FACTORS AFFECTING THE POPULATION AND NESTING ECOLOGY OF SARUS CRANE IN RUPANDEHI, NEPAL

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Batch: 2076

A thesis submitted in partial fulfilment of the requirements for the award of the degree of Master of Science in Zoology with special paper Ecology and Environment

Submitted to

Central Department of Zoology

Institute of Science and Technology

Tribhuvan University

Kirtipur, Kathmandu

Nepal

May, 2023

DECLARATION

I hereby declare that the work presented in this thesis has been done by myself and has not been submitted elsewhere for the award for any degree. All sources of information have been acknowledged explicitly by reference to the author (s) or institution (s).

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LETTER OF APPROVAL

On the recommendation of supervisor "Prof. Dr. Tej Bahadur Thapa" this thesis submitted by Ms. Sheela Bhattarai entitled "Factors affecting the population and nesting ecology of Sarus crane in Rupandehi, Nepal" is approved for the examination and submitted to the Tribhuvan University in partial fulfillment of the requirements for Master's Degree of Science in Zoology with special paper Ecology and Environment.

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CERTIFICATE OF ACCEPTANCE

This thesis submitted by Mrs. Sheela Bhattarai entitled "Factors affecting the population and nesting ecology of Sarus crane in Rupandehi, Nepal." has been accepted as partial fulfillment for the requirements of Master's Degree of Science in Zoology with special paper Ecology and Environment.

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ACKNOWLEDGEMENT

My sincere gratitude and respectable appreciation go to my supervisor Prof. Tej Bahadur Thapa, Central Department of Zoology. As the supervisor, his timely advice and guidance, on developing and refining the research concept as well as from executing the research to finalizing the thesis is highly appreciated. Easy access to him was the most important aspect of my relationship with him. This report would not have taken its present shape and quality without his untiring efforts.

I would like to thank Professor Dr. Kumar Sapkota, Head of the Central Department of Zoology, for providing administrative supports and facilities.

I am obliged to Mr. Kailash Jaishwal, Mr. Suraj Bhattarai and Mr. Tribhuwan Pandey during the field survey. Similarly, I am grateful to administration of Central Department of Zoology providing GPS monitoring device and other necessary equipment for the bird survey.

I would like to pay my heartfelt thanks to Mr. Himal Upreti for providing me fooding and lodging facility and also local people who helped me by providing the related information during the survey period.

I am indebted to all my friends who directly or indirectly helped me for my work. I extend my thanks to all of my respected teaching and non-teaching staff of the Central Department of Zoology for their kind support, guidance and feedback on my research project and other academic courses during my study at the department.

Last but not the least I am grateful to my parents, and all the family members who persistently encouraged me in my mission with sincere compassion. Words of thanks will not be sufficient for their ultimate understanding patience and sacrifices. Finally, I appreciate everyone whom I have missed to remember and all my well-wishers who have contributed towards completion of the work.

Sheela Bhattarai

Examination Roll No: 849

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LIST OF ABBREVIATIONS

GPS – Global Positioning System

BCN- Bird Conservation Nepal

LCSA- Lumbini Crane Sanctuary Area

DNPWC- Department of National Parks and Wildlife Conservation

IUCN- International Union for Conservation of Nature

CITES- Convention on International Trade in Endangered Species of Wild Fauna and Flora

ABSTRACT

Sarus crane is the World's tallest flying water bird listed as a globally threatened in the IUCN Red List. Sarus cranes are distributed mainly in the wetland and farmland of Terai of Nepal. The study was carried out in Rupandehi District on September to December 2022 to identify the factors affecting population and nesting ecology of the Sarus crane. Roads were used as a transect to count the crane in different area using motorbike, rikshaw or on foot. A total of 174 individuals including 157 adults and 17 juveniles were recorded. Estimated density of Sarus crane was 0.32 crane/km². The average area of nest was 1.95 m². Among the 28 nesting sites, 4 nests were found inside the Lumbini Crane Sanctuary Area and 24 outside the sanctuary area. Population and nesting sites of Sarus crane are influenced by different types of habitats and environmental variables. Presence of Sarus cranes is found to be nearer to the road. Also, the presence of nesting site relies heavily on the water body. Road construction, destruction of wetland, conversion of farmland to settlement, electrocution were the major threats seen in the study area. Increasing awareness to local people, restoration of wetland and their protection and reducing the disturbance factors are some ways to save the Crane in Rupandehi.

Keywords: Population status, Nest ecology, Water bird

1. INTRODUCTION

1.1 Background

The Sarus crane (*Antigone antigone*) is one of the world's tallest-flying water birds (Linnaeus 1789). Sarus cranes belonged to Gruidae, are distinguish by the overall grey colour and the contrasting red head and upper neck (Gyawali 2015). Adults weight up to 7 to 10 kilograms and are about 5.5 feet tall (Singh & Tatu 2000). Sarus cranes feeds on aquatic plants, roots, tubers, seeds, insects, invertebrates, crustaceans, butterflies, fishes, frogs and reptiles (Verma & Prakash 2021) and rarely feed on the eggs of other birds (Sundar et al. 2000). Sarus crane is the only resident breeding crane found in South Asia (Inskipp et al. 2016). The Sarus crane is monogamous bird that symbolizes the eternal love, devotion and good fortune (Tiwari et al. 2017). Sarus crane is known for its marital loyalty and they are believed to mate for life and grieve the loss of their partners to the point of starving to death (Yaseen et al. 2013). Out of 15 species of Crane found worldwide, four are recorded in Nepal (Inskipp et al. 2016).

Sarus crane is listed as a globally threatened bird in IUCN red data book and appendix II of CITES (Gyawali 2015). Approximately 8000 – 10000 individuals of the *Antigone* sub species inhabit Nepal, India and Pakistan (List 2012) with occasional migrants in Bangladesh (Archibald et al. 2003). Its range has reduced towards the north and west of the subcontinent (Sundar et al. 2000) and its population is considered to decline (Archibald et al. 2003). The state of Uttar Pradesh in northern India remains the species main habitat with an estimated population of more than 6000 individuals (Sundar 2011). South-East have shown some increase in the Asian population, however, cranes in Tram Chin's population viability reveals that if the current rates of habitat loss continue, the population is highly unstable and prone to extinction (Archibald et al. 2003).

There are probably less than 500 of them in all of Nepal and their range has been slowly decreasing (Suwal 1999). The Sarus crane occurs rarely in Pakistan, India's Punjab and western Bangladesh (Meine & Archibald 1996). At Dhangadi, the Sarus crane has been observed at a maximum altitude of 300m (Johnsgard 1983). Uncommon and local resident in the west central Terai: 75-300 m (Gyawali 2015). A Terai survey conducted in 1992 showed that the species range extend from Sukla- Phanta to Chitwan and due

to the degradation of wetlands, the species was declining (Suwal 1999). Sarus crane have evolved to live in wetlands and often nests in marshlands(Walkinshaw 1973, Ali & Ripley 1983, Gole 1989) Tradition for species with fidelity, physical features and pressure from conspecifics or guardian species are all example of proximate cues in general habitat selection (Bongiorno 1970). The only time marsh nesting species can do so is when the physical environment is suitable for nesting (Burger 1974). Nests are submerged in water and typically composed of aquatic vegetation and have a broad base and are circular in shape and are oblong with depression in the centre (Mukherjee et al. 2000). Nest site selection is a process of selecting a specific location to build a nest and it usually takes place right before egg laying (Cody 1985). Both sexes take part in nest building (Hume & Marshall 1881).

