

## ARTICLE

IDENTIFYING SITES FOR PROMOTING ECOTOURISM IN  
PHULWARI-KI-NAL WILDLIFE SANCTUARY (PWLS),  
SOUTHERN ARAVALLI HILLS OF INDIA

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## ABSTRACT

**Background:** Promoting eco-tourism in Wildlife Sanctuaries without compromising conservation can provide an opportunity for interested people to be in the midst of biodiversity and rare biota. The study was carried out in Phulwari-ki-nal Wildlife Sanctuary of Rajasthan with an objective to identify potential sites for promoting ecotourism. Plant wealth of the region was enumerated using vegetation samples and information obtained from vegetation samples like richness, diversity, density of all life forms were brought into GIS platform. Normalization and scaling techniques was adopted and weightage was given according to floral components to generate floral diversity map. Based on thematic maps plant diversity hotspot, tourism spots, path for nature walk and habitats for threatened plants and orchids distributions were identified to promote the Ecotourism in PLWS.

## INTRODUCTION

Phulwari-ki-Nal one of the ecological fragile area, forming the catchments of Wakal (Sabarmati) river is the lifeline of this sanctuary [1]. Presence of diverse micro and macro habitats is said to support considerable number of medicinally important plants and rich flora and fauna [2]. The southernmost sanctuary of Udaipur district and Rajasthan state, which is contiguous with the Polo forests of Vijaynagar Range of North Gujarat Region, forms a bridge for the wild animals to cross between the two forests. It is situated in 24° 00' - 24°10'N latitude and 73° 10' - 73° 20' E longitude [3]. The climate of the area is sub-tropical, characterized by three distinct seasons, Summer (March – June), Rainy season (July – September) and Winter (October – February). Rains, generally starts from mid June and continue till September. The forest of PWLS falls into the II Dry Tropical Forest as per classification [4]. This is further sub-classified into 5B - Northern Tropical Dry Deciduous Forest and C2 – Northern Dry mixed Deciduous Forest. The river and stream courses being rich in moisture provide special microhabitats, which encourage tall evergreen trees with dense undergrowth. The natural regeneration of all species is generally profuse and abundant [3].

A number of taxa of angiosperms are present in addition to that it is a home for orchids, tuberous plants, climbers and lianas. Based on published information a total 346 species belonging to 20 life forms [Table 1] and had a five species of Orchids [2, 5, 6, 7, 8, 9]. Crustose lichens are also present on rock and tree trunks that increase the floral diversity values of PWLS [2]. There are several deep pools along the riverbed Sabarmati, which are ideal home for crocodiles and other water dependent fauna. This forest is bestowed with patches of *Madhuca latifolia* groves, some extending to even c. 20 ha and forms an ideal habitat for the threatened Indian Flying Squirrel [2]. This sanctuary with its dense forest has rendered protection to threatened and conservation significant floral species viz. *Anogeissus serecea*, *Chlorophytum borivillianum*, *Commiphora wightii*, *Gloriosa superba*, *Strecculia urens*, *Tecomella undulata*, and faunal species like Indian Balloon Frog, Mugger or Marsh Crocodile, Alexandrine Parakeet, Grey Jungle Fowl, Aravalli Red Spurfowl, Flying squirrel, Sloth Bear, Leopard, Ratel and Pangolin [2]. The proposed study is “to examine the floral components and promote the ecotourism using geo-spatial technology that will attract the more tourists and also offer economical benefits to the villagers present in and around of PWLS.

## MATERIALS AND METHODS

The approach followed is an integrated method that accounts ecological, social, cultural factors of plants resources and biological factors influences the diversity of plants. This was carried out in three steps. (i) The mapping of forest and other related parameters. (ii) Field survey both rapid and intensive and group specific methods to collate information on floral biodiversity. (iii) The collected data processed in GIS flat form. Interpolated data helps in developing floral biodiversity map with Low, Moderate, High and Critical Areas of PWLS.

## Mapping the Land use and Forests

This process was started by procuring the topo maps of PAs with the boundaries for the respective forest department, digitized using GIS software and overlaid on the LISS IV P6 satellite data of November-December 2006, after geo-referencing boundaries and important places. Then the landscapes falling within the boundaries were classified into different land use categories, with details on broad forest types [10]. Following ground truthing method, the vegetation map was finalized [Map 1].

