	0.00	0.27	0.11	0.02	0.07	5.95	0.20	3.08	6.60	0.22
Cheetrawas	9.88	4.04	6.96	0.03	0.00	0.02	3.94	0.18	2.06	13.85	4.22
Rojani	0.43	NA	0.43	0.18	NA	0.18	1.51	NA	1.51	2.12	NA
Rajakhedi	1.42	NA	1.42	0.12	NA	0.12	2.46	NA	2.46	4.00	NA
Jagatpura	0.14	NA	0.14	0.10	NA	0.10	2.21	NA	2.21	2.45	NA
BAIF SUPPORTED VILLAGES											
Jodha Ka Kheda	0.67	0.06	0.37	0.10	0.11	0.11	0.57	0.02	0.29	1.34	0.19
Gudha Gokulpura	0.28	0.00	0.14	0.03	0.09	0.06	0.42	0.34	0.38	0.73	0.43

*All values in t/ha

The figures in Table 26 indicate an improvement in palatable biomass in the villages in comparison to the areas outside the protected plots. Here too, the maximum palatable biomass is derived from the category of grasses/herbs in almost all areas, save for the plots in Bharenda and Amaritya where the dense overgrowth of the *Anogeissus Pendula* has hampered the undergrowth of grasses and herbs but has itself proven to be a good source of fodder.

4.5 DISTRIBUTION AND USE OF DIFFERENT SPECIES

An analysis of the relative importance of the selected species found in different watersheds and villages has been attempted while keeping in consideration their ecologic, economic and social importance. A ranking has subsequently been devised, in the order of importance under different uses. The tables, showing the distribution of different species, have been provided in the annexure.

5. Discussion

THORIA

As observed in the study, the landscapes in the Thoria watershed are undergoing a process of restoration and succession. The biomass analysis reveals significant improvement in biomass of the area post the project interventions. In comparison to the control area, the overall standing biomass in the watershed is more than 9 ton/ha. The amount of palatable biomass is also seen to have improved from 0.62 t/ha to 1.88 t/ha in this watershed. The increase in number of trees per unit area, regeneration density and plant diversity indices also support the indication of improvement in the ecological health of the area.

LADWAN

The characteristics of Ladwan watershed differ from those of Thoria watershed owing to its location, climate and forest type. The type of intervention in this watershed has also been slightly different, where community governance and protection have played a major role in comparison to other measures such as direct biophysical support and fencing of the area (for supporting biomass growth). Community protection has helped increase the standing biomass from an average of 6.64 ton/ha to 15.64 ton/ha on the common lands. The palatable biomass has also improved to 5.37 ton/ha in comparison to 0.95 ton/ha in the control area.

A process of positive ecological succession can be observed in the watershed, with an increasing number of plant species inhabiting the priorly denuded areas. The regeneration is also seen to be increasing with the progressing age of restoration. Rich in nutrients, the soil in this region has the potential of yielding good results with effective mechanisms for protection. Greater efforts can be made in the area for the conservation and enrichment of rare species such as *Commiphora Wightii*.

SELECTED VILLAGES

The study of the selected villages across the two States has aided in a general understanding of the vegetational composition and patterns of resource use in these regions. The study has helped establish a direct relationship between ecological parameters, management systems, resource use patterns and socio-economic conditions of the selected areas. On the one hand, there are areas like Ladwan and Thoria, which have been developed with watershed approaches and the establishment of TGCSs in some villages, while on the other are the plots in southern Rajasthan which are under Joint Forest Management. There is observed a variation in the forest types and climate, and subsequently the vegetation of these areas, which is evident in all the vegetation parameters that have been studied. The study has included an analysis of vegetation composition in the high biomass-high biodiversity areas in Udaipur as well as the low biomass-low biodiversity areas like those in Bhilwara-Ajmer. However, as a general observation, the biomass as well as biodiversity has seen an improvement across all the areas with the improvement in management strategies. Further studies could be conducted in other villages of these areas and elsewhere, in order to gain a deeper understanding of the issues and processes prevalent in these regions - in ecological, social and economic terms.¹

¹ The summary of the phytosociological analysis has been provided in this report. The details of the analysis and the methods/formulae used for the same can be provided upon request.

