Relevance of Ecosystems Approach to Sustainable Development

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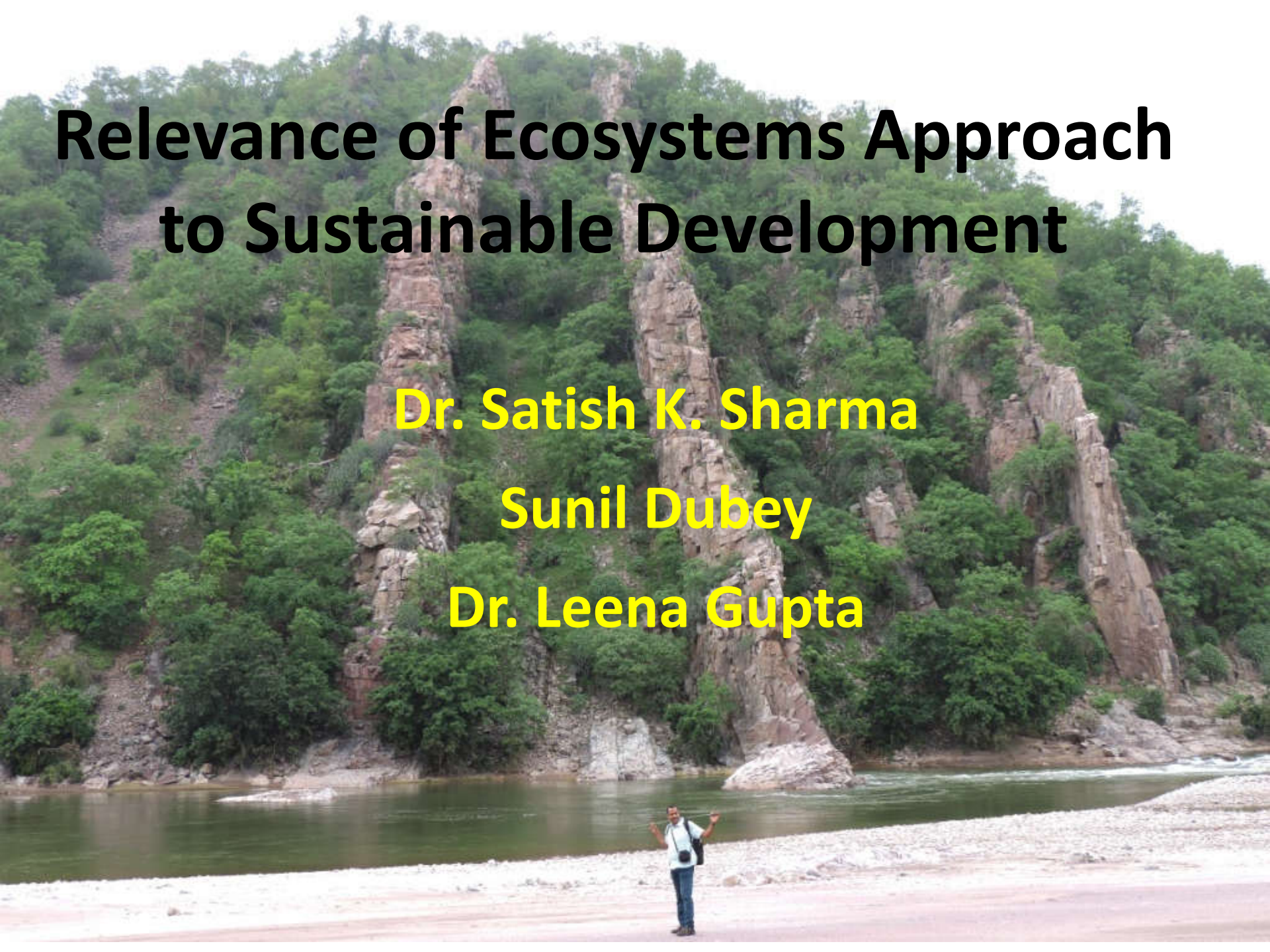


Ecosystem Services for Sustainable Living

Provisioning

Products obtained from ecosystems

- Food
- Fresh Water
- Fuel wood
- Fibre
- Biochemicals
- Genetic Resources

Regulating

Benefits obtained from regulation of ecosystem processes

- Climate Regulation
- Water Regulation
- Disease Regulation
- Pollination
- Water Purification

Socio - Cultural

Nonmaterial benefits obtained from ecosystems

- Recreational
- Aesthetic
- Educational
- Heritage
- Spiritual & Religious
- Inspirational

Supporting

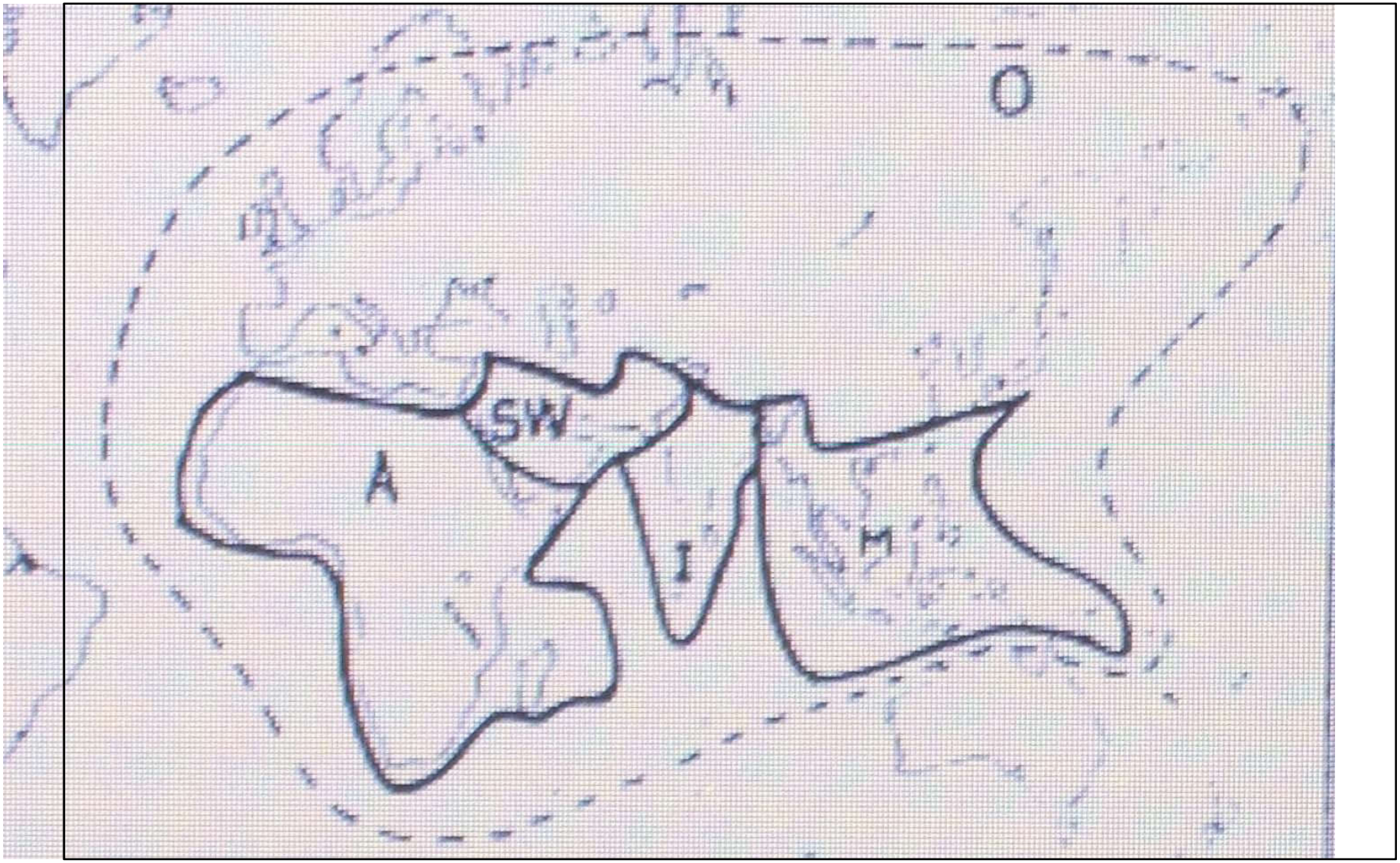
Services necessary for the production of all other ecosystem services

