



Ecological Indicators

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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, <i>P.juliflora</i> 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

Main features considered... few examples

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 (Humpty) & 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**

- **Ecological** – ‘Ecological’ relates to the interrelationships of organisms and with their environment. The science of ecology is the study of how organisms interact with each other and with their physical environment.
- **Biophysical** – ‘Biophysical’ refers to the biological and physical components of the environment put more simply, biophysical refers to the *living* (the biological) and the *nonliving* (the physical) components of the environment.
- **Ecosystem** – An ‘Ecosystem’ refers to communities of organisms and their physical environment that interact as a unit. The scale of an ecosystem is not fixed.
- **Landscape** – A portion of land or territory which the eye can comprehend in a single view, including all the objects it contains. A landscape level approach takes into account biological, geophysical and a range of social and cultural factors that affect how the land is used (Frost et al, 2006). The science of landscape ecology is concerned with the “entire complex cause-effect network between living communities and their environmental conditions which prevails in a specific section of the landscape (Odum and Barrett, 2005).

ECOLOGICAL INDICATORS

- To understand Environmental, Ecological, Biophysical & Socio-economic impacts of physical interventions (watershed, ecorestoration & reclamation, BD conservation, agro-forestry, agricultural, pasture dev., Mining, energy gen projects, industries, etc.)
- Present easily understandable, scientifically methods for data collection, resource & niche mapping and analysis
- easily understandable, educational manner
- Help to improve productive capability in degraded production lands
- Help to enhance nature conservation values at larger landscapes
- Help to restore ecological processes over broad landscape-scale or regional areas

ECOLOGICAL INDICATORS

- To quantify the flows of benefits that communities obtain from regenerating lands;
- To improve cost effectiveness and planning of future activities;
- To determine if resource use patterns are sustainable;
- To collect data that can be used for ecological auditing, water resource estimation, water budgeting, biomass change, successional change, Natural Resource Accounting System, etc);
- To uncover unexpected impacts;
- To provide data that can be used to advocate for policy changes.
- To do impact assessment of Development projects in a short time for social & ecological justice (when EIA, SIA not mandatory)

- **All the parameters explained here, are direct or indirect connected with the whole system**
- **Their complete details are necessary to understand whether ecosystem functional or not, ecological processes are going on normally or they are interrupted because, these are natural and normal linkages between plants and animals in a functional ecosystem**

Major Indicators	Indication
Plant Biomass (required for)	Calculation of Carbon sequestration; to estimate production/Supply – Demand (Food, fodder, fuel, timber, NTFPs, etc.); Determine biomass extraction (Use) rates; Management & conservation related decisions
Increase of Biomass	Increase in Soil porosity & fertility, soil moisture holding capacity & duration of moisture availability, soil depth & soil bulk density, soil permeability, % organic Carbon in soil, soil microbes, Surface water availability & quality; Increase insects, birds, mammals; terrestrial habitat diversity & quality; Aquatic habitat diversity & quality; Floral & Faunal sp. association; Pollinators diversity, Seed dispersal; increase competition among species (fauna, flora)
Increase of Biomass	Decrease in Soil erosion, decrease Runoff speed, siltation in water-bodies, Turbidity of water
Natural regeneration & recruitment	Species recovery, problems associated with sapling establishment, future food, fodder etc. resources security, moisture availability, natural protection to sp. community

Indicators	Indications
Species diversity, richness, distribution & Association (F&F)	Status of food web and food chains, ecosystem health, forest composition, resource facilitation, status of stress elements. Status of flora – fauna relation (food, habitat, safety, survival)
Invasive species	Source of stress on ecosystem, level of competition among species communities
Endemic species	Highly adapted to home range so any change comes from anthropogenic or Natural cause, their adaptation can function as source of competitive strength/weakness. So great indicator of change/wrong in ecosystem/life support system. Restricted distribution so threat to the sp. carry risk of extinction (it takes with it associated endemic animal sp. too)
Rare, Threatened & Endangered species	Loss of species trigger the loss of other species within its ecosystem and associated social aspects.
Supporting species	Bird diversity and population due to great support of roosting, nesting, foraging, food, safety. Bee hives & bee population. Plant-animal interactions
Plus tree traits	Forest living seed banks, ideal source of new progeny for the forest