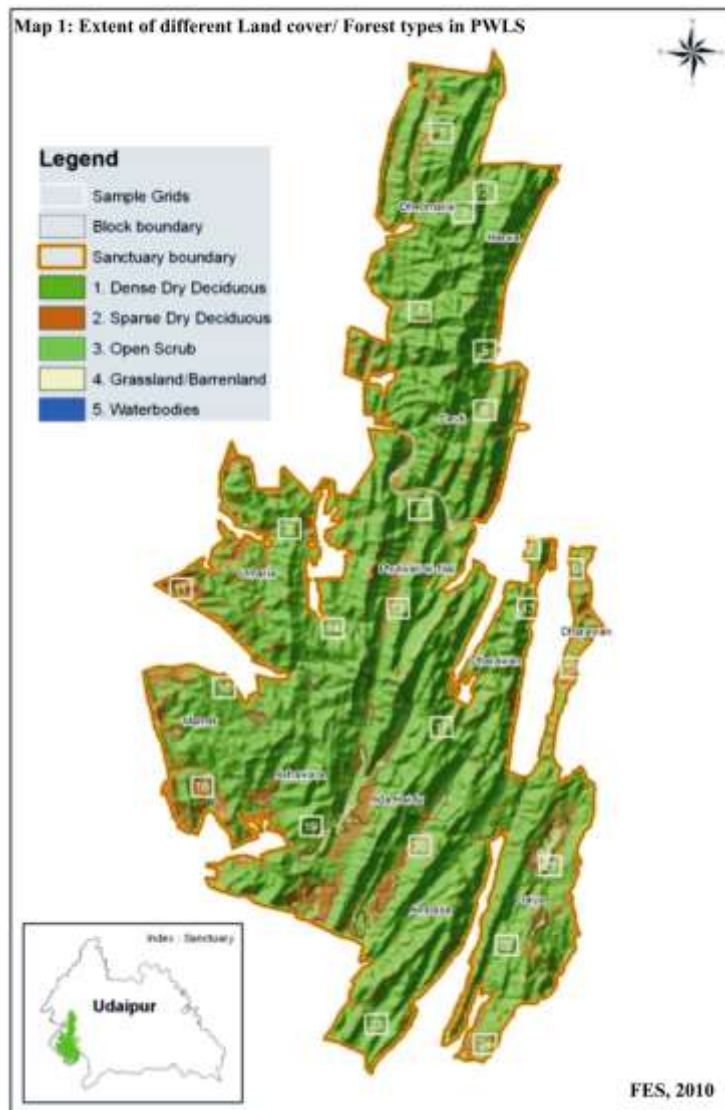
## KEY WORDS

Aravalli, Phulwari-ki-nal, Ecotourism, thematic map, GIS

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**Map 1:** Extent of different land cover/ forest types in PWLS.

### Field Data Collection

The entire area (vegetation map) of PWLS was divided into 1 km x 1 km grids. Based on the extent of vegetation types, grids were identified, it was sampled to assess the floral diversity and its components. The selection of grids based on approachability, accessibility, spatially distributed covering different altitude categories and distributed entire landscapes of respective vegetation type [Map 1].

The sampling was being done along a transect running in the diagonal axis of the grid, which extend to about 1.4km. In the case of sacred groves, reserved forest and community forest depending upon their extent of area, transects were used along with perambulation to record the floral components. Along this transect, taxa specific techniques was being adopted. At every 200 m intervals plots are being used to quantify vegetation [11, 12]. The plots are of varying size with 15m radius plots for trees, 5 m radius for shrubs, climbers and recruitment (gbh < 20cm and height >50cm) class of tree species and five plots of 1m x 1m for herbs, grass and regeneration class of tree and shrub (< 50cm height) species, smaller plots nested within the larger plot. For all trees (>20cm gbh at 1.3 m height) information on gbh, height, cutting, lopping signs if any and phenology at the time of sampling are being recorded. For shrubs, the species, cutting, lopping, browsing signs were being documented along with their phenology. In the case of climbers, liana, orchids the species, host plant species, height reached were documented. The species, numbers and percent cover (line-intercept method) was noted for the herbs and the grass species [13]. The numbers were being documented for the recruitment and regeneration class also. Surveys were conducted in all the three seasons (summer, winter & monsoon). In addition to the quantification, listing of plants species as part of inventORIZATION of each selected grids was also being done.

The threatened floral species were also searched along the entire length of transect within a width of 10 – 15m (belt-transect). Along these transects whenever a targeted species was located a species specific plot (vary in size according to the plant form) was used to enumerate and record the abundance, phenology, regeneration, associated species, macro & micro habitat parameters (habitats, terrain, slope, substrate, soil type, soil moisture, ground cover, canopy cover and other related environmental information) and site specific threats to the threatened plants.

