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White-rumped Vulture's Distribution in Relation to the Landscape Factors in Arunachal Pradesh, India

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ABSTRACT: Avian distribution over the globe is normally influenced by many environmental factors including landscape factors. The present study was undertaken to evaluate the influence of landscape factors like elevation, vegetation, and land covers on occurrence of White-rumped Vultures in Arunachal Pradesh. The occurrence and abundance data were obtained following road count and point count methods from 2016 to 2020. The digital elevation model and normalized difference vegetation index data were obtained from the USGS database. The land-use land-cover data was obtained from the ESRI database. To evaluate the correlation between the WRV distribution and prevailing landscape factors spearman ranked correlation was used. Our correlation analysis showed highly negative correlation between elevation and WRV distribution (r_s = -0.77, n=53, p <0.0001), moderately negative correlation between NDVI11 and WRV distribution (r_s = -0.57, n=53, p <0.0001), moderately negative correlation between NDVI02 and WRV (r_s = -0.56, n=53, p <0.0001), and moderately negative correlation between NDVI06 and WRV distribution (r_s = -0.62, n=53, p <0.0001). In case of land-use land-covers, WRV was found most abundant in shrubs/ scrubs followed by croplands, barren areas, areas with trees, built areas, grasslands, and areas with waterbody. According to the present study, WRVs prefer habitats with lower elevation, lower NDVI values, and open areas with scattered vegetation, particularly trees. These findings provide more insight into the habitat requirements of WRV, which is significant information for conservation of WRV.

KEYWORDS: White-rumped Vulture, Elevation, Vegetation, Land use-Land cover, Habitat, Arunachal Pradesh

INTRODUCTION

White-rumped vulture (WRV) is an old world vulture belonging to the genus *Gyps*. WRVs are well adapted to scavenging lifestyles and function as natural incinerators. They keep the environment clean, healthy and prevent the spread of zoonotic diseases (Markandya et al., 2008; Pain et al., 2003). They have a wide distribution range, starting from Pakistan in the west to Vietnam in the east. However, despite their wide distribution, they are patchily and sparsely distributed throughout the Indian state (BirdLife International, 2021). Such distribution pattern is observed to be influenced by the prevailing factors of the area or habitat (Ferguson-Lees & Christie, 2001). The factors can be landscape factors, anthropogenic factors, and climatic factors. For the present work, we have only tried to analyze the influence of landscape factors. The availability of required features of environmental factors such as optimal climate and landscape conditions define the habitat of particular species. The distribution of WRV can be directly or indirectly impacted by the landscape factors. Such as vegetation, directly and indirectly, influence the distribution of WRV by controlling the availability of food in terms of the ungulates population (Bamford et al., 2009; KC et al., 2019; Krüger et al., 2015; Thiollay, 2006). Scavenging species like WRVs are strongly limited by food availability. The changes in forest cover have resulted in a decrease in the density of raptors in tropical regions (Carrete et al., 2007; Khatri, 2013). The land use and land cover (LULC) of the region also influence the distribution of WRV. The LULC components such as forest and waterbody were the most influencing factors for vultures distribution in Madhya Pradesh (Jha & Jha, 2020). Elevation can also influence the distribution of WRV. They are observed mostly in the plains and less frequently in hilly regions, ranging from lowland to 1000m amsl (Chakraborty, 2010; Grimmett et al., 2014). However, they have been also recorded from high-altitude regions in Nepal at 3100 m amsl (Baral et al., 2005). In terms of habitat conditions, they prefer grasslands, scattered forest areas, semi-deserts, riverine forests, and areas near human habitation (BirdLife International, 2021).

Arunachal Pradesh has a landscape ranging from lowland plains attached to Assam to gradually ascending hilly regions towards the north. Different components of landscape factors may play a significant role in determining the distribution of WRV in the state. Arunachal Pradesh has recorded the presence of WRV along with other 7 vulture species however very few works have been carried out relating to WRV or other vulture species. Available reports suggest WRVs are present in Siang valley (Chettri et al. 2006; Katti