- Soil Formation - Nutrient Cycling - Primary Production - Habitat

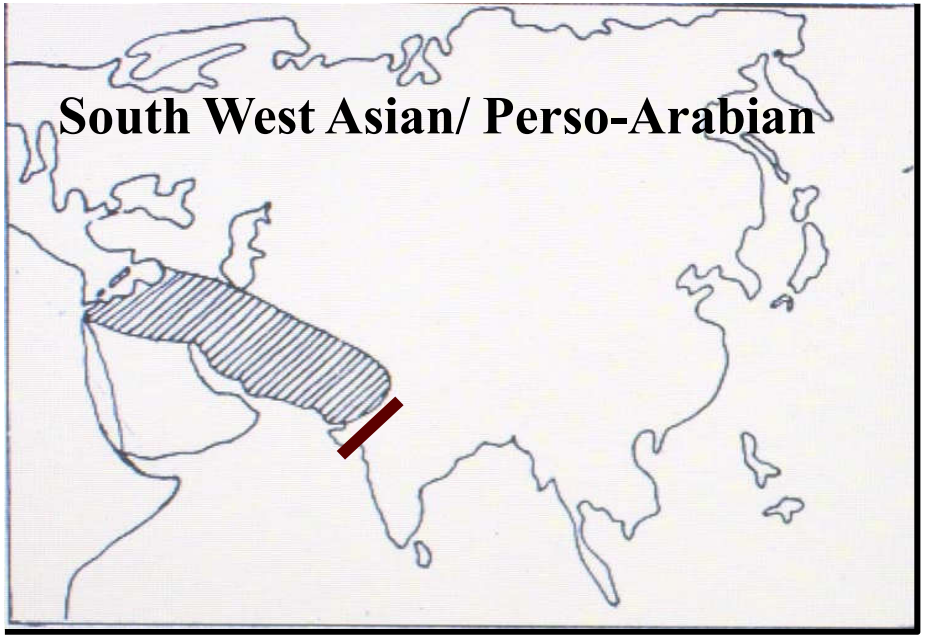
Classification of ecosystem services developed by the Millennium Ecosystem Assessment 2005

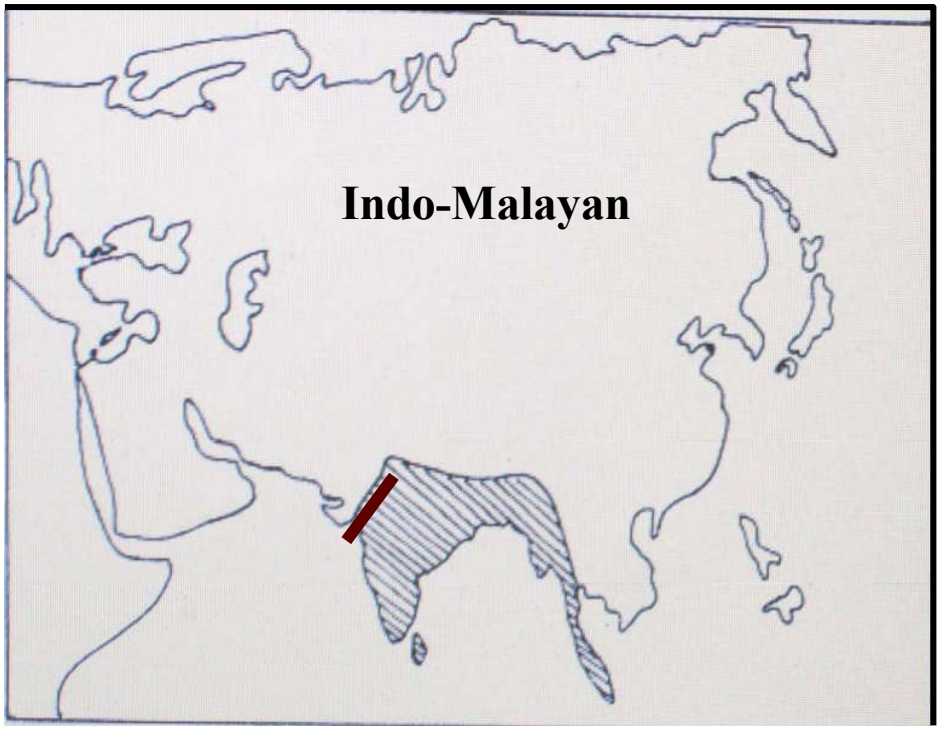
Relevance of Aravallis

Global Importance of the Region



Phyto-Geographical Regions - Distribution patterns (Hypothetical)
O-Old world, A- African, SW- South West Asian, I-Indian, I+M-Indo-Malayan

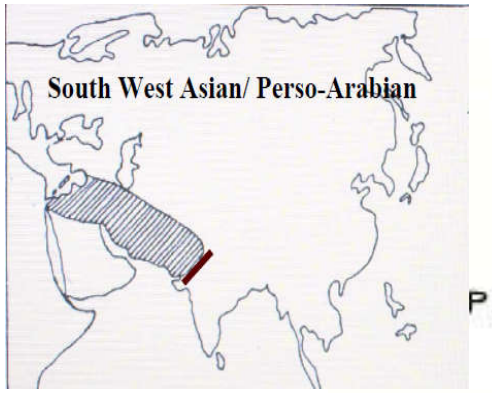




Great Aravallis : Drude's Line

- Drude (1890,1913) stated - the line limiting **Perso-Arabian** and **Indo-Malayan** elements runs along the Aravallis and extends southwards to the Gulf of Cambay.
- The western or **Perso-Arabian** elements (Mediterranean, south-west Asian and African) are dominant over the eastern or Indo-Malayan element in the region west of Aravallis. In the Aravallis and the eastern region the proportion of eastern element exceeds that of the western element.
- Drude's line runs along the western side of the Aravallis, being the region of changeover between the two floras dominated by eastern or western elements.

Aravalli Mountain Range as Determinant of Ecological Features, Resources & Livelihood



Drude Line

by Oscar Georg Drude 1890- 1913

Western Side: Arid Zone / Desert

Eastern Side: Dry-Deciduous Forest

Between the South West Asian/ Perso- Arabian and Indo Malayan floral elements.

