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ECOLOGICAL RANKING OF DISTRICTS OF PAKISTAN: A GEOSPATIAL APPROACH

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Abstract

Ecological indicators were synthesized to identify ecologically significant and priority areas within each province/administrative territory of Pakistan. We compiled the spatial distribution of six aspects of ecological value for geographical targeting of conservation priority areas. A Geographic Information System (GIS) based overlay analysis of ecological dynamics was carried out. Indices for forest cover, vegetation zones, endemic mammals, highly significant wetlands, bird species richness and mammal species richness were developed by compiling the secondary data into Geographic Information System. Analytical hierarchy process was used to weight these indicators and also multi-attribute utility theory to combine them into a single spatial layer of ecological value. On the basis of these indices each district was ranked within its respective province/administrative territory. The results highlighted ranking of districts in order of their ecological significance within the province for all the provinces/administrative territories. The study is a pioneer study to identify administrative areas of high ecological value and can guide in setting the conservation priorities. The current broad scale study can help decision makers in provincial level policy making. In the highly significant districts, development activities should require special attention to assess their environmental impacts. In contrast, for the least significant districts a set of indicators can be identified and shared with the District Governments to improve and monitor their ecological conditions.

Introduction

Pakistan has highly diverse geographical area, which includes majestic mountain ranges of the Himalayas, Karakorum, and Hindu Kush, the Indus plains, deserts and coastal areas. Altitudinal variations range from world's second highest mountain (K2) in the north to the sea level in the south (Khan, 2006). The country has a rich variety of wetlands, and other wildlife habitats and landscapes with their associated fauna and flora. Varied habitats range from permanent snow fields/glaciers to dry alpine and cold deserts, alpine scrub/moist alpine, Himalayan dry coniferous, Himalayan moist temperate forest, sub-tropical pine forest, subtropical dry mixed deciduous scrub forest, Balochistan juniper/pistachio scrub forest, dry sub-tropical & temperate semi-evergreen forest, tropical thorn forest, sand dune desert and mangrove/littoral (Roberts, 1997). The present varied and interesting composition of biodiversity in Pakistan is largely due to its being a transitional zone between two of the world's six major zoogeographical regions, the Palearctic, and the Oriental, species have also come from as far as the Ethiopian region (Roberts, 1997; Zaman, 2008).

Prioritizing areas in terms of their ecological significance and selection of conservation areas using a set of indicators is an important aspect of conservation planning (Phua & Minova, 2005). There are many key ecological indicators for the assessment of ecological significance of natural areas which may include species richness, species endemism, spatial arrangement of natural areas and measures of probability of species persistence (Bryan *et al.*, 2010).

A geographic information system (GIS) is a computer based system which can integrate quantitative methods to provide an excellent framework for data capture, storage, synthesis and analysis (Zang *et al.*, 2011). The capability of GIS in handling spatial aspects of conservation has boosted its use in the criteria-based evaluation for prioritization and selection of potential conservation areas. This is because most of the criteria for conservation planning are spatial data (Jones *et al.*, 1997; Phua & Minova, 2005). GIS has the ability to quickly and accurately extract a variety of basic information of ecological and environmental aspects, generate and update thematic maps of different ecological factors in different phases (Zang *et al.*, 2011).

Prioritizing the ecologically significant areas is the key of conservation planning. Pakistan has established many conservation sites (Protected Areas) based upon their ecological significance and they are designated with protection status viz., national parks, wildlife sanctuaries, game reserves and wildlife refuges (Khan, 2003). Most of these areas are large forested areas or landscapes indentified for conservation because they harbor high level of biological diversity. The majority of conservation efforts are directly focused on these protected areas which are mainly concentrated in southern and north-western parts of Pakistan (Khan, 2003; Anon., 2003). There are a number of smaller units of the wilderness that are significant for their ecological relevance but out of sight due to the lack of information. A need therefore still exists to establish conservation priorities on the basis of uniform set of indicators and at a certain spatial scale.