The data thus collected were analyzed in grid wise, information like species richness, diversity and density of trees, its regeneration and recruitment, shrubs, climbers, herbs, grass, threatened species and % ground cover were derived into map. All these factors were brought into GIS domain and prepared floral diversity map of PWLS.

### Mapping of Floral diversity & Analysis

All these non spatial and spatial data (research components) were brought into GIS domain as separate layer to contribute maps on floral diversity. This analyzed data in terms of each column as variables were attached to the respective grid and used to generate the Arcinfo vector coverage file. Further the grid centers were extracted from Arcinfo coverage file using toolbox of ArcGIS as centroid along with the analyzed data. This point layer of centroids were used to perform the simple ordinary Kriging in Spatial Analyst to generate interpolated continuous raster layer as Arcinfo grids, such Kriging calculates the interpolated values for that particular parameter where the sampling grids was lacking within the extent of PWLS. With this approach floral diversity maps were prepared and ranked in the form of Low, Moderate, High and Critical Areas. Such continuous raster layers were reclassified into four categorical layers or classes as Low, Moderate, High and Very High. Further, distribution of threatened and endemic species, orchid with help of GPS reading that was taken at the time of data collection, were also added to floral diversity map to identify the sites for promoting eco-tourism in PWLS.

## RESULTS

### Species Richness of PWLS

The secondary information collected on the flora of PWLS, it was apparent that in total 346 species. As part of inventory, a total 515 species of plants was recorded belonged to 297 genera and 89 families. So the PWLS is a home for 616 species belongs to 340 genera and 92 families [3]. These species were represented from 21 life forms or habits [Table 1].

**Table 1:** Overall Status of Plants Species in Phulwari Ki Nal Wildlife Sanctuary

S. No	Habit/Life Forms	Primary Information			Secondary Information			Overall species in Phulwari Ki Nal WLS		
		F	G	S	F	G	S	F	G	S
1	Aquatic Herb	1	2	2	1	1	1	1	2	2
2	Climber	5	9	12	6	10	12	7	12	15
3	Climbing Herb	1	3	4	1	2	2	1	3	4
4	Climbing Shrub	1	1	1	0	0	0	1	1	1
5	Grass	1	30	53	1	27	35	1	38	69
6	Herb	49	122	201	32	75	112	52	135	239
7	Orchid	1	5	6	1	5	5	1	7	9
8	Parasite	2	3	4	2	3	3	2	3	5
9	Prostrate Herb	2	3	3	1	1	1	2	3	3
10	Scandent Shrub	2	2	3	2	2	2	2	2	3
11	Sedge	1	4	10	1	1	2	1	4	10
12	Shrub	17	28	32	13	22	24	19	35	40
13	Small Tree	17	20	22	16	16	18	19	22	25
14	Stragglng Shrub	8	9	11	6	6	6	9	10	12
15	Tree	33	55	81	32	57	79	33	61	94
16	Twiner	5	6	11	6	8	10	6	8	13
17	Twining Herb	4	10	15	3	6	9	5	11	18
18	Twining Shrub	4	6	6	3	4	4	5	8	8

19	Under Shrub	12	32	32	8	17	19	12	28	40
20	Woody Climber	3	3	4	1	1	1	3	3	4
21	Woody Twiner	2	2	2	1	1	1	2	2	2
	<b>Total</b>	<b>89</b>	<b>297</b>	<b>515</b>	<b>75</b>	<b>235</b>	<b>346</b>	<b>92</b>	<b>340</b>	<b>616</b>

### Diversity of Plant species in PWLS

Quantification of plants species was performed through grid based method. On the whole 280 plant species were recorded from 67 families and 192 genera. Mature tree showed richness of 52 species with the diversity of 2.55 and density of 234/ha. Regeneration showed 43 species with the diversity of 2.66 and density of 14068/ha. The regeneration ranges from 1000/ha to 42286/ha. 47 species were recorded from recruitment stage, with the diversity of 2.26 and density was 1695/ha (it ranges from 249/ha to 2659/ha). Shrub with a richness of 51 species and diversity showed 2.93, density was 740 shrubs/ha, climbers were 27 species, diversity 2.54 and density 259/ha. Herb form showed 109 species, diversity 2.55 and density was 17/sqm with the ground cover of 21%, finally grass were 28 species with the diversity of 2.12, density was 7/sqm and ground cover was 7 % [Table 2].