Eastern Side: Dry-Deciduous Forest; Western Side: Arid Zone / Desert

Administrative Coverage of Aravalli Hills

- 16 districts (covering fully or partly 120 Developmental Blocks; 6854 hill villages, 43 hill towns)

1. Ajmer	2. Alwar	3. Banswara	4. Bhilwara
5. Bharatpur	6. Chittaurgarh	7. Dungarpur	8. Jaipur
9. Jhunjhunu	10. Nagaur	11. Pali	12. Sawai Madhopur
13. Sikar	14. Sirohi	15. Tonk	16. Udaipur

The Aravalli hills spread in 12.65% area of Rajasthan influencing ecological equilibrium in 29.92% of the state area directly whereas climatically and hydrologically influence much large area in the state and the surrounding regions indirectly.

Source: Eco-crisis in the Aravalli Hill Region - Dhabriya, 1988

SALIENT FEATURES OF THE DESERT
The western side of Aravallis

- Center of Endemism
- Eastern most fringe of great Saharo-Tharian desert
- Hot desert, drought prone area
- Spread over parts of Gujarat, Rajasthan, Haryana and Punjab.
- Stunt and sparse vegetation
- Storeyfication lacking or poorly developed
- Supports pastoral system (route, fodder (>35 Grass sp.), food, etc)
- Nesting ground of Flamingo birds & Wild Ass habitat

Rajasthan – Forest Cover and Biodiversity

Forest Cover – 16655 sq km. **4.87 %** of state's Geographical Area
0.51% of Country's Geographical Area

2.33 % of Country's Forest Cover

Recorded Forest Area – **9.57%** of state's Geographical Area
~ 1% of Country's Geographical Area

Plant Species 2697
≈5.50% of the Country
Animal species ~ 835
~0.92% of Country

3 major forest Types: (1) **Tropical Dry Deciduous Forest**; (2) **Tropical horn Forest**; and (3) Sub-Tropical Broad-Leaved Hill Forest (Majority is of 1 & 2)

Geographical Importance of Drude Line in Extent of Forest in the State

- Drude line runs along the western side of the Aravallis, making boundary for two floras dominated by ‘Eastern Indo Malayan’ and ‘South West Asian/ Perso- Arabian’ elements.
- The 20 districts located in the eastern part of the Aravalli range account for 75% of the state's forest area, and Pali and Sirohi, the two districts in the south-west, account for 9% of the state's total forest area respectively (making total 84%).
- ~ 95% of the dense forest area is also found in these 22 districts

The Aravalli mountains play an important role as a barrier in keeping these densely forested areas from spreading to the western desert. Therefore, whatever anthropogenic impacts happens with the Aravalli that directly affects the ecology of natural habitats, ecosystems & their functions, biodiversity, species distribution & interaction as well as residence, health and livelihood of most of the people of the state.

तालिका–1: अरावली के पूर्वी भाग में वन क्षेत्र का विवरण				
राजस्थान: अरावली के पूर्व में वन क्षेत्र का प्रतिशत				
क्र.सं.	अरावली के पूर्व में स्थित ज़िले	वन क्षेत्र (वर्ग किलोमीटर)	अरावली के पूर्व में स्थित कुल वन क्षेत्र का प्रतिशत	अरावली के पूर्व में स्थित कुल सघन वन क्षेत्र का प्रतिशत
1.	अजमेर	618.4419	2.50	0.76
2.	अलवर	1783.6148	7.21	8.76
3.	बाँसवाड़ा	1006.3866	4.07	1.85
4.	बाराँ	2239.6901	9.05	3.31
5.	भरतपुर	434.9344	1.76	0.69
6.	भीलवाड़ा	779.6888	3.15	0.76
7.	बूँदी	1557.3335	6.29	3.25
8.	चित्तौड़गढ़	1793.4145	7.25	13.23
9.	दौसा	284.4934	1.15	0
10.	धौलपुर	638.3859	2.58	1.82
11.	डूँगरपुर	692.7533	2.80	0.98
12.	जयपुर	945.6630	3.82	2.82
13.	झालावाड़	1349.7943	5.45	1.85
14.	करौली	1810.0470	7.31	0
15.	कोटा	1322.4592	5.34	3.4
16.	प्रतापगढ़	1666.3071	6.73	0
17.	राजसमन्द	401.2779	1.62	2.91
18.	सवाई माधोपुर	952.8829	3.85	5.6
19.	टोंक	330.0466	1.33	0.73
20.	उदयपुर	4142.3344	16.74	31.58
	कुल	**24749.9496**	**100.00**	**84.30**

Rajasthan – Floral Elements

(After Bharucha and Meher-Homji 1965; Maheshwari 1977)

1. **Endemic Element** (*Euphorbia jodhpurensis* , *Convolvulus densiflorus* etc.)
2. **Indian Element** (*Rhus mysurensis* , *Anogeissus pendula* , *Sarcostemma acidum* etc)
3. **Eastern Element or the Indo Malayan Element**

   (*Capparis sepiaria* , *Leptadaenia reticulata* , *Adhatoda vasica* etc.)
4. **Western Element**

   I. Indian Desert Element or the Saharo-Sindian Element

   (*Fagonia cretica* , *Heliotropium rariflorum* , *Lycium barbarum* etc)

   II. Tropical and North African-Indian Desert Element or the Sudano-Rajasthanian Element

   (*Acacia senegal* , *Balanites aegyptiaca* , *Capparis decidua* etc)

   III. Mediterranean-Oriental-Europian Element (*Lathyrus aphaca* , *Vicia hirsuta* etc)
5. **General Element**

   I. Pantropical Element

   (*Ageratum conyzoides* , *Cassia tora* , *Boerhavia diffusa* , *Tribulus terrestris*)

   II. Pantemperate Element

   (*Ranunculus scleratus* , *Veronica anagallis-aquatica*)

   III. Cosmopolitan Element

   (*Solanum nigrum* , *Cyanodon dactylon* , *Cyperus rotundus* etc)

Endemic Flora in Rajasthan

S. No.	Taxa / Group	No. of Species / Sub-species
1	Bacteria	1
2	Lichen	1
3	Bryophyta	3
4	Pteridophyta	10
5	Algae	2
6	Monocots	6
7	Dicots	27
	Total	**50**

Awasthi (1995), Bhandari (1978), Shetty & Singh (1987, 1991, 1993), Sharma S. K. (2014, 2015)

Some Examples –

Riccia jodhpurensis (Bryophyte)

Selaginella rajasthanensis (fern)

Isoetes rajasthanensis (Fern)

Marsilea rajasthanensis (Fern)

Cleome gynandra nana (Dicot)

Anogeissus sericea nummularia (dicot)

Pulicaria rajputanae (Dicot)

Convolvulus blatteri (Dicot)

Merremia rajasthanensis (Dicot)

Euphorbia jodhpurensis (Dicot)

Phyllanthus ajmerianus (Dicot)

Apluda blatteri (Grass)

Cenchrus rajasthanensis (Grass)