Current study was planned to prioritize the district within their respective province/administrative territory. We compiled and mapped the spatial distribution of six aspects of ecological value for geographical targeting of conservation priority areas. The study is based on these six ecological indicators and their synthesis to identify ecologically significant and priority areas within each province/administrative territory of Pakistan.

Materials and Methods

A Geographic Information System (GIS) based overlay analysis of ecological dynamics was carried out. We compiled the spatial distribution of six aspects of ecological value for geographical targeting of conservation priority areas. The aspects include indices on forest cover (Anon., 1992; Anon., 2004), vegetation zones (Roberts, 1997), endemism (mammals) (Sheikh & Molur, 2004), highly significant wetlands (Qamer *et al.,* 2009), bird species richness (Roberts, 1991 & 1992) and mammal species richness (Roberts, 1997) were developed by compiling secondary literature data into GIS systems. Analytical hierarchy process was used to weight these indicators and also multi-attribute utility theory to combine them into a single spatial layer of ecological value. On the basis of these indices each district was ranked within its respective province/administrative territory. A brief description of the indicators and the criteria used in as under:

Forest cover: Forest cover is used as the percentage of the total area of a district. Forested areas of each district have been calculated from GIS datasets developed under the Forestry Sector Master Plan, 1992. On the basis of forest cover present in the respective provinces four classes were identified which are given in Table 1 along with the criteria.

Table 1. Criteria for indices of forest cover, birds and mammals.

No.	Forest cover (%)	No. of species (Mammals)	No. of species (Birds)	Weight
		AJ &K		
1	>> 26.4 (max. 35.14)	>> 40 (max. 49)	>> 138 (max. 172)	1
2	17.61 – 26.4	32 – 39	104 – 137	0.75
3	8.81 – 17.6	26 – 31	70 – 103	0.50
4	0.1 – 8.8	18 – 25	36 – 69	0.25
		Balochistan		
1	>> 28.2 (max. 37.63)	>> 46 (max. 57)	>> 162 (max. 198)	1
2	18.81 – 28.2	35 – 45	126 – 161	0.75
3	9.41 – 18.8	24 – 34	90 – 125	0.50
4	0.1 – 9.4	13 – 23	54 – 89	0.25
		Gilgit - Baltistan		
1	>> 16.8 (max. 22.4)	>> 32 (max. 37)	>> 159 (max. 191)	1
2	11.21 – 16.8	38 – 31	128 – 158	0.75
3	5.61 – 11.2	24 – 27	97 – 127	0.50
4	0.1 – 5.6	20 – 23	66 – 96	0.25
		KPK & FATA		
1	>> 63 (max. 84.12)	>> 46 (max. 55)	>> 227 (max. 277)	1
2	42.1 – 63	36 – 45	177 – 226	0.75
3	21.1 - 42	26 – 35	127 – 176	0.50
4	0.1 – 21	16 – 25	77 – 126	0.25
		Punjab		
1	>>6.55 (max. 8.72)	>> 50 (max. 60)	>> 302 (max. 346)	1
2	4.37 – 6.54	41 – 49	260 – 301	0.75
3	2.19 – 4.36	32 – 40	219 – 259	0.50
4	0.1 – 2.18	23 – 31	177 – 218	0.25
		Sindh		
1	>> 14.1 (max. 18.83)	>> 45 (max. 51)	>> 263 (max. 301)	1
2	9.15 – 14.1	40 – 44	226 – 262	0.75
3	4.71 – 9.14	35 – 39	189 – 225	0.50
4	0.1 – 4.7	30 – 34	152 – 188	0.25

Vegetative zones: Twelve vegetative zones occur in Pakistan (Roberts 1997).