Each year, the female produces only two eggs that are oval in shape, weigh around 300 grams, with an axial length of about 13 cm and a circumference of about 10 cm (Adesh Kumar 2014) and the hard cell bears light grey wavy lines and is tall. In natural wetlands, the species has high rate of breeding success but this rate is lower in area with increased agricultural practise (Sundar 2018).

Sarus crane are threatened throughout their range. Habitat loss, reduction in breeding success, wetland reduction, excessive harvesting, disturbance (Jones et al. 2005), poaching and the destruction of eggs and juveniles (Kaur et al. 2008) reduces the Sarus population worldwide. Rainfall, food sources, parental care, predator and disturbances effect on Sarus crane behaviour (Monichan & Sharma 2003).

This species is threatened by human activities because its habitat are close to activities like increasing crop field size and human settlement, which degrades the habitat (Aryal et al. 2009). Imigration after eradication of malaria and large-scale agricultural expansion were major contributors to habitat degradation which reduce the range and population of Sarus crane in lowlands Nepal (Jha & McKinley 2014). Similar disappearance of the Sarus crane has also been reported from other parts of its range (Gole 1991). Increased agricultural production and human population also have indirect impacts on wetland habitat such as hydrological changes, high rates of sewage inflow, extensive agricultural runoff and high level of pesticides residues. These have big impacts on water and wetland quality in places like India, Nepal, Vietnam, Philippines, and other areas (Meine & Archibald 1996).

Although there are many information on the Sarus Crane, the social aspects of this bird's conservation is poorly documented (Suwal 1995). The main thing that is protecting the Sarus Cranes in villages is their religious sentiment. Only small and isolated population estimated of less than 500 Indian Sarus Crane occurs now in Terai lowlands of Nepal (Suwal et al. 2003). The majority of Indian Sarus cranes occurs in farmland, outside the protected areas (Aryal et al. 2004).

1.2 Objectives

1.2.1 General Objective

To assess the factors affecting population and nesting ecology of the Sarus crane in Rupandehi, Nepal.

1.2.2 Specific Objectives

The specific objectives of the proposed research are:

- To assess the current population size and nesting sites of Sarus Crane in Rupandehi.
- To evaluate factors that influence population and nesting ecology of the species.

1.3 Significance of the study

Numerous researches have been carried out to focus the population dynamics and habitat suitability and very few studies were done on affecting factors and their conservation regime so this study was conducted to generate current information on population status, nesting sites and their causes of declines, conservation practices and subsequently informing the future research needs and management decisions.

2. LITERATURE REVIEW

Global Distribution of Sarus Crane

A globally threatened Sarus crane is a declining species crane that is distributed in Nepal, Australia and Southeast-Asia and breeds primarily in wetlands and owned the commonly used agricultural field (Archibald et al. 2003, Sundar 2011). with an estimated population size of about 13,000-15,000 (Verma & Prakash 2021).With three recognized subspecies, they are confidently present in Nepal, India, Myanmar, Cambodia, Lao People's Democratic Republic, Vietnam, China, Pakistan and Australia, and became regionally extirpated in Malaysia, Thailand and Philippines (Archibald et al. 2003). The Sarus Crane (*G. a. antigone*) has been extirpated from a huge amount of its historic range and is still declining in regions where it still survives (Aryal et al. 2004).

The largest population of the species can be found in Gangetic Plain in Uttar Pradesh, Gujrat, eastern Rajasthan and Haryana (Ali & Ripley 1983, Verma & Prakash 2016). Uttar Pradesh supports the biggest number of Sarus Crane in India (Adesh et al. 2019). In Uttar Pradesh, Etawah and Manipur are the major districts with maximum number of Sarus Cranes (Archibald et al. 2003). In Uttar Pradesh, a total of 11,905 individuals were documented from entire state and was more concentrated in the South and Western districts of state around common Gangetic Plains, Yamuna and Chambal rivers (Jha & McKinley 2014). Maximum number of populations are concentrated along the Gangetic Plain whereas, minimum in Bundelkand region in Uttar Pradesh, India. The reason behind the maximum population is because of maintained water level from Ganga River, which indicate as a favourable habitat for Sarus Crane breeding and foraging. On the other hand, Bundelkand is water scarce area that results in declining number of Sarus Crane (Adesh et al. 2019).

A total of 1,902 Sarus Cranes were documented from the 43 districts of Uttar Pradesh from 2008-2017 (Adesh et al. 2019). Also, a comparative analysis in eight consecutive years from 2012-2019 in Alwara Lake of Kaushambi district of Uttar Pradesh documented the increasing trend of Sarus Cranes (Ashok Kumar Verma 2019). And the reason behind its increasing pattern was due to positive efforts, proper management and awareness campaigns (Prakash and Verma 2019) which results in the favorable

environmental conditions for Sarus Crane in and around Alwara lake (Verma & Prakash 2016). In addition, very few populations of about 500 were observed from Madhya Pradesh, Maharashtra and Bihar states in central India (Sundar 2019).

Distribution of Sarus crane in Nepal

Manandhar (2014) estimated population comprising 158 adults and 14 chicks in Rupandehi District, 82 adults and 4 chicks in Kapilbastu District and 30 adults five chicks in Nawalparasi District. A total of 190 individuals and 19 nests were observed (Gyawali 2015) and 147 Sarus crane were recorded in 2016 in Rupandehi District. Poaching of Sarus crane and stealing of egg are the main cause of decline in population (Gosai et al. 2016). Tiwari et al. (2017) reported 51 Sarus crane in Banke District. A pair of Sarus crane was recorded in Dang district and believed as they remain there for short period during the migration between Banke and Kapilbastu (Bhattrai et al. 2019).

Sarus crane nest primarily during the rainy season and lay their eggs (Sundar et al. 2000). The nest are mainly distributed in paddy cultivable area and non- cultivable agricultural marshland (Mukherjee et al. 2000). The vegetation on the ground affects the choice of nesting material. Rice plant was used to build nest in paddy and *Elecochris*, *Ipomea* were used in wetlands and ponds. *Imperata* grass was used in all types of nest (Aryal et al. 2004).

Majority of nests were seen within water bodies in the Triveni (Chaudhary 2008). The electrocution possesses a risk to Sarus crane as their death were caused by powerline collisions (Aryal et al. 2009). Broods hatched in regions with fewer wetlands have low survival rate. Change in vegetation and disturbance during collection of crops had a lower probability of success of broods. The survival of Sarus crane nests and broods depends on maintaining a patchwork of shallow wetland in rice dominated landscapes (Sundar 2011).

Loss of wetland and degradation was the major threats to Sarus crane throughout its range (Suwal 1995). In recent times, due to the destruction of its habitats, pollution and agricultural development the population of Sarus crane is in threats (Aryal et al. 2004). The major threat to Sarus crane in the study area was the conversion of agricultural land and wetlands for various industries such as cement factories (BCN 2011). Drying of wetlands, expansion of agricultural land, conservation of wetlands, poaching, disturbance in foraging and nesting place were the major threats to Sarus crane (Tiwari

et al. 2017). Habitat destruction, hunting of Sarus crane for meat, stealing of egg, electrocution, cattle grazing, use of pesticides in agricultural field were the major threats to Sarus crane and also recorded that the highest number of Sarus crane were found in agricultural land and wetland (Gosai et al. 2016) .

Sarus crane is a flagship species which was first reported in 1879 (Scully 1879). It is one of the nine protected bird species in Nepal (Baral 2009). Habitat loss, pollution and agricultural expansion are the major threats that the Sarus crane is facing these years (Aryal et al. 2009). Despite having a long recorded history, less research has been carried out in Nepal (BCN 2011). Most of the previous studies shows the Sarus crane's declining population in Nepal (Baral et al. 2012). This study is focused on population and nesting ecology of Sarus crane, it's disturbance factors and potential threats for its conservation.

In 2004, 76 adults and 23 immature individuals were recorded (Aryal et al. 2004). Similarly, a total of 280, 257 and 202 Sarus crane in pre- nesting, nesting and post-nesting period was observed respectively in western part of Nawalparasi District that prefer wetlands for foraging and nesting habitat (Chaudhary 2008). Due to habitat degradation, Sugarcane cultivation, increasing electri cal cable line, dam and cementation in water canal, water pollution and other environmental contamination the population of the Sarus crane seems to be decline in Rupandehi and Kapilbastu District as there were 100 cranes in Rupandehi and 68 in Kapilbastu District (Aryal et al. 2009).

3. MATERIALS AND METHODS

3.1 Materials

The scientific instruments used during the field study were:

a. GPS: Garmin Etrex 10

b. Camera

c. Binoculars: Bushnell Falcon 10*50s

d. Measuring tape

3.2. Study area

This study was conducted in Rupandehi District in the latitude (27°20'00" to 27°47'25") and the longitude of (83°12'16" to 83°38'16"). Rupandehi District lies in Terai region and is situated in Lumbini Province of Nepal (Figure 1). The elevation ranges from 100 m to 1229 m covers an area of 1360 km² with 16.1% in Churiya Range and rest in Terai region. Nawalparasi district lies to the east, Kapilbastu district to the west, Palpa district to the north and Uttar Pradesh lies to the south.

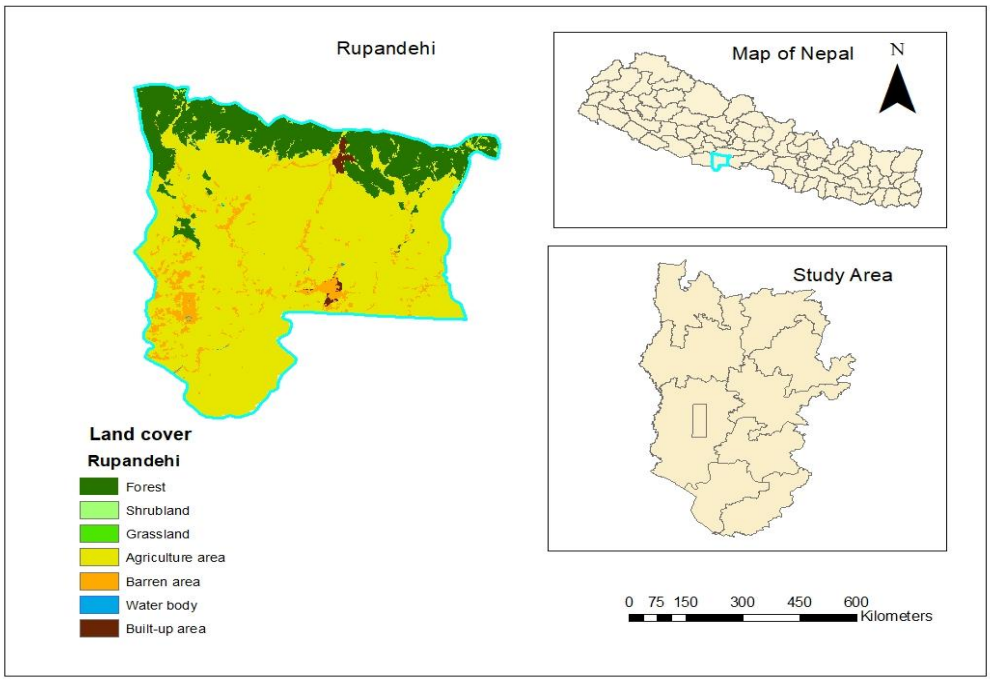

Figure 1. Map of study area

3.2.1 Land use

Agriculture is the main land use in Rupandehi district constitutes plains in the south and Churia hills to the north. The forest, wetlands, scrub and grassland that surround Lumbini (the birthplace of Lord Buddha) are significant refuge for wildlife(Burfield et al. 2017). In Rupandehi district almost 60.2% of the area is covered by agricultural land.

3.2.2 Water resources

Tinau, Rohini, Kanchan and Godaha are the major rivers of this district whereas Gaidahawa, Gajedi, Nanda vauju and Sukaiya are the major lakes in the district (District Profile 2021). A number of perennial and seasonal rivers and streams including the Dano floodplains are identified as significant habitats for bird life (Bhandari 1996).

3.2.3 Flora and Fauna

Generally, two types of forest is found in Rupandehi in which one is natural forest and another is artificial forest (Aryal et al. 2004). Sal (*Shorea robusta*), Kadam (*Anthcephalus cadamba*), Khayar (*Acacia* spp.), Jamun (*Syzygium* spp.), Satisal (*Dalbergia* spp.), Saaj (*Terminalia elliptica*), Sisso (*Dalbergia sissoo*), Harro (*Terminalia chebula*) and Pipal (*Ficus religiosa*), Babool (*Acacia nilotica*) and Bakaino (*Melia azedarach*) are the major tree species found in Rupandehi District (Singh 2017).

In Nepal, Rupandehi has best known population of the globally threatened Sarus crane and here the species regularly breeds (Burfield et al. 2017). A total of eight globally threatened species of birds have been recorded here that includes Indian Spotted eagle (*Aquila hastate*), White-rumped vulture (*Gyps bengalensis*), Slender-billed vulture (*Gyps tenuirostris*), Cinerous vulture (*Aegpius monachus*), and Lesser adjutant (*Leptoptilos javanicus*) (Suwal et al. 2003). The globally threatened Nilgai (*Boselaphus tragocamelus*), Barking deer (*Muntiacus vaginalis*), Wild cat (*Felis silvestris*), leopard (*Panthera pardus*), Jackel (*Canis aureus*) and variety of birds are common fauna of the Rupandehi District (Aryal et al. 2016).

3.2.4 Population and community

Rupandehi district consists of one sub- metropolitan municipality, 5 municipality and 10 Rural Municipality (District Profile 2021). According to 2021 Nepal census, the population of Rupandehi is 1121957 in which 49.1% (550478) are male and 50.9%

(571479) of population are female (Source: There are 163916 households with the population belonging to age group more than 65 years is 6% (67493), 66.9% (750129) is the population of 15-64 years age group and 27.1 % (304340) are children belonging to age group 0-14 (Source: https://www.citypopulation.de/)

3.2.5 Culture and ethnicity

The study area is inhabited by Tharu and Madhesi along with other ethnic groups such as Brahmin and Chhetri. The major religion practised by the people in the study area is Islam and Buddhism (Baral 2018). The primary occupation and major source of income is Agriculture. The major crops grown here are rice (*Oryza sativa*) and wheat (*Triticum* spp.) whereas Potato (*Solanum tuberosum*) and Sugarcane are the cash crops grown here. People in the area are involved in livestock farming as the important component of agriculture system (Gyawali 2021).

3.3. Methods

3.3.1 Preliminary Survey

A preliminary survey was carried out on May, 2022 to locate the Sarus crane's potential areas before the beginning of field work. Every Municipalities and Rural Municipalities were surveyed to find the presence and absence of Sarus crane, and discussions were made with experts and staffs of Lumbini Development Trust, members of Lumbini Crane Sanctuary and local people to find the distribution of Sarus crane.

3.3.2 Bird Survey

Population of Sarus crane were counted by direct observation method in their potential habitat during September 2022 inside the Lumbini Development Area and in November, December 2022 outside the Developmental area in different Municipalities and Rural Municipalities. The population was counted with the assumption that during the breeding season, Sarus crane activities were remain within the fixed territory in order to avoid double counting. Road as a transect was used to count the crane in different area using motorbike, rikshaw and on foot to reach every potential site. Any Sarus crane seen with the naked eye or binoculars within a 500 m radius on either side of the road was recorded. Adult Sarus crane were recognized by size and height as well as the bright red patch of bare skin on the crown which was absent in juveniles. Population

density of Sarus crane was determined by using the following formula (Aryal et al. 2004).

Population density of sarus= Total number of Sarus crane observed/ Total area of the observed population

Habitat types such as agricultural land, wetland and grasslands were also recorded. Paddy fields were noted as agricultural land that is used by the crane as sub-optimal nesting habitat. Non-agricultural marshland was noted as wetland which includes fallow land, water canal and ponds. Soil which is not waterlogged during the study was noted as grassland.

3.3.3 Nest Survey

Nest and nesting sites were also identified and counted at the time of survey. During nest survey, number of nests and nesting sites and threats around the nesting sites were recorded. GPS coordinates of the nesting sites were also recorded. Old nests and nesting sites were identified from local informants. Area of nest of their heads was calculated (Gyawali 2015) as;

Nest area (A) = $\pi \left(\frac{d^2}{4}\right)$

where $\pi = 3.14(constant)$ and D= diameter of nest

3.3.4 Environmental Variables

The nearest distance from the presence points of Sarus crane and nest location to human settlements, road, water resources were measured and recorded. The nearest distance to these sources was measured using measuring tape, however, the distance >200 m was measured using the Google Earth.

Table 1 Environmental Variables and their codes used

S.N.	Environmental Variables	Codes used
1	Distance to nearest road	DR
2	Distance to nearest settlement	DS
3	Distance to nearest water body	DW
5	Number of Sarus crane	INDIV
6	Number of nests	Nest

3.3.5 Questionnaire survey

A set of questionnaires with several options was prepared for local people regarding their interest on the Sarus crane. The status of Sarus crane population distribution, nests, feeding habits, threats factors, conservation practices etc. were included in the questionnaire. The questionnaire survey was conducted in Mujrahawa, Piprahawa, Farhena, Aama, Khadaiya, Lalpur, Kanijhawa, Bishnupura, Bhagwanpur and Lumbini. Two hundred respondents were selected randomly for survey.

Both questionnaire and field survey, investigation was done to identify and quantify the factors affecting Sarus crane population and nesting ecology. (Appendix 6: Sample format of questionnaire)

Data analysis

Data collected from the field were recorded and saved in Excel. Questionnaire were analyzed in Excel to find the percentage and frequency of questionnaire. Mean value of each factor was obtained for analysis of the population and nest with the environmental variables using the software R studio.

The Kruskal- Wallis test was used to determine the significant difference of different habitats such as agricultural land, wetland and grassland on a dependent variable of population and nest. This method is a non-parametric test approach to one-way ANOVA.

4. RESULTS

4.1 Distribution and population estimate

Sarus crane were recorded specially in the south-central part of the Rupandehi district. Relative higher frequency of Sarus crane were recorded in Lumbini and surrounding area (Figure 2)

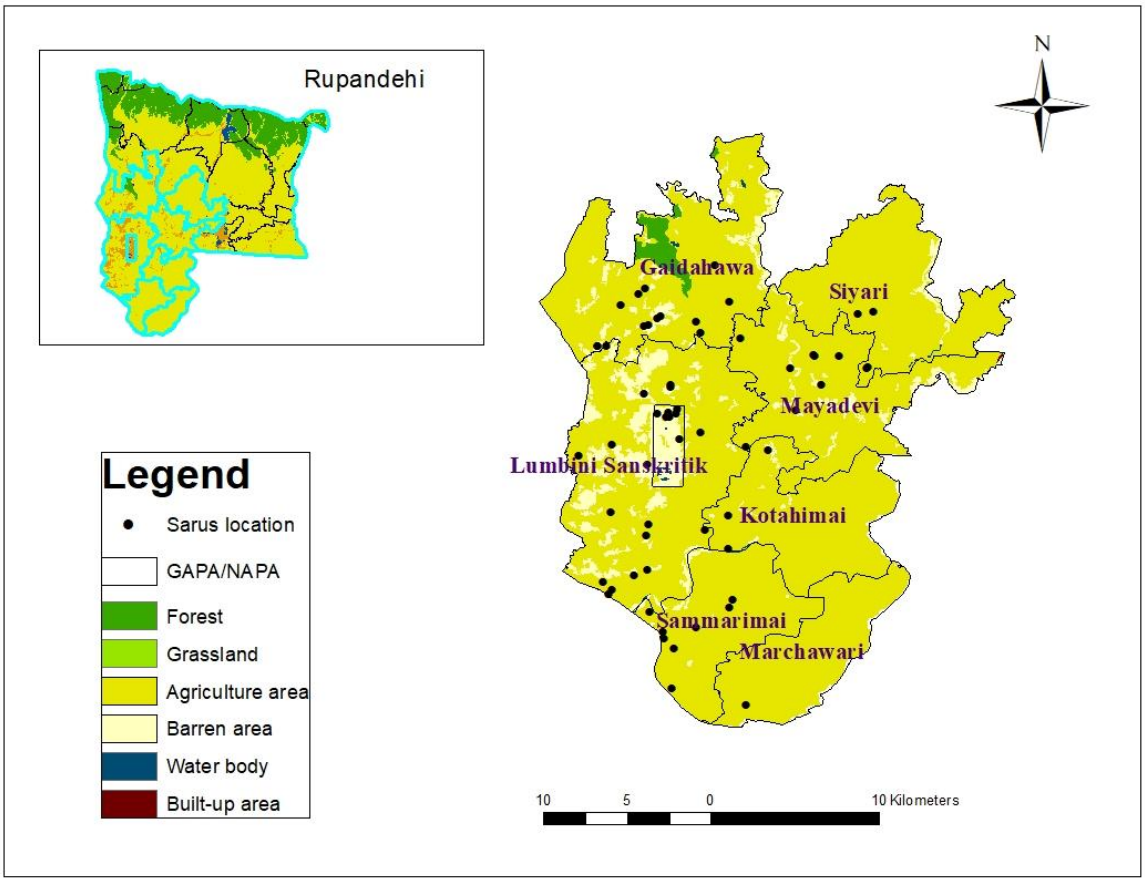

Figure 2. Presence location of Sarus crane in study area

A total of 174 individuals of Sarus cranes were counted in Rupandehi District. Out of them 157 were adults and 17 were juveniles (Table 2). Population of Sarus crane was found to be more in Lumbini Sanskritik Municipality (n=65) followed by (Gaidahawa, Samarimai, Mayadevi, Kotahimai, Siyari and Marchawari) rural municipalities.

The estimated population density of the Sarus crane was 0.32 crane/km². In Rupandehi district, the total available area of my study site for Sarus crane is 531.23 sq.km comprising agricultural land, wetland land and grassland.

Table 2 Population distribution in different municipality/rural municipality

Municipality/ Rural municipality	Adults	Juveniles	Total	Habitat types		
				Wetland	Agricultural land	Grassland
Gaidahawa	31	8	39	2	30	7
Kotahimai	10	0	10	0	10	0
Mayadevi	18	5	23	0	23	0
Lumbini Sanskritik	62	3	65	15	50	0
Siyari	10	0	10	0	10	0
Samarimai	22	1	23	6	17	0
Marchawari	4	0	4	0	4	0
Total	157	17	174	23	144	7

A total of 12 cranes were counted in the LCSA. Out of them, 11 were adults and 1 was Juvenile.

4.2 Habitat use

Out of the total recorded, majority were found in agricultural land followed by wetland and grassland. (Table 2, Figure 3)

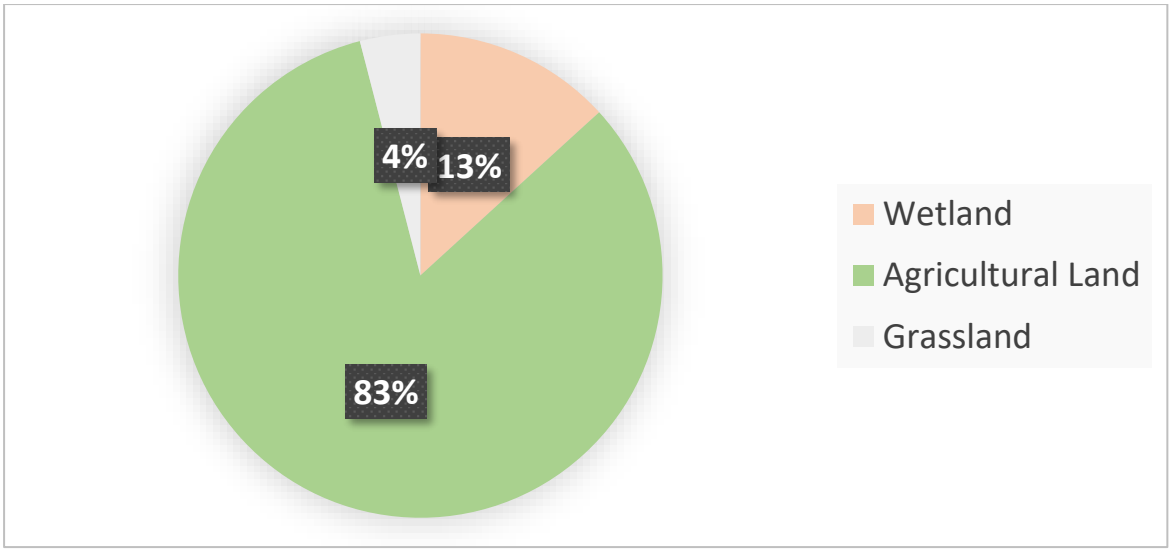

Figure 3. Different types of habitats used by Sarus crane

Respondent's response on population trend of Sarus Crane

Thirteen percentage of the total respondents agreed that the populations were declining gradually since last few years and 42% of them agreed the increase in population. Since the people are aware about the conservation of Sarus crane as it is the symbol of love and related to Buddha. People also agreed that Sarus crane are not harmful to them and believed that they do not destroy the farmland. So, most of the respondent's response that there is no change in the population of Sarus crane in their area.

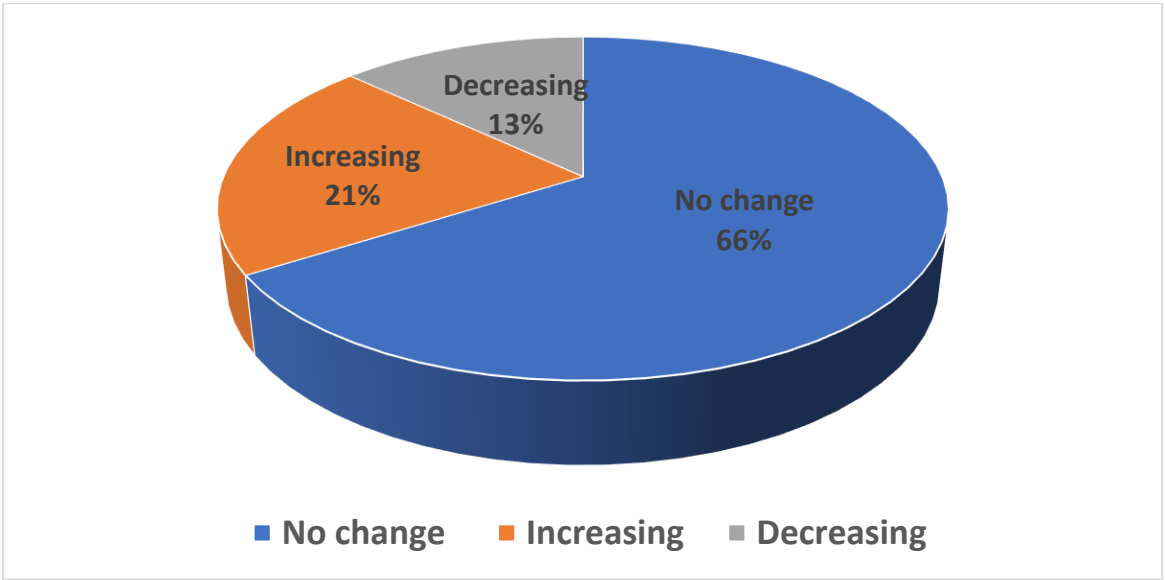

Figure 4. Respondent's response on population trend

4.3. Factors affecting population of Sarus crane

The minimum average distance of population presence location to nearest road was 120.40±106.67 (range from 51.37 to 733.48) and followed by water body 124.26±107.23 (range from 0 to 607.58), whereas, maximum average distance to human settlements was 229.58±158.78 (range from 45.03 to 632.31).

4.4 Nest distribution

A total of 28 nest including 4 nests inside the LCSA (during the breeding season) and 24 nesting sites were observed outside the LCSA (Table 4).

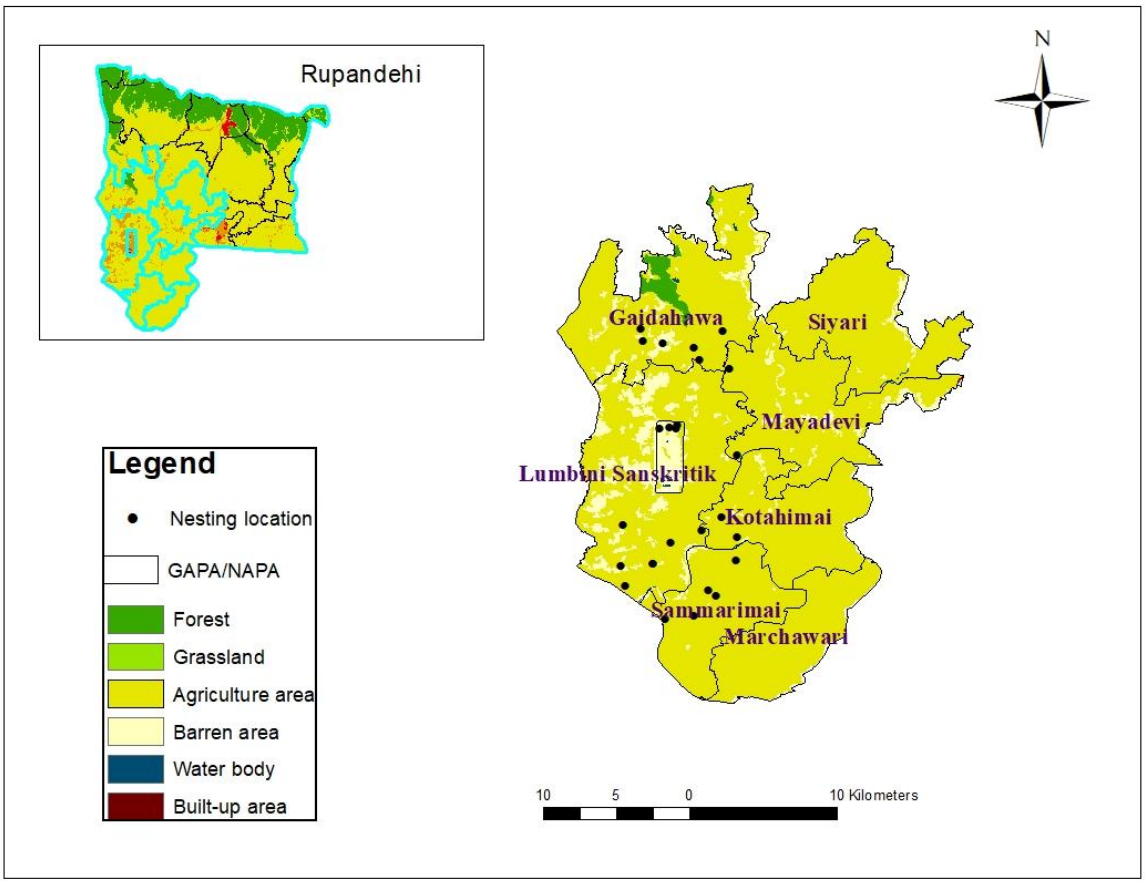

Fig 5. Presence points of nesting sites in the study area

Table 3 Number of nesting sites in different area

S.N.	Study Area	Number of nests	Land use type
1	Lumbini Crane Sanctuary Area	4	Wetland
2	Mujhana	1	Wetland
3	Aama east	1	Agricultural land
4	Aama west	2	Wetland
5	Banjarahi	1	Wetland
6	Bhagwanpur	1	Agricultural land
7	Ardaula east	1	Wetland
8	Sipawa	1	Agricultural land
9	Rohinihawa	1	Agricultural land
10	Bedkuiya	1	Agricultural land
11	Tanijawahawa	1	Wetland
12	Bishnupura	2	Agricultural land
13	Mud Phutwa	2	Agricultural land
14	Lalpur	1	Grassland
15	Thumahawa	1	Wetland
16	Fahrena	1	Agricultural land
17	Bagdiya	1	Agricultural land
18	Piprahawa	1	Wetland
19	Barhadwadi	1	Wetland
20	Arauli	1	Grassland
21	Mujrahawa	1	Wetland
22	Khadaiya	1	Wetland
	Total	28	

4.5 Nest dimension

The average area of nest inside the Lumbini Crane Sanctuary Area was found to be 1.955 m²; the largest nest was 2.20m² and smallest was 1.48m².

Table 4 Average area of nest

S.N.	Diameter of nest (cm)	Nest height (cm)	Area (m²)
1	162.56	78.74	2.07
2	137.16	60.96	1.48
3	162.56	30.48	2.07
4	167.64	60.96	2.20
Mean			1.955

4.6 Vegetations used for nest building

Local plant species were used to build the nest by Sarus cranes. The vegetation used for nest building were *Ipomoea aquatica*. *Elaeocharis dulces*. *Oryza sativa*, *Cynodon dactylon* and *Imperata cylindrica.*

4.7 Nesting sites in different habitat

Out of three types of habitats surveyed, most of the nest were built in wetlands followed by agricultural land and grassland. (Figure 6)

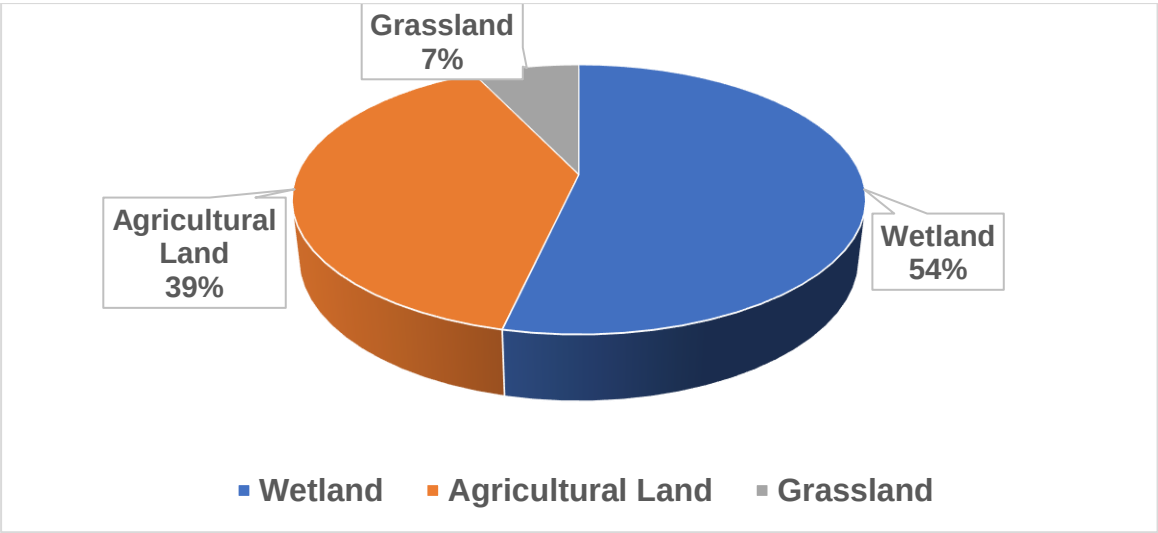

Figure 6. Percentage occurrence of nest in different habitats

4.8 Factors affecting nesting ecology

The minimum average distance of nest location to water body was 96.44±142 (range from 0 to 410.63) and followed by road was 133.352±94.49 (range from 54.5 to502.76). Whereas, maximum average distance to human settlements was 246.51±141.57 (range from 57.48 to 535.57).

The p value obtained from the Kruskal-Wallis test for different habitat types on population and on nesting sites was less than the significance level of 0.05.

Respondents' views on threats to Sarus crane

Destruction of wetland was the major threat to Sarus crane habitat and their nesting ecology followed by, destruction of nests, destruction of eggs by stealing and poaching, disturbance by other animals, (Figure 7). Farmers blamed that most of the Sarus cranes used their farmlands for food and habitat that destroy their crops, so the people destroy their nests. Some chicks were also been killed by other animals and birds.

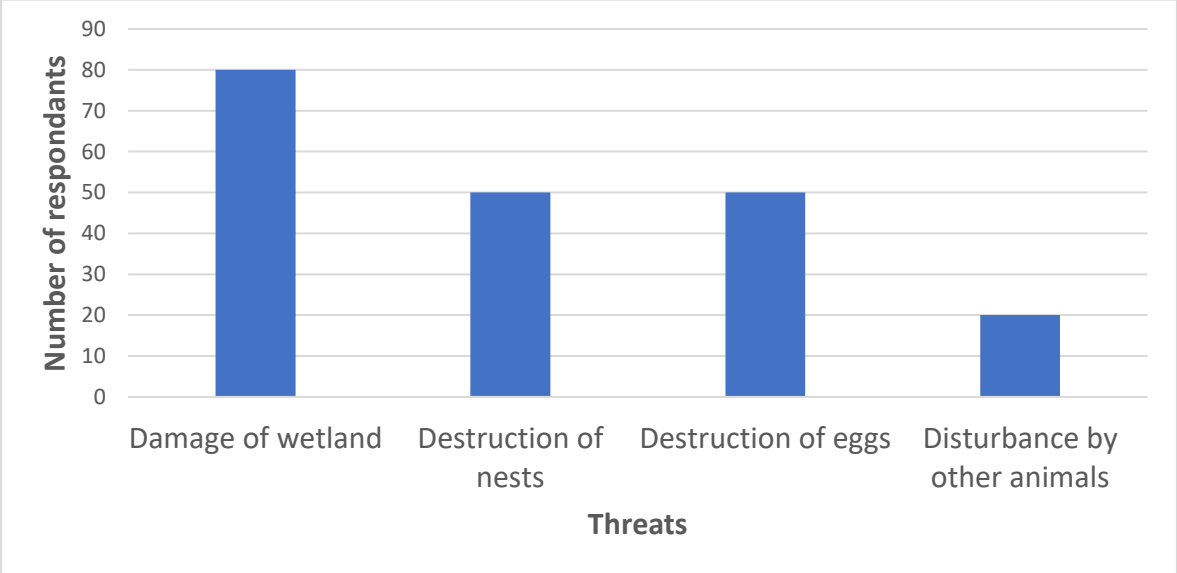

Fig 7. Respondent's views on threats to Sarus crane

Respondent's reactions on conservation practices on Sarus Crane

Among the respondents, 34% of them agreed that conservation awareness campaign is a best way for local people to conserve Sarus crane and to increase their contribution on Sarus Crane habitat. Twenty-four percentage respondents responded that conservation of wetland on their natural environment can also help in Sarus crane conservation. Twenty-one percentage respondents stated that the access to important

nesting grounds should be banned, 16% of them stated that minimum pesticides must be used in croplands and 5% voiced industrialists must stop industrial effluent disposal as the waste water can mix with the water resources in which Sarus crane depends upon (Figure 8).

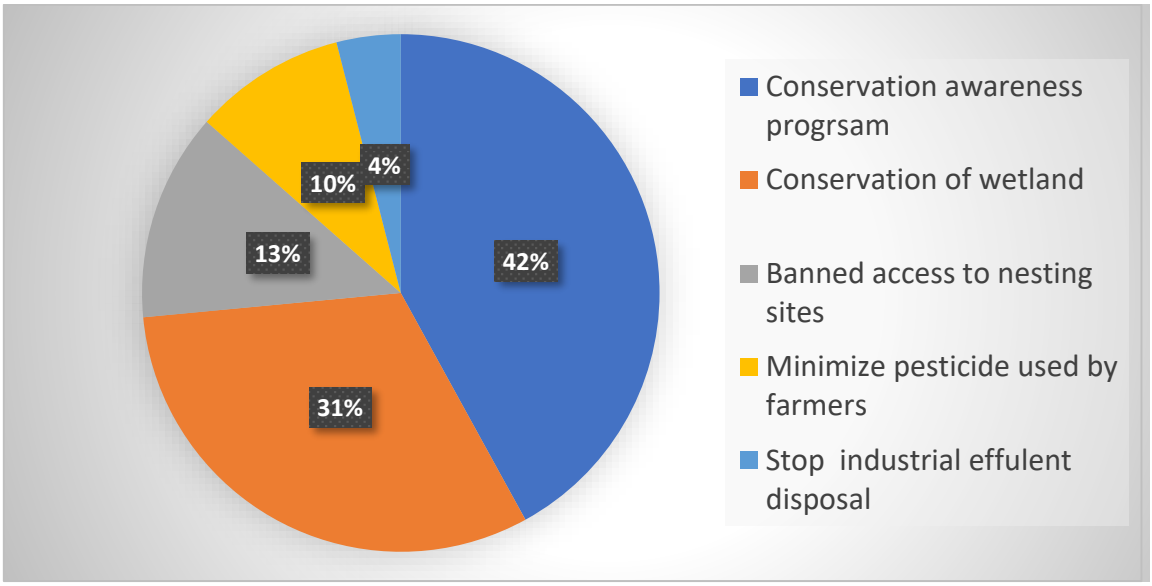

Figure 8. Respondent's reactions on conservation practices on Sarus crane

5. DISCUSSION

This study recorded total 174 Sarus Cranes in Rupandehi district. Previously, different researcher reported different number of Sarus crane such as Tiwari et al. (2017) reported 51 Sarus crane in Banke district, Manandhar (2014) estimated the population of 158 adults and 14 chicks in Rupandehi district but Gyawali (2015) reported 190 individuals , 95 Sarus crane in Northern region of Rupandehi district was reported by Gyawali and Gosai reported 95 Sarus crane in southern part of Rupandehi district in 2014. More than 350 individuals were reported in Rupandehi district (Katuwal 2016). The population had increased in Rupandehi and Kapilvastu districts, but decreased from other parts of Nepal. However, the overall as a whole population has increased in Nepal (Katuwal 2016).

The total density of Sarus crane is 0.32 per square km comprising agricultural land, wetland and grassland. The population density of Sarus Cranes in Banke district was 0.136 individual per square km (Tiwari et al. 2017).However, Gosai et al. (2016) reported that the population density of Sarus Cranes in Rupandehi and Kapilvastu district was 0.1152 and 0.0725 individual per square km. This discrepancy could be the difference in the area covered during field observation and data generation.

Sarus crane prefers farmlands as their habitat in this study. The habitat used by Sarus crane depends upon the availability of the food. Sarus crane prefers farmlands (Aryal et al. 2009, Manandhar 2014), agricultural fields (Mukherjee et al. 2002) and paddy fields (Sundar et al. 2000) which is similar to my research results. Agricultural lands and human settlements provide important habitats for various bird species (Katuwal et al. 2022). The agricultural land in the Terai support to the existence of frog, fish, snail and other insects which are used by the Sarus crane and also, they depend on rice crops for foraging. Therefore, agricultural land is the suitable habitat for Sarus crane in compare to wetland and grassland (Aryal et al. 2009). As the farmlands are near to the road, Sarus cranes were seen nearer to the road. The habitat uses of the Sarus crane depend on food availability, cropping pattern and other seasonal factors (Mukhargee 2001).

The total of 28 nesting sites were found in the study area. The vegetation used to build nest in this study are: *Ipomoea aquatic* (kerungo), Elaeocharis *dulces, Oryza sativa*(rice), *Cynodon dactylon*(dubo) and *Imperata cylindrica* (siru) that makes to

realise quite similar to the previous study. The predominant nesting materials used by Sarus crane were Katara, Thoti, katara , water hyacinth in wetlands and in agricultural land Thothi, Gahachira, Kerunga, Siru, Gahachira, Rice were the materials used by the Sarus crane (Manandhar 2014). One hundred ninety individuals were observed in 2016 with 19 nests (Gyawali 2015).The average area of nest was 2.14m² that was quite similar to the findings of Gosai et al. (2016).The Sarus crane made nest generally close to water body because this bird depends on water for their breeding, fledging and foraging. Also, the wetland or marshland around nesting site that were inaccessible experienced low predation and mortality (Adesh Kumar 2017). However, nest located farther away from roads and human settlement have higher probability of successful hatching and experience low egg mortality (Mirande 2019).

The Sarus crane prefers natural wetlands as their nesting habitats (Gole 1989, Vyas 2002, Yaseen et al. 2013). Yaseen et al. (2013) observed 52% of the nest in wetland in Southern Rajesthan. Gyawali (2015) found maximum number of nests in wetland than in other habitats. Among the 28 nesting sites in this study, 54% of nests were observed in wetlands, 39% in agricultural land and 7% were observed in grassland. Hence, there was similarities in the nesting habitat of the Sarus species. Aryal et al. (2009) found 76 adults and 24 chicks in Rupandehi district. Out of 174 individuals, only 17 juveniles were recorded in this study. In comparison, the survival rate of chicks seems low. Breeding success of Sarus crane is found to be independent of habitat and proximity to road but mortality of chicks occurs due to human interference (van Zalinge et al. 2023).

Due to agricultural expansion and vegetation succession, wetlands became the most vulnerable and threatened habitats in Nepal. Local people are closely related with the conservation of wetland in their village, but due to lack of education, they are not known about effects of overuse of natural resources. Tiwari (2016) stated that the conversion of wetland into farmland, hunting, stealing of eggs and chicks, collision of Sarus in electrical cables and lack of awareness were major threats to Sarus crane in Lumbini.

Several threats were observed in the study area to the existence of sarus crane and their nests. Road construction was the major threat inside the LCSA that causes the disturbance to them. Breeding success improves in years with normal or high rainfall whereas, declines with low rainfall because low water level facilitates in the increased predation rates of chicks and eggs (Sundar 2009). The rainfall has significant impacts

on breeding success of Sarus Crane. Due to the low rainfall this year, no eggs were found inside the Lumbini Crane Sancturay Area. Drying of wetland, destruction of natural wetland, conversion of wetland into agricultural land, conversion of farmland to settlement, electrocution, water pollution, predation, pesticides and fertilizers used by farmers were the major threats in the study area. The use of chemical fertilizers and pesticides, habitat destructing, stealing and poaching of eggs, hunting, cattle grazing were the major threats factors to Sarus crane population (Manandhar 2014) which are similar to the study. In addition, the major natural threat was the regular flood in wetland that sweep away the nest of Sarus crane.

6. CONCLUSIONS

The total population was found to be declining than previous year. The fluctuation of population might be due to the change in area coverage or season of the study and also due to the land use change particularly conversion of wetlands into agricultural lands, overexploitation of wetland resources, disturbances in the foraging and nesting places. The Sarus Crane was found to use all available habitats, but analysis of the frequency of habitat uses clearly indicated that the Sarus Crane preferred farmlands followed by wetlands and grasslands.

Population and nesting sites of Sarus crane are significantly influenced by different types of habitats and environmental variables. As the agricultural lands are very near to the road, presence of Sarus crane is found to be nearer to the road. Also, the presence of nesting site relies heavily on the water body as it provides good physical environment for nesting. Road construction, destruction of wetland, conversion of farmland to settlement, electrocution were the major threats seen in the study area.

7. RECOMMENDATIONS

- Nests of Sarus were also found in wetland the rice plants were used mostly for nest building so the wetlands should be protected. In the meantime, the farmers should also be friendlier with the bird and its nest.
- Restoration and management of existing wetland are required for the habitat of Sarus Crane. Management plans and conservation programs are required for proper conservation of Sarus crane.
- Electric poles should be made higher so that the Sarus crane does not touch the powerlines.

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APPENDICES

Appendix 1: Presence and absence point of number of Sarus crane for different habitats used in Kruskal Wallis test.

Points	AGLAND	WTLAND	GLAND	INDIV
1	0	1	0	2
2	0	1	0	2
3	0	1	0	3
4	0	1	0	2
5	0	1	0	1
6	0	1	0	2
7	1	0	0	1
8	1	0	0	2
9	1	0	0	4
10	1	0	0	2
11	1	0	0	2
12	1	0	0	2
13	1	0	0	2
14	0	1	0	3
15	1	0	0	2
16	1	0	0	2
17	0	0	1	4
18	0	0	1	3
19	1	0	0	4
20	1	0	0	2
21	1	0	0	6

22	1	0	0	2
23	0	1	0	2
24	1	0	0	1
25	1	0	0	5
26	1	0	0	2
27	1	0	0	4
28	0	1	0	2
29	1	0	0	2
30	1	0	0	2
31	1	0	0	4
32	1	0	0	2
33	1	0	0	4
34	1	0	0	2
35	1	0	0	3
36	1	0	0	2
37	1	0	0	2
38	1	0	0	4
39	1	0	0	2
40	1	0	0	2
41	1	0	0	4
42	1	0	0	2
43	1	0	0	2
44	1	0	0	2
45	1	0	0	2
46	1	0	0	2

47	1	0	0	2
48	1	0	0	3
49	1	0	0	6
50	1	0	0	3
51	1	0	0	2
52	1	0	0	2
53	1	0	0	2
54	1	0	0	3
55	1	0	0	3
56	1	0	0	2
57	1	0	0	3
58	1	0	0	2
59	1	0	0	4
60	0	1	0	2
61	0	1	0	4
62	1	0	0	3
63	1	0	0	4
64	1	0	0	4
65	1	0	0	4

Appendix 2: Presence and absence point of number of nests for different habitats used in Kruskal Wallis test.

Points	AGLAND	WTLAND	GLAND	Nest
1	0	1	0	1
2	0	1	0	1
3	0	1	0	1
4	0	1	0	1
5	0	1	0	1
6	1	0	0	1
7	0	1	0	2
8	0	1	0	1
9	1	0	0	1
10	0	1	0	1
11	1	0	0	1
12	1	0	0	1
13	1	0	0	1
14	0	1	0	1
15	1	0	0	1
16	1	0	0	1
17	1	0	0	2
18	0	0	1	1
19	0	1	0	1
20	0	1	0	1
21	0	0	1	1
22	0	1	0	1
23	1	0	0	1
24	1	0	0	1
25	0	1	0	1
26	0	1	0	1

Appendix 3: Opinion of respondents towards the population trend of Sarus crane (n=200)

Opinion	Number of Respondents
Increasing	42
Decreasing	26
No change	132

Appendix 4: Respondent views on threats to Sarus crane

Threats	**Number of respondents**
Damage of wetland	80
Destruction of nests	50
Destruction of eggs	50
Disturbance by other animals	20

Appendix 5: Respondents' reactions on conservation practices on Sarus Crane

Conservation practices	**Number of respondents**
Conservation awareness program	84
Conservation of wetland	63
Banned access to nesting sites	26
Minimize pesticide use by farmers	19
Stop industrial effluent disposal	8

Appendix 6: Sample of format of questionnaire

Questionnaire for factors affecting the population status and nesting ecology of sarus crane in rupandehi, nepal

Date: Village: Ward no: District:

1. Name .....
2. Occupation .....
3. Age .....
4. Sex: M/F
5. Have you seen any Sarus Crane? Yes...../ No.....
6. If yes, where? Wetland...../ Agricultural field...../ Grassland.....
7. How many are seen? One/ Two/ More than two.
8. How do you identify it? by its appearance/ by its voice/ mode of flyings/ others
9. Have you seen nest in your area? Yes/No
10. Does it come to your village? Regularly/ Sometimes.
11. What do you think, for what purpose Sarus come to your area? Food/ Good habitat/ Others
12. Have you seen any Sarus that are killed or poached? Yes/ No….
13. By whom the Sarus are killed/Poached? Human/ Animals/ Others
14. Do you know about the population trend? Increase/ Decrease/ No change
15. What factors affects most to Sarus crane?
16. Destruction of wetland/ Destruction of nest/ Disturbance by other animals/ stealing of eggs?
17. How the Sarus crane will be conserved?

Conservation awareness program/ Conservation of wetland/ Banned access to wetland/ Minimize pesticide use by farmers/ stop industrial effulent disposal.

PHOTOPLATES

Flying Sarus crane

Sarus cranes in paddy land

Sarus crane and Blue bull in the same habitat

Sarus cranes flying across ta power lines

Sarus cranes nearer to r Sarus crane near to road

Sarus cranes near to human settlements

Sarus crane pair in nest

Local guide and me examining the nest

Sarus crane in Lumbini Crane Sanctuary Area

Old nest of Sarus crane

Sarus crane's nest in wetland

Red head and grey scaled Sarus crane