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et al. 1992), Mehao wildlife sanctuary (Katti et al., 1992), Seijusa (Singh, 1994), Namsai (Singh, 1994), Pakke tiger reserve (Datta et al., 1998), D'Ering memorial wildlife sanctuary (Biswas et al., 2005; Kumar, 2010; Mize et al., 2014; Rahmani et al., 2016), and Dehang-Debang biosphere reserve (Rangini et al., 2014). From these findings it can be assumed that the WRV are sparsely distributed in the state and these may be attributed to the prevailing landscape condition of the state. There are still chances of finding more regions with WRV distribution, as most of these works were just mere sighting reports. Also, over the years there have been changes in landscape features within the state, mainly due to many anthropogenic activities (Chettri et al., 2006; Katti et al., 1992). And these may alter the range of distribution of WRV in the state. Considering the research gap, the present work aims to find out the relationship between the WRV distribution and prevailing landscape factors in Arunachal Pradesh. The findings of the work will help us to understand the habitat requirements of WRV related to landscape.

MATERIALS AND METHODS

Study area

Arunachal Pradesh is a north-easternmost state in India that lies between 26°28′ - 29°30′ north latitude and 91°30′ - 97°30′ east longitude and has an area of 83,743 km^2 (Figure 1). The state's rich forest covers, topographical elevation gradient, and varied climate regimes state has supported its rich terrestrial biodiversity. The state has a forest cover of 66,687.78 km^2, accounting for 79.63 % of the state's total geographical area (Forest Survey of India, 2019). In terms of vegetation types, the state includes tropical forests, sub-tropical forests, pine forests, temperate forests, alpine forests, degraded forests, and grasslands. The average elevation ranges from 67 m to 6853 m in the state (SRTM, Digital Elevation Model, 30 m, 2021). Depending upon the elevation, the state displays different climatic zones, and these zones vary from sub-tropical to temperate climates. During the summer, the highest temperature in the foothills can reach 40°C. However, in the winter and monsoon months, average temperatures range from 0° to 21°C and 22° to 31°C, respectively. Moreover, the annual temperature varies from below 0°C to 31°C. The state receives annual rainfall ranging from 2,000 mm to 8,000 mm, where it receives most of the rainfall from May to early October (Forest Survey of India, 2019).

