

Gap Analysis for Protected Areas of Andhra Pradesh, India for conserving biodiversity

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Abstract: A gap analysis was carried out to assess the Protected Area (PA) network system in Andhra Pradesh, India. The decisive factors of vegetation type distribution, elevation and endemism was used to determine the representativeness of PA system. In Andhra Pradesh, vegetation cover occupies 23.03% of geographical area and distributed in Coastal Plains, Deccan Plateau and Eastern Ghats. There are 27 PAs for conservation in Andhra Pradesh. The total area protected for biodiversity is about 12,555 km² or 4.56% of geographical area of Andhra Pradesh. Of the three physiographic regions, Eastern Ghats represents very high area under PAs which was estimated as 7811.38 km² followed by Deccan plateau of 3526.89 km². Three main forest types (semi evergreen forests, thorn forests and dry evergreen forests) missing in the existing PA network were identified. Moist deciduous forests of Eastern Ghats of northern Andhra Pradesh were under-represented in PAs. The land area in an elevation range of 900m-1527m was not included in PA network. Of the 103 species of endemics, 64 species were not included in PA system. Many PAs are experiencing threat from invasive species, forest fires, grazing pressure etc. There is a need to consider for possible ways for effective conservation and to extend the present PA network system in India.

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1. Introduction

International treaties call for the conservation of biodiversity in all its manifestations including ecosystem level diversity. Conservation biology is concerned with developing the scientific support for conservation policy and management decisions. Conservation efforts have focused on maintaining biodiversity through establishment of networks of protected areas. Protected areas (PAs) are the priority centers of biodiversity and wildlife conservation. The criteria of biodiversity inventory, vegetation type distribution, topographic variability, climatic gradient and biotic pressure are basic stuff in conservation planning. These surrogates can be effective at representing other aspects of biodiversity, such as ecological uniqueness, species distributions, species diversity and contiguous intact natural habitats (Kirkpatrick and Brown, 1994, Wessels *et al.* 1999). Conservation planning exercises also call for data on the distribution of PAs. But many PA systems across the world were chosen based on socio-economic and aesthetic criteria (Oldfield *et al.* 2004). Gap analysis is a comprehensive approach for assessing conservation needs. The gap analysis has been undertaken by few researchers (Hunter and Yonzon, 1993; Fearnside and Ferraz, 1995; Powell *et al.* 2000; Scott *et al.* 2001; Bon and Gaston, 2005)

India is one of the mega-diversity nations in the world. India has 590 PAs (ca. 500 wildlife sanctuaries and 90 national parks. PAs of India cover 156,700 km², roughly 4.95% of the total geographical area (<http://en.wikipedia.org.2010>). There is a pressing requirement to identify gap areas of high biological richness to declare new Protected Areas in India. Spatially explicit inventories of vegetation types and land cover permit comparisons between particular vegetation distributions and distributions of land cover, land-cover change, expected changes and issues of protected areas. With the current trend of increasing rate of deforestation and loss of habitats in densely populated developing countries, there is a urgent need to generate database which is available for planning, decision making and further objective oriented requirements. Satellite remote sensing along with Geographic Information System (GIS) provides a cost and time effective solution to collect, process and integrate database in an effective manner. In the present study, an attempt was made to identify 'gap areas' in PA network of Andhra Pradesh, India which covers a major part of Deccan Plateau, Eastern Ghats and East Coast regions by integrating spatial and non spatial databases.

2. Material and Methods

The study was conducted in Andhra Pradesh, is the largest State of southern India. The State of Andhra Pradesh (The land of Telugu people) is situated in the middle of eastern half of the Indian Peninsula lying between 12° 41' - 19° 54' N latitudes and 76° 46' - 84° 45' E longitudes. It is bounded by the Bay of Bengal in the east, Tamil Nadu in the south, Karnataka in the west, and Maharashtra, Chhattisgarh and Orissa in the north. Administratively, Andhra Pradesh has 23 districts which were grouped into three zones: (1) *Circars* or *Coastal Andhra* with nine districts, i.e. East Godavari, Guntur, Krishna, Nellore, Prakasam, Srikakulam, Vizianagaram, Visakhapatnam and West Godavari (2) *Royalaseema* with four ceded districts, i.e. Anantapur, Chittoor, Cuddapah and Kurnool (3) *Telangana* (Deccan or erstwhile Nizam's Dominions of Hyderabad State) with 10 districts, i.e. Adilabad, Hyderabad, Karimnagar, Khammam, Mahabubnagar, Medak, Nalgonda, Nizamabad, Rangareddy and Warangal.

Geographically, the State is categorized into three regions, namely: (1) the *Coastal Plains* (along the east coast, a low-lying area from from Srikakulam to Nellore) mainly of agricultural land and mangroves (2) the *Eastern Ghats*, forming a chain of discontinuous range of hills along the coast with good vegetation, and (3) the *Deccan Plateau* consisting of agricultural lands, scrub and deciduous forests, which cover part of Kurnool (excl. Nallamalais), Anantapur districts (excl. Nigidi hills) and the major part of Telangana. The total forest cover of the State is 44,419 km², which occupies 16% of the total geographical area of 275,068 km² (FSI, 2003). The highest peak in Andhra Pradesh is Sambarikonda (1527 m), found in RV nagar range of Visakhapatnam district.

Preparation of vegetation type and land use map was accomplished through visual interpretation of multi-season IRS P6 LISS III images as part of project on "biodiversity characterization at landscape level" (Reddy et al. 2008). The protected areas information was accessed from the Protected Areas Database (Anonymous, 2007). In the present study vegetation type information, elevation data (<http://www.landcover.org/data/srtm/>) and endemism was used to determine 'gap areas' for Protected Areas network (Reddy et al. 2006).

