Orinigal Article

Distribution, Nesting Preferences and Conservation Threats of White-Rumped Vulture (*Gyps bengalensis*) In Rupandehi, Nepal

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Abstract: Vulture populations in Nepal, India, and Pakistan have declined dramatically since the mid-1990s, with losses of more than 97% of the resident species, Gyps bengalensis. Vulture monitoring in Nepal has revealed comparable reductions, with more than 91% drop in populations from 1995 to 2011. It is necessary to evaluate and address these factors in this domain. It is expected that the population of Vultures is declining due to the rapid decline in forest areas and Vultures preferred tree species for breeding. No appropriate management plan or conservation action can be formulated unless a full analysis of the population distribution, preferable habitat for breeding and existing threats are carried out. This study assessed the information on the distribution, nesting preferences and conservation threats of White-rumped Vulture (Gyps bengalensis) in Gaidahawa and Kanchan rural municipalities, Rupandehi, Nepal. The primary data for the study were collected through direct observation, questionnaire surveys and interviews with key informants. At first, the geographic locations of distribution variables were entered in the excel sheet in excel workbook 2013 format and then uploaded to the Arcgis 10.8 to generate the distribution map in the land cover map of the study area. descriptive statistical analysis was done for the variables like nest direction, nesting site distance from human settlement and water bodies to identify the preference of nesting site selection. t-Test was used for testing the significance of difference between two means of independent variables. Remote sensing data of 2017 and 2022 covering the study area were used for the spatial-temporal land cover change over the period of 5 years. The data obtained from the remote sensing were later analyzed in ArcGIS 10.8. Images were re-projected to the UTM 45 by using nearest neighbor resampling. As a result, it's critical to understand the present state of vultures and their habitat, as well as human attitudes and behaviours toward conservation and management.

Keywords: nesting preferences, white-rumped vulture, gyps bengalensis, Nepal

1. INTRODUCTION

Birds are Aves and Vertebrata bipeds, birds are most known for their feathers and wings. Bird-like Archaeopteryx descended from a reptile ancestry like dinosaurs 140 million years ago. Around 1.5 million of the world's 10 million species have been formally described. Due to population expansion and rising consumerism, our planet's biological diversity is diminishing 5% every decade [1]. Nepal's vast floral and faunal resources and distinct environment from 26°27' to 30°27' north latitude and 84°4' to 88°12' east longitude have made it a naturalist's paradise. Subtropical to alpine climate changes in Nepal within 200 kilometers [2]. Southern lowlands are 60 m above sea level; northern lowlands are 8,848 m. Due to its location at the junction of two biogeographic areas, the Palearctic to the north and the Oriental to the south, its flora and fauna are extraordinary. Nepal's ecosystems range from alpine scrub to tropical lowlands rainforest [3]. Animal corpses are the principal diet of vultures, by performing sky funerals on animal and human bodies, vultures help clean the planet. Gyps vultures eat 1 kilogram of meat every three days across Asia and Africa. Out of 23 vulture species worldwide, nine are resident and one is migratory in South Asia. Six permanent and three migratory vulture species live in Nepal. Eight resident and one migratory vulture species have been recorded from South Asia, out of 23 worldwide. A few decades ago, vultures were ubiquitous in India. They are extremely endangered there. The White-rumped Vulture (Gyps bengalensis) is Critically Endangered (CR) according to criteria A1c, e and A2c, e for imminent extinction [4]. A species' population is expected to decline by at least 80% within 10 years or three generations, whichever comes first, due to a decline in area of occupancy, extent of occurrence, or quality of habitat and the effects of introduced taxa, hybridization, diseases, pollutants, competitors, and parasites [5]. The vulture population's rapid decline has worried conservationists, biologists, and birdwatchers since the 1990s. One of Nepal's largest bird conservation groups, Bird Conservation Nepal (BCN), has been conserving vultures in-situ and ex-situ [6]. Nepal created the first Vulture Safe Zone (VSZ) at Gaidatal Village Development Committee (VDC), Rupandehi district, alongside local people in 2009. A VSZ is a Diclofenac-free area with vulture nesting colonies sufficient to cover the feeding range (>30,000km^2). The district-by-district, province-by-province strategy to diclofenac-free areas prompted groundbreaking conservation efforts that led to the VSZ concept [7]. Three Indian vulture species—WRV, IV, and SBV—have suffered catastrophic population declines due to CR status. Diclofenac, an NSAID used to treat cow discomfort and inflammation, killed RHV animals, putting the species at risk of extinction. Electrocution, poisoning, habitat degradation, localized food shortages, and other causes may have endangered the small population. Nepal created the VCAP in two stages. The first VCAP (2009–2013) was successful, and the second (2015–2019) is being implemented to eradicate diclofenac, increase wild breeding populations, manage a science-based information system, raise conservation awareness, and collaborate with national and international organizations [8]. Lowland Slender-billed and White-rumped Vultures breed in Nepal. In southern Nepal, the White-rumped Vulture is most common. White-rumped Vultures maintain stronghold habitats in Nawalparasi Forests, Southern Rupandehi, Rampur Valley, and Dang forests despite their small population. India has nine of the world's 23 vulture species. Oriental white-backed or White-rumped Vulture, Slender-billed, Long-billed, or Indian Vulture, Egyptian Vulture, Red-headed or King Vulture, Indian Griffon, Himalayan Griffon, Cinereous Vulture, and IUCN recognizes four Critically Endangered, one Endangered, three Near Threatened, and one Least Concern Vultures [9]. Five Gyps species—Indian White-rumped Vulture (Gyps bengalensis), Long-billed Vulture (Gyps indicus), Slender-billed Vulture (Gyps tenuirostris), Eurasian Griffon (Gyps fulvus), and Himalayan Griffon (Gyps himalayensis)—are residents and winter there [10]. The other four species—Lammergier (Gypaetus barbatus), Egyptian (Neophron percnopterus), Red-headed (Sarcogyps calvus), and Cinereous (Aegypius monachus)—are resident or wintering. Eight resident and one migratory vulture species have been recorded from South Asia, out of 23 worldwide. Nepal has six resident and three migratory vulture species from 87 to 4100 m above sea level [11]. In Nepal's lowlands, White-rumped and Slender-billed Vultures breed, with the former being the most prevalent in the west. White-rumped Vultures still live in the Nawalparasi Forests,

Southern Rupandehi, Rampur Valley, and Dang forests, despite their small population, white-rumped Vultures are most abundant in Nepal's Rampur Valley, Palpa. Inurva, Koshi province contains white-rumped and slender-billed vultures, as does Rupandehi district near Lumbini, Royal Bardia National Park, and Royal Suklaphanta Wildlife Reserve. White-rumped Vultures, like most Vultures, have bald heads, huge wings, and short tails. Wingspans are 535–578 mm. Very small compared to the European Griffon [12]. A white neck ruff is on it, long, slender neck and bill help it to feast inside carcasses. The adult's dark plumage contrasts with its pale back rump and underwing conversion. Males and females are alike, baby birds have no white back or underwing bands and are browner. Bad white fluffy down on the head and neck. Some fieldworkers confuse this bird with the Long-Billed Vulture [13]. From October to March, Gyps bengalensis breeds, the sexes fly in slow circles with their wing tips close together near the breeding zone and mating occurs at the nest or on a branch nearby. Loud calling is associated with mating. Monogamous mating occurs seasonally. First step in white-rumped vulture breeding is nest construction. Rocky outcrops and towering trees house breeding colonies. To allow birds to move, nesting trees need equally spaced branches. The male collects the twigs, while the female builds the nest. The devastating Vulture drop is now attributed to Diclofenac, an NSAID used to rehabilitate cattle across India. Vultures swallowed diclofenac from treated cattle carcasses. After eating tissues from domestic animals that had received a typical veterinary dose of the medicine a few hours before death, captive WRVs died from renal disorders [14]. All birds had widespread visceral gout with uric acid deposits on and within internal organs due to kidney failure. Many dead or dying wild Vultures in Pakistan, India, and Nepal showed the same symptoms. To rescue the Critically Endangered, veterinary Diclofenac has been banned, a captive breeding center built, Vulture colonies monitored, and conservation awareness raised. Few Nepalese pharmaceutical businesses produced Vulture-friendly Diclofenac replacement Meloxicam. Vulture populations worldwide have declined due to habitat destruction, food shortages, human persecution, poisoning, and pesticide use [15]. Maximum numbers of Gyps bengalensis reported in one day in Rupandehi district near Lumbini had declined from 160 in July 2000 to 64 in March 2002. Afterward, not any further official research on this subject in this area has been conducted. The majority of the remaining Oriental White-Rumped vultures in Nepal's lowlands are now only restricted in the country's western areas, with few population and nesting colonies persisting in the districts of Kapilvastu, Dang, Nawalparasi, and Rupandehi. It is necessary to evaluate and address these factors in this domain. It is expected that the population of Vultures is declining due to the rapid decline in forest areas and Vultures preferred tree species for breeding. No appropriate management plan or conservation action can be formulated unless a full analysis of the population distribution, preferable habitat for breeding and existing threats are carried out. To keep these magnificent scavenging birds from extinction, frequent monitoring is necessary.

2. LITERATURE REVIEW

Population trends at three Pakistani Oriental White-rumped Vulture colonies, visceral gout from Diclofenac exposure killed most Vultures tested. It assessed the least rates at which colonies encountered carcasses with enough diclofenac to kill 1.26–1.88 carcasses per colony per month based on the spatial and temporal distribution of dead vultures and their approximate time of death [15]. The estimation of total carcass devoured at each colony yielded 1.41–3.02 % diclofenac-contaminated corpses, exceeding the minimum needed to produce the observed population decline. The population was shrinking by 50% annually. It detected an intracellular malarial parasite in White-rumped Vulture tissues, both alive and dead, in a sparsely inhabited and densely forested region of Central India [16]. It has found 22 nesting colonies with 77 nests and 56 pairs that bred successfully during the breeding season. Breeding success rose 16% in 2011 from 56% to 73%. The Indian White-rumped Vulture preferred well-foliaged pine trees near water bodies in pure Chir-pine forest for nesting. All Indian White-rumped Vulture nests were in Pinus roxburghii. Monkeys also disturbed breeding colonies [17]. White-rumped vultures were rare in Pakistan's 2010 and 2011 assessments of a colony in Sindh's Tharparkar District. Active nests in this colony grew from 11 to 34 between 2011 and

2014, despite a decrease in density from 13.7 to 9.2 km², indicating colony expansion. Although population demographics do not support the observed rate of rise in nests, the study found that immigration was supporting the increase and showed how a clustered pattern of nesting trees in colonies promotes a highly clustered pattern of nests in spatial breeding dynamics for the Oriental White-rumped Vulture [18]. Carcass distribution, size, and interspecific aggressiveness can harm species. Vulture restaurants or feeding stations help track numbers. The behavioral and morphological study examined how Cambodian vulture restaurants allow the gregariously breeding and feeding White-rumped Vulture (Gyps bengalensis), Slender-billed Vulture (Gyps tenuirostris), and solitary Red-headed Vulture (Sarcogyps calvus) to access food. The film documented attendance time, order, and dominance at different carcasses. Interspecific conflict at carcasses was lowest for the little White-rumped Vulture. The'small' White-rumped Vulture was less hostile than the 'large' Slender-billed and'medium' Red-headed Vultures [19]. It examined site-specific nesting success and selection in two White-rumped Vulture colonies in coastal Maharashtra's Raigad district. It has been identified that essential habitat features and ecological niche models to predict prospective Western Ghats reintroduction sites to improve the species' regional persistence. Models for current and future climate change scenarios used nesting and foraging data. Gujarat had two White-rumped Vulture deaths in 2019, two vultures reportedly died from poisoning near Sanand, Gujarat. Two more vultures died in Dhrangadhra's Wild Ass Sanctuary in October 2019. Tumorological examination on all four vultures' tissues and gastrointestinal contents determined NSAID-induced death [20]. High tissue Nimesulide levels and gout symptoms indicate that the vultures perished from Nimesulide toxicity. While many NSAIDs may be harmful to White-rumped Vultures, only Nimesulide has been linked to gout in wild birds, similar to Diclofenac. Nimesulide kills White-rumped Vultures like diclofenac [21]. Field surveys in Rampur, Syanja, and Tanahu from September 2006 to May 2007 used repeated absolute counts to evaluate Gyps bengalensis population and breeding success at nesting and roosting sites. Using active nests as primary units, Rampur had 40% breeding success, Syanja and Tanahu 71%. Rampur had 42 trees of nine kinds, while Syanja and Tanahu had 15 of six. The study's seven transects followed Nepal's East-West highway for 1,010 km in three years and 638 km in four. Rare Slender-Billed vultures (G. tenuirostris) were just five in 2002 and none in 2010 or 2011. The Oriental White-rumped Vulture was the most common, declining from 205 to 68 birds each year at an estimated 14% annual rate. White-rumped Vultures in Nepal may have declined 91% if population declines began the same year as in India [22]. In Rupandehi district's Bishnupura Village Development Committee's Vulture Safe Feeding Site, the researchers examined whether the average total number of different species of vultures visiting for carcass feed varied significantly throughout the year. There was a significant difference in the number of different species of vultures visiting VSFS (Rupandehi) for carcass feed between seasons (F1cal=6.025>F1tab), but no significant difference among seasons (F2cal = 0.6<F2tab). Gyps bengalensis was abundant per carcass feed in summer, autumn, and spring, and himalayensis in winter [23]. The Khaireni community forest had 21 White-rumped Vulture nests in February–April, tiny sticks and twigs with dried leaves make up the nests. Also seen were dry grasses and plants. The canopy center had the most nests, followed by the east and southeast borders. The top canopy had the most nests, whereas the upper middle canopy showed good colonization. The nests chose flat terrain, especially in trees along riverbanks at close distance from water bodies (Mean distance: 186 m), a mean height of 22 m (perhaps for protection), and forested areas. As study used the point count method to count vultures at 11 probable feeding or roosting sites in the Pokhara Valley [24]. The most common vultures were the white-rumped, Egyptian, and Himalayan. They also asked valley inhabitants about vulture ecology and protection. Most responders (98%) had observed wild vultures. Officially educated respondents saw vultures slightly more than non-officials. Habitat destruction was the biggest threat to Pokhara valley vulture populations, according to 58% of respondents [25].

3. MATERIALS & METHODS

Gaidahawa Rural Municipality and Kanchan Rural municipality of Rupandehi district were selected as the study area, located at the western lowland of Lumbini province, having 96.8 km² and 58.51 km² area respectivel. Gaidahawa Rural Municipality includes nine wards with 37,013 total population and Kanchan Rural Municipality includes 5 wards with 33,072 total population.

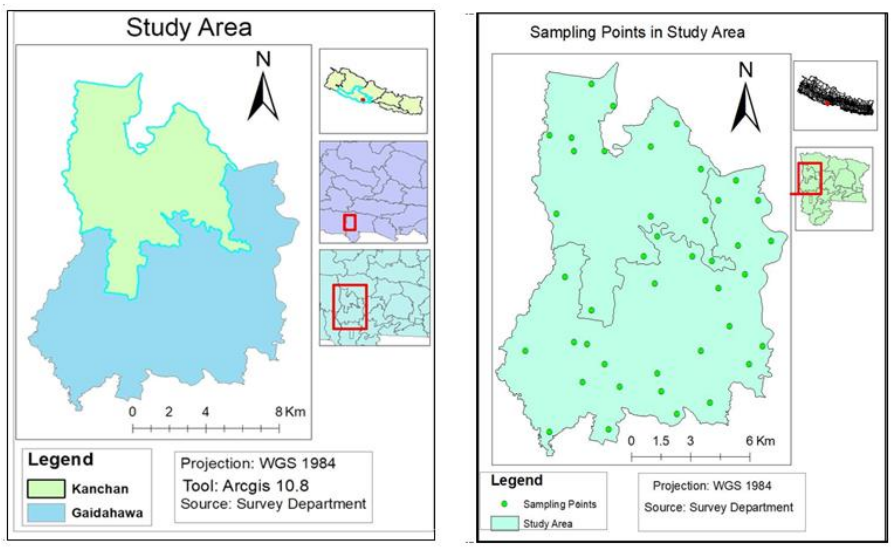

Figure 01: Map showing study area.

Camera (Nikon DSLR, AF 50-250 mm lens), GPS device (Garmin eTrex 10), Measuring tap, Data sheet, Samsung A10 (Android phone), Handheld rangefinder (50×250 m), Measuring tape, Notebook, Binocular (Olympus, 8-16×40,200m), Helm field guide (Birds of Nepal). Gaidahawa and Kanchan rural municipalities of Rupandehi district of Lumbini province were selected as the study area. Areas with greater possibility of occurrence with respect to water resources, nesting trees availability and food availability were firstly estimated by the help of Landcover map to study the distribution and Nesting preference of White-rumped Vulture. Various articles, journals, books and other various secondary sources were literatured at pre-study period as references. The preliminary field survey was conducted around the southern part of Rupandehi district and its vicinity to locate the nesting and feeding sites of vulture. The primary data for the study were collected through direct observation, questionnaire surveys and interviews with key informants. All the obtained information and data were categorized and tabulated according to the objectives of the study to assess the distribution, nesting preference and conservation threats of the studied species in the study area. The distribution of Gyps bengalensis in the study area was assessed by illustrating the feeding sites, roosting sites and nesting sites by generating distribution map with the help of Arcgis 10.8. At first, the geographic locations of distribution variables were entered in the excel sheet in excel workbook 2013 format and then uploaded to the Arcgis 10.8 to generate the distribution map in the land cover map of the study area. For the analysis of nesting preferences, Pearson's correlation analysis was done to identify the variables (nesting tree height, nest height, DBH of nesting tree) that are correlated to nesting site selection and the regression analysis was done to determine the functional relationship between the variables (nesting tree height, nest height and DBH of the nesting tree), Whereas descriptive statistical analysis was done for the variables like nest direction, nesting site distance from human settlement and water bodies to identify the preference of nesting site selection. t-Test was used for testing the significance of difference between two means of independent variables (nesting tree height and non-nesting tree height) assuming the equal population variance. Remote sensing data of 2017 and 2022 covering the study area were used for the spatial-temporal land cover change over the period of 5 years. The data obtained from the remote sensing were later analyzed

in ArcGIS 10.8. Images were re-projected to the UTM 45 by using nearest neighbor resampling. Digitized map was re-projected to UTM/WGS 1984, Zone 45 to match with satellite images. Supervised classification method with maximum likelihood algorithm was used for the classification of two different years' images. GPS locations corresponding to each LULC class were collected from the field and used as training samples for the image classification and accuracy assessment. Five land cover classes were considered in image classification for producing land cover maps and detecting changes that occurred during the period 2017 to 2022. The major land cover classes considered were waterbodies, forest cover, agricultural land, human settlement and bare land.

4. RESULTS & DISCUSSION

4.1 Distribution

To show the distribution of White-Rumped vulture (Gyps bengalensis) in the study area, distribution map of feeding sites, roosting sites and nesting sites were generated by using Arcgis 10.8 and the average number of individuals of Gyps bengalensis from the different visits in the respective sites were calculated to determine the distribution type within the study area. The GPS point of feeding, roosting and nesting sites were overlaid on the Landcover map of the study area to create the distribution map.

4.1.1 Feeding Sites

Altogether 9 feeding sites were recorded from the study area, whereas 6 feeding sites were reported Gaidahawa Rural Municipality and remaining 3 feeding sites were recorded from Kanchan Rural Municipality.

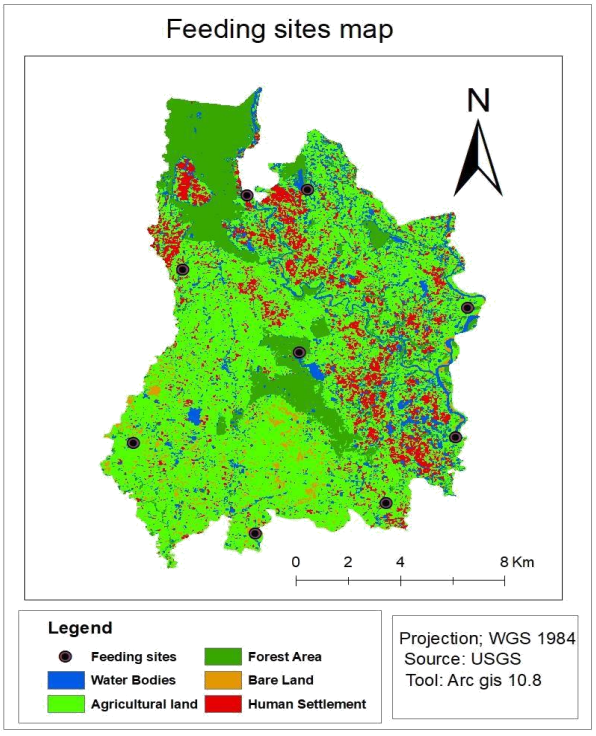

Figure 02: Feeding sites of Gyps bengalensis in the study area

Table 01: Location of feeding sites

No	Latitude	Longitude	DHS(m)	DWB(m)	Avg Individuals
1	27.599	83.279	500	200	21
2	27.617	83.333	500	30	14

3	27.57	83.329	250	5	17
4	27.546	83.305	300	30	7
5	27.535	83.26	350	20	18
6	27.569	83.218	350	30	11
7	27.658	83.257	300	10	14
8	27.66	83.278	300	20	9
9	27.631	83.235	300	50	16

DHS: Distance from human settlement, DWB: Distance from waterbody.

The average distance between feeding sites to the human settlement area was 350 m and the average distance from feeding sites to the water body was 43.88 m. The average number of individuals of Gyps bengalensis from three visits in each feeding sites were calculated. As a result, the highest average number of individuals was recorded from the feeding site of Vulture Restaurant of Gaidahawa-4, Gaidatal (21) was 500 m far from human settlement area and 200m distance from water body, and the lowest average number recorded was 7, from the feeding site of ward-3 of same rural municipality, which was 300 m distance from human residence area and 30 m from water body. Furthermore, the highest average number of individuals in Kanchan rural municipality was 16, recorded from the feeding site of ward-4 with 300 m distance from human settlement and 50 m away from water resource, while the lowest average number of individuals (9) was recorded from ward-2 with 300 m distance from human settlement area and 20 m distance from water body.

4.1.2 Roosting Sites

After the survey of the study area, 10 roosting sites were identified from both rural municipalities. Out of which, 7 roosting sites were recorded from Gaidahawa rural municipality (1 from ward-2, 2 from ward-5, 1 from ward-6, 2 from ward-8 and 1 from ward-1) and 3 roosting sites were recorded from Kanchan rural municipality (1 from ward-4, 1 from ward-2, 1 from ward-5).

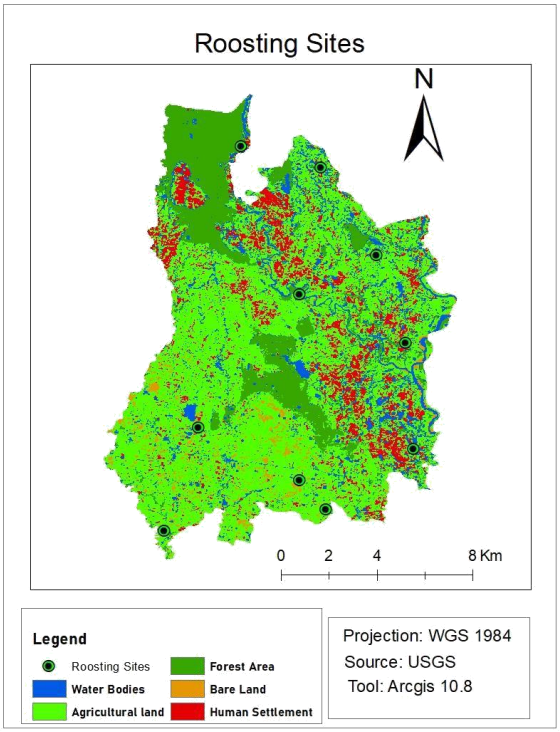

Figure 03: Roosting sites of Gyps bengalensis in the study area

The average number of individuals (8) of Gyps bengalensis were observed on the roosting site of ward-6 of Gaidahawa rural municipality on the tree species Bombax ceiba of height 20m of DBH 1.45 m and the distance of roosting tree from human settlement was 150 m. However, the average number of individuals (3) were recorded from the roosting site of ward-8 of same rural municipality on the tree species Shorea robusta of height 18.5 m with DBH 1.35 m and the distance of the tree from the human settlement was 200 m. Furthermore, the highest average number of individuals (7) were recorded on Bombax ceiba of height 19.5 m with DBH 0.49 m and was 250 m far from human settlement area of ward-2 in Kanchan rural municipality, while the lowest average number of individuals (4) was recorded from the roosting site of ward-2 on the tree species Shorea robusta of height 22.5 m of DBH 0.41 m which was comparatively nearer (100 m) from human residence than other roosting sites. The above data represents that 3 species of trees were used for the roosting purpose by Gyps bengalensis (40% Bombax ceiba, 50% Shorea robusta and 10% Schleichera oleosa.

4.1.3 Nesting sites

After conducting the survey on the 15 stations, three nesting colonies (C1, C2 and C3) with altogether 18 nests were discovered, one nesting colony (C1) with five nests from Gaidahawa ward-4 near vulture restaurant, two nesting colonies (C2 and C3) from Kanchan rural municipality ward-4, having seven nests in C2 colony and six nests in C3 colony. All the nesting colonies were reported from the forest buffer zone. A total of 13 nests from two nesting colonies (C2 and C3) were reported from Kanchan rural municipality, whereas single colony (C1) with five nests was reported from Gaidahawa rural municipality. Only one nest was reported from single nesting tree.

Table 02: Table representing the nesting location,

Latitude	Longitude	Altitude(m)	Nesting tree
27’39.361’	83°14.172’	114	Terminalia alata
27°39.327’	83°14.239’	111	Shorea robusta
27°39.351’	83°14.132’	114	Terminalia alata
27°39.431’	83°14.595’	108	Terminalia alata
27°39.493’	83°14.703’	116	Terminalia alata
27°39.359’	83°14.133’	115	Shorea robusta
27°39.477’	83°14.961’	115	Terminalia alata
27°39.893’	83°14.399’	120	Terminalia alata
27°39.893’	83°14.337’	121	Shorea robusta
27°39.895’	83°14.331’	118	Shorea robusta
27°39.923’	83°14.324’	122	Shorea robusta
27°39.93’	83°14.328’	120	Terminalia alata
27°39.671’	83°14.831’	117	Terminalia alata
27°35.978’	83°16.467’	101	Terminalia alata
27°35.917’	83°16.404’	98	Terminalia alata
27°35.977’	83°16.463’	102	Shorea robusta
27°35.966’	83°16.466’	106	Shorea robusta
27°35.969’	83°16.459’	102	Terminalia alata

The data and information from the above table shows that the distribution of nesting sites ranged from 98 m to 122 m altitude within the study area. It also can be interpret as all the nests were built in two different tree species and were distributed in the range of 25 m of altitude. All 13 nests of Kanchan rural municipality was distributed from 111-122 m, whereas five nests of single colony of Gaidahawa rural municipality were distributed from 98-106 m of altitude.

4.2 Nesting Preferences

For the analysis of nesting preferences of White-rumped Vulture (Gyps bengalensis) in the study area, nesting tree species, tree height, nest height, breast height diameter (DBH) of nesting tree, distance from nesting sites to the human settlement area (DHS) and distance from water bodies to the nesting sites and the non-nesting trees around the nesting sites were recorded and further analysis was carried out. Three nesting colonies with altogether 18 nests were discovered, one nesting colony with five nests from Gaidahawa ward-4 near vulture restaurant, two nesting colonies from Kanchan rural municipality ward-4, having seven nests in C2 colony and six nests in C3. All the nesting colonies were reported from the forest buffer zone. A total of 13 nests from two nesting colonies were reported from Kanchan rural municipality, whereas single colony with five nests was reported from Gaidahawa rural municipality.

4.2.1 Nesting preference variables

[1] Nesting tree species

Altogether three nesting colonies with total 18 nests were recorded from the survey of sampling points in the study area, out of which two nesting colonies with total 13 nests were recorded from ward-4 (C2 and C3) of Kanchan rural municipality, seven nests in C2 and six nests in C3 nesting colonies. However, one nesting colony with total five nests was recorded from ward-4 (C1) of Gaidahawa rural municipality near vulture restaurant. All the nests were built only on two tree species (Shorea robusta and Terminalia alata). Whereas 11 nests (61.1%, n=18) were built in Terminalia alata and seven nests (38.9%, n=18) were recorded from Shorea robusta.

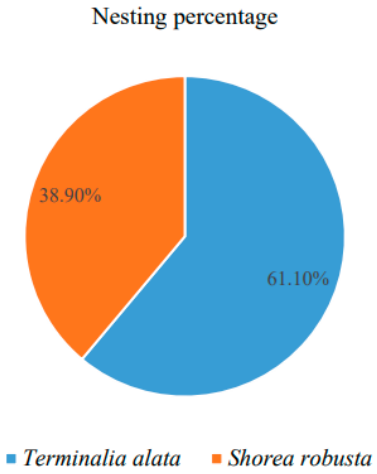

Figure 04: Occurrence of nest on two tree species

[2] Nesting tree height

The maximum and minimum height of the nesting tree was 32.5 m and 29 m from the ground level respectively and both are of same species (Terminalia alata). The average height of nesting tree was 30.88 m (n=18) with the standard deviation 1.10 (S.E= 0.26).The average height of nesting Terminalia alata species was 31.18 m (n=11) and the nesting Shorea robusta species was 30.42 m (n=7), that means the average height of nesting tree species (Terminalia alata) is greater than the average height of nesting tree species (Shorea robusta). The maximum and minimum height of the nesting tree species (Shorea robusta) are 31.5 m and 29.5 m respectively. The nesting trees with 29.5 m and 31.5 m height had greater number of nests (4) each, following that nesting trees with 31 m height had three nests, nesting trees with 30.5 m, 32 m and 32.5 m had two nests each and only one nest was found in 29 m of nesting tree.

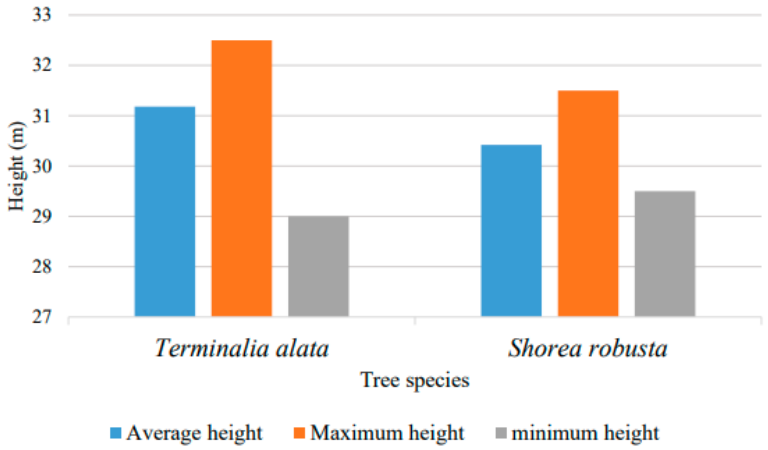

Figure 05: Average height, maximum height and minimum height of two different nesting tree species

[3] Nest height

The maximum height of the nest was 30 m in Terminalia alata with tree height 32.5 m and the minimum height of the nest was 26 m in Shorea robusta with tree height 29.5 m. The average height of the nests was 27.97 m (n=18) with the Standard Deviation 1.156 (S.E=0.27). The maximum nest height in the Terminalia alata was 30 m, while the minimum nest height in the same tree species was 26.5 m. The maximum nest height in the Shorea robusta was 28.5 m and the minimum nest height in the same species was 26 m. Furthermore, the average nest height in the Terminalia alata was 28.40 m (n=11), whereas the average nest height in the Shorea robusta was 27.28 m (n=7). Out of total 18 nests in three colonies, highest number of nest (4) was at the height of 31.5 m, three each nests were at the height of 28.5 m and 29 m, two nests were at the height 27.5 m and at the height 26 m, 29.5 m and 30 m, minimum number of nests were present (1 nest each).

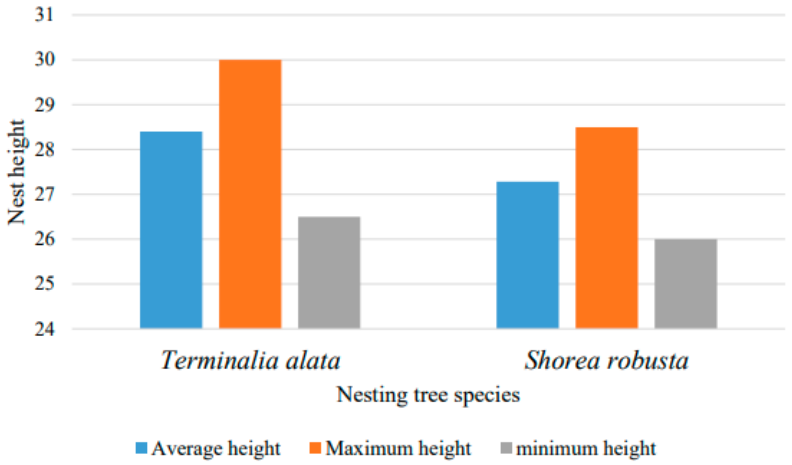

Figure 06: Average, maximum and minimum nest height (m) in the two different tree species

[4] Nesting tree's Breast Height Diameter (DBH)

Terminalia alata with the height 32.5 m had maximum DBH (0.57 m) with the nest located at 30 m height, whereas Shorea robusta with 29.5 m height had minimum DBH (0.47 m) with the nest located at 26 m height from ground level. The average DBH of the nesting trees (n=18) was 0.51 m with standard Deviation 6.70 (S.E=1.58). The nests were all recorded from the trees with DBH ranges from 0.47 to 0.57 m. Five nests were recorded from the trees with DBH ranges from 0.47-0.50 m while the maximum number of nests i.e. 12 were recorded from the trees with DBH ranges from 0.51-0.54 m and only one nest was recorded from the tree with DBH ranges from 0.55- 0.59 m.

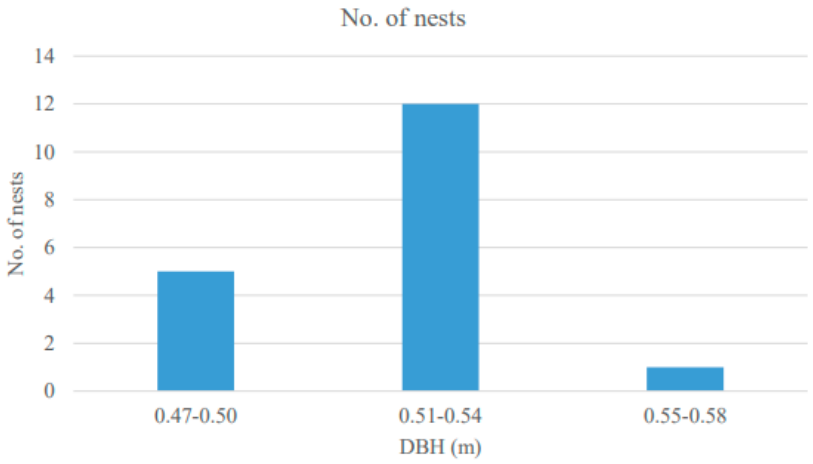

Figure 07: Number of nests at different range of DBH

[5] Nest Direction

The direction of nest was recorded by assuming the tree trunk as the axis. Out of 18 nests, eight nests were recorded at the East (44.44%, n=18), two nests at the middle of the trunk (11.11%, n=18), five nests toward the South-East (27.77%, n=18) and three nests in the North-East direction. As a result, the most preferred direction for the nest-building by Gyps bengalensis was toward East (44.44%), South-East (27.77%), North-East (16.66%) and least preferred to build the nest at the middle of the trunk (11.11%). According to the

data, not any nest was recorded in the west direction so the west direction is considered as unprefered direction to build the nest by Gyps bengalensis in the study area at the study period.

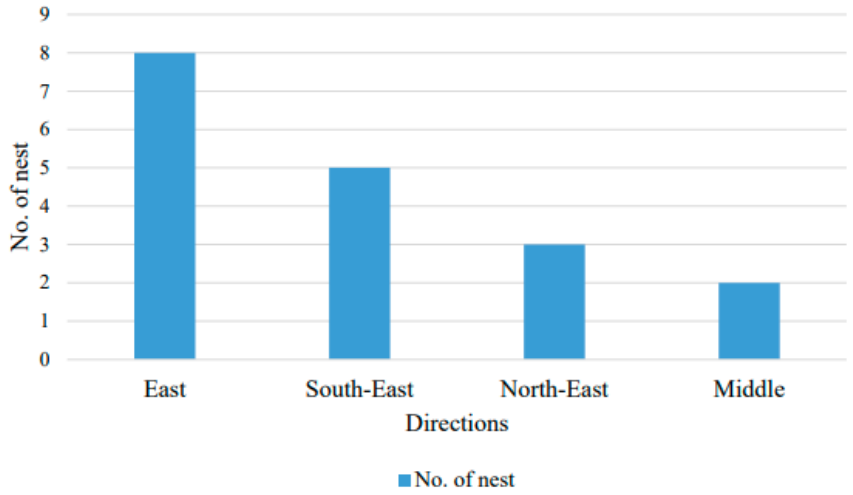

Figure 08: Number of nests recorded at the respective directions by assuming the tree trunk as the axis

[6] Distance of nesting sites from human settlement area (DHS)

The minimum distance from nesting site to human settlement area was 100m, located at the nesting colony (C2 and C3) of ward-4, Kanchana rural municipality and the maximum distance of nesting site from the human residence was 400 m, located at the nesting colony of ward-4 (C1) Gaidahawa rural municipality. The average distance of nesting sites from human settlement was 219.44 m (n=18). All the nesting sites were recorded from the agricultural land in two colonies of Kanchan rural municipality and remaining one nesting colony (C1) of Gaidahawa rural municipality was recorded from the Forest buffer zone.

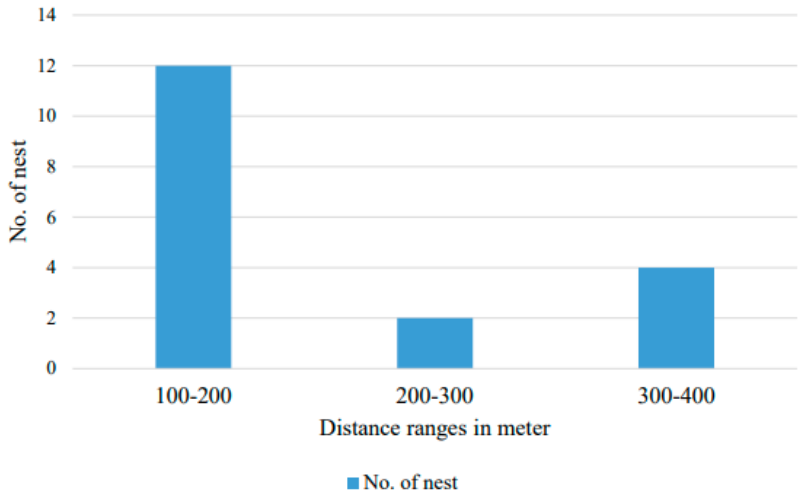

Figure 09: Number of nest and distance from human settlement area

[7] Distance of nesting sites from nearest water body (DWB)

The minimum distance from nesting site to nearest water body was 200 m, while the maximum distance was 350 m. The average distance of nesting sites from nearest water body was 286.11 m (n=18). All the nesting sites were located at the range from 200 to 350 m from the water body.

4.3 Statistical Analysis

[1] Correlation and Regression between nesting tree height, nest height and DBH of nesting tree.

Table 03: Correlation between tree height, nest height and DBH of nesting tree

	Tree height(m)	*Nest height(m)*	*Tree DBH(m)*
Tree height(m)	1		
Nest height(m)	0.917623	1	
Tree DBH(m)	0.633903	0.763246	1

It was found that there was a significant correlation between nesting tree height and nest height i.e., the nest height increases with the increasing of tree height (Pearson's Correlation, r = 0.917, P < 0.001, $S.E$ = 0.473, n = 18). Furthermore, it was found that there was also a significant correlation between the nest height and DBH of the nesting tree i.e., the nest height increase with the increasing in DBH of the nesting tree (Pearson's Correlation, r = 0.633, P < 0.001, $S.E$ = 0.678, n = 18). However, there was no correlation between the DHS and DWS with the nest height (Pearson's Correlation, r = −0.219, P < 0.001, $S.E$ = 0.572, n = 18).

[2] Regression between nesting tree height and nest height

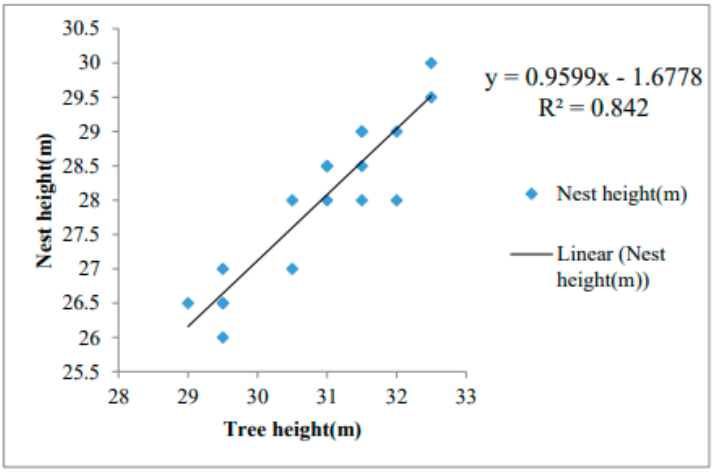

Figure 10: Linear regression plot showing the association between Nesting tree height and nest height

The above linear regression plot shows that there is a positive relationship between the nesting tree height and the nest height i.e., as the height of tree increases, the height of nest also increases and is defined by the simple linear regression equation (= 0.9599 − 1.6778, 2 = 0.842), while < 0.001, . = 0.10 at 95% confidence level.

[3] Regression between Nest height and nesting tree DBH

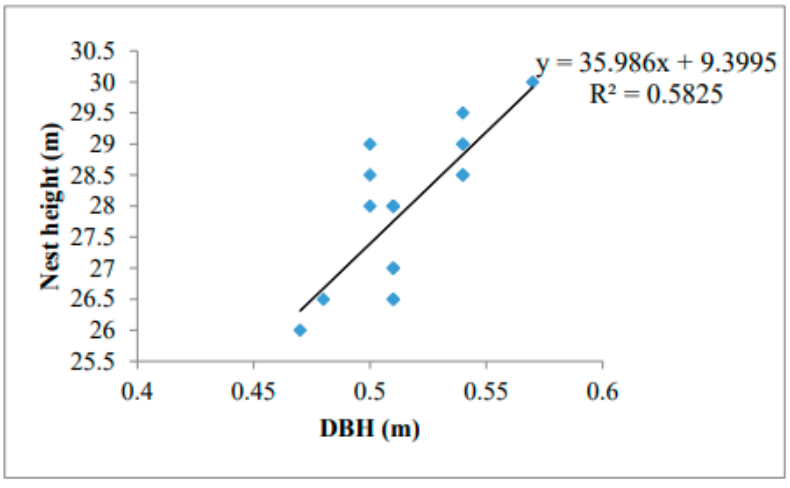

Figure 11: Linear regression plot showing the relationship between nesting tree DBH and nest height

The above linear regression plot shows that there is a positive relationship between the nesting tree DBH and nest height i.e., as the DBH of the tree increases, the height of the nest also increases and is defined by the simple linear regression equation (= 35.986 + 9.399, 2 = 0.582) where, < 0.001, . = 0.02, = 18 at 95% confidence level.

4.4 Hypothesis testing

t-Test was carried out to test the significance difference between the two mean heights of nesting trees and non-nesting trees by assuming equal variances. Null hypothesis, H0: μ1 = μ2 i.e., there is no significance difference between the mean height of nesting trees and non-nesting trees. Alternative hypothesis, H1: μ1>μ2 i.e., the mean height of nesting trees is greater than the mean height of non-nesting trees (right-tailed test).

Calculated value (tcal) = 6.674

d .f = (1 + 2 − 2) = (97+18-2) = 113

Level of significance = 5% + + + =+0 +.05+

Tabulated value (tab) = 1.658 for one-tailed test at 5% level of significance for 113 . .

(i.e., tcal = 6.674 > ttab = 1.658)

Since, tcal is greater than ttab, the null hypothesis is rejected and alternative hypothesis is accepted at 5% level of significance and it is concluded that the mean height of the nesting tree is greater than the mean height of non-nesting tree.

4.5 Discussion

In Nepal, vultures used to be the most prevalent avian species. Monitoring of the vulture population in Nepal's lowlands between 1995 and 2011 revealed reduction of 91% in the White-rumped. There has been occurrences of White-rumped Vultures in the districts of Kanchanpur, Tanahun, Baitadi, Gulmi, and Dang, additionally the species has been found in the districts of Gulmi (1559 m asl.) and Baitadi (1627 m asl.), which are above the typical upper limit for the species of 1500 m asl [26]. Furthermore, 11 potential feeding or roosting sites in Pokhara valley were recorded, where the critically endangered White-rumped Vulture, Egyptian Vulture, and Himalayan vulture were found widely distributed in places like the landfill and vulture feeding locations (Ghachowk), which probably offer them with an abundant supply of food [27]. And a total of 1,632 White-rumped Vultures were recorded in Nepal, monitoring the annual counts of White-rumped Vultures reveals a consistent trend across regions with numbers declining during the 2000s and then rising in the next decade in the Eastern Terai, Western Terai, and Western Pahad, while the Western Terai and Western Pahad regions, where five of the seven Vulture Safe Feeding Sites are located, are where the majority of White-rumped Vultures were found, according to a map showing their transect sites [28], while 11 and 14 nests of Gyps bengalensis were recorded from Nawalparasi and Palpa respectively. Furthermore, Gyps vultures are randomly distributed over India. Generally, Gyps bengalensis was found in the Indus valley, along the Himalayas to the Assam valley, the southern Assam highlands, and from Himachal Pradesh, India [29], 24 breeding colonies of White-rumped Vultures were discovered in the Kangra District's Shahpur, Nurpur, and Kangra regions in India, with three nesting colonies of 102 nests altogether [30], White-rumped Vultures were spotted roosting on a Silk Cotton tree near water body in Uttar Pradesh. However, during this research, nine feeding sites with average 14 individuals, 10 roosting sites with average five individuals on three different tree species (Bombax ceiba, Shorea robusta and Schleichera oleosa Lour.) and three nesting colonies with altogether 18 nests in two different tree species (Terminalia alata and

Shorea robusta) were recorded in the studied area of 155.31 sq.km. The distribution of Gyps bengalensis was found at the altitudinal range between 98-122 m Altitude from sea level (asl.) within the studied area. The occurrence of feeding sites, roosting sites and nesting sites of White-rumped Vulture were reported from several parts of the study area and the distribution of White-rumped Vulture (Gyps bengalensis) was random, whereas the individuals were occurred at unpredictable distances from each other [31].

5. CONCLUSION

Nine feeding sites with average 14 individuals, 10 roosting sites with average five individuals on three different tree species (Bombax ceiba, Shorea robusta and Schleichera oleosa Lour.) and three nesting colonies with altogether 18 nests in two different tree species (Terminalia alata and Shorea robusta) were recorded in the studied area of 155.31 sq.km. The distribution of Gyps bengalensis was found at the altitudinal range between 98m-122 m altitude from sea level (asl.) within the studied area. The occurrence of feeding sites, roosting sites and nesting sites of White-rumped Vulture were reported from several parts of the study area at unpredictable distances from each other, so it is concluded that the distribution of White-rumped Vulture (Gyps bengalensis) was random. However, the occurrence of white-rumped Vulture were reported close to the human settlement area at the average distance of 250 m and 300 m average distance from nearest waterbodies and it shows the co-existence between human and vultures in the study area. A total of 15 species of trees were recorded from the study area, out of which the dominant tree species was Sal (Shorea robusta) with IVI of 63.66 followed by Sissoo (Dalbergi sissoo) with an IVI value 34.07 as second most dominated species in the study area and altogether 9 species of shrubs were recorded from the study area, whereas Dhursilo (Colebrookea oppositifolia) with Prominence value (PV) 132.32 was found as the most dominant shrub species in the study area, followed by Rudhilo (Pogostemon benghalensis L.) with PV 128.42.

6. RECOMMENDATIONS

It has been a strenuous challenge to conserve the critically endangered Gyps bengalensis due to the rapid increasing human population resulting in the devastating destruction of natural resources. To prevent the extinction of the critically endangered White-rumped Vultures, the following actions should be taken into consideration:

- The regular monitoring of distribution of Gyps bengalensis and their nesting habitat in this area is highly recommended.
- Because most of the vulture nesting sites are on private property, there is an urgent need to advocate the landowners.
- The deforestation and forest encroachment should be strictly prohibited.
- As it is a home to a colonies of the critically endangered White-rumped Vulture, a comprehensive conservation effort should be launched and the other nearby area should be researched.
- Establishment of more vulture feeding sites and their regular monitoring is necessary.
- Public awareness programmes should be frequently conducted to enhance the public participation of local people toward the vulture conservation.

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