- Permanent snowfields and glaciers
- Dry alpine and cold desert zone
- Alpine scrub and moist alpine
- Himalayan dry coniferous with baloot oak
- Himalayan moist temperate forest
- Sub-tropical pine forest
- Dry sub tropical and temperate, semi-evergreen scrub forest,
- Sub-tropical dry mixed deciduous scrub forest
- Balochistan juniper and pistachio scrub forest
- Tropical thorn forest
- Sand dune dessert
- Mangrove and Littoral

The criteria for vegetative zone indexing are as under:

- Four or more vegetative zone in any district = 1
- Three vegetative zone in any district = 0.75
- Two vegetative zone in any district = 0.50
- One vegetative zone in any district = 0.25

Endemism (mammals): Endemic species are those that are only found in a particular geographical area. Such species have high conservation value. There are five mammal species identified as endemic to Pakistan (Sheikh & Molur, 2004 and Gippoliti, 2008) which include Indus Dolphin (*Platanista gangetica minor*), Balochistan Black Bear (*Ursus thibetanus gerardiana*), Punjab Urial (*Ovis vignei punjabiensis*), Woolly Flying Squirrel (*Eupetaurus cinereus*) and Balochistan Dormouse (*Dryomys niethammeri*). The district which has an endemic mammal species of Pakistan is given an index value equal to 1 and those not having any endemic mammal species are given the value equal to 0.

Highly significant wetlands: More than 200 wetlands are considered significant Pakistan. There are 49 highly significant wetlands which are designated or part of the Protected Areas under the category of National Park, Wildlife Sanctuary, Game Reserve and Ramsar Site. Indexing criteria for highly significant wetlands are given below:

- Three significant wetlands in any district = 1
- Two significant wetlands in any district = 0.66
- One significant wetland in any district = 0.33

Mammal species richness: Species richness is a relative term that refers to the number of species in a community, and is directly associated with measuring the diversity of species in a given area. Mammal species richness of each district of Pakistan was calculated by overlay analysis of the species distribution polygons developed from 'The Mammals of Pakistan by Roberts (1997). Criteria used to plot indices for districts of each province/territory are given in Table 1.

Bird species richness: Bird species richness of each district of Pakistan was calculated by overlay analysis of the species distribution polygons developed for the 'Field Guide of Birds of Pakistan by Richard Grimmett, Tom Roberts and Tim Inskipp (2009). Criteria used to plot indices for districts of each province/territory are given in Table 1.

Results and Discussion

The districts ranked in top five categories, from each province, based on the above mentioned ecological factors are listed in Table 2. Figures 1 to 6 show the rank of each district in their respective province/administrative territory.

Prioritization of ecosystems, geographic areas, and individual species plays a key role in devising conservation related actions to minimize biodiversity loss (Brooks *et al.*, 2006; Taylor *et al.*, 2010). There has been a great increase in the use of systematic conservation planning methods implemented through software tools, mainly GIS, that provides numerous benefits over adhoc planning approaches based primarily on expert opinion (Sarkar *et al.*, 2006; Zafra-Calvo *et al.*, 2010). Conservation biologists are using Geographic Information System applications extensively in two general directions i.e., developing algorithms to predict species' geographical distributions and prioritizing areas for conservation. These two efforts, collectively, can provide strong basis for decision on geographical priorities for conservation (Peterson & Chen, 2002).

Table 2. Summarized province based ranking of the districts

No.	Province	District	Rank
1.	Azad Jammu & Kashmir	Neelum	1
		Muzaffarabad	2
		Bhimber, Mirpur	3
		Hattian	4
		Bagh, Kotli	5
2.	Balochistan	Lasbela	1
		Ziarat, Khuzdar	2
		Awaran, Sibi	3
		Gawadar	4
		Zhob	5
3.	Gilgit-Baltistan	Diamir	1
		Ghizer	2
		Skardu/Baltistan	3
		Gilgit	4
		Astor	5
4.	Khyber Pakhtunkhwa & FATA	Chitral	1
		Mansehra	2
		Swat	3
		D. I. Khan	4
		Upper Dir	5
5.	Punjab	Jhelum	1
		Khushab	2
		Rawalpindi	3
		Chakwal, M. Garh, D.G. Khan	4
		Mianwali	5
6.	Sindh	Thatta	1
		Sukkur	2
		Dadu	3
		Khairpur, Qambar Shahdad kot	4
		Karachi	5