3. Results

In Andhra Pradesh, vegetation cover occupies 23.03% of total geographical area. While forest cover of the State is estimated as 44,334 km². The area under forest cover is proportionately 16.12% of total geographical area (Table 1). The forest types found in Andhra Pradesh are Semi

Evergreen, Moist Deciduous, Dry Deciduous, Dry Evergreen, Thorn, Teak mixed, Bamboo mixed, mangrove, riverine forest, woodland, savannah and forest plantation (Table 2). Most abundant forest type was Dry Deciduous forest (Fig. 1) which comprises 73.36% of the total forest area, followed by Moist Deciduous forest of 10.98%. Scrub/shrub land occupies significant area, which is about 6.54% of total geographical area of State. There are about 18,443 wetlands, accounts for 11,572.50 km² (4.21%) of total area of State.

Table 1. Areal extent of Vegetation and Land Use of Andhra Pradesh, India

Sl.no.	Class	Area (km ²)	% of Area
1	Forest	44334	16.12
2	Scrub	17982.9	6.54
3	Grassland	1032.7	0.38
	Subtotal	63349.5	23.03
4	Wetland	11572.5	4.21
	Other Land		
5	Use	200146	72.76
	Subtotal	211718.5	76.97
	Grand total	275068	100

Table 2. Areal extent of forest types of Andhra Pradesh, India

Class	Area (km ²)	% of Area
Semi Evergreen forest	1585.4	3.58
Moist Deciduous forest	4865.85	10.98
Dry Deciduous forest	32524.03	73.36
Thorn forest	66.42	0.15
Dry Evergreen forest	221.55	0.5
Teak mixed forest	461.14	1.04
Bamboo mixed forest	654.02	1.48
Mangrove	329	0.74
Riverine forest	1209.09	2.73
Forest Plantation	1156.99	2.61
Woodland	397.59	0.9
Savannah	862.92	1.95
Grand total	44334	100

3.1 Total coverage of PAs

There are 27 PAs declared for conservation in Andhra Pradesh, comprising 22 wildlife sanctuaries and 5 national parks (Table 3; Fig.2). The areas of the individual PAs range from 1.42 to 3,568 km². Taking into account the wildlife sanctuaries and

national parks, the total area protected for biodiversity is about 12,555 km² or 4.56% of geographical area of Andhra Pradesh. Of the 63,349.5 km² of natural vegetation in State, 11,773 km² (18.6%) of area was under PA network. Of the three physiographic regions, Eastern Ghats represents very high area under PAs which was estimated as 7811.38 km² (62.2% of total PA) followed by Deccan plateau of 3526.89 km² (28%). Altogether an area of 1287.83 km² (10.3%) was demarcated for PA system in coastal plains. Nagarjunasagar Srisailem Tiger Reserve is largest tiger reserve of the country, occupies 28% of the total PA of Andhra Pradesh. Of the five PAs of coastal plains, Nelapattu wildlife sanctuary is smallest with an area of 4.58 km² and Kolleru is largest with an area of 308.55 km². Of the eight wildlife sanctuaries in Deccan Plateau (Telangana), Pakhal (860.2 km²) and Eturnagaram (803 km²) are occupying 47.42% area. The PA area under grassland and wetlands are accounted as 6.14 km² and 782.1 km² respectively.

Table 3. Protected Areas of Andhra Pradesh and representation of Vegetation types

Protected Area	Area (km ²)	% of PA	Habitat/Veg. type	Elevation (m)
Coastal Plains				
Coringa	235	1.87	Mangroves, Wetland	<100
Krishna	200	1.59	Mangroves, Wetland	<100
Pulicat lake	469	3.74	Wetland	<100
Nelapattu	4.58	0.04	Wetland	<100
Kolleru	308.55	2.46	Wetland	<100
Sub total	1217.1	9.69		
Eastern Ghats				
Nagarjunasagar Srisailem Tiger Reserve	3568	28.42	Dry deciduous forest, Scrub	100-800
Gundla Brahmeswaram	1194	9.51	Dry Deciduous forest, Moist deciduous forest, Scrub	300-900
Rollapadu	6.14	0.05	Grassland	200-300
Rajiv Gandhi National Park	2.3	0.02	Dry deciduous forest, Scrub	400-500

Peninsula Narasimha	1030.9	8.21	Dry Deciduous forest, Scrub and Pennar basin	100-900
Sri Lankamalleshwara	464.42	3.7	Dry deciduous forest, Scrub	100-800
S.V. Wildlife Sanctuary and National Park	525.97	4.19	Dry deciduous forest, Scrub	200-900
Kaundinya	357.6	2.85	Dry deciduous forest, Scrub	300-700
Papikonda	591.4	4.71	Dry Deciduous forest, Moist deciduous forest, Scrub	100-700
Kambalakonda	70.7	0.56	Dry deciduous forest, Scrub	100-400m
Sub total	7811.4	62.22		
Deccan Plateau				
Kawal	893	7.11	Dry deciduous forest, Scrub	100-600
Pranahita	136.02	1.08	Dry deciduous forest, Scrub	100-200
Sivaram	29.81	0.24	Dry deciduous forest, Scrub	100-200
Kinnerasani	635.4	5.06	Dry deciduous forest, Scrub	100-400
Eturnagaram	803	6.4	Dry deciduous forest, Scrub	100-200
Pakhal	860.2	6.85	Dry deciduous forest, Scrub	200-400
Manjira	20	0.16	Dry deciduous forest, Scrub	400-600
Pocharam	129.8	1.03	Dry deciduous forest, Scrub	400-600