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ANNEXURE DISTRIBUTION AND IMPORTANCE OF DIFFERENT SPECIES

1. List of selected tree species for their occurrence and importance in studied areas

Tree Species	Local Name	Fodder Use			Other Uses			Rajasthan Villages										Madhya Pradesh Villages					Water-sheds	
		Cattle	Goat/Sheep	Fuel	Timber	NTFP	TH	DH	SB	SK	JD	AM	BH	GG	DM	CH	KK	BP	RJ	RO	JG	TW	LW	
1. <i>Acacia nilotica</i>	Desi Babool	■	■	■	■	■	■	■	■	■						■	■					■	■	
2. <i>Acacia leucophloea</i>	Arunja	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
3. <i>Butea monosperma</i>	Khakra/Palas	■	■	■	■	■	■	■		■	■	■			■	■	■	■	■	■	■	■	■	
4. <i>Anogeissus pendula</i>	Dhok	■	■	■	■		■	■		■	■	■										■		
5. <i>Azadirachta indica</i>	Neem		■		■	■	■	■			■	■	■			■	■	■	■	■	■	■	■	
6. <i>Prosopis cineraria</i>	Khejri	■	■		■	■	■	■														■		
7. <i>Acacia catechu</i>	Khair	■	■	■	■					■						■	■	■	■	■	■	■	■	
8. <i>Acacia senegal</i>	Kumta	■	■	■	■	■	■			■												■		
9. <i>Acacia tortilis</i>	Israeli Babool	■	■	■	■		■	■														■		
10. <i>Allanthus exceisa</i>	Ardu/Adusa	■	■	■	■		■	■						■		■	■	■	■	■	■	■	■	
11. <i>Leucaena leucocephala</i>	Su-babool	■	■	■			■	■					■		■	■	■	■	■	■	■	■	■	
12. <i>Moringa oleifera</i>	Ghoda neem/Saijan	■	■			■								■										
13. <i>Boswellia serrata</i>	Salar		■	■	■	■							■	■	■									
14. <i>Lannea grandis</i>	Godal				■									■										
15. <i>Diospyros melanoxylon</i>	Tendu					■								■	■	■	■	■	■	■	■	■	■	
16. <i>Wrightia tinctoria</i>	Khirmi				■									■										
17. <i>Balanites aegyptiaca</i>	Hingot		■			■	■	■		■												■		
18. <i>Holoptelia integrifolia</i>	Chhal/Churel	■	■	■	■		■	■							■	■	■	■	■	■	■	■	■	
19. <i>Pongamia pinnata</i>	Karanj			■	■	■	■	■							■	■	■	■	■	■	■	■	■	
20. <i>Terminalia ballerica</i>	Bahera	■	■		■	■								■		■	■	■	■	■	■	■	■	

■ Very High/High; ■ Moderate; ■ Low

Abbreviations

AM = Amaritya
BH = Bharenda
BP = Bhanpura
CH = Cheetrawas
DH = Dhuwadiya
DM = Dheemri

GG = Gudha Gokalpura
JG = Jagatpura
JO = Jodha Ka Kheda
KK = Karwakhedi
LW = Ladwan Watershed
NTFP = Non Timber Forest Produce

RJ = Rajakhedi
RO = Rojani
SB = Sanajadi Ka Badiya
SK = Saredi Kheda
TH = Thoria
TW = Thoria Watershed