**Table 2:** Floristic Diversity of Phulwari Ki Nal Wildlife Sanctuary

Overall	Mature Tree	Regeneration	Recruitment	Shrub	Climber	Herb	Grass	Total
Family	29	26	26	23	12	31	2	67
Genus	41	38	39	45	21	76	19	192
Species	52	43	47	51	27	109	28	280
Density	234	14068	1695	740	259	17	7	0
Abundance	2432	1034	5006	2186	814	12190	5042	28704
Diversity	2.55	2.66	2.26	2.93	2.54	2.55	2.12	3.82
% Cover	0	0	0	0	0	21	7	28

The mapping of the floral diversity showed that the vegetation assemblage was moderate all over the sanctuary with high diversity found in two distinct patches, one in the central part and other larger patch located in the lower half at the central portion extending to the western boundary of the study area [Map 2]. Very high floral diversity was also recorded at two locations but in comparatively smaller patches. One located at the northern boundary of the Phulwari-ki-Nal forest block and another at the northeastern boundary of Ambasa and northwestern boundary of Daiya forest blocks [Map 2]. The block wise diversity revealed that Dharavan, Daiya, and Adahaldu forest blocks had high to moderate floral diversity, while Phulwari-ki-Nal, Ambasa and Ashawara blocks had moderate to high diversity. Devali, Harwa, Umaria and Mamer forest blocks were found with moderate diversity. Dhedmariya block had moderate to low diversity [Map 2].

### Distribution of Threatened Plants and Orchids

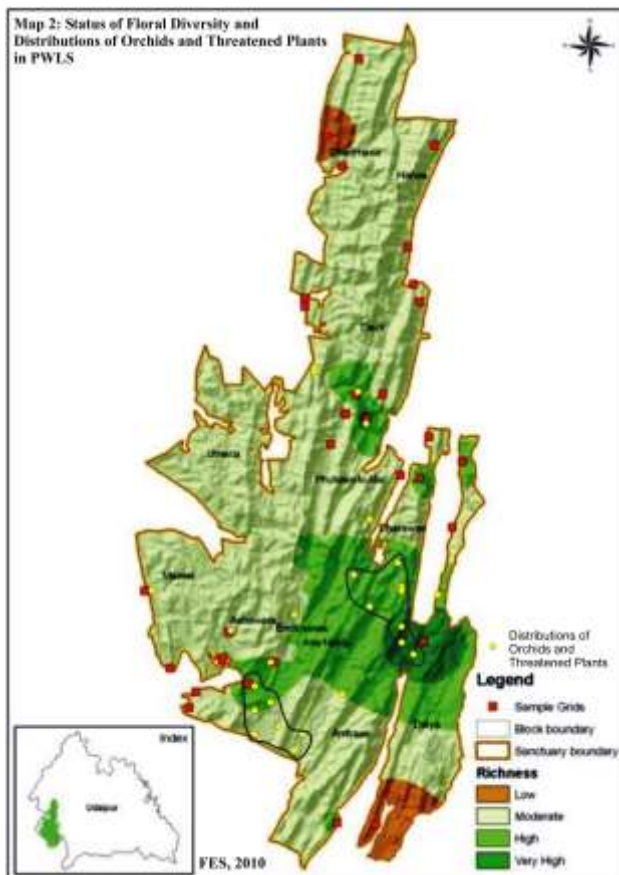
The presence of 25 threatened plants species belongs to 25 genera and 18 families were recorded from PWLS. The threat status revealed that four were endangered, 12 vulnerable, two near threatened, one intermediate and six with status as unknown [Table 3]. The PWLS is a home of 9 orchid species, based on available information 4 aerial and 5 ground orchids were recorded from this sanctuary [Table 4].

The mapping of the richness of the orchids and threatened species being found in central portion and below, majorly two groups, one is located in south west (Ambasa, Ashawara blocks) and other in south east (Dharavan, Ada Haldu and Ambasa blocks) part of PWLS. Few scattered locations in blocks of Phulwari-Ki-Nal, Mamer, Ashawara and Devli were also recorded.