KBR National Park	1.425	0.01	Dry deciduous forest, Scrub	500-600
Mrugavani National Park	3.6	0.03	Dry deciduous forest, Scrub	500-600
MHV National Park	14.59	0.12	Dry deciduous forest, Scrub	500-600
Sub total	3526.9	28.09		
Grand total	12555	100		

3.2 Coverage by vegetation type distribution

The semi evergreen forests of Andhra Pradesh were not covered under PA network. Semi evergreen forests were seen only in the northern parts of Andhra Pradesh above an elevation of 900m to 1500m and found in Chintapalle, Gudem, Lankapakala, Sambarikonda, Upper Sileru, Sapparla hills of Visakhapatnam, Dummakonda, Maredumilli, Peddakonda hills of East Godavari. Total area covered by this forest is 1,585.4 km² (3.58% of total forest area). The mean annual rainfall in semi evergreen forests is high as compared with other forest types, which is in the range of 1300mm-1700mm.

Moist Deciduous forests are found extensively in Eastern Ghats of northern Andhra Pradesh region, parts of Khammam, Warangal, Adilabad, Gundlabrahmeswaram of Nallamalais and Talakona RF in Chittoor district. The area coverage is about 4,865.85 km² (10.98% of total forest area). These forests were exists between elevation of 600m to 900m and mean annual rainfall of 1000mm-1300mm. Moist deciduous forests of East Godavari, Visakhapatnam, Srikakulam, Vizianagaram and West Godavari districts and Mothugudem of Khammam district were unique and not present in PA network. Sal mixed deciduous forests of parts of Srikakulam (Seethampet and Donubayi) and Vizianagaram districts also significant and can be prioritized for protection.

The dry deciduous forests are conspicuous throughout Andhra Pradesh with supremacy in Telangana and Rayalaseema districts. It occurs at an altitude of around 200m-600m. It is spreading over an area of 32,524 km² (73.36% of total forest area). Dominance of species differs across different regions. Red Sanders (*Pterocarpus santalinus*) is gregarious species and forms Red Sanders mixed forest in Seshachalam hills of Cuddapah and Chittoor districts. Teak and Bamboo often occurs gregariously and characterize similar associations of dry deciduous

forests. Even though, 20 PAs were represented in dry deciduous forests, still forests like Nigidi hills of Anantapur, Mahadevpur-Kaleshwaram of Karimnagar, Narsapur of Medak, Manchippa of Nizamabad and Chathakonda, Venkatapuram of Khammam need to be considered in view of their community distinctness, geographical situation and topographic variability.

Thorn forests are prevails mostly in Anantapur, Chittoor, Cuddapah, Kurnool and Nalgonda districts. This is characteristic of the dry areas with low rainfall and high temperatures. There is no any PA for thorn forests. The forests of Erramalais of Kurnool, parts of Palakonda hills of Cuddapah and Nagalapuram hills of Chittoor can be prioritized for conservation. Dry Evergreen forest is a unique forest shows dominance of deciduous elements and small leathery-leaved evergreen trees with short trunks and the dense shrubby undergrowth. Dry evergreen forests of Vinukonda range of Guntur district and Kondapalle of Krishna district need to be considered for PA network.

Mangroves are unique systems of east coast, distributed mainly in East Godavari, West Godavari, Krishna, Guntur and parts of Prakasham districts. Total area covered by mangroves is 329 km². The major area of Mangrove was under protection in Coringa wildlife sanctuary and Krishna wildlife sanctuary. Grasslands are mostly found in Rollapadu sanctuary and environs of Kurnool district and in hill tops of Eastern Ghats of northern Andhra Pradesh. Grasslands of Dummakonda and Peddakonda of East Godavari and Gudem, Sapparla, Sileru and Sambarikonda of Visakhapatnam are potential areas for PA network.

3.3 Coverage by Elevation

Most of Andhra Pradesh (91.73%) is covered by land with an elevation of <600 m (asl) but only 3.76% of this area corresponds to PA status (Table 4), (Fig. 3). The land between elevation of 300-600m represents 2% of area coverage under PAs. The proportion of PA is very less (0.80%) in an elevation range of 600-900m. However, about 75% of the land between elevation of 900m and 1527m in Eastern Ghats of northern Andhra Pradesh has vegetation cover, but there is no single PA. The geographical area of elevation above 900m occupies 3598.72 km² (1.31% of total TGA) need to be considered for declaration of 'Biosphere Reserve'. Coastal plains were received consideration of forest managers and important wetlands of international/national importance were included in PA network.

Table 4. Proportion of PAs with reference to elevation range and geographical area of Andhra Pradesh

Elevation Range (m)	Geographic area (km ²)	% of geographic area	% of PA network
<100	63156.85	22.96	0.44
100-300	91065.96	33.11	1.32
300-600	98110.11	35.67	2
600-900	19136.18	6.96	0.8
>900	3598.72	1.31	0
Total	275068	100	4.56

3.4 Coverage by Endemism

Endemism is a special criterion in conservation of any area. The word 'endemic' is ascribed to any taxon, which has a restricted distribution. Because of their narrow distributional zonation, endemic species became important target for global conservation efforts. Of the 27 Protected Areas in Andhra Pradesh, Sri Venkateshwara wildlife sanctuary/national park, Nagarjunasagar-Srisailem tiger reserve, Gundlabrahmeswaram wildlife sanctuary, Sri Lankamalleshwara wildlife sanctuary, Peninsula Narasimha wildlife sanctuary and Pakhal wildlife sanctuary represents endemic species (Table 5). Sri Venkateshwara wildlife sanctuary represents 24 endemic species, which are edaphically and climatically adapted to occur in small ecological refugium. So, there is an urgent need to elevate the status of Sri Venkateshwara wildlife sanctuary and national park as 'Seshachalam Biosphere Reserve'. Of the 103 species of endemics, 64 (62%) species were not included in PA network. Of the 45 red listed (threatened) species, 24 (53%) were not covered in PA network. The upper hills of Visakhapatnam district represents 27 endemic species and seven endangered species, needs immediate concern.