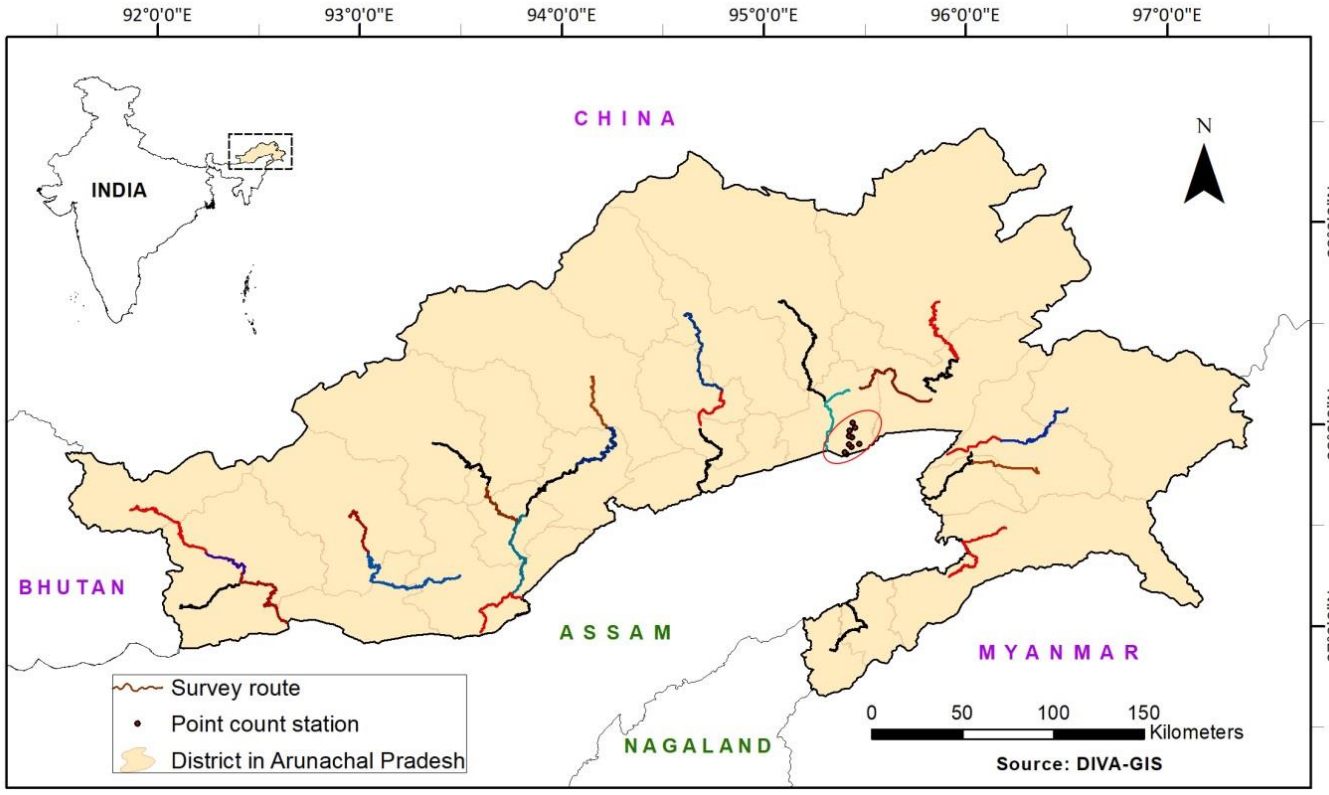

Figure 1. Study area map with survey routes and point count stations

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Data collection and processing

To know the present distribution of WRV in the state, a continued survey from January 2016 to May 2020 was carried out following the method of modified road count, point count, and opportunistic sighting method (Fuller & Mosher 1987; Bibby et al. 1992). For the road count survey, 27 road transects (routes) were laid on the existing intra-state roadways covering almost all the administrative districts (Figure 1), and vehicles with an average speed range of 20-30 km/h were used. D'Ering memorial wildlife sanctuary (DEMWLS) has been identified as a potential site with reports of WRV presence (Biswas et al. 2005; Kumar 2010; Mize et al. 2014) however, it lacks roadways connectivity. Therefore we conducted point count inside the sanctuary. 10 point count stations (pcs) were fixed along the forest trails (Figure 1). A minimum of 30 minutes stay was fixed at each pcs. For both methods, surveys were carried out from 0800 hours to 1600 hours. By the end of the survey, a total of 53 georeferenced points (28 points with WRV's presence and 25 points with WRV's absence) were recorded. Garmin GPS was used to record the coordinates.

For landscape variables, digital elevation model (DEM), normalized difference vegetation index (NDVI), and land-use land-cover (LULC) data were used. DEM data were obtained from https://earthexplorer.usgs.gov/. NDVIs data were obtained from https://lpdaac.usgs.gov/products/mod13a3v006/. LULC data were obtained from https://livingatlas.arcgis.com/landcover/. Since, the raw data had different spatial extent, resolution, and projection, processing of the data was done to create superimposed layers of variables with the same extent, resolution, and projection clipped to the study area boundary. The processing of data was performed in ArcGIS platform (ArcMap 10.4). The DEM layer has "0.00027777778 x 0.00027777778" spatial resolution and "GCS_WGS_1984" projection. The NDVI data have "926.6254331 x 926.6254331" spatial resolution and "sinusoidal grid" projection. The LULC layer has "10 x 10" spatial resolution with "WGS_1984_UTM_Zone" projection. All the layers were resampled to "0.0083333333 x 0.0083333333" spatial resolution and projected to "GCS_WGS_1984". Along with these, the habitat conditions of the recorded points were examined and collected during the field survey.

Table 1. Points of WRV occurrence with abundance and associated values of DEM, NDVIs, and LULC