**Table 3:** Status of Threatened plants species in Phulwari Ki Nal Wildlife Sanctuary

S. No	Scientific Name	Status	Total
1	<i>Alysicarpus tetragonolobus</i> Edgew.	?	49
2	<i>Ampelocissus latifolia</i> (Roxb.) Planch.	?	45
3	<i>Anogeissus sericea</i> Brandis var. <i>nummularia</i> King ex Duthie	I	12
4	<i>Barleria acanthoids</i> Vahl	VU	9
5	<i>Blepharis linariaefolia</i> Pers.	VU	3
6	<i>Boswellia serrata</i> Roxb. ex Cocls.	EN	23
7	<i>Butea monosperma</i> var. <i>lutusa</i> (Witt.) Maheshwari.	?	2
8	<i>Celastrus paniculata</i> Willd.	VU	27

9	<i>Costus speciosus</i> (Koenig ex Retz.) Sm.	VU	6
10	<i>Feronia limonia</i> (L.) Swingle	VU	2
11	<i>Gloriosa superba</i> L.	VU	47
12	<i>Habenaria furcifera</i> Lindl.	?	8
13	<i>Manilkara hexandra</i> (Roxb.) Dub.	EN	3
14	<i>Moringa concanensis</i> Nimmo ex Dalz. & Gibs.	VU	4
15	<i>Nervilia aragoana</i> Gaud.	?	168
16	<i>Ocimum gratissimum</i> L.	VU	4
17	<i>Oroxylum indicum</i> (L.) Vent.	EN	5
18	<i>Ougeinia oogeinsis</i> (Roxb.) Hochr.	EN	1
19	<i>Peristylus stocksii</i> (Hk. F) Kranz.	?	68
20	<i>Pueraria tuberosa</i> (Roxb. ex Willd.) DC.	VU	5
21	<i>Sarcostemma viminale</i> (L.) R. Br. subsp. <i>viminale</i>	VU	1
22	<i>Schrebera swieteinoides</i> Roxb.	VU	10
23	<i>Soymida ferbrifuga</i> (Roxb.) A. Juss.	NT	9
24	<i>Sterculia urnes</i> Roxb.	VU	3
25	<i>Terminalia arjuna</i> (Roxb. ex DC.) Waight & Arn.	NT	9
<b>Total Abundance</b>			<b>523</b>
<b>Species Richness</b>			<b>25</b>



**Map 2:** Status of Floral Diversity, Distribution of Orchids and Threatened Plants in PWLS.

### Tourism Hot spots

Important areas for conservation through ecotourism were selected from the blocks, which has high numbers of threatened plants and orchids. The selected sites [Map 3] for promoting ecotourism activities are Ambasa-Ashawara (high to moderate diversity) and Dharavan-AdaHaldu-Ambasa (high to very high diversity of floral components). Apart from identified sites, the tourism activity can be promoted in floral diversity rich areas of Map 2 (northern boundary of the Phulwari-ki-Nal forest block, northeastern boundary of Ambasa and northwestern boundary of Daiya forest blocks). Further, the area marked under the low diversity and moderate diversity of vegetation can be improved through conservation measures involving eco-tourist. Tourist will inspire with the ambiance of natural forest cover and values, showing as a model for improving the degraded lands through active participations.



**Map 3:** Sites for Promoting Ecotourism in PWLS.

**Table 4:** Status of Orchid species in Phulwari Ki Nal Wildlife Sanctuary

Sl. No	Scientific Name	Pri. Info.	Sec. Info.	Orchid in PWLS
1	<i>Acampe praemorsa</i> (Roxb.) Blatt. & McCann.		*	*
2	<i>Aerides crispum</i> Lindl.	49		*
3	<i>Aerides maculosum</i> Lindl.	*		*
4	<i>Eulophia ochreatea</i> Lindl.		*	*
5	<i>Habenaria furcifera</i> Lindl.*	8		*
6	<i>Habenaria longicorniculata</i> Grah.		*	*
7	<i>Nervilia aragoana</i> Gaud.*	168	*	*
8	<i>Peristylus stocksii</i> (Hk. F) Kranz.*	68		*
9	<i>Vanda tessellata</i> (Roxb.) Hook. ex G. Don	*	*	*

\* Threatened Species

## CONCLUSION

Promoting tourism is a basic principle of wildlife conservation. Phulwari-ki-nal Wildlife Sanctuary has a good scope of tourism since it has rich floral diversity along with multifarious tribal culture. This sanctuary is a natural home 616 species that includes 9 orchids and 25 locally and globally endangered plant species. But this sanctuary not familiar for the ecotourism activities, very few people visits this sanctuary. Apart from conventional practices, the science and technology approaches will help the forest department do a systematic plan for ecotourism activities. i.e developing tourism facilities, nature trails, identifying more watching point, camping site, publicity, brochure and signage in this sanctuary. Also these kinds of study very useful to have a regular monitoring of biodiversity components and developing a long term conservation plan for PWLS.

## CONFLICT OF INTEREST

None

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## FINANCIAL DISCLOSURE

None

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