Table 5. Distribution of Endemic species of Andhra Pradesh

Taxon	Protected Area	Red Data Book category	Veg. type
<i>Acacia campbelli</i> Arn.	N.A.	Vu	DD
<i>Albizia thompsonii</i> Brandis	Gundlabrahmeswaram	Vu	DD
<i>Alphonsea madraspatana</i> Bedd.	N.A.	-	MD
<i>Alysicarpus mahabubnagarensis</i> Raghavarao et al.	N.A.	-	DD

<i>Alysicarpus monilifer</i> (L.) DC. var. <i>cuddapahensis</i> Almeida & Almeida	N.A.	-	DD
<i>Andrographis beddomei</i> Clarke	Nagarjunasagar-Srisailem and Sri Lankamalleshwara	-	DD
<i>Andrographis nallamalayana</i> Ellis	Nagarjunasagar-Srisailem and Gundlabrahmeswaram	-	DD
<i>Aphyllorchis montana</i> (Thw.) Reichb.f.	Sri Venkateshwara	Vu	DD
<i>Argyrea arakuensis</i> Balakr.	N.A.	-	SEG
<i>Argyrea srinivasanii</i> Subba Rao et Kumari	N.A.	-	SEG
<i>Arthraxon depressus</i> Stapf ex Fischer	N.A.	Vu	DD
<i>Arthraxon lanceolatus</i> (Roxb.) Hochst. var. <i>echinatus</i> (Nees) Hack.	N.A.	-	DD
<i>Arundinella setosa</i> Trin. var. <i>lanifera</i> Fischer	N.A.	Vu	DD
<i>Atylosia cajanifolia</i> Haines	N.A.	Vu	MD
<i>Barleria morrisiana</i> Bor ex Fischer	N.A.	-	DD
<i>Boswellia ovalifoliolata</i> Balakr. & Henry*	Sri Venkateshwara	En	DD
<i>Brachystelma glabrum</i> Hook.f.	N.A.	-	DD
<i>Brachystelma volubile</i> Hook.f.	N.A.	-	DD
<i>Bridelia cinerascens</i> Gehrm.	Sri Venkateshwara	-	DD
<i>Bulbophyllum kaitiense</i> (Wight) Reichb.f.	Sri Venkateshwara	Vu	DD
<i>Bupleurum andhricum</i> Nayar & Banerji	N.A.	-	SEG
<i>Caralluma indica</i> N.E.Br.	N.A.	-	DD
<i>Caralluma lasiantha</i> N.E. Br.	N.A.	-	Thorn
<i>Ceropegia spiralis</i> Wight.	Nagarjunasagar-Srisailem and Sri Venkateshwara	Vu	DD
<i>Chamaesyce linearifolia</i> Sojak var. <i>nallamalayana</i> (Ellis) V.S. Raju & P.N. Rao	Nagarjunasagar-Srisailem	-	DD