Prioritization of efforts to maintain biodiversity is an important component of conservation, but is more often applied to ecosystems or species (Taylor *et al.*, 2010). Current study introduced a possible way to integrate bio-physical (ecological) variables (Bryan *et al.*, 2010; Taylor *et al.*, 2010) to obtain a sound evaluation of ecological significance at administrative unit level i.e., districts within the country. We have attempted to propose an objective and workable methodology by integrating the ecological data into GIS System. This helped to identify the areas with high ecological value as well as areas of low ecological values (Myers *et al.*, 2000; Zafra-Calvo *et al.*, 2010).

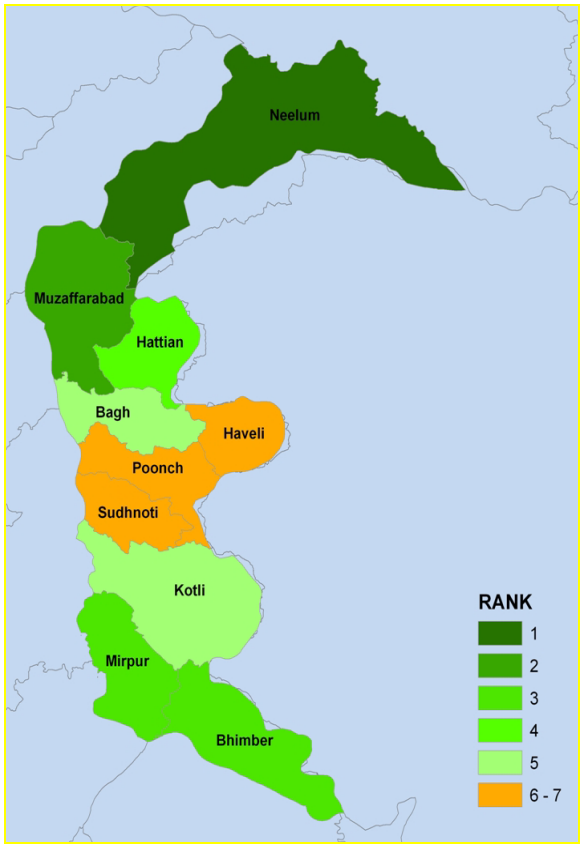

Fig. 1. Thematic map showing ecological ranking of the districts of AJK.

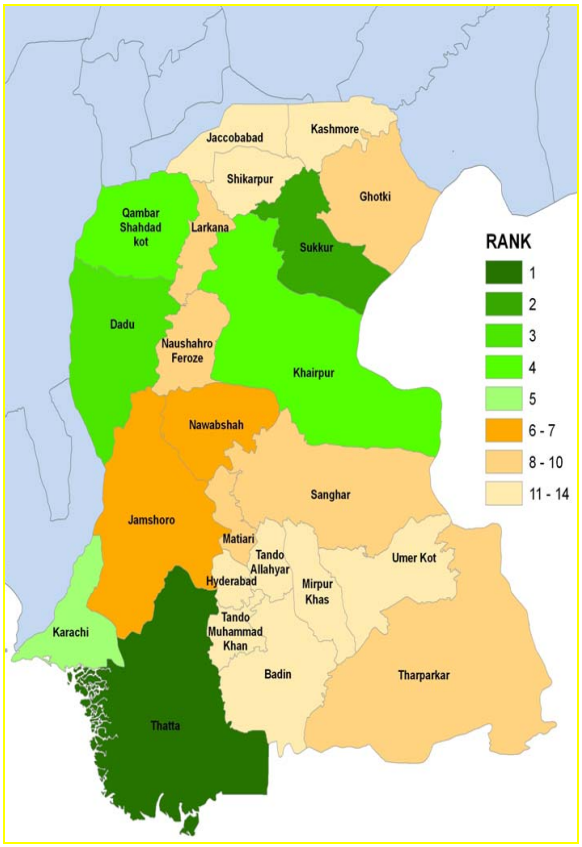

Fig. 2. Thematic map showing ecological ranking of the districts of Sindh.

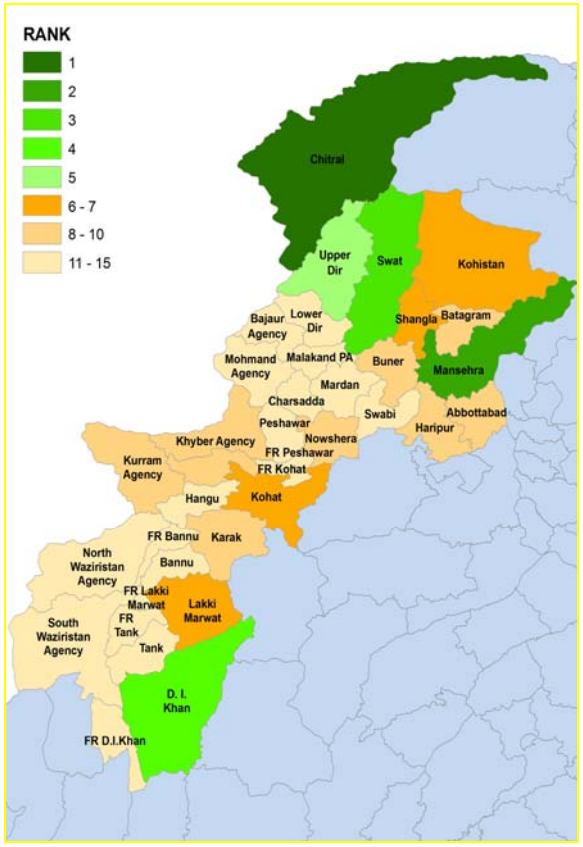

Fig. 3. Thematic map showing ecological ranking of the districts of Khyber Pakhtunkhwa and FATA.

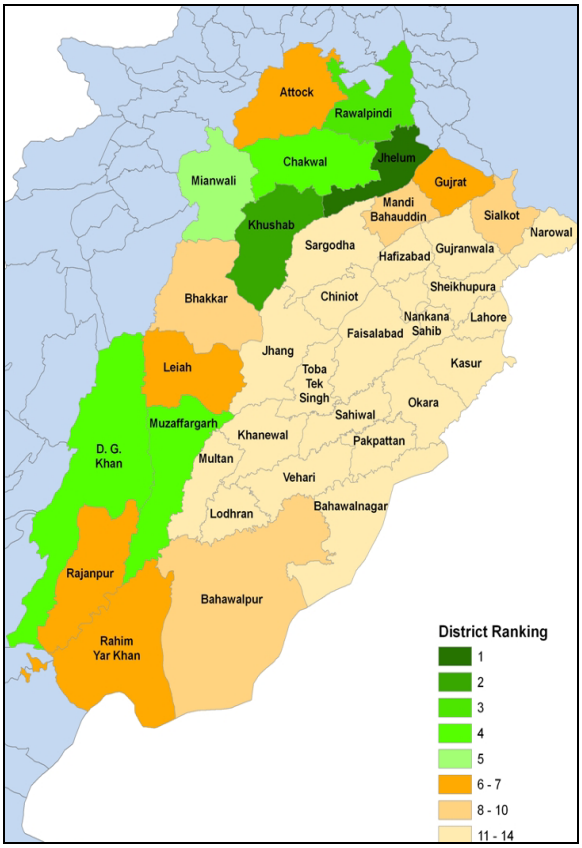

Fig. 4. Thematic map showing ecological ranking of the districts of Punjab.

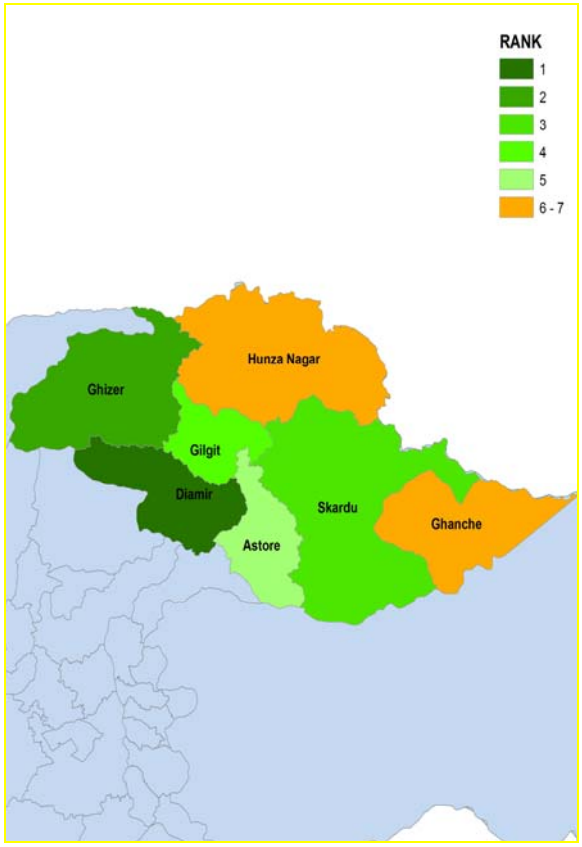

Fig. 5. Thematic map showing ecological ranking of the districts of Gilgit-Baltistan.

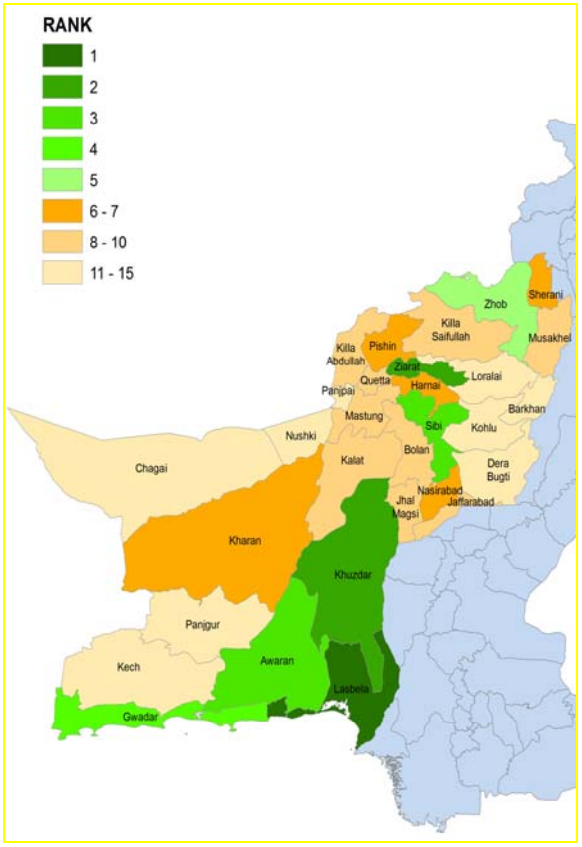

Fig. 6. Thematic map showing ecological ranking of the districts of Balochistan.

This study can serve as a pioneer study to guide us regarding conservation interventions to the priority areas within the province. It is expected that project interventions in high priority districts may require further analysis disaggregated to the tehsil and union council level. The current broad scale study can help decision makers in provincial level policy making. In the highly significant districts, development activities should require special attention to assess their environmental impacts. In contrast, for the least significant districts a set of indicators can be identified and shared with the District Governments to improve and monitor their ecological conditions.

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