Sl. no.	Longitude	Latitude	WRV	DEM (m)	NDVI02	NDVI06	NDVI11	LULC
1	93.788618	27.518327	0	1433	0.5448	0.7719	0.716	2
2	93.838335	27.516164	2	1571	0.6182	0.7505	0.7344	7
3	93.954979	27.719575	0	622	0.6522	0.8724	0.7254	2
4	94.238499	27.977696	0	318	0.5524	0.7426	0.712	7
5	94.158472	28.116854	0	586	0.745	0.8334	0.8401	2
6	93.694301	27.116854	0	146	0.3739	0.4586	0.4232	7
7	93.672951	27.577006	0	1325	0.738	0.8283	0.8106	2
8	93.486183	27.858324	0	868	0.7157	0.8002	0.8179	2
9	95.35639	28.14583	3	296	0.6136	0.7841	0.7467	7
10	95.468725	28.079391	7	163	0.5958	0.6897	0.7357	5
11	95.436281	27.936512	2	135	0.4871	0.757	0.692	2
12	95.402573	27.855225	1	127	0.4746	0.6103	0.6101	6
13	95.410916	27.859111	11	128	0.4376	0.6021	0.5717	6
14	95.403853	27.858924	7	127	0.4746	0.6103	0.6101	6
15	95.409617	27.852331	14	127	0.4582	0.6261	0.3341	6
16	95.399355	27.859726	6	124	0.4371	0.6459	0.5889	6
17	95.416694	27.875388	9	130	0.4376	0.5808	0.5373	8
18	95.421133	27.943133	14	134	0.458	0.6905	0.4673	6
19	95.448133	27.90925	14	132	0.4919	0.6912	0.5467	8
20	95.405	27.863111	8	128	0.4825	0.6173	0.6015	8

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21	95.431861	27.886666	10	131	0.4145	0.6674	0.5314	6
22	95.225147	28.478454	0	946	0.7399	0.834	0.7977	7
23	95.304849	28.107996	0	164	0.5855	0.7107	0.7005	2
24	95.668083	28.143555	4	198	0.4665	0.7602	0.6989	8
25	95.707694	28.144719	4	200	0.3115	0.712	0.6121	2
26	95.796976	28.112374	0	255	0.6253	0.8214	0.7777	2
27	95.922579	28.295699	0	2060	0.8199	0.5004	0.8758	2
28	95.846729	28.474484	0	712	0.787	0.8308	0.8081	2
29	94.71268	27.763537	0	476	0.7256	0.8133	0.8615	2
30	94.793877	28.09201	0	436	0.5348	0.7883	0.7548	2
31	94.676373	28.272919	0	299	0.5385	0.6975	0.7086	5
32	93.308375	27.200607	0	1552	0.7155	0.7028	0.7838	2
33	93.011844	27.416673	0	444	0.5837	0.8122	0.7951	2
34	95.494468	26.997136	0	732	0.6765	0.7205	0.7971	2
35	96.083101	27.440878	0	194	0.6082	0.8239	0.7843	2
36	95.824694	27.630722	10	148	0.569	0.6574	0.7332	5
37	95.848834	27.616384	2	148	0.5997	0.688	0.7358	7
38	95.8284	27.629441	8	147	0.5699	0.5536	0.577	5
39	95.822607	27.628177	8	148	0.569	0.6574	0.7332	5
40	95.825	27.630055	10	148	0.569	0.6574	0.7332	5
41	95.826264	27.631393	2	148	0.569	0.6574	0.7332	5
42	95.829597	27.642183	2	147	0.5715	0.6033	0.692	3
43	95.83475	27.644444	11	146	0.5116	0.6565	0.7637	2
44	96.027333	27.852972	6	158	0.1537	0.2943	0.1777	8
45	96.030333	27.845055	2	162	0.4034	0.5381	0.5309	1
46	96.335359	27.774226	0	357	0.6893	0.8835	0.8316	2
47	96.022819	27.888122	6	168	0.5593	0.726	0.7685	2
48	96.117951	27.924399	0	209	0.5237	0.7191	0.7104	2
49	96.493662	28.06309	0	581	0.6334	0.7995	0.7468	7
50	92.639052	27.016562	2	226	0.4395	0.7861	0.6164	7
51	92.262787	27.347117	0	1679	0.4861	0.7518	0.6159	7
52	91.909215	27.5749	0	2255	0.4765	0.8177	0.6643	7
53	92.266252	27.139562	0	2145	0.6305	0.792	0.7464	2

Data analysis

ArcGIS (ArcMap 10.4) was used to process geotagged layers of WRV occurrence and landscape variables. Spearman rank correlation was used to estimate the correlation between WRV distribution and prevailing landscape factors and the accepted significance level was set at $\alpha < 0.05$ (Quinn & Keough, 2002). The correlation coefficient (r_s) tells the direction and strength of the relationship between the WRV distribution and landscape factors. The calculated p-value was used to evaluate the significance. Correlation analyses were performed in Prism Graphpad.