Rajasthan: Physiography

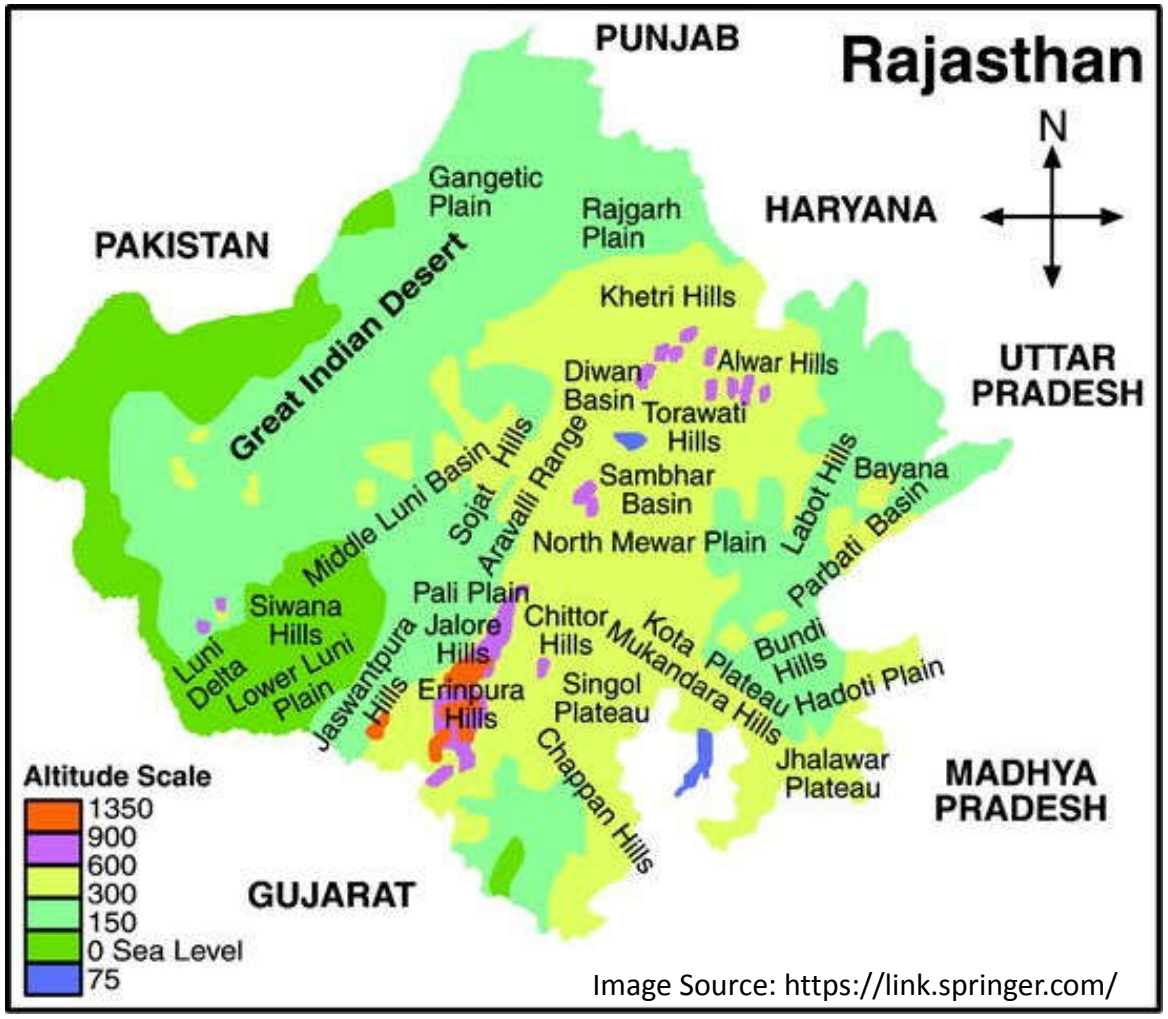


Image Source: https://link.springer.com/

***Aravalli Ranges also serve as dividing line for rivers ending into Arabian Sea and Bay of Bengal**

Major Ecosystems:

1. **Desert Ecosystem**
   - i. Canal Command Area
   - ii. Non Command Area
   - iii. The Luni Basin
2. **Aravalli Hill Ecosystem**
   - i. Northern Aravalli Region
   - ii. Central Aravalli Region
   - iii. Southern Aravalli Region
3. **Eastern Plain Ecosystem**
   - i. Banas Basin
   - ii. Mahi Basin
   - iii. Banganga Basin
   - iv. Sahibi Basin
   - v. Gambhiri Basin
   - vi. Barah Basin
4. **Hadoti Plateau and Ravine Ecosystem**
   - i. Chambal Basin
   - ii. Dang Area

Rajasthan – Summary Data of Animal and Plant Diversity

- Fishes 146,
- Frogs & Toads 12 ,
- Crocodiles 2,
- Tortoise & Turtle 11,
- Lizards 27,
- Snakes 35 ,
- Birds 510,
- Mammals 92

Angiosperms: 2203

(Sharma & Dubey,2008)

Wild Species: 2011

Cultivated: 192

- Algae 280,
- Fungi 61,
- Bryophytes 89,
- Pteridophytes 63,
- Gymnosperm 1 (*Ephedra foliata*)

Endemic Plant Species: ~ 50

Terrestrial Orchids – 8

Epiphytic Orchids – 6

Parasite Plants – 10

Carnivorous Plants – 5

Medicinal – 157+

Important Forest Plants

Hindi Name	Scientific Name	Hindi Name	Scientific Name
खेजड़ी	*Prosopis cineraria*	चन्दन	*Santalum album*
धोंक	*Anogeissus pendula*	गम्हार / हवन	*Gmelina arborea*
महुआ	*Madhuca longifolia*	अमलतास	*Cassia fistula*
चिरोंजी	*Buchanania latifolia*	कड़ाया	*Sterculia urens*
बहेड़ा	*Terminalia bellirica*	सेमल	*Bombax ceiba*
हरड़	*Terminalia chebula*	हल्दू	*Haldina cordifolia*
धावड़ा	*Anogeissus latifolia*	झींझा	*Bauhinia vahlii*
तेंदू	*Diospyros melanoxylon*	हरसिंगार	*Nyctanthes arbor-tristis*
बेल	*Aegle marmelos*	सागवान	*Tectona grandis*
बीजासाल	*Pterocarpus marsupium*	गोंदल	*Lannea coromandelica*
अर्जुन	*Terminalia arjuna*	खिरनी/दूधी	*Wrightia tinctoria*
सालर	*Boswellia serrata*	रोंझ	*Acacia leucophloea*
रोहण	*Soymida febrifuga*	कुमठा	*Acaia senegal*
करंज	*Pongamia pinnata*	पलाश	*Butea monosperma*
चुरैल/पापड़ी	*Holoptelia integrifolia*	पाखड़	*Ficus virens*
रायण	*Manilkara hexandra*	आसन	*Terminalia tomentosa*