<i>Chamaesyce senguptae</i> (Balakr. & Subr.) V.S. Raju & P.N. Rao	Nagarjunasagar-Srisailam and Gundlabrahmeswaram	-	DD	<i>Eriolaena lushingtonii</i> Dunn	Nagarjunasagar-Srisailam	Vu	DD
<i>Chrysopogon velutinus</i> (Hook.f.) Bor	N.A.	-	DD	<i>Glochidion tomentosum</i> Dalz.	N.A.	Vu	SEG
<i>Cleome chelidonii</i> L.f. var. <i>pallai</i> C.S. Reddy & V.S. Raju	Pakhal	-	DD	<i>Habenaria ramayana</i> Ramachandrachary & Wood	Nagarjunasagar-Srisailam	-	DD
<i>Cleome viscosa</i> L. var. <i>nagarjunakondensis</i> Sund.-Ragh.	Sri Venkateshwara	-	DD	<i>Halophila ovalis</i> (R.Br.) Hook.f. ssp. <i>ramamurthiana</i> Ravi & Ganesan	N.A.	-	Aquatic vegetation
<i>Commelina hirsuta</i> Clarke	N.A.	Vu	DD	<i>Heterostemma deccanense</i> (Talb.) Swarup & Mangaly	N.A.	En	MD
<i>Cordia domestica</i> Roth	N.A.	-	DD	<i>Hildegardia populifolia</i> (Roxb.) Schott. & Endl.	Sri Venkateshwara	En	DD
<i>Corymborkis veratrifolia</i> (Reinw.) Bl.	N.A.	Vu	DD	<i>Hybanthus vatsavayii</i> C.S. Reddy	Pakhal	-	DD
<i>Crotalaria clarkei</i> Gamble	N.A.	-	SEG	<i>Indigofera barberi</i> Gamble	Sri Venkateshwara	Vu	DD
<i>Crotalaria filipes</i> Benth.	N.A.	En	DD	<i>Iseilema venkateshwarluui</i> Satyavathi	N.A.	-	DD
<i>Crotalaria longipes</i> Wight & Arn.	N.A.	En	DD	<i>Isonandra villosa</i> Wight	N.A.	Vu	MD
<i>Crotalaria madurensis</i> Wight var. <i>kurnoolica</i> Ellis & Swamin.	Nagarjunasagar-Srisailam	-	DD	<i>Kalanchoe cherukondensis</i> Subbarao & Kumari	N.A.	-	MD
<i>Crotalaria paniculata</i> Willd. var. <i>nagarjunakondensis</i> Thoth.	Nagarjunasagar-Srisailam	-	DD	<i>Lasianthus truncatus</i> Bedd.	N.A.	-	MD
<i>Crotalaria rigida</i> Heyne ex Roth	N.A.	Vu	DD	<i>Lasiococca comberi</i> Haines (Homonoia <i>comberi</i> (Haines) Merr.)	N.A.	-	MD
<i>Croton scabiosus</i> Bedd.	N.A.	-	DD	<i>Leucas diffusa</i> Benth.	N.A.	-	MD
<i>Cyathocline manilaliana</i> C.Raju & R. Raju	N.A.	-	DD	<i>Leucas indica</i> (L.) R. Br. var. <i>nagalapuramiana</i> (Chandr. & Sriniv.) Moulali & Pullaiah	N.A.	-	DD
<i>Cycas beddomei</i> Dyer	Sri Venkateshwara	Vu	DD	<i>Leucas mollissima</i> Wall. var. <i>mukherjiana</i> Subbarao & Kumari	N.A.	-	SEG
<i>Cycas sphaerica</i> Roxb.	N.A.	-	MD	<i>Leucas mollissima</i> Wall. var. <i>sebastiana</i> Subbarao & Kumari	N.A.	-	SEG
<i>Decalepis hamiltonii</i> Wight. & Arn.*	Nagarjunasagar-Srisailam and Sri Venkateshwara	En	DD	<i>Leucas mollissima</i> Wall. var. <i>silvestriana</i> Subbarao & Kumari	N.A.	-	SEG
<i>Decaschistia cuddapahensis</i> Paul & Nayar	Sri Venkateshwara	-	DD	<i>Leucas mukherjiana</i> Subbarao &	N.A.	En	SEG
<i>Decaschistia rufa</i> Craib	Sri Venkateshwara	En	DD				
<i>Dendrobium ovatum</i> (Willd.) Kranz	Sri Venkateshwara	Vu	DD				
<i>Dicliptera beddomei</i> Clarke	Nagarjunasagar-Srisailam	-	DD				
<i>Dimorphocalyx kurnoolensis</i> R. Raju & Pullaiah	N.A.	-	DD				

Kumari					Narasimh.			
<i>Lipocarpha reddyi</i>	N.A.	-	DD		<i>Polycarpaea</i>	N.A.	-	Thorn
Hooper					<i>corymbosa</i> var.			
<i>Maytenus</i>	N.A.	-	MD		<i>yadagiriense</i> C.S.			
<i>bailadilliana</i>					Reddy, Y.N.R.			
(Narayan &					Varma & V.S.			
Mooney) D.C.S.					Raju			
Raju & Babu					<i>Pterocarpus</i>	Sri	En	DD
<i>Memecylon</i>	N.A.	-	MD		<i>santalinus</i> L.f.*	Venkateshwar		
<i>jadhavii</i> K.N.						a and		
Reddy, C.S. Reddy						Peninsula		
& V.S. Raju						Narasimha		
<i>Memecylon</i>	N.A.	-	MD		<i>Rhynchosia</i>	Sri	Vu	DD
<i>madgolense</i>					<i>beddomei</i> Baker	Venkateshwar		
Gamble						a		
<i>Mimosa barberi</i>	N.A.	-	MD		<i>Rostellularia vahlii</i>	Nagarjunasaga	-	DD
Gamble					(Roth) Nees var.	r-Srisailam		
<i>Murdannia</i>	N.A.	Vu	DD		<i>rupicola</i> Ellis			
<i>juncoides</i> (Wight)					<i>Shorea</i>	Sri	En	DD
Rolla Rao &					<i>tumbugaia</i>	Venkateshwar		
Kammathy					Roxb.*	a		
<i>Nilgirianthus</i>	N.A.	-	SEG		<i>Syzygium</i>	Sri	En	DD
<i>circarensis</i>					<i>alternifolium</i>	Venkateshwar		
(Gamble) Bremek.					(Wight) Walp.*	a		
<i>Nothopegia</i>	N.A.	Vu	SEG		<i>Terminalia pallida</i>	Sri	En	DD
<i>heyneana</i> (Hook.f.)					Brandis*	Venkateshwar		
Gamble						a		
<i>Oianthus</i>	Nagarjunasaga	-	DD		<i>Toxocarpus</i>	N.A.	En	SEG
<i>disciflorus</i> Hook.f.	r-Srisailam				<i>roxburghii</i> Wight			
<i>Ophiorrhiza</i>	N.A.	-	SEG		& Arn.			
<i>chandrasedkharanii</i>					<i>Trichosanthes</i>	N.A.	CR	DD
Subbarao &					<i>anaimalaiensis</i>			
Kumari					Bedd.			
<i>Oropetium</i>	N.A.	Vu	DD		<i>Triphasia</i>	N.A.	-	DD
<i>roxburghianum</i>					<i>reticulata</i> Smith			
(Steud.)					var. <i>parviflora</i>			
S.M.Phillips					Santapau			
<i>Panicum fischeri</i>	Sri	Vu	DD		<i>Tripogon</i>	N.A.	Vu	DD
Bor	Venkateshwar				<i>jacquemontii</i> Stapf			
	a				<i>Tripogon wightii</i>	Sri	Vu	DD
<i>Paraphyrrhenia</i>	N.A.	Vu	DD		Hook.f.	Venkateshwar		
<i>bellariensis</i>						a		
(Hack.) Clayton						N.A.	Vu	DD
<i>Pavetta</i>	N.A.	-	DD		<i>Urginea</i>			
<i>madrassica</i>					<i>nagarjunae</i>			
Bremek.					Hemadri &			
<i>Pentanema</i>	Nagarjunasaga	-	DD		Swahari*			
<i>indicum</i> (L.) Ling	r-Srisailam				<i>Vanilla wightiana</i>	Sri	Vu	DD
var.					Lindl.	Venkateshwar		
<i>sivarajanianum</i> C.						a		
Raju & R. Raju					<i>Wendlandia</i>	N.A.	Ex	DD
<i>Phlebophyllum</i>	N.A.	En	SEG		<i>angustifolia</i> Wight			
<i>jeyporensis</i> (Bedd.)					& Arn.			
Bremek.					<i>Wendlandia</i>	N.A.	-	SEG
<i>Phyllanthus</i>	Sri	Vu	DD		<i>gamblei</i> Cowan			
<i>indofischeri</i>	Venkateshwar							
Bennet*	a and							
	Gundlabrahme							
	swaram							
<i>Phyllanthus</i>	N.A.	En	SEG					
<i>narayanaswamii</i>								
Gamble								
<i>Pimpinella</i>	Sri	En	DD					
<i>tirupatiensis</i>	Venkateshwar							
Balacr. &	a							
Subram.*								
<i>Polycarpaea</i>	Sri	-	DD					
<i>corymbosa</i> var.	Venkateshwar							
<i>longipetala</i>	a							
Srinivas. &								