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RESULTS AND DISCUSSION

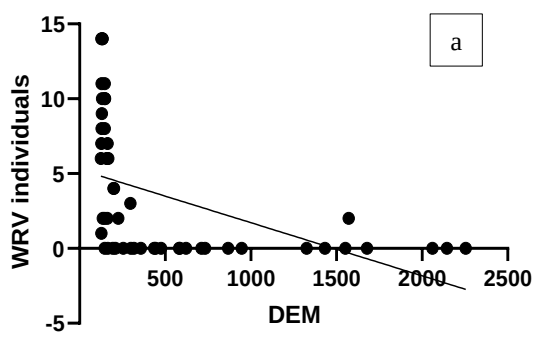
The surveys result confirms the occurrence of WRV from regions of Bhalukpong (West Kameng), Siro (Lower Subansiri), Bomjir area (Lower Dibang Valley), Mahadevpur (Namsai), Tezu-Sunpura road (Lohit), Alubari area (Lohit), Kamlang vill area (Lohit), DEMWLS (East Siang), Borguli area (East Siang), and Pasighat-Mebo area (East Siang) (Figure 3).

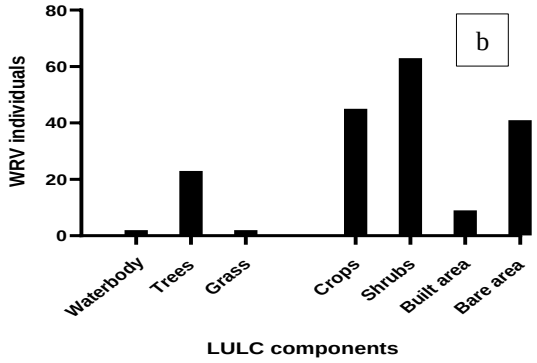
Spearman rank correlation coefficient (r_s) was evaluated to assess the monotonic relationship between WRV abundance and landscape factors (DEM and NDVIs). However, for LULC direct graph interpretation was used to evaluate the relationship between WRV abundance and LULC components. There was significant high negative correlation between the WRV abundance and DEM (r_s = -0.77, n=53, p <0.0001) (Table 2). This relationship indicates that as elevation increases, abundance decreases. This means the WRV prefers to live in the lowland area. Most of the observed elevation of the point of WRV presence in Arunachal Pradesh ranges from 120 m to 300m. However, 2 WRVs were recorded from an elevation of 1571 m (Figure 2(a)). Since this observation was the first time record of WRV in that region we assumed that it was a vagrant record. The p-value of less than 0.05 indicates that there is a correlation between the two variables in the population. Also, there was significant moderate negative correlation between the WRV abundance and NDVI11 (r_s = -0.57, n=53, p <0.0001), NDVI02 (r_s = -0.56, n=53, p <0.0001), NDVI06 (r_s = -0.62, n=53, p <0.0001) (Table 2). These negative relationships between WRV abundance and NDVIs indicate that with the increase in one variable, other variables will decrease. The NDVI values range from -1 to +1, where values nearer to +1 mean more greenery and values closer to -1 indicates less or no greenery. This data can be used for vegetation gradient throughout the state, and also as a proxy layer for ungulate forage availability. Low forage availability may cause increase in ungulates mortality and can lead to an increase in carrion availability to the WRV. Maximum numbers of WRV were observed in areas with lower NDVI values for the three selected months (Figure 2(c-e)). LULC variables were categorical data, 1 stand for waterbody, 2 for trees, 3 for grass, 5 for crops, 6 for shrubs/scrubs, 7 for the built area, and 8 for the bare area (Table 1, Figure 2(b)). More number of WRV individuals were observed in shrubs/scrubs areas (n=63), followed by areas with Crops or croplands (n=45), barren areas (n=41), areas with trees (n=23), built areas (n=9), grasslands (n=2), and areas with waterbody (n=2). These results indicate that WRV prefers open areas with grass, shrubs, and tall trees population. They were also observed living in proximity to humans as many of them were recorded from the areas with croplands. Such relationships provide them with easy food in the form of dead bodies of domestic animals, especially ungulates, and may explain their prevalence in those areas.

Table 2. Spearman's correlation between WRV abundance and landscape factors

	DEM	NDVI11	NDVI02	NDVI06
WRV abundance	-0.77	-0.57	-0.56	-0.62
p value	<0.0001	<0.0001	<0.0001	<0.0001
significance	*	*	*	*

*correlation is significant at the 0.05 level (2-tailed)





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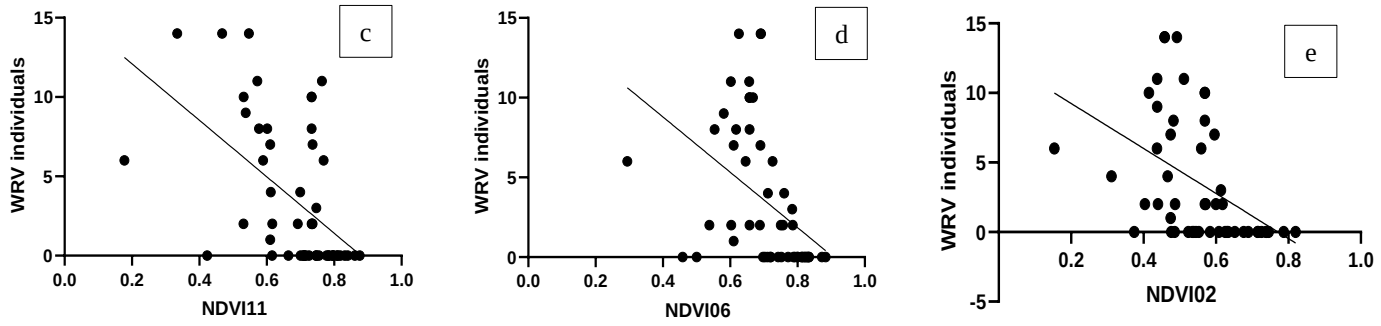
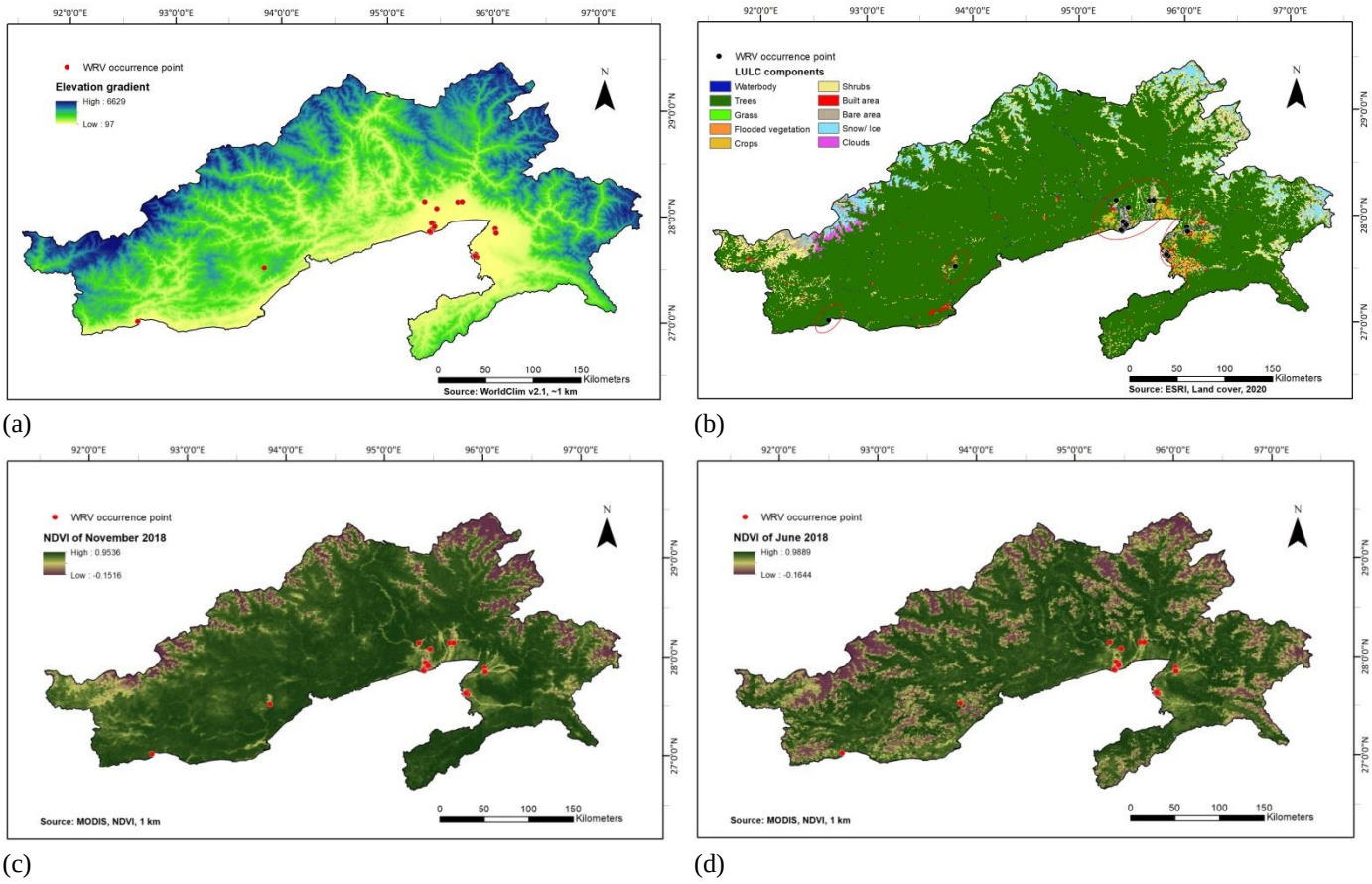


Figure 2. Graph showing the relationship between WRV abundance and 5 variables of landscape factors (a) DEM, (b) LULC, (c) NDVI11, (d) NDVI06 and (e) NDVI02



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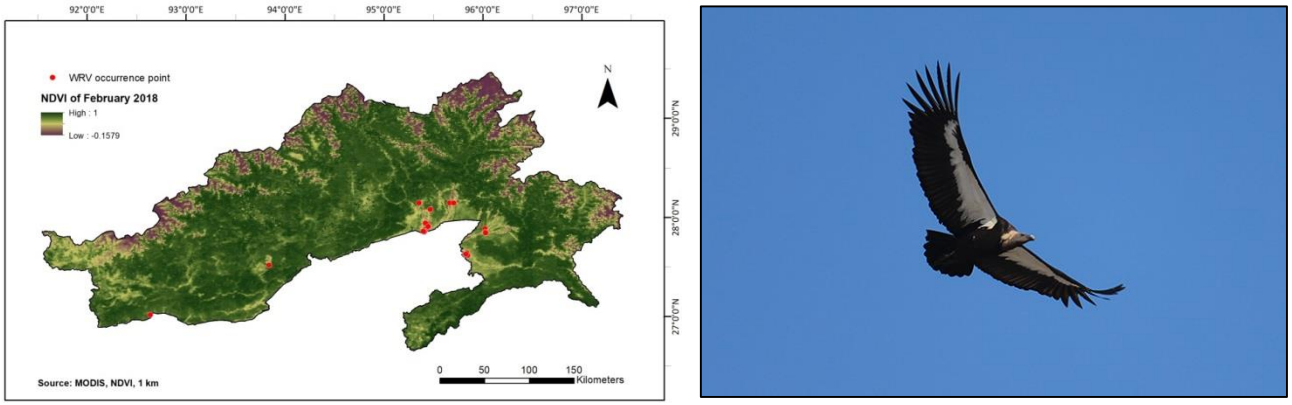

(e) (f)

Figure 3. Distribution point of WRV in relation to (a) DEM, (b) LULC, (c) NDVI11, (d) NDVI06, (e) NDVI02; and (f) White-rumped vulture (adult) at flight recorded from Mahadevpur point 3 (27.628177 N, 95.822607 E)

CONCLUSION

The knowledge of WRV abundance, distribution, and habitat preference is crucial for their monitoring and management. The present study indicates that the landscape factors significantly influence the distribution of WRV in Arunachal Pradesh. The preferred habitats of WRVs are the areas in lowlands with lower NDVI values, and open areas with scattered vegetation, particularly trees. Despite the larger total geographical area, WRVs are only recorded from a few places in the state. However, this small distribution range of WRV has still the potential to sustain the prevailing WRV population in the state.

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