Important Medicinal Plants Found in the Aravallis

- **कालमेघ** *Andrographic paniculata*
- **अश्वगंधा** *Withania somnifera*
- **गिलोय** *Tinospora cordifolia*
- **निर्गुन्डी** *Vitex negundo*
- **अड़ूसा** *Adhatoda vasica*
- **भूमि आंवला** *Phyllanthus amarus*
- **हरिसंगार** *Nyctanthes arbor-tristis*
- **चिरमी** *Abrus precatorius*
- **गुड़मार** *Gymnema sylvestre*
- **शतावर** *Asparagus racemosus*
- **मालकांगणी** *Celastrus paniculatus*
- **पुनर्नवा** *Boerhavia* sps.
- **अतिबला** *Abutilon indicum*
- **मकोय** *Solanum nigrum*
- **गोखरू** *Tribulus terrestris*
- **वज्रदंती** *Barleria prionitis* (yellow flower) and *B. acanthoides* (white flower)
- **सर्पगंधा** *Rauwolfia serpentina* and *Raulvolfia tetraphylla*
- **मरोड़ फली** *Helicterus isora*
- **केवकन्द** *Costus speciosus*
- **सफ़ेद मूसली** *Chlorophytum borivillianum*
- **अनंतमूल** *Hemidesmus indicus*
- **कलिहारी** *Gloriosa superba*

Threatened Medicinal Plants

- **Conservation Assessment and Management Prioritization (CAMP) Workshop, 2007**
- Assessment of threat status as per IUCN Categories & Criteria
- **39** plants were identified that have immense medicinal values and their threat status was determined
- Medicinal Plant Conservation Areas (**MPCA**) were developed for in-situ conservation

  - CR - 06 species
  - EN - 12 species
  - VU - 19 species
  - NT - 01 species
  - DD - 01 species

CR species include - *Chlorophytum borivilianum, Cochlospermum religiosum, Commiphora wightii, Eulophia ochreata, Pterocarpus marsupium, Tribulus rajasthanensis*

Importance of Wild Plants in Food & Nutrition

- **Wild Relatives** (Evolutionary linkage, Original Genes)
- **Grown in Wild** (i.e. chemical free, disease resistant)
- **Climate Resilient** (Can withstand climate change)
- **Indigenous Culinary** (Nutrient balance)
- **Rich in Nutrients** (Immunity booster Vitamins & Minerals)
- **Availability According to the Season & Local weather**
- **Availability according to the biological need during different seasons.**
- **Festive culinary, recipes, indigenous species use**
- **Livestock dependence on seasonal wild (naturally available) species.**

Major Food Supplying Ecosystems

- Forest
- Corridors between forest and villages
- Wilderness areas around villages / Village outskirts
- Agriculture fields
- Fences of agriculture fields
- Common property resources (pastures, river banks, rivers, hillocks, sea shores, sea, lakes, fallow lands, wastelands etc.)

Plant & Animal Species Documented in Different Ecosystems

Resource Area	Flora Sp.	Fauna Sp.	Plants used by local community			
			Wild Edible	Medicine	NTFP	Fodder
Agriculture fields (Chhogala, Gunja, Mavli, Kada, Kheralu, Jhadol, Dungarpur, Visnagar, Nakalank, Kanthariya, Ghaghret, Kalpavalli	91	>140	104	67	3	41
Fences of agriculture fields (Chhogala, Gunja, Mavli, Kada, Kheralu, Visnagar, Jhadol, Upli Sigri, Undarada	189	>90	62	76	31	32
Forest (Jessore WLS, Balaram WLS, Polo, Kawant, Naswadi, Taranga, Kalpavalli, Kuvarsi-Danta, Shamlaji-Sabarkantha, Pavagadh, Sitamata & Mount Abu WLS	972	>735	498	538	127	94
Corridors between forest & villages (Balaram WLS, Chitrasani-Palanpur, Zer Dhareshwar-Vijaynagar, Undapani- Bhiloda, Devas, Pachmadhi	476	>570	194	297	98	58
Wilderness / Village outskirts (Vadnagar, Ishwariya, Lakhabaval, Gunja, Jhadol, Gogunda, Valam, Udalpur, Valasana, Vadgam, Thalota, Mandropur, Nakalank, Mushtikovila)	269	>300	137	174	53	49

Resource Area	Flora Sp.	Fauna Sp.	Plants used by local community			
			Wild Edible Plants	Medicine	NTFP	Fodder
Common property resources						
Pastures (Kachchh, Tharad, Idar, Kalpavalli)	**268**	**>180**	**79**	**163**	**41**	**52**
River banks, rivers, lakes (Narmada, Tapi, Banas, Jaisamand	**329**	**>400**	**91**	**168**	**82**	**71**
Sea shores, Sea (Jamnagar, Chorwad, Kodinar, Pirotan Island, Navinal Island, Nana Layja, Mota Layja, Okha, Surat, Shravan Kavadiya,)	**>294**	**>300**	**81**	**74**	**42**	**48**
Hillocks (Taranga, Southern Aravallis - Rajasthan, Jhadol, Pavagadh, Shoolpaneshwar, Kalpavalli)	**>349**	**>200**	**160**	**127**	**72**	**48**
Waste lands (North Gujarat, Vadodara, Saurashtra,)	**192**	**>200**	**76**	**71**	**37**	**69**
Total	**1687**	**>900**	**687**	**693**	**241**	**167**

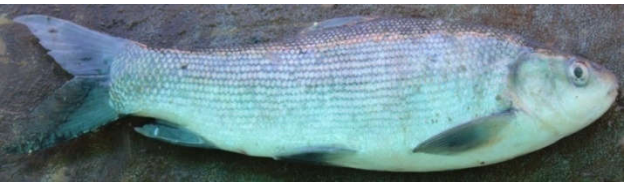
Important Fish Species of Freshwater Ecosystems

Labeo rohita
(Rohu)

Catla catla
(Catla)

Cirrhinus mrigala
(Mrigal)

Notopterus notpoterus
(Patola)



Labeo gonius
(Sarsi/Khursa)

Ophiocephalus marulius
(Sanwal)

Wallago attu
(Lanchi)

Rohu-Catla Hybrid
(Dogla)

Mystus seenghala
(Singhara)

Mastacembalus armatus
(Bam)

*** In Rajasthan the average fish yield from tanks is - 25 kg/Hectare (More than the National average of yield 20kg/Ha from tanks)**

Animal & Plant Species as Ecological Indicators

- **Garra** (Fish) – hillstream habitat / Lotic aquatic ecosystem
- **Mahseer** (Fish) – Freshwater ecosystem
- **Spiny-tailed Lizard** (Reptile) – arid & semi-arid grasslands
- **Lesser Florican** (Bird) – Medium & tall grassland
- **Sarus Crane** (Bird) – Tall grasslands, wetland-agrarian habitat
- ***Typha angustata*** (Hydrophyte) – Waterlogged conditions
- ***Fagonia indica* & *Peganum harmala*** (Herbs) – Sandy soil
- ***Anogeissus pendula*** (Tree) – Edaphic climax forest
- **Salvadora** (Tree) – Salt affected soil

Overview of the work through Ecological Indicators

State	Region	Work
Andhra Pradesh	Kalpavalli, Guttur RF (Anantpur)	Biodiversity assessment for CDM project impacts on Ecology, Biodiversity, community & livelihoods, TK
Gujarat	Vadodara	BD assessment for FRA implementation impacts on Ecology & Livelihoods, Traditional knowledge
	North Gujarat regions	BD assessment for FRA implementation impacts on Ecology & Livelihoods, Desertification impacts in Southern Aravallis of Gujarat, Traditional knowledge
Rajasthan	Central Aravalli Ajmer, Beawar, Nagor	BD study to understand Ecological & climatic changes in central Aravallis, *P.juliflora* impacts on ecology & livelihoods, land-use change impacts, TK
	Ranthambhore, Sariska, Kailadevi	Wildlife conflict, FRA implementation & ecological overview, species centered approach & conflicts, TK
	Udaipur	Environment education for conservation and NR enhancement, BD assessment, ecological profile, Protected area study. People's Biodiversity register, TK
Karnataka	Bellary	BD assessment for EIA in Iron ore mining, Iron ore mining impacts on archeological monuments, TK