*Species marked with asterisk are prioritised for conservation, C.A.M.P., 2001. Andhra Pradesh; Jadhav *et al.* 2001. Ex: Extinct; CR: Critically Endangered; En: Endangered; Vu: Vulnerable; N.A.: No Protected Area Available.

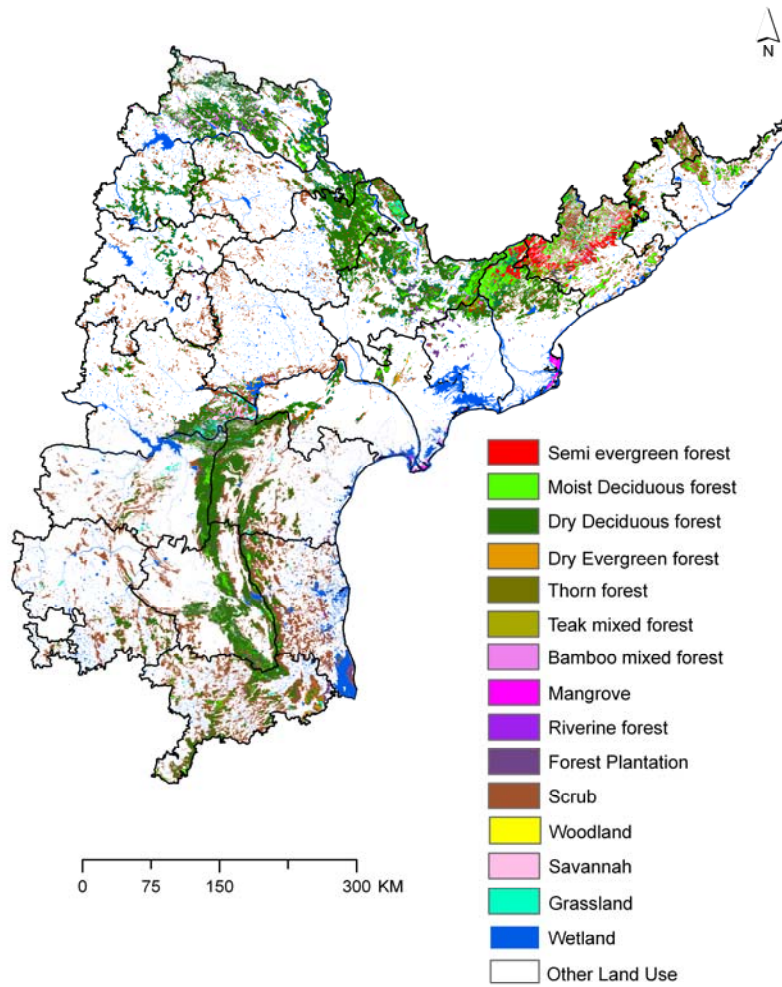
Figure 1. Vegetation type and Wetland map of Andhra Pradesh