Indicators	Indications
Aquatic Sp. (Azolla, etc.)	Soil fertility, best forage (19-30% crude Protein), pH 6-7
Epiphytes (lichen, moss, ferns, orchids, etc.)	Species association, moist condition. Forest continuity & naturalness, great exchange of eco-services with host sp. (mosses to prevent host desiccation, orchids to attract pollinators). Depend on environmental variables
Lower taxa- Algae, lichen, bryophytes, pteridophytes	Moist habitats, ground cover spread contributing to nutrient cycles, providing seed-beds for larger plants, micro habitats for insects. Their cover help to prevent soil erosion, abundance of liverworts adding to hill stability.
Parasites (plants)	Host range & preference indicates status of host sp. Relationship with host negative (food, water extraction) and/or positive (pollinators, seed dispersal agents attracting). Some sp harmful to some economic important plants.
Leguminous plants	Nitrogen fixation in soil, increase soil fertility and soil microbes
Surrogate species (Keystone, Umbrella sp.)	Sensitive to habitat alteration-fragmentation-destruction, weed/pest invasion.

Indicators	Indications
Grass diversity and cover	Pasture support, increase in soil nutrition, preventing soil erosion, habitat of ground insects & birds
Bulbous plants	Contain food reserves to enable plant in extreme condition survival. Last without replanting for several/ many years.
Species loss	Process of succession, highlights existence of stressors
Root stock availability	Capacity of ecosystem to regenerate naturally
Carnivores plant species	Plant-animal interaction, specialist species
Pollinators	Increase ecosystem productivity (food, crop)– increasing food security and improving livelihood (Agri., NTFPs). Decreasing pollinators indicate big damage in ecosystem-habitat loss, fragmentation, fire, toxic impacts of chemicals & pesticides/ insecticides. Great plant-animal interaction service.
Seed dispersal agents (zoochory)	Plant-animal interaction, seed treatment, plant population dynamics, Species distribution & survival through migration, decrease competition= mother plant & seed

Indicators	Indications
Top predators	Food web dynamics, completeness of food chain, resource facilitation, increase health problems due to decreasing predators, sensitive to ecosystem dysfunction
Scavengers	Nature's trash trucks, Important in food web, sensitive to ecosystem dysfunction. Availability of food & habitat. Improved ecosystem health. Increase health problems when they decrease.
Ground-dwelling insects	Forest composition. Sensitive to disturbance, re-introducing nutrients in soil, change in sp. composition indicates succession.
Land snails	Moist habitat. Decomposers (litters, fungi, dead plants & animals) and enrich soil. "Soil engineers"
Dragonflies, Damselflies	Water availability and quality, quality of the biotope, wetland health "Conservation soldiers"
Spiders	Species richness indicates non-harming effect of burning & mowing. Quality of micro climate, physical structure of habitats, vegetation characteristics. Bio pest control agents.

Indicators	Indications
Broadleaf species	Climatic conditions and natural adaptation. Status of moisture & light availability. Water relation & energy balance, pollution level, Biomass, herbivore population support
Xerophytes increase	Increasing Aridity, stressful environmental conditions
NTFP / MFP / Medicinal plants	Productivity of ecosystem, Human-biodiversity interaction, forest products (tangible & intangible) based socio-economic survival, nutrition & energy transfer. species population decrease when use/exploitation increase
Bee Hives	Healthy-clean environmental conditions. Decrease Bee hives indicates stress in ecosystem health (despite more trees/plants)
Wildlife conflicts	Stressful human-biodiversity interactions, disturbance increase in life support systems (food, habitat, safety, survival)
Habitat diversity, quality & complexity	Forest status. Species area relationship. Spatial or temporal change across a landscape. Habitat loss/alteration cause species loss
Genetic diversity	Gene pool of the forest
Temperature Increase	Mosquitoes and related diseases increase, aridity increase