Kalpavalli, Guttur RF (Anantpur)	Ecological, social & cultural history. 23 years of regeneration process-BD, ecosystem, habitat improvements & change matrix. waves & noise sensitive BD, stress to water resources, ecosystem, food web study to understand impact of Windmills-ecological, socio-economic aspects
Vadodara	NTFP/MFP diversity, richness & economics, land regularization impacts-land-use change impacts (previous & FRA),
North Gujarat regions	Biodiversity, community-BD relationships, Sloth bear food niche & conflicts, ecological & climatic changes in S.Aravallis of Gujarat. FRA implementation.
Central Aravalli	Invasive sp. Gaps/doors in Aravalli hills- increase of arid species due to increasing dessert conditions. Decrease of MFP, ground cover, palatable grasses, vulture population. Soil erosion, habitat loss, species loss
Ranthambhore, Sariska, Kailadevi	Impacts of resource use by wild & domestic animals, change in agriculture system, rehabilitation impacts on community & livelihoods
Udaipur	Presence of heavy metal indicating sp. Lack of nests, Bee hives due to pollution and other stress conditions in ecosystem health.
Bellary	Iron ore mining- Major catchments destroyed. Come-back call to nature after bane, increase pollinators, ground cover. Mining impacts on ancient monuments (Humpy) & Decreasing tourism income.

Local Community's Relation with Biodiversity for Survival & in Daily Life

- **Wild edibles (flora & fauna)**
- **Medicinal plants (>90% from forest areas, better than cultivated one)**
- **NTFPs/ MFPs (>90% from forest areas, significant role in local economy)**
- **Fodder (better quality & quantity, diversity, richness)**
- **Fuel (better-comfortable-viable options- many species availability)**
- **Agro-forestry support (soil binders, local seeds, fruits, climbers, etc.)**
- **Water regime balance through forest cover (stop desertification & soil erosion)**
- **Pasture system (cover, abundance, diversity of grasses, ecological shifting)**
- **Agriculture (ecosystem supported agriculture, low input, quality production)**
- **Oil yielding plants (edible, economic, species conservation)**
- **Dye yielding plants (traditional, economic, species conservation)**
- **Beverage making plants (tradition, economic, species conservation, medicine value)**
- **Religious & Spiritual uses of species/ Sacred elements (conservation)**
- **Poisonous plants (hunting, fish catching, species conservation, association)**
- **Natural-Traditional routes and groves (landscape level relation)**
- **Hut construction material (shelter, safety, storage, social need, diversity, durability)**
- **Craft making (tradition/ culture, diversity, economic, species association)**
- **Habitat conservation, protection, cultural diversity, Survival supports**

Major Threats to Biodiversity & Overall Environment of Aravallis

- Habitat Destruction
- Invasive Alien Species (IUCN, CBD)
- Fires (Natural, Human Induced)
- Illegal Wildlife Trade, Poaching / Smuggling
- Human-Wildlife Conflicts
- Disintegration of Wildlife Corridors and Migration Routes
- Encroachments / Expansions in Forest Land for Non-Forestry Purpose
- Unsustainable Development Projects
- Destruction of Watersheds and Catchments of Wetlands & Reservoirs
- Pollution (Industrial Wastes, Urban Wastes, Electronic Wastes)
- Overexploitation of Natural Resources

Wildlife Trade

- **Major Trade contribution from Rajasthan –**

- Tiger and Leopard (Bones, Skins, Claws, Teeth and Whiskers)
- Snake (Skins or Live Snakes, Venom) (Cobra, Royal snake, Red Sand Boa etc)
- Caged Birds (Parakeets, Mynas and Munias)
- Pangolin (live or killed for Meat & Scales) **(Largest smuggled mammal in the world)**,
- Tortoise and Turtle (Live and Shells)
- Bear (Skin, Paws, Nails)
- Fox and Mongoose (Skin and Hairs)
- Deers and Antelopes (Meat, Horns& Antlers, Skin)
- Plants (Timber, Medicinal Plants, Ornamental)

Alien Invasive Species

In Rajasthan > 80 Alien Species representing 26 plant families

- **Potential Invaders –**
- ***Ageratina adenophora*** (Mexican Devil, Kala Bansa),
- ***Hyptis suaveolens*** (Vilayati Tulsi)
- ***Alternanthera philoxeroides*** (Alligator Weed)
- ***Lantana camara*** (Lantana),
- ***Chromolaena odorata*** (Bitter Bush)
- ***Eichhornia crassipes*** (Water hyacinth),
- ***Parthenium hysterophorus*** (Congress grass)
- ***Prosopis juliflora*** (Vilayati Babool)
- ***Senna uniflora*** (Oneleaf senna),
- ***Senna tora*** (Sickle senna)
- **Ageratum conyzoides**
- ***Leucaena Leucocephala*** (Subabool)
- ***Ximenesia encelioides***

Major Native Regions Represented (order of merit):

I. South America (Brazil, Peru, Chile, Argentina, Colombia, Ecuador),

II. North America (Mexico, USA),

III. Central America,

IV. Caribbean,

V. Northern Africa, Southern Africa, Madagascar

VI. Middle East, SE Asia, China etc.

Habit-wise Order - **Herbs > Shrubs > Climbers > Trees**

Aquatic Invasives -

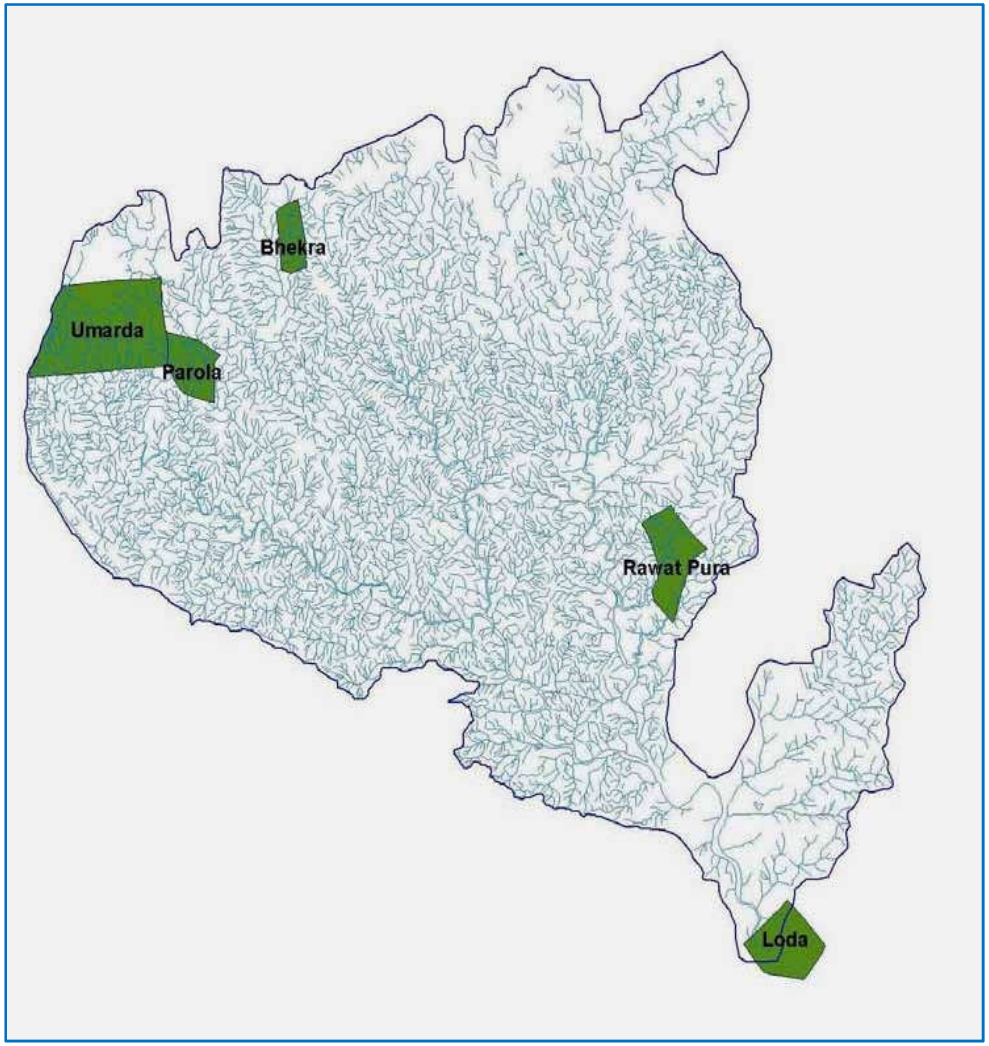
- Five primary aquatic plant weeds of the world as well as worst weeds in India (Rajasthan) -
  - *Eichhornia crassipes,*
  - *Salvinia molesta,*
  - *Hydrilla verticillata,*
  - *Alternanthera philoxeroides*
  - *Pistia stratiotes*

Aquatic and Terrestrial Invasive Alien Animal Species

- **Giant African Snail**
- **Tilapia Fish**
- **Thai Magur Fish**
- **Big-head Carp Fish**
- **Hammer-headed Worm**

Some Case Studies

1. Ecology & Livelihood in Jaisamand Catchment Area: Jhamri Sub-Basin



Major Ecological Indicators…

Availability

- Water
- Feed

Physiographic features & Soil condition

- Upstream–Midstream-Downstream
- Slope
- Soil depth, structure Social Indicators
- Livelihood pattern
- Social customs Economic Indicators
- Investment pattern

Stress (Pollution)

Bio-indicators: Nests, Hives, Bat Roosting, Water Bloom

Physical Indicators: Dust, Water Quality

Industrial Area: Umarda

Baghdara Nature Park

Agriculture & A H : Rawatpura (Dangi)

Agriculture & A H : Rawatpura (Rawat)

2. ECOLOGICAL CHANGES IN UMARADA

Time period	Status	Changes/ Impacts
Before Independence	Good density of wild & domestic flora-fauna	
60s	Tree felling on large scale	Vegetative cover decline
70s	Establishment of Jamarkotara Rock-Phosphate mine	Loss of vegetation & top soil cover
80s	Severe drought	Major livestock & vegetation decline
90s	Establishment of Processing Units	Air & water pollution, Species population decreased, some species locally got extinct
20s and afterwards	More industrial units & Urban influence	Change in landuse, livestock population & human health

CHANGES IN AGRICULTURE SPECIES

S. No.	Local name	Scientific name	Past status	Present status
1	Chana	*Cicer areitinum*	++++	-
2	Gawar	*Cyamopsis tetragonoloba*	++++	+
3	Khira	*Cucumis sativus*	++	+
4	Kikodi	*Momordica dioica*	++	+
5	Lauki	*Lagenaria siceraria*	++	+
6	Maal	*Eleusine corocana*	+ with Makki	-
7	Makki	*Zea mays*	100%	20%
8	Mirch	*Capsicum annuun*	++++	-
9	Samlai	*Panicum sumatranse*	+	Rarely
10	Til	*Sesamum indicum*	++++	++

* : ++++ = Abundant, +++ = Common, ++ = Less common, + = Occasional (in some area only), - = Absent

CHANGES IN WILD PLANT SPECIES

S. No.	Local Name	Scientific name	Past status	Present status *
1	Aam	*Mangifera indica*	++*++	- if +, fruitless
2	Anwala	*Emblica officinalis*	+25%	5%
3	Atedi	*Helicteres isora*	++	-
4	Bel	*Aegle marmelos*	++	15%
5	Dhavda	*Anogeissus latifolia*	++++	+
6	Gingasi	*Grewia flavescens*	++++	16%
7	Godal	*Lannea coromandelica*	++++	+
8	Gonda	*Cordia dichotoma*	++++	+
9	Kamdi	*Carissa congesta*	++++	-
10	Khair	*Acacia catechu*	++++	-
11	Khajur	*Phoenix sylvestris*	++++	-
12	Khakhara	*Butea monosperma*	++++	1-2%
13	Mahua	*Madhuca indica*	++++	-,only 2 trees but fruitless
14	Pipal	*Ficus religiosa*	+++	+
15	Thoor	*Euphorbia caducifolia*	++++	-
16	Timaru	*Diospyros melanoxylon*	++++	+

* : ++++ = Abundant, +++ = Common, ++ = Less common, + = Occasional (in some area only), - = Absent

S. No.	Common english name	Local name	Scientific name
1	Black Kite	Harjan	*Milvus migrains*
2	Black Redstart		*Phoenicurus ochruros*
3	Black-rumped Flameback	Suthariya	*Dinopinum beghalense*
4	Changeable Hawk Eagle	Harjan	*Spizaetus cirrhatus*
5	Common Moorhen		*Gallinula chloropus*
6	Common Pochared		*Aythya ferina*
7	Common Tailorbird		*Orthotomus sutorius*
8	Europeon Wryneck		*Jynx torquilla*
9	Gray Francolin	Titar	*Francolinus pondicerianus*
10	Grey-breasted Prinia		*Prinia hodgsonii*
11	House Crow	Kagda	*Carvus splendens Vieillet*
12	Indian Bushlark		*Mirafra erythropera*
13	Indian Nightjar		*Caprimulgus asiaticus*
14	Indian Peafowl		*Pavo cristatus*
15	Indian Robin	Devti	*Saxicoloides fulicata*
16	Indian Silverbill		*Lonchara malabarica*
17	Jungle Bush Quail	Lawri	*Perdicula asiatica*
18	Laughing Dove	Chhoti	*Streptopelia senegalensis*
19	Lesser Whitethroat	Jarki Kamedi	*Sylvia currca*
20	Paddy field Pipit		*Anthus rufulus*
21	Spotted Dove	Kamedi	*Streptopelia chinensis*

CHANGES IN BIRD POPULATION IN THE AREA

Decline

Locally Extinct

- Egyptian Vulture
- Long-billed Vulture
- White– Umped Vulture

3. Biodiversity Study of Ajmer

- Increased aridity
- Increased presence of sand and desert biodiversity East of the Aravallis indicating that relvance of the Aravalli has reduced
- West facing side of Nag Pahad well protected due to being a sacred grove (no juliflora) indicating role of Aravallis (Nand Tillora) as barrier, however East facing side to Ajmer had large amount of juliflora indicating how deforestation can desertify the ecology.
- West and East facing sides of nand Tillora had different types of species indicating the role of Aravalli as a barrier.

4. Adaptation to Change in Interlinked Cultivated and Wetland Ecosystem (N-E Rajasthan)

Adaptation to change in interlinked cultivated and wetland ecosystem: a study in Western India

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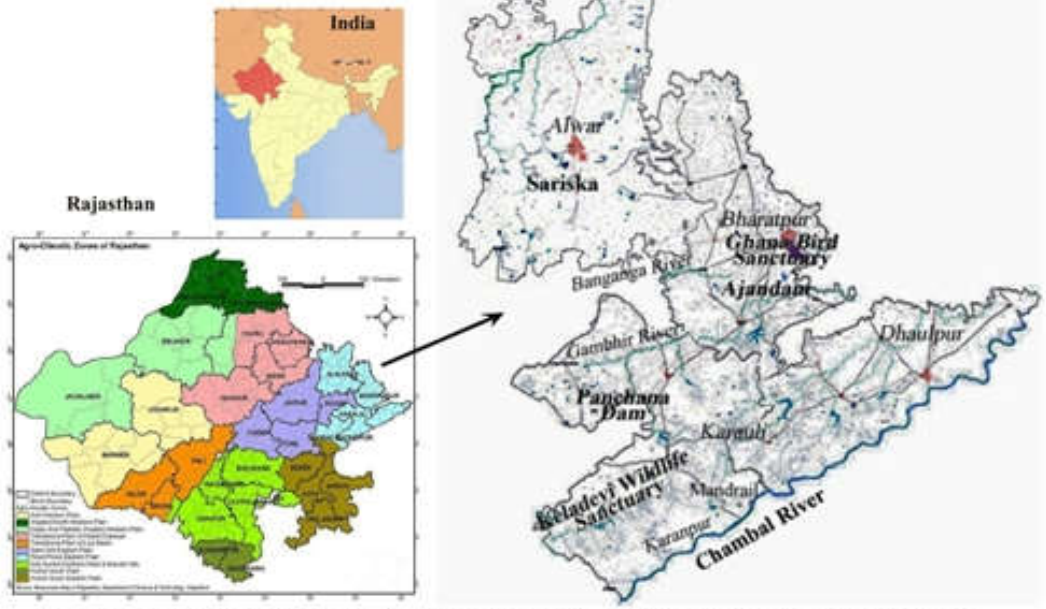
SPWD

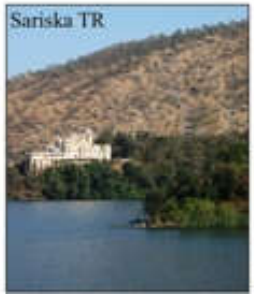
Study Location - Flood Prone Eastern Plains



Changing character of the Agro Climatic Zone from flood prone to water scarcity

Ecosystems Assessed:

Forests:	Ghana NP, Sariska core area, Mandrail Alligator Sanctuary, Kailadevi WLS
Grasslands:	Bharatpur environs, Kailadevi pastures, Pasture resources of Sariska (Core & Buffer zone),
Mountains:	Aravallis of Alwar
Drylands:	Bharatpur, Alwar, Area between Kundanpur to Mandrail
Agriculture:	Sariska Buffer zone, Karauli, Bharatpur, Alwar, Kundanpur
Urban:	Bharatpur, Alwar, Karauli



Ecosystem Services Assessed:

1. **Provisioning:**
   - **Food:** Wild edibles, fruits, vegetables, crops & spices
   - **Water:** River Chambal, Ruparel, Gambhiri, Chambal canal, water bodies of Orans (Sacred groves)
   - **Genetic resources:** Wild relatives of Crop plants, Wild relatives of breeds
   - **Energy/Fuel:** Existing forest depended & other biomass energy resources
2. **Regulating:**
   - **Erosion prevention:** Tree cover, Ground cover, *Cyperus* beds in rivulets, contributions of Orans
   - **Pollination:** Diversity of pollinating agents
   - **Climate regulation:** Tree cover (air) & ground cover (earth) for moisture retention
3. **Supporting:**
   - **Nutrient cycling:** Leaf-litters biomass, ground insects, regular functioning food webs
   - **Soil formation & fertility:** Organic biomass from leaf-litters, nutrition cycles
   - **Primary production:** Richness & diversity of primary producers (flora)
4. **Cultural:**
   - **Recreation & tourism:** Tiger Reserve, Ghana NP-Ramsar Site, Mandrail Alligator Sanctuary, Orans

Ecological Indicators used in Ecosystem & Services Assessment

(All indicators with detail in separate document available)

Species diversity, richness, distribution	Habitat diversity, quality, complexity	Natural regeneration
Plant Biomass	Grass diversity, cover	Keystone Species, Umbrella Species
Pollinators	Seed dispersal agents (Zoochory)	Biological pest controlling agents
Rare, Threatened, Endangered species	Root stock availability	Species loss
Food web	Epiphytes (Lichen, moss, Orchids, ferns)	Lower taxa
Bulbous plants	Plus Tree traits	Leguminous plants
Invasive Species	Parasites (Plants)	Aquatic Species
Water colour, odor	Change in Runoff	Soil texture, colour, depth, microbes

Negative changes in Ecosystems (Sariska, Bharatpur)

- Deterioration in soil health; Soil erosion increased
- Decreasing ground water table
- Change in diversity & richness of indigenous flora-fauna
- Conflicts in Pasture resources
- Negative impacts on indigenous seeds & livestock breeds
- Increasing human-wildlife conflicts
- Water supply in Ghana Bird NP by Canal instead of Ecological flow - quality and quantity of feed changed
- Heavy disturbances in Protected Areas

External Forces

Market fluctuations
Change in cropping pattern (high inputs)
Faulty policy implementation

Positive Changes in Ecosystems (CCA- Orans):

- Enhancement of vegetation cover, prevent Soil erosion
- Better Soil Health, Better productivity
- Increasing Biodiversity (Flora & Fauna)
- Increasing Plant Genetic diversity
- Quality & quantity increased of Surface water bodies
- Positive impacts on Ground water table
- Better Pasture resources
- Increased Biomass
- Enhancement of Agriculture fields
- Diversity & rich population of Pollinators
- Availability of economically important plants
- Community involvement in conservation & management of resources

Possible Remedies for Negative Changes

> Sustainable Agriculture with low inputs (Soil health enhancing), Indigenous Seed bank creation in the region
> Ecologically sound & Community rights supporting management strategy to ensure sustainability of natural resources & reduce conflicts
> Regular assessment of ecological economics

Ongoing Tasks

> Data collection for Ecosystem mapping & Modelling
> Status of Aravalli ridge as ecological barrier to combat desertification
> Stakeholder consultations

Future Tasks

> Implementation of Biodiversity Act 2002; Creation of BMCs to protect Common resources
> Ecosystem Modelling
> Manual for assessment of Interlinked Ecosystems

Thank You