Figure 2. Map of Andhra Pradesh showing districts and Protected Area network

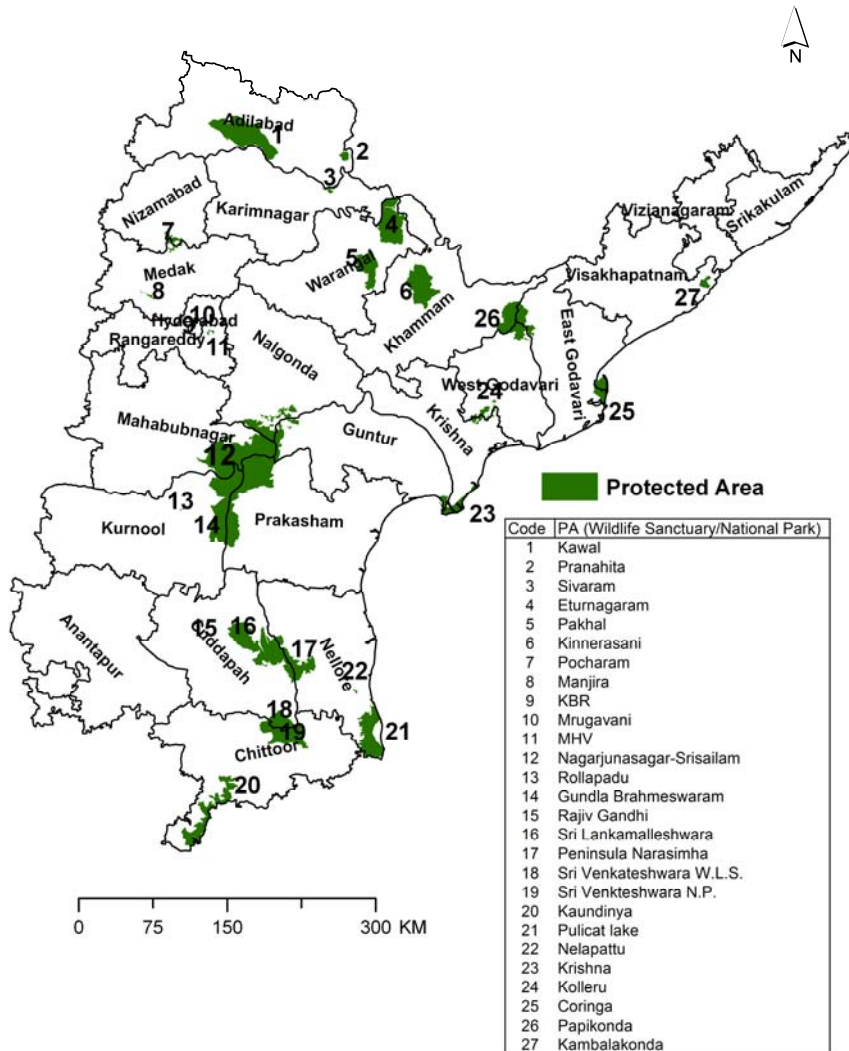


Figure 3. Elevation range map overlaid on districts of Andhra Pradesh

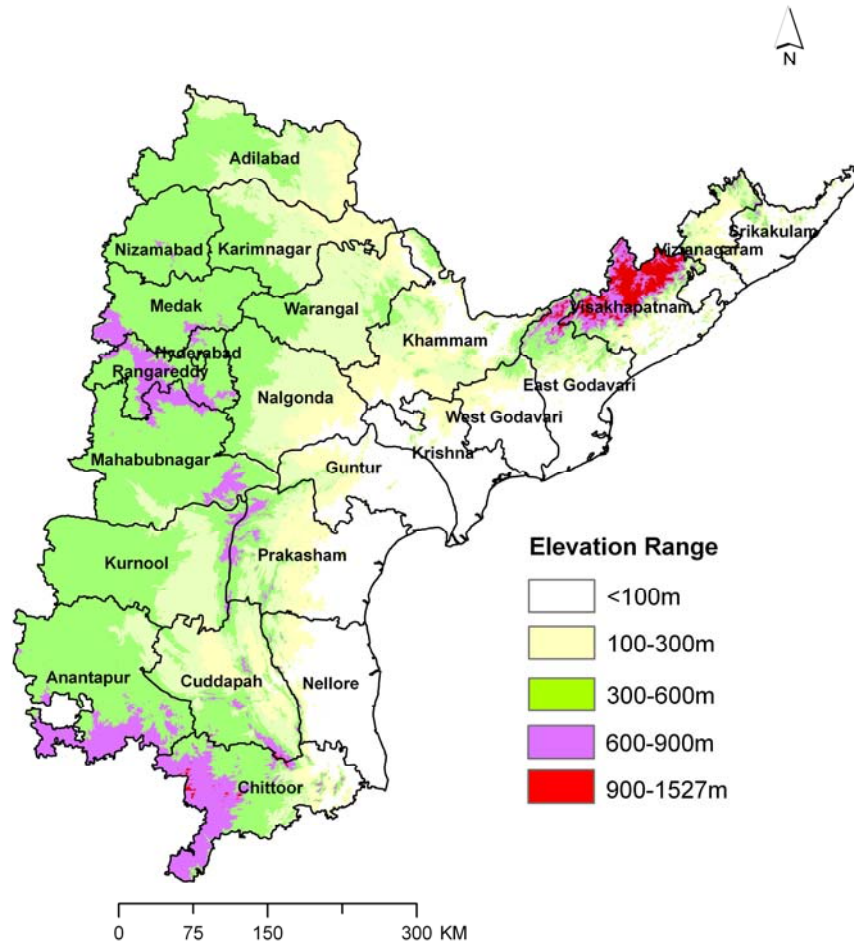
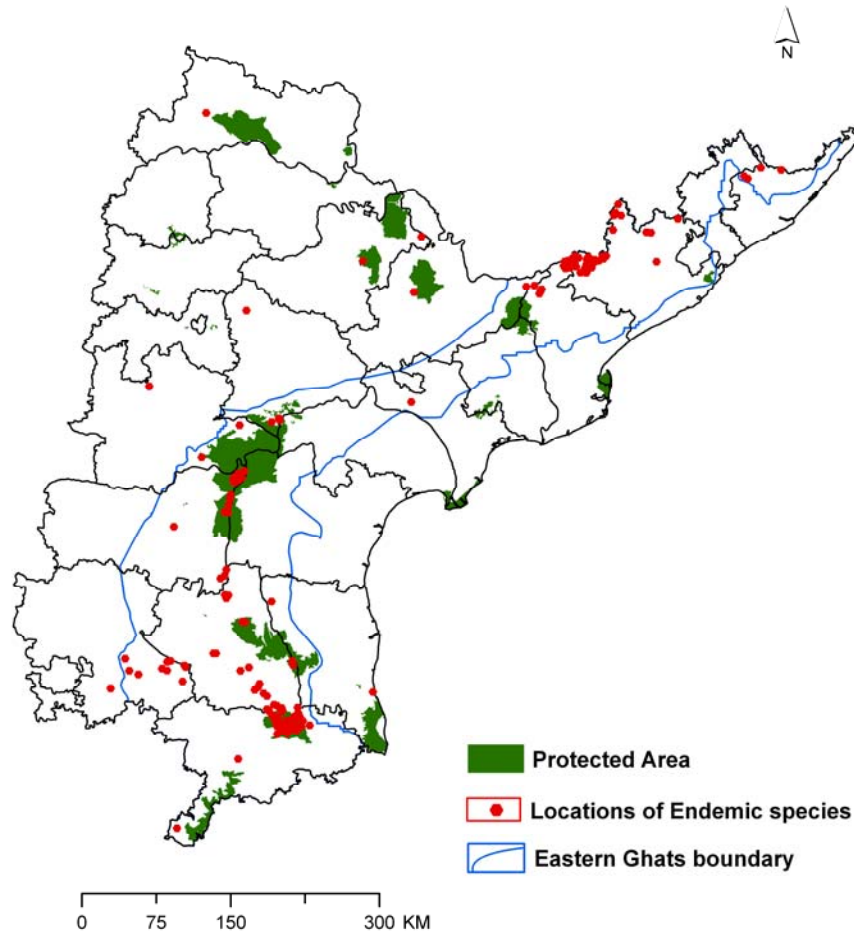