Indicators	Indications
Water colour	Turbidity in water. If water bodies have very clean water after rainfall, soil erosion is less.
Well/ Step well level	Variation of water table and piezometric surface of unconfined & confined aquifers
Number, type, location, function of wells	Water extraction pattern
Water loving species, wet land species, Presence of fish, water snails, macro invertebrates	Water availability. Certain species only flourish in high quality water condition
Change in runoff	Changes in infiltration, water quality, ground cover
Duration of Soil moisture availability	Availability of ground cover, fodder, etc. Determines what rain-fed crops can be grown in fields.
Soil texture	Porosity, permeability, water holding capacity, water movement, root penetration
Soil colour	Mineral composition
Soil depth	Erosion & soil formation. Influences species composition

Biophysical & Ecological changes in Kalpavalli region

Biophysical changes	Ecological changes
<p>Eco-restoration work: Soil moisture increased & maintained for longer time</p>	<p>Increased soil moisture allowed water loving sp. algae, moss, ferns, lichens, etc established in several microhabitats</p>
<p>Increased forest cover resulted in a greater amount of leaf litter/ biomass on the ground</p>	<p>Increased leaf litter provided ideal habitat for insects, ground birds; Increased moisture and soil fertility; established ideal food chains and food web</p>
<p>Windmills operation: Damage of catchment area in Mustikovila & Kogira Watershed; Blockage of rivulets & streams due to Windmill interventions</p>	<p>Decreased water availability-reduced ground cover, grass habitats/ Pasture. Ground nesting/roosting birds begin to leave the area. Negative impacts on fields</p>
<p>Deforestation & increased erosion. Water bodies become perennial to short time/dry</p>	<p>Reduced ability of ecosystem to regulate water cycle.</p>
<p>Change in soil depth due to erosion.</p>	<p>Change in soil nutrient cycling-impact on production. Change in the dominance of certain grass & herbs as a result of changing soil fertility.</p>

Kalpavalli: Habitat diversity-indicator of forest improvement

- **Moist & marshy habitat:** A very dense Kewra grove (*Pandanus fascicularis*)
- **Valley line:** *Borassus flabellifer* (Toddy tree)
- **Riparian species:** *Syzygium heyneanum*
- **Forest outskirts:** *Cordia dichotoma*
- **Aquatic & semi aquatic:** *Bacopa monneri*, *Typha angustata*, *S. spontaneum*
- **Valleys:** *Tecomella undulate*, *Phoenix sylvestris*, *Desmostachya bipinnata*
- **Foot hills:** *Barleria prionitis*, *Tectona grandis*, *Gmelina arborea*, *G. superba*
- **Along streams:** *Vitex negundo*
- **Moist open & fields:** *Digera muricata*
- **Gravelly rock area:** *Pupalia lappacea*, *Aristida adscensionis*, *Melanocenchris sp.*
- **Moist, shady places:** *Commelina benghalensis*
- **Hill slopes:** *Apluda mutica*, *Heteropogon contortus*
- **Agro fields:** *Urochloa panicoides*
- **Host species:** *Epiphytes and parasites*

Species distribution in different location in Aravallis of Gujarat

Local Community's Relation with Biodiversity in Daily Life & Livelihoods:

Location	Fauna Sp.	Flora Sp.	No of plants used by local community			
			Wild edible	Medicine	NTFP	Fodder
Jessore WLS & Ambaji –Balaram WLS	>450	428	80	253	69	31
Kuvarsi-Danta	>200	389	74	207	55	30
Chitrasani-Palanpur	>300	394	69	211	46	20
Bhuro dungar- Vijaynagar	>250	421	66	213	44	19
Zer-Dhareswar- Vijaynagar	>200	419	73	214	51	28
Undapani-Bhiloda	>138	345	22	213	23	10
Hathol-Bhiloda	>280	328	31	203	31	27
Shamalaji- Sabarkantha	>300	480	39	200	48	32
Taranga hills- Mahesana	>140	289	39	97	39	19
Mahesana	>390	460	106	329	40	42
Pavagadh hill-Panchmahal	>400	398	42	279	49	39
Total	>700	>1200	170	453	139	69

Incomplete list...Biodiversity study is going on...

RED LISTED PLANTS OF THE REGION

36 Species



Butea monosperma var. lutea

(Yellow flowered *Butea*)

&

Eulophia ochreatea

(Rare-terrestrial Orchid)

Reported first time from the
Aravallis of Gujarat

Species	Family	Life form
<i>Barleria acanthoides</i>	Acanthaceae	Shrub
<i>Boswellia serrata</i>	Burseraceae	Tree
<i>Buchanania lanzan</i>	Anacardiaceae	Tree
<i>Butea monosperma var. lutea</i>	Fabaceae	Tree
<i>Celastrus paniculatus</i>	Celastraceae	Climber
<i>Chlorophytum borivilianum</i>	Liliaceae	Herb
<i>Commiphora wightii</i>	Burseraceae	Tree
<i>Ephedera foliata</i>	Ephedraceae	Shrub
<i>Eulophia ochreatea</i>	Orchidaceae	Herb
<i>Gloriosa superba</i>	Liliaceae	Climber
<i>Limonia acidissima</i>	Rutaceae	Tree
<i>Manilkara hexandra</i>	Sapotaceae	Tree
<i>Moringa concanensis</i>	Moringaceae	Tree
<i>Oroxylum indicum</i>	Bignoniaceae	Tree
<i>Ougeinia oogeinsis</i>	Fabaceae	Shrub
<i>Peganum harmala</i>	Zygophyllaceae	Herb
<i>Pterocarpus marsupium</i>	Fabaceae	Tree
<i>Sterculia urens</i>	Sterculiaceae	Tree
<i>Tecomella undulata</i>	Bignoniaceae	Tree
<i>Terminalia arjuna</i>	Combretaceae	Tree
<i>Withania coagulans</i>	Solanaceae	Herb

Species Extinction from the region

Species	Site of presence	Yrs of Extermination (Approx.)
Lion	Ahmedabad (Gujarat)	1830
	Baroda (Gujarat)	1832
	Deesa (Gujarat)	1878
	Palanpur (Gujarat)	1880
	Anadara (Rajasthan)	1872
	Abu (Rajasthan)	1881

Wild life Corridor from Gujarat to Southern Rajasthan & Vis.

Species extinction record helps to understand the history of the ecosystem,

history of habitats, history of Species population & association,

Timeline & status of parameters responsible for changes & Species Extinction

in the region (Landscape)

Application

- Certain indicators like, increase of aridity, mosquitoes, unhygienic conditions due to absence of scavengers & predators, require specific Health programmes in the area (help to develop Health index of ecosystem & community).
- **EEP**- various activities with community to understand their knowledge on these indicators and related changes in their surrounding environs (to enhance their participation) = Outcome- PBR, Kalpavalli & Kawant resource profile
- Monitoring ecological health- management plan & policy

Cont...

Application

- Ecological indicators prove the status of Kalpavalli forest, micro & macro habitats, micro & macro species associations, status of ecoservices & life support systems (Agri., pasture, NTFPs, energy, food, shelter, etc.), which ensured the richness of biodiversity of the region and helped to apply the Biodiversity conservation Act 2002 through BMCs registration.
- Ecological indicators helped to understand CDM issues and violation of many acts & community rights in Kalpavalli. Based on them comment reports were sent to UNFCCC Secretariat & PIL filed at National Green Tribunal of India