2. List of selected shrub/climber species for their occurrence and importance in studied areas

Shrub Species	Local Name	Fodder Use		Other Uses		Rajasthan Villages										Madhya Pradesh Villages					Water-sheds		
		Cattle	Goat/Sheep	Fuel	NTPF	TH	DH	SB	SK	JO	AM	BH	GG	DM	CH	KK	BP	RJ	RO	JG	TW	LW	
1. <i>Zizuphus numularia</i>	Ber/Bor	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
2. <i>Rhus mysorensis</i>	Dansra	■	■	■		■	■	■	■													■	
3. <i>Prosopis juliflora</i>	Vilayati babool	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
4. <i>Euphorbia caducifolia</i>	Thor		■			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
5. <i>Carissa carandas</i>	Karonda				■											■	■	■	■	■	■	■	■
6. <i>Maytenus emarginatus</i>	Kankero/Baikal	■	■	■		■	■	■	■	■		■			■	■	■	■	■	■	■	■	■
7. <i>Annona squamosa</i>	Sitaphal			■	■								■	■	■	■	■	■	■	■	■	■	■
8. <i>Capparis decidua</i>	Ker		■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
9. <i>Jatropha curcas</i>	Ratanjot			■	■								■	■	■	■	■	■	■	■	■	■	■
10. <i>Phoenix sylvestris</i>	Khajoor			■		■	■	■	■				■	■								■	
11. <i>Securinega sp.</i>	Salepan					■	■	■	■	■		■			■	■	■	■	■	■	■	■	■
12. <i>Asparagus racemosus</i>	Narkanta/Satavar				■	■	■	■														■	
13. <i>Dendrocalamus strictus</i>	Bans	■	■		■								■	■									
14. <i>Halarrehena antidysentrica</i>	Kadwa			■	■								■	■									
15. <i>Commiphora wightii</i>	Gugal			■	■	■									■	■	■	■	■	■	■	■	■
16. <i>Grewia tenax</i>	Gangan		■			■	■	■	■	■			■									■	
17. <i>Calotropis procera</i>	Aak		■			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
18. <i>Capparis horrida</i>			■						■	■	■	■											
19. <i>Capparis sepiaria</i>			■										■	■									
20. <i>Crotalaria burhia</i>	Shinio					■	■	■	■	■			■									■	
21. <i>Cucumis sativus</i>		■	■			■	■	■	■	■	■	■	■	■								■	

■ Very High/High; ■ Moderate; ■ Low

Abbreviations

AM = Amaritya
BH = Bharendra
BP = Bhanpura
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LW = Ladwan Watershed
NTPF = Non Timber Forest Produce

RJ = Rajakhedi
RO = Rojani
SB = Sanajadi Ka Badiya
SK = Saredi Kheda
TH = Thoria
TW = Thoria Watershed

3. List of selected grass/herbs species for their occurrence and importance in studied areas

Shrub Species	Local Name	Fodder Use		Other Use	Rajasthan Villages										Madhya Pradesh Villages					Water-sheds			
		Cattle	Goat/Sheep		TH	DH	SB	SK	JO	AM	BH	GG	DM	CH	KK	BP	RJ	RO	JG	TW	LW		
1. Cenchrus sp.	Dhaman/Bhurat	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
2. Aristida adscensionis	Lapda	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
3. Apluda mutica		■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
4. Cynodon dactylon	Dhob/Doob	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
5. Cassia tora	Kankeriyo			■										■	■	■	■	■	■	■	■	■	■
6. Heteropogon contortus	Suva-ghas	■	■										■	■	■	■	■	■	■	■	■	■	■
7. Commelina spp.		■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
8. Indigofera cordifolia	Bekar		■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
9. Bothriocloa pertusa		■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
10. Chloris spp.	Chinki	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
11. Cucumis sp.		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
12. Cyperus spp.	Motho	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
13. Dactyloctenium aegyptium		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
14. Digitaria spp.		■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
15. Echiochloa spp.	Jirio	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
16. Eclipta alba	Jal bhangaro/Bhringraj			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
17. Eragrostis major		■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
18. Evolvulus alsinoides	Phooli/Shankha pushpi			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
19. Iseilema laxum		■	■											■	■	■	■	■	■	■	■	■	■
20. Justicia simplex	Kagner				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
21. Melanocentris jacquemontii		■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
22. Sehima nervosum	Seran	■	■										■	■									
23. Setaria verticillata		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
24. Sporobolus sp.		■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
25. Tephrosia purpurea	Bisoni/Sarpankho				■	■																■	
26. Themeda sp.		■	■										■	■									
27. Tribulus terrestris	Kanti	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
28. Tridax procumbens				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
29. Vetiveria zizanioides	Khas	■	■	■										■	■	■	■	■	■	■	■	■	■
30. Zornia gibbosa		■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

■ Very High/High; ■ Moderate; ■ Low

Abbreviations

AM = Amaritya
BH = Bharendra
BP = Bhanpura
CH = Cheetrawas
DH = Dhuwadiya
DM = Dheemri

GG = Gudha Gokalpura
JG = Jagatpura
JO = Jodha Ka Kheda
KK = Karwakhedi
LW = Ladwan Watershed
NTPF = Non Timber Forest Produce

RJ = Rajakhedi
RO = Rojani
SB = Sanajadi Ka Badiya
SK = Saredi Kheda
TH = Thoria
TW = Thoria Watershed

SOUTH ASIA Pro Poor Livestock Policy Programme

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Our Motto

“development of healthy environments in which healthy animals are reared by healthy people”

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