Figure 4. Endemic species locations and Protected Areas in Andhra Pradesh

4. Discussion

Most PA systems around the world have a tendency to over-represent highland areas (Fearnside and Ferraz, 1995; Powell et al. 2000; Scott et al. 2001) and the study results show a different pattern for Andhra Pradesh. Study found that there is no PA in the elevation above 900m, which is representing semi evergreen forests, moist deciduous forests and savannah. The area above 900m elevation harbours 29 endemic species.

Total PA coverage was low when compared with the commonly used target of 10% (Miller, 1984) with only 4.56% of geographical area of the Andhra Pradesh having PA status. But total proportion of PAs with reference to natural vegetation infer 18% of the area was included under conservation. The analysis of vegetation type distribution reveals that dry deciduous

forests were represented in 20 PAs, where as moist deciduous forests were noticed in two PAs only (Gundlabrahmeswaram and Papikonda). The percentage of PA above 600m, need to be expanded in view of varied vegetation types, species diversity and terrain complexity. Three main vegetation types of State (semi evergreen forests, thorn forests and dry evergreen forests) missing in the existing PA network were identified. Moist deciduous forests of Eastern Ghats of northern Andhra Pradesh were under-represented in PA system (Fig. 4).

Gap analysis also determined the number of endemic and threatened plant species currently not protected. Considering vegetation type distribution, elevation and endemism, Upper Godavari and Upper Visakha hills (Eastern Ghats of northern Andhra Pradesh) can be prioritised to the status of 'biosphere reserve' along

with Seshachalam hills (Eastern Ghats of southern Andhra Pradesh). Many PAs have low levels of protection with multifarious threat from invasive species, habitat degradation, forest fires, grazing, illegal extraction of wood, shifting cultivation etc. Deciduous forests are vulnerable ecosystems because of very high economic potential. According to the Directorate of Revenue Intelligence, Govt. of India, the smuggling of Red Sanders wood from Sri Venkateshwara Wildlife Sanctuary to South East Asia has emerged as a significant area of concern. During 2003-04, the Directorate of Revenue Intelligence had seized 151 MTs of Red sanders wood valued at Rs.6 crores (approx.) in the illegal market in India. During 2004-05, 347 MTs of Red Sanders valued at Rs.13.88 crores (approx.) was seized. During 2005-06, the smuggling of Red Sanders continued and 449 MT of Red Sanders valued at Rs. 17.98 crores was seized (<http://www.dri.nic.in>). Pranahita wildlife sanctuary of Adilabad district, had witnessed loss of forest cover of 248 ha area during 1993-2004 (Giriraj et al. 2007). In PAs of Andhra Pradesh, aggressive colonization by invasive plant species (*Hyptis suaveolens*, *Lantana camara*, *Chromolaena odorata*, *Prosopis juliflora*, *Ageratum conyzoides*, *Cassia tora*, *Cassia uniflora*, *Parthenium hysterophorus*) are posing survival threat to native biodiversity. Aquatic habitats also suffering by invasion of *Eichhornia crassipes*, *Alternanthera philoxeroides*, *Ipomoea carnea*, *Typha angustata*, *Pistia stratiotes* etc (Reddy, 2008).

Analysis of endemism also provides a strong platform for the necessity of new protected areas to safeguard unique biodiversity of Andhra Pradesh. To save the biodiversity from human interference, we need to resolve for strong conservation efforts. Consequently, there is need to consider ways to create a network of continuums of Protected Areas in India.

The advent of the remote sensing has made it possible to prepare precise vegetation type maps. The study demonstrated the usefulness of information of vegetation types, elevation and endemism for the conservation prioritisation. The study suggests for declaration of new PAs in semi evergreen forests, moist deciduous forests, dry evergreen forests and under-represented vegetation types. Further, it is recommended that the habitats of endemic species can be preserved by appropriate conservation planning.

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