HABITAT ASSESSMENT, BEHAVIOR AND CONSERVATION PRACTICES OF SARUS CRANE (*Antigone antigone* LINNAEUS, 1758) IN LUMBINI IMPORTANT BIRDS AND BIODIVERSITY AREA, NEPAL

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Submitted to
Central Department of Zoology
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28, December 2017

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 of any degree. All sources of information have been specifically acknowledged by reference to the author(s) or institution(s).

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LIST OF ABBREVIATIONS

Abbreviated form	Details of abbreviations
ANOVA	Analysis of variance
BCN	Bird Conservation Nepal
CBS	Central Bureau of Statistics
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
DDC	District Development Committees
DHM	Department of Hydrology and Meteorology
DNPWC	Department of National Park and Wildlife Conservation
GPS	Global Positioning System
GIS	Geographic Information System
IBAs	Important Bird and Biodiversity Areas
ISC	India Sarus Crane
IUCN	International Union for Conservation of Nature
LDT	Lumbini Development Trust
MAB	Man and Biosphere
MoFALD	Ministry of Federal Affairs and Local Development
MoFSC	Ministry of Forest and Soil Conservation
SCS	Sarus Crane Sanctuary
SPSS	Statistical Package for the Social Sciences
VDC	Village Development Committee
UP	Utar Pradesh

ABSTRACT

The present study was carried out on Sarus Crane (*Antigone anitigone*) to know the current population status, their habitat, behavior and the conservation practices used by local people in Lumbini IBA. Road transect method was used to count the Sarus Crane population. The survey was carried out on July and August, 2017. Total 127 transects having length 5km each were surveyed covering cropland and wetland of Lumbini IBA. Habitat parameters were determined by measuring the distance of nest from water source, road, forest and resident area using Google Earth Pro. Climatic-parameter (mean temperature and relative humidity) were determined from EasyLog USB data loggers. Similarly, water parameter of nesting sites were recorded from alcohol-thermometer and pH meter respectively. Behavior was studied by focal scan sampling method observing two pairs of Sarus Crane, a pair in wetland and other pair in cropland for four days. Conservation practices and threats to Sarus Crane were carried out by household questionnaire survey in Bishnupura VDC.

Total 180 Sarus Cranes were recorded including 88 pairs of male and female and four undistinguished. Among them 146 Sarus Cranes were recorded in cropland and only 34 in wetland. Significance difference (F_{ratio}= 5.198, d.f.= 1, 64; P-value = 0.026) was found in site utilization by Sarus Crane. Maximum (36.67%) Sarus Cranes were found in Lumbini Sanskritik Nagarpalika and least (2.22%) in Sammarimai Gaunpalika. Uniform distribution of Sarus Crane was found with the density 0.285/km^2 area. No Sarus Crane was observed in Pakadisakron, Betakuiya,Titrirkhi and Asurena.

Total of 12 nests were recorded out of which maximum nests (n=8) were in cropland and minimum (n=4) in wetland. Altogether, 17 eggs were recorded in 12 nests. Two eggs were recorded in five nests whereas only one egg was recorded in seven nests. Majority (24.80%) of Sarus Cranes were observed sitting on nest, and least (0.21%) running behavior was recorded during the study period. There was no significant difference (F_{ratio}=1.1658, d.f.=1, 27; P-value=0.344) in the behavior of Sarus Crane on wetland and cropland. Positive correlation was found between behavior pattern of male and female. Most of the respondent (68%) agreed with no change in population of Sarus Crane in the area and 94% respondents showed positive attitude toward Sarus Crane conservation. Harassment, destruction of nests, destruction of eggs, stealing of eggs, and wetland damage were observed as existing major threats to Sarus Crane in the study area.

Key words: Conservation, Lumbini IBA, Sarus Crane, threats, vulnerable

1 INTRODUCTION

1.1 Background

Nepal is rich in avifauna diversity, containing 878 bird species that is eight percent of the world's known birds (BCN and DNPWC, 2016; MoFSC, 2014). Nine bird species including two species of storks, three species of pheasants, two species of floricans, one hornbill and one crane are protected by National Park and Wildlife Conservation Act – 1973 (Baral, 2009). Out of them Black Stork and Sarus Crane occur in the wetlands of Lumbini (Aryal, 2004). Sarus Crane belongs to family Gruidae, which includes 15 species belonging to four genera. Among them, four species of cranes are found in Nepal (BirdLife International, 2012).

Sarus Crane *Antigone antigone* (Linnaeus, 1758) was previously placed in the genus *Grus* (Del Hoyo *et al*., 2014) which is the world's tallest flying bird (Archibald *et al*., 2003) and is the only resident breeding, non-migratory crane in India and Nepal (Sundar and Choudhury, 2003; Baral, 2009). Sarus Crane is a monogamous, omnivorous and social bird (Baral, 2009). There are three subspecies of Sarus Cranes, the Indian Sarus Crane (*Antigone antigone antigone),* Eastern Sarus Crane (*Antigone antigone sharpie)* and the Australian Sarus Crane *(Antigone antigone gilli)* (Meine and Archibald, 1996).

It is listed as vulnerable in the IUCN Red list due to declining population (IUCN, 2017) and kept in Appendix II by CITES (CITES, 2017). It is a large, elegant, light grey crane (Baral**,** 2009). It measures 176 cm in height, weighs about 6.35 kg and wingspan of 240 cm (Ali and Ripley, 1987). Males and females are virtually indistinguishable but within pairs, females are usually smaller than males (Grimmett *et al.,* 1998).

1.2 Distribution

Sarus Crane is distributed in Nepal, India, Myanmar, Vietnam, Cambodia, China, Laos and Australia (BirdLife International, 2012). In Nepal, this bird was first reported in 1877 (Scully, 1879). It has been observed at about 300 m (maximum altitude) at Dhangadi (Johnsgard, 1983). In the past, it was distributed in the entire lowlands from east to west; however, at present, its distribution is recorded only from central to western lowlands of Nepal (Baral, 2009; Inskipp *et al*., 2016). More than 90% of its habitats lie outside the protected areas (Baral**,** 2009). Farmlands of Rupandehi and Kapilvastu districts are the only areas where it breeds regularly (BCN and DNPWC, 2011). Rupandehi and Kapilavastu are stronghold districts with more than 85% of its overall population (Katuwal, 2016).

1.3 Ecology

Sarus Crane feeds on insects, aquatic plants, seeds, roots, tubers, invertebrates, crustaceans, butterflies, fishes, frogs, reptiles and eggs of birds (Verma *et al*., 2016). The family group occurs in whole year but during non-breeding season, the congregation of Sarus Cranes are reported up to 200 for mate finding or pair formation (Gole, 1989).

In South-East Asia and Australia, the species shows a preference for dry savannah woodlands with ephemeral pools during the breeding season, frequently open and man-made wetlands during the non-breeding season (Archibald *et al*., 2003). In India, the species is increasingly forced to use suboptimal rice paddies as breeding habitat because of the deterioration and destruction of its natural wetland habitat (Meine and Archibald, 1996; Sundar and Choudhury, 2003).

Sarus Crane is mostly found in crop fields and natural marshlands. They have adapted to the dense human population (Suwal, 1999). Sarus Cranes utilize a wide variety of landscapes, depending on food availability, cropping patterns, and other seasonal factors. Often they focus their foraging on underground tubers of native wetland vegetation such as *Eleocharis* spp. (Sundar *et al.*, 2000).

1.4 Reproduction

Sarus Crane breeds primarily during the rainy season. The peak breeding season is from July to October; however, if the conditions are suitable, it can breed anytime throughout the year (Suwal, 1999). Breeding pairs place their nests in a wide variety of natural wetlands, long canals and irrigation ditches, beside village ponds, and in rice paddies (Suwal, 1999). Nests are located in shallow water where short emergent vegetation is dominant (Sundar, 2009). They use rice paddies and wetlands nearby human settlements for nesting (Meine and Archibald, 1996). In Lumbini, nests located in flooded rice paddies are constructed entirely of rice stalks (Suwal, 1999).

The nests can be more than two meter in diameter and nearly a meter high (Walkinshaw, 1947). The clutch is generally one or two eggs which are incubated by both sexes (Sundar and Choudhury, 2005**)** for about 31days and fledge at 50-65 days (Gole, 1989; Sundar, 2009).

1.5 Threats

Although hunting is no longer a critical threat in most countries, eggs and chicks are still stolen for food or for pets in Nepal, Cambodia and possibly Laos (BirdLife International, 2000). Optimistic expected population of this species in Nepal is about 200-500 and the range has been slowly shrinking for the last decade due to pesticide, poisoning, developmental activities and direct human persecution (Suwal, 1999).

They prefer crop field thus it has become a cause of conflict with farmers. Disturbance, trapping, hunting, loss and degradations of the habitat are the major threats of the precipitous decline in population of the species (Aryal, 2004). The main threats are combination of loss and degradation of wetlands because of drainage and conversion to agricultural land (Archibal *et al.*, 2003), Ingestion of pesticides in agricultural land (Sundar, 2005). Hunting of adults, collection of eggs and chicks for trade and food as well as medicinal purposes may be the cause of rapidly extirpate localized populations (Sundar *et al*., 2000).

The mechanization of farming practice may threaten bird breeding in agricultural land (Aryal, 2004). Collision with power lines may be significant threat in parts of its range. High human usage of wetland reflects the high rate of disturbances to bird and ultimately limits the breeding success (Sundar and Choudhury, 2003).

1.6 Objectives

General objective

- The study was conducted with the aim to study the population density, habitat, behavior and conservation practices of Sarus Crane in Lumbini IBA, Nepal.

Specific objectives

- To assess population density and habitat of Sarus Crane in study area.
- To explore the general diurnal behavior of Sarus Crane.
- To outline current conservation perceptions for the conservation of Sarus Crane.

1.7 Rationale of the study

Birds are at the great rate of extinction. There are 27 Important Bird and Biodiversity Areas (IBAs) in Nepal (BirdLife International, 2017) which inhabits many residential, migratory birds. Most of the previous studies are focused in entire Rupandehi and Kapilvastu distrists highlighting population dynamics leaving the assessment of habitat and behavior untouched except trace. Therefore, this study was conducted to generate current information on the habitat condition, distribution pattern, behavior and exiting conservation practices of Sarus Crane in the farmlands of Lumbini IBA, Nepal, which are the required baseline information to prepare species management guideline by concern authorities in IBAs system.

1.8 Limitation

- During the survey, there was communication problem because of language during questionnaire.

2 LITERATURE REVIEW

Shrestha (1996) used transect line method for counting sarus crane only in vehicle accessible roads and found 98 males and 93 female Sarus Cranes in Rupandehi district and 30 males and 38 female Sarus Cranes in Kapilvastu district. Similarly, Sharma (2006) observed total 280, 257 and 202 Sarus Cranes in pre-nesting, nesting and post-nesting period respectively in western part of Nawalparasi district with preferred habitat as wetlands for foraging and nesting followed by grasslands and cultivated lands. Aryal *et al.* (2009) recorded 100 Sarus Crane in Rupandehi and 68 in Kapilvastu district and found habitat degradation, high electrical cable line, sugarcane cultivation, dam and cementation in water canal, water pollution due to nutrients and chemical leakage in water bodies, environmental contamination and other anthropogenic activities as threats to the Sarus Crane. Poudel (2012) studied status, habitat preference and conservation threats of Sarus Crane around Jagadispur Reservoir, Kapilvastu, Nepal and estimated 82, 68, and 52 Sarus Cranes in winter, summer and rainy season respectively and also observed that the preferred habitat as wetland for foraging followed by cultivated lands and grasslands.

Manandhar (2014) estimated 270 adult Sarus Cranes, among them 158 adults and 14 chicks in Rupandehi district, 82 adults and 4 chicks in Kapilvastu district and 30 adults five chicks in Nawalparasi district. Similarly, Gyawali (2015) conducted thesis in Rupandehi on Sarus Crane by using road transect and observed 95 individuals of Sarus Crane among. Among 19 nests, 42.10 % were observed in wetland, 5.26 % in agricultural land and 52.6 % in the interface of wetland and agricultural land but Gosai *et al.* (2016) recorded 143 Sarus Cranes in Rupandehi district in 73 Sarus Crane detection sites of which 68.5% were in agricultural land, 21.9% were in wetland and 9.6% in mixed habitats. Their study also reported that the major threats to the survival of Sarus Crane were habitat destruction, hunting for meat, egg stealing, electrocution, cattle grazing and the agricultural use of pesticides. Panthi (2016) carried out research on Sarus Crane during the November in Nawalparasi District, Western Nepal and estimated 19 birds from the four VDCs of the district, out of which six birds were seen in pair, four sub adults, two juvenile and one chick. Moreover, 53% birds were recorded in wetland and 47% in cropland. Habitat loss and degradation, conversion of wetland, lack of awareness, introduction of pollution, anthropogenic activities were analyzed as major threats to Sarus Crane. Similarly, Tiwari *et al.* (2017) carried out study to access the population status and habitat suitability of Sarus Crane in Banke District and found 51 Sarus Cranes. They were found to use all habitats viz. farmlands, wetlands, grasslands. Farmlands and wetlands areas contained the highest number of Sarus Crane but preferred more farmlands for foraging followed by wetlands and grasslands. The frequency of the Sarus Cranes was highest in farmlands (62.74%), followed by wetlands (31.37%) and grasslands (5.88%).

Yaseen *et al.* (2013) studied population composition, distribution and habitat preference of Indian Sarus Crane in Chittaurgarth District, southern Rajasthan and recorded the total 280 Sarus Cranes in 2010, 322 in 2011 and 329 in 2012 survey and found wetlands as most

commonly frequented by Sarus Crane. Similarly, Yaseen *et al.* (2014) again studied population status of Indian Sarus Crane in south Rajasthan, India and estimated 458 adults and 90 juveniles during the winter survey. While 687 adults and 111 juveniles during summer and also observed 83.21% and 80.83% of Sarus Crane in marshes and close to wetlands whereas 16.79% and 19.17% in harvested and crop fields during two surveys respectively. Jha and Mckinley (2014) studied demography and ecology of Indian Sarus Crane in Uttar Pradesh, Northern India and found total population 11,905 and observed central plain and south western semiarid plain as preferred habitat for foraging and nesting followed by Tarai Agro-climatic zone, and no Crane were observed in Vindhyan zone. Ansari (2015) studied population composition and distribution of Indian Sarus Crane in Gautam Budha Nagar district and found six individuals in 2010, four in 2012, 14 in 2013 and 22 in 2014 as well as he recorded maximum number of Sarus Crane in summer season and minimum number in monsoon season. Verma *et al.* (2016) found total 335 Sarus Crane in 2012 and 425 in 2013 around Alwara Lake. Alwara Lake of District Kaushambi (UP).

3 MATERIALS AND METHODS

3.1 Study area

The study area is the farmlands of Lumbini IBA, Nepal (Figure 1) having 141,367 ha area and altitude of 95m to 1,219m asl with 83º 17.00' East and 27º 29.00' North central coordinates (BirdLife International, 2016). The study area includes much part of Rupandehi district and some part of Kapilvastu district. Geographically, Rupandehi district lies at longitude 83° 12'16"east to 83°38'16" east and latitude 27°20'00" north to 27°47'25" north and altitude ranges from 100 m to 1,229 m above the sea level (DDC, 2013). Kapilvastu district lies west of Rupandehi and covers 1,738 km^2 of Nepal's western region. Geographical position is at 27° 25'- 27° 84' latitude and 82° 75'- 83° 14' longitude and its elevation ranges from 90 to 824 meters above sea level and it is 48 km long and 34 km wide (DDC, 2013).

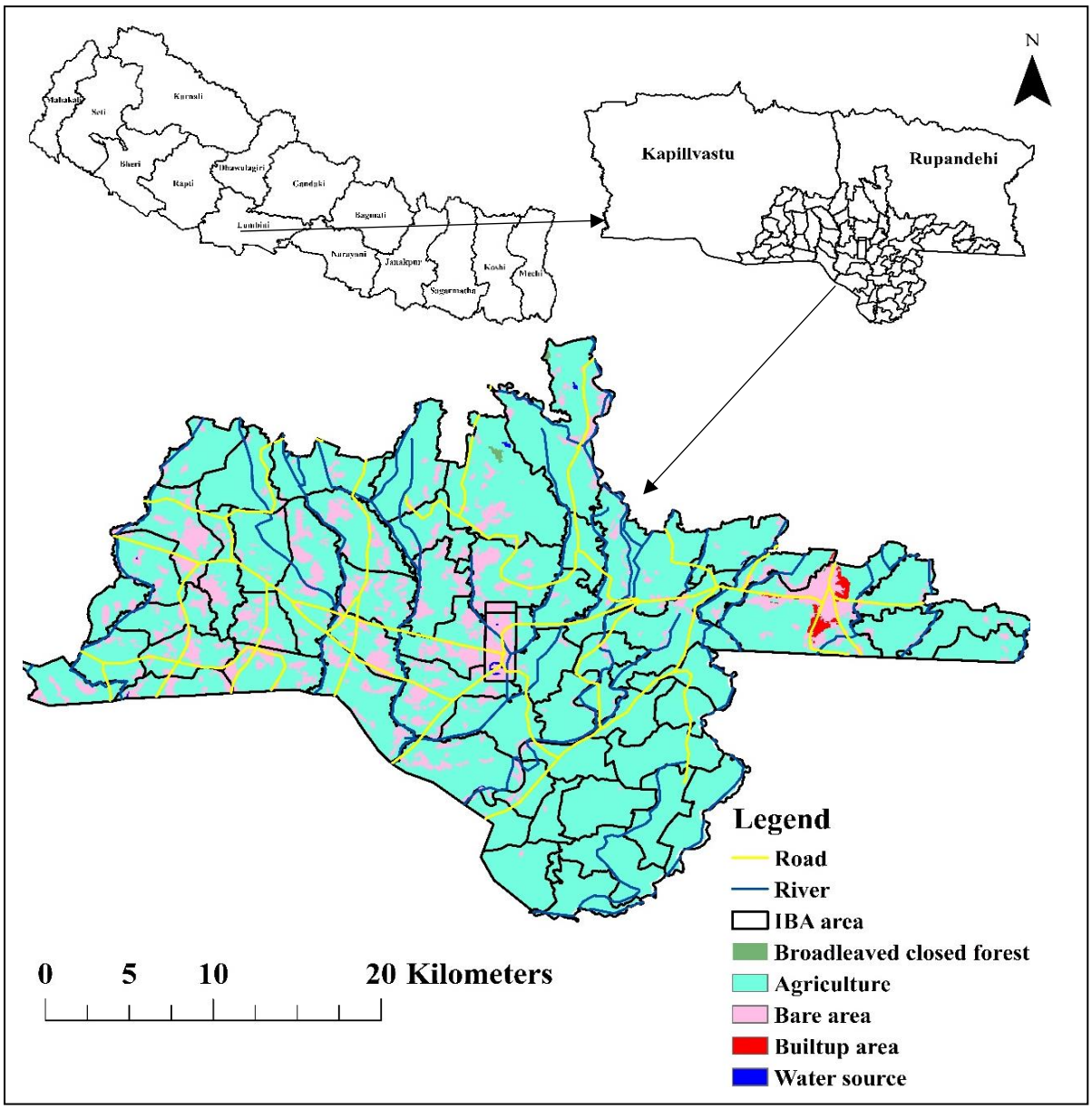

Figure 1: Lumbini IBA, Nepal

3.1.1 Land resources of Rupandehi and Kapilvastu

The farmlands of Rupandehi and Kapilvastu districts encompass a large rural area where agriculture is the main land use followed by forests with plains in the south and dry Bhabar and Churia hills to the north. The forest, scrub, wetlands and grasslands surrounding Lumbini (the birthplace of Lord Buddha) are an especially important refuge for wildlife (BirdLife International, 2017). A number of perennial and seasonal rivers and streams including the Telar, Tinau, Sundi and Dano river systems flow through the area (DDC, 2013). The Telar and Dano floodplains are recognized as important habitats for bird life (Bhandari, 1998).

In Rupandehi, 87.37% of land is under agriculture, forests, and pastures and a little more than 10% of land is allocated for other purposes including residential and real state. More than half of the land in the district (58.45 % or 826.22km^2) is under cultivation and 70% (989.56km^2) of population are engaged in agriculture (CBS, 2012). While 56 % of the cultivable land is seasonally irrigated. Only 3.98% of the land is covered by year round irrigation, and 96.02% is rain-fed (DDC, 2013).

Total area of forest in Kapilvastu district is 60,500ha. The land used for agriculture is 10, 4141ha (DDC, 2003). District also includes shrubs areas of 2,232ha with 2,632ha area of water bodies and 3,951ha of barren land. The main crops produced in Kapilvastu are Paddy, Maize, Wheat, Barley, Millet, and variety of cash crops (Mustard Oil Seed, Potato, Sugarcane) which are cultivated as winter seasonal, summer seasonal and non-seasonal (CBS, 2012).

3.1.2 Flora and fauna of study area

Rupandehi and Kapilvastu landscapes consists generally two types of forest one is natural forest and another is artificial forest (Aryal, 2004). Major flora of IBAs area are Sal (*Shorea robusta*), Khayar (*Acacia* spp), Satisal (*Dalbergia* spp), Jamun (*Syzygium* spp), Kadam (*Anthcephalus cadamba*), Saaj (*Terminalia elliptica*), Sisso (*Dalbergia sissoo*), Harro (*Terminalia chebula*) and Bojho (*Acorus calamus*) (DDC, 2013).

In 2000, a biodiversity assessment found 210 bird species in Rupandehi district. A total of eight globally threatened birds have been recorded here including White-rumped Vulture (*Gyps bengalensis*), Indian Spotted Eagle (*Aquila hastate*), Slender-billed Vulture (*Gyps tenuirostris*), Cinereous Vulture (*Aegypius monachus*) and Lesser Adjutant (*Leptoptilos javanicus*) (Suwal, 2002). This area has the best known population of the globally threatened Sarus Crane in Nepal and is the only known site in the country where the species breeds regularly (BirdLife International, 2016).

Mammal species include the globally threatened Nilgai (*Boselaphus tragocamelus*), Smooth-coated Otter (*Lutrogale perspicallata*) and Striped Hyaena (*Hyaena hyaena*) (BirdLife International, 2017).

3.1.3 Climatic condition of study area

Average minimum temperature in study area fluctuates from 9.59 ºC (in January) to 28.31 ºC (in June) and average maximum temperature varies from 23.27 ºC (in January) and 39.42 ºC (in May) based on temperature records from DHM for Rupandehi from 1971- 2016. December, January and February are the coldest months whereas; April, May and June are the hottest months (Figure 2). Monthly average precipitation observed over 1971 through 2016 ranges from 2.89mm in November to 297.85mm in July based on the precipitation records from DHM. Maximum rainfall recorded in the month of July and August (Figure 3).

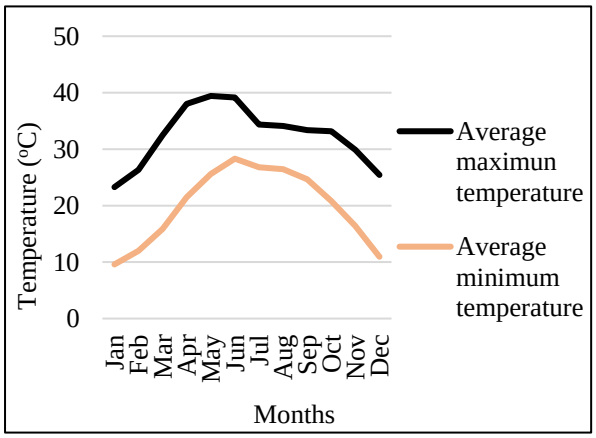

Figure 2: Monthly average temperature observed from 1971 through 2016

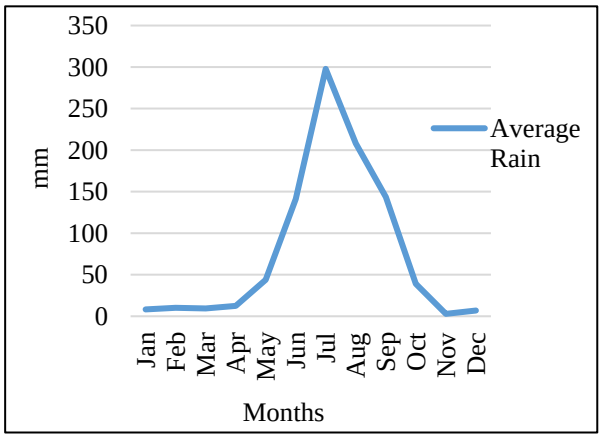

Figure 3: Precipitation observed from 1971 through 2016

(DHM, 2016)

3.1.4 Population and community

Rupandehi district is divided into five Nagarpalika, one Upamahanagarpalika and 10 Gaunpalika (MoFALD, 2017). About 1 million people inhabit in Rupandehi; 49.10% are male and 50.89% of population are female. There are about 163916 households with 37.75 percent of population belongs to the age group of 20-50, while 39.5 percent are children aged 14 and under (CBS, 2012). Kapilvastu is divided into six Nagarpalika and four Gaunpalika (MoFALD, 2017). There are 285599 males and 286337 females with 91321 households. The major ethnic groups in this districts are Nepali (90%) and 10% Indian. Eighty percent of the people speak Awadhi followed by Tharu (5%) and 15% are native Nepali speakers (CBS, 2012).

3.2 Methods

3.2.1 Population status and distribution of Sarus Crane

The preliminary survey was carried out in July to locate the Sarus Crane's potential areas prior to actual fieldwork. Monitoring of the Sarus Crane was done by direct visual observation method in all the accessible areas between 07:00 to 18:00 (Aryal, 2004) with the assumption that Sarus Crane activities remain within the fixed territory in nesting period avoiding the double count of same species.

Extensive field survey was carried out from July-August, 2017 in Lumbini IBA. Road transect method was used to count the Sarus Crane population. Total 127 transects of 5km each covering cropland and wetland of Lumbini IBA were surveyed using motorbike, bicycle and on foot as per accessibility of the trails in the study area. Any Sarus Cranes observed with naked eye or with the binocular within 500m on left and 500m right of the transect were recorded because it is the identifiable distance of species. The sex, numbers of birds, number of nests, habitat types and potential threats to Sarus Crane were also recorded during the field period (Annex 1 and 2).

3.2.2 Habitat assessment and preferences

GPS reading of all the sightings of Sarus Crane and nesting sites were taken by Germin eTrex30 GPS receiver (Plate 17) and were plotted on GIS map. Google earth pro, ArcGIS9.3 and topo maps were used to determine Land coverage and all the possible habitat parameters (distance of nest from nearest water source, road, forest and residential area). Measurements of nests and eggs were made by measuring tape (Plate 3 and 14). Water temperature and pH of nesting sites were determined by alcohol-thermometer and pH meter (Plate 23). Climatic parameters of nesting sites were determined by using EasyLog USB data loggers.

3.2.3 Behavior of Sarus Crane

Body events of the Sarus Cranes were recorded in the intervals of two minutes by focal scan sampling methods (Altmann, 1974 ; Gosai, *et al*., 2016). Birds (n= 2 pairs) were observed in nesting sites, one pair in wetland and other pair in cropland from 06:00 to 18:00 hours for four days during the study period (Annex 3). Body events were categorized into 29 different activities (Annex 4).

3.2.4 Conservation practices of Sarus Crane

Conservation strategies adopted by different organizations were observed. Conservation practices and threats to Sarus Crane were carried out by semi structured open ended questionnaire survey (Singh, 2010) in Bishnupura (Plate 24 and 26). Random sampling was done to select 10% (Thompson, 2002) respondents to represent the total of 2230 households.

3.3 Data analysis

Microsoft Excell was used for data entry and graphical representation. R-studio version 3.0 was used to test the significance association between nest diameter and nest height, nest diameter and water column, nest diameter and egg numbers and similarly for egg length of cropland and wetland. Questionnaire data was analyzed from SPPS package.

3.3.1 Population status and distribution of Sarus Crane

The global positioning system (GPS) coordinates of the location of Sarus Cranes were recorded from the field. Distribution map based on these GPS point was created using ArcMap (version, 9.3). Place wise Sarus Crane numbers were also calculated and illustrated in suitable diagram.

The population density of Sarus Crane and distribution patterns was calculated by the equations 1 and 2 (Odum, 1971).

$$\text{Population density of Sarus Crane} = \frac{\text{Total no. of individuals of Sarus Crane}}{\text{Total Survey Area}} \quad \ldots 1$$

$$\text{Distribution pattern} = \frac{\text{Variance } (S^2)}{\text{Mean } (\bar{X})} \quad \ldots 2$$

For equation 2, if

$\frac{S^2}{\bar{X}} = 1$, random distribution

$\frac{S^2}{\bar{X}} > 1$, clumped distribution

$\frac{S^2}{\bar{X}} < 1$, uniform distribution

3.3.2 Habitat assessment and preferences

Analysis of Variance (ANOVA) was used for inferential statistics to judge the significant association between habitat utilization and population of Sarus Crane. Data was presented in suitable illustration forms.

$$\text{F-test} = \frac{\sigma_1^2}{\sigma_2^2} \quad \ldots 3$$

Where, σ_1^2= Variance one

σ_2^2= Variance two

Mean temperature and relative humidity of study area during the study period were recorded using EasyLog USB data loggers. A data logger is an electronic device that records data over time or in relation to location either with a built instrument or sensor or via external instruments and sensors. They generally are small, battery powered, portable, and equipped with a microprocessor, internal memory for data storage and sensors. Data loggers are used to collects data on 24-hour basis automatically and record information for the duration of the monitoring period.

3.3.3 Behavior of Sarus Crane

The frequency of observed 29 behaviors were determined from SPSS 23.0 and comparisons were made between behavior of Sarus Crane from cropland and wetland. Significance association was tested from ANOVA using R-studio (3.0) at 5% level of significance.

3.3.4 Conservation practices of Sarus Crane

The questionnaire data was analyzed with SPSS to calculate the frequency of different conservation practices stated by the respondents (Annex 5).

4 RESULTS

4.1 Population status and distribution of Sarus Crane

4.1.1 Population density and distribution pattern

Total 180 Sarus Crane were recorded including 88 pairs of male and female and four undistinguished (Figure 4). Population density of Sarus Crane was 0.285 per km^2 and 1.417 per line transect in farmlands of Lumbini IBA.

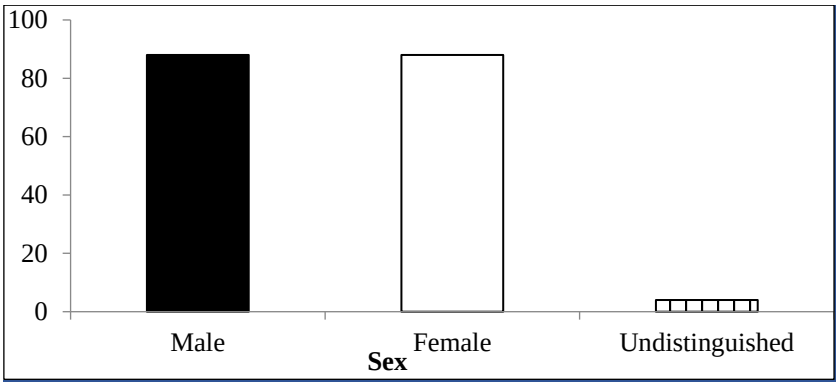

Figure 4: Population of Sarus Crane in Lumbini IBA

Variance to mean ratio was 0.8635 shows Sarus Crane were uniformly distributed in study area (Figure 5). No Sarus Crane was observed in Pakadisakron, Betakuiya,Titrirkhi and Asurena.

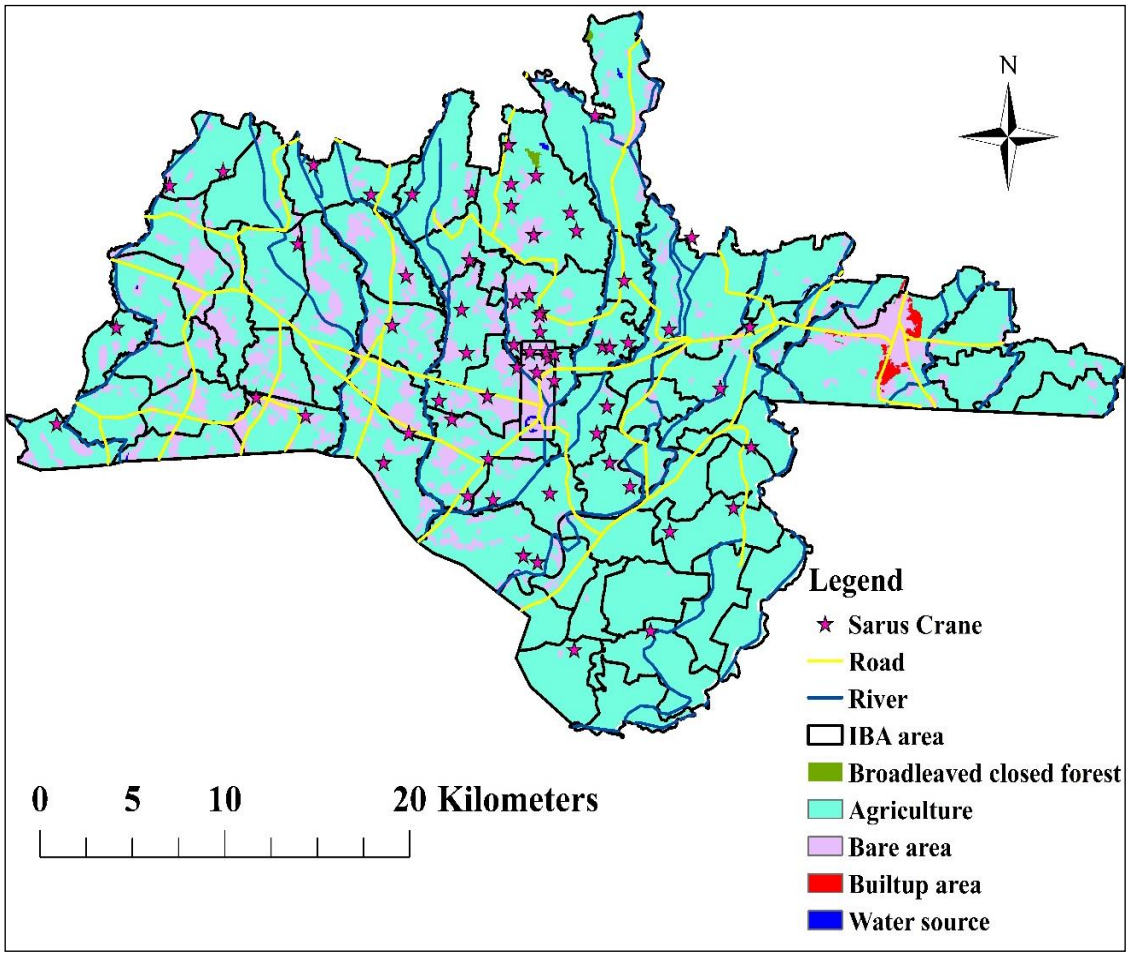

Figure 5: Distribution of Sarus Crane in farmlands of Lumbini IBA

4.1.2 Population distribution of Sarus Crane in Lumbini IBA

Their distribution was found high in Lumbini Sanskritik Nagarpalika whereas least in Sammarimai Gaunpalika (Figure 6).

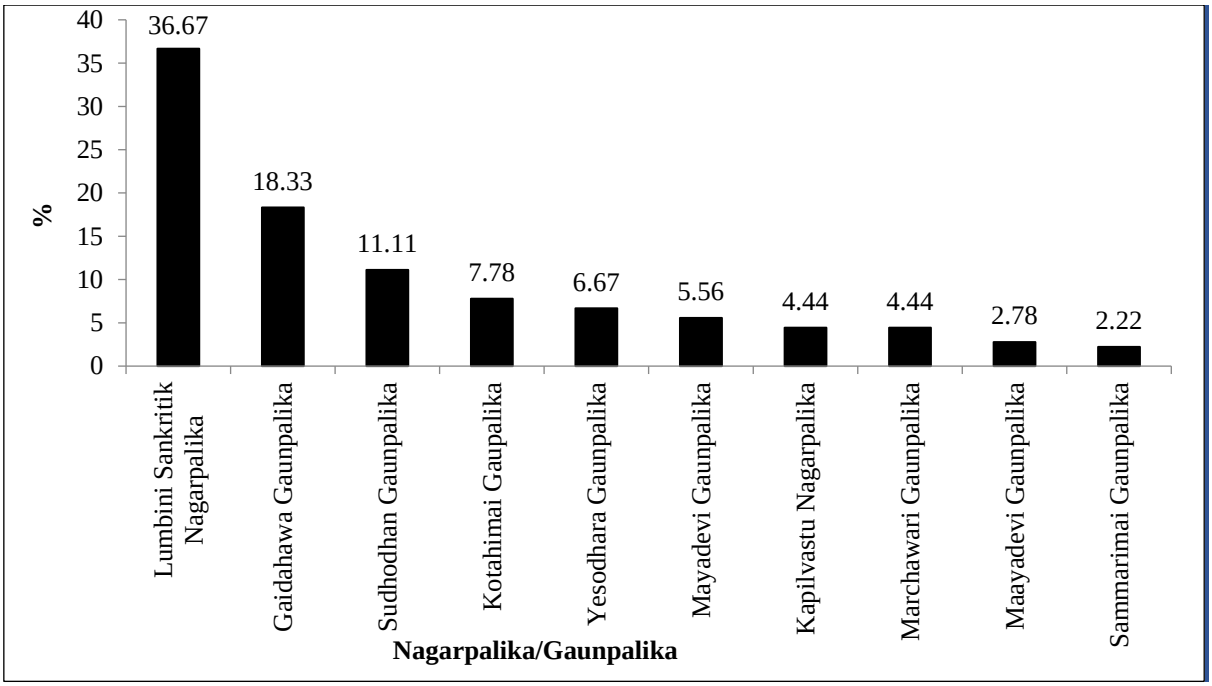

Figure 6: Population and distribution of Sarus Crane in different places of Lumbini IBA

4.2 Habitat assessment and preferences

In the study area, 85.92% was agriculture land, 13.60% bare land, 0.31% builtup area, 0.1% wetland and 0.07% broadleaved closed forest. A total of 146 Sarus Crane were observed in cropland and 34 were in wetland (Figure 7). Among 66 Sarus Crane detection sites, 86.36% were in cropland and 13.64% were in wetland (Figure 8). Significance difference (F_{ratio}= 5.198, d.f.= 1, 64; P_{value}= 0.026) was found in site utilization by Sarus Crane (Annex 6).

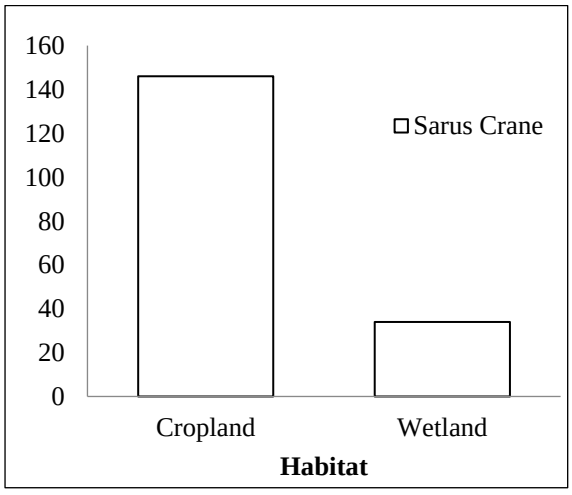

Figure 7: Sarus Crane in cropland and wetland

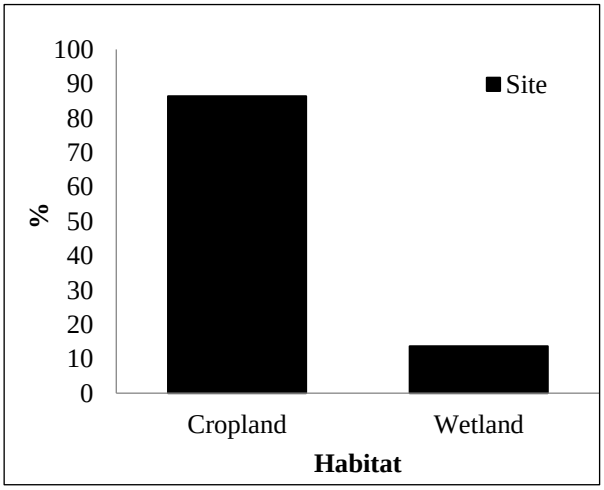

Figure 8: Habitat utilized by Sarus Crane in Lumbini IBA

Majority of Sarus Crane (n=125) were recorded around 8.41km from Sarus Crane Sanctuary of Lumbini Development Area. Most of Sarus Cranes were recorded far from the human settlements but inside the Lumbini Development Area, Ramawanapur, Ekala and Bhaisihawa, they were recorded near human settlements.

4.2.1 Nesting sites, nests and eggs

Total of 12 nests were recorded out of which eight nests were in cropland and four in wetland (Figure 9). Altogether, 17 eggs were recorded in 12 nests. Two eggs were recorded in five nests whereas only one egg was recorded in seven nests. Among 17 eggs, five eggs were recorded in wetland and 12 eggs in cropland. There was no significance differences in site utilization for laying eggs (F ratio= 0.606, d.f.=1, 10; P-value= 0.454) (Annex 7). Most of the nesting materials were paddy plants (Plate 15).

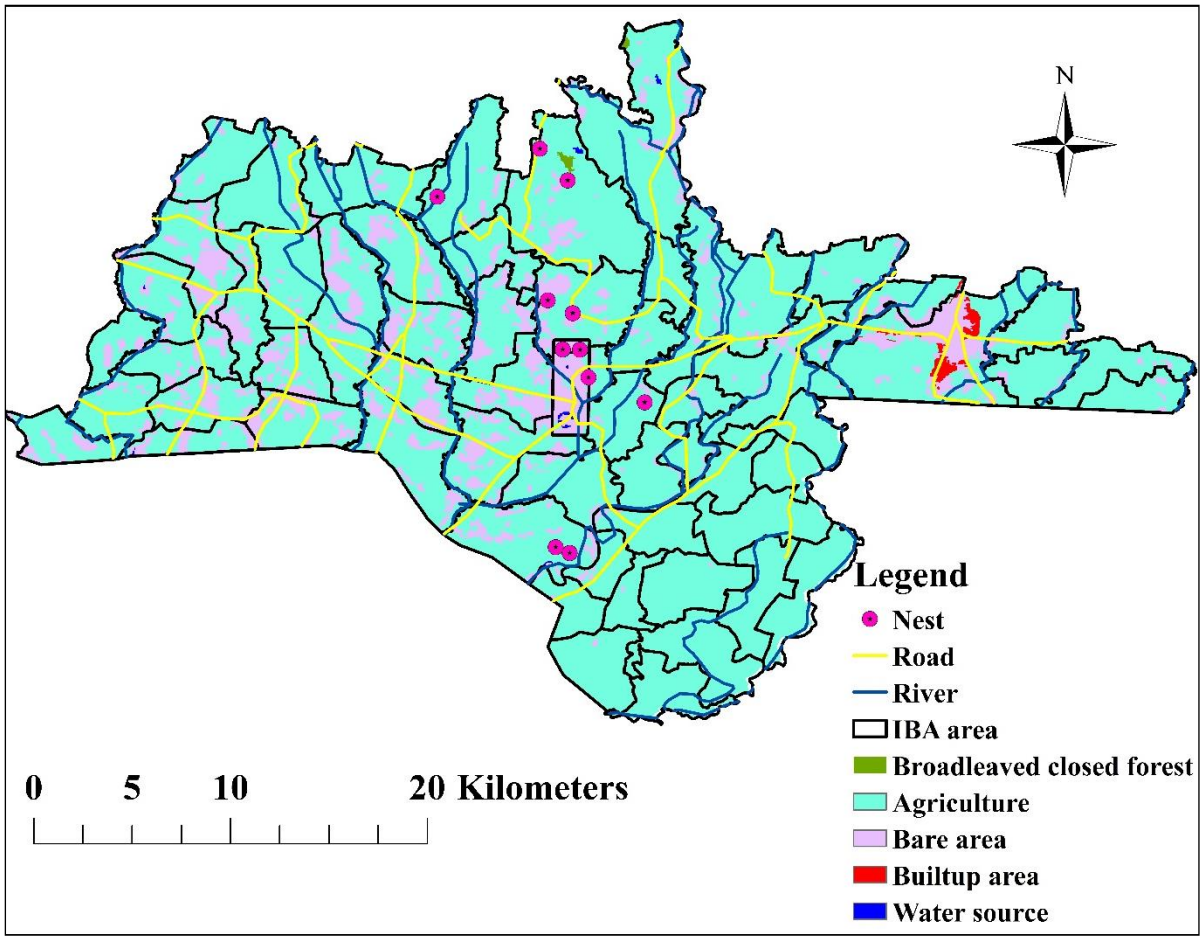

Figure 9: Distribution of nests of Sarus Crane in Lumbini IBA

The diameter of nests varied from 88.9cm to 264.16cm with average 187.11cm and the average nest height from water level was 11.52cm. Significant variation was found between nest diameter and nest height from water level (student's t-test = 9.4724, d.f. = 11.125, p-value = 1.161e-06). Similarly, significant association was found between nest diameter and water column (student's t-test = 8.3997, d.f. = 11.404, p-value = 3.216e-06); and nest diameter and egg numbers (student's t-test = 10.046, d.f. = 11.001, p-value = 7.055e-07). Egg length varied

from 3.2 inch to 4.6 inch with average 3.99 inch and there was no significant association between egg length of cropland and egg length of wetland (student's t-test = 0.46393, d.f. = 9.9155, p-value = 0.6527). Negative correlation was found between nest water pH and nest water temperature (r = -0.098). The nest temperature varied from 30.5°C to 39 °C with average 36.38 °C, average water temperature at nest was 26.22 °C with average pH 6.79 (Annex 8).

4.2.2 Habitat parameters of nesting sites of Sarus Crane

Habitat parameters were determined through Google earth pro. The average distance of nests from nearest road, settlements, forest and river were 275.221m, 378.50m, 260.16m and 1787.86m respectively (Annex 9).

4.2.3 Climatic parameters of habitat of Sarus Crane

During one month (July-August) of study period, average maximum temperature 37.7°C was observed on 26 August and average minimum temperature 25.2°C was observed on 1 August. Maximum 93.9% relative humidity was found on 13 August and minimum 77.9% on 26 August using Easy USB data logger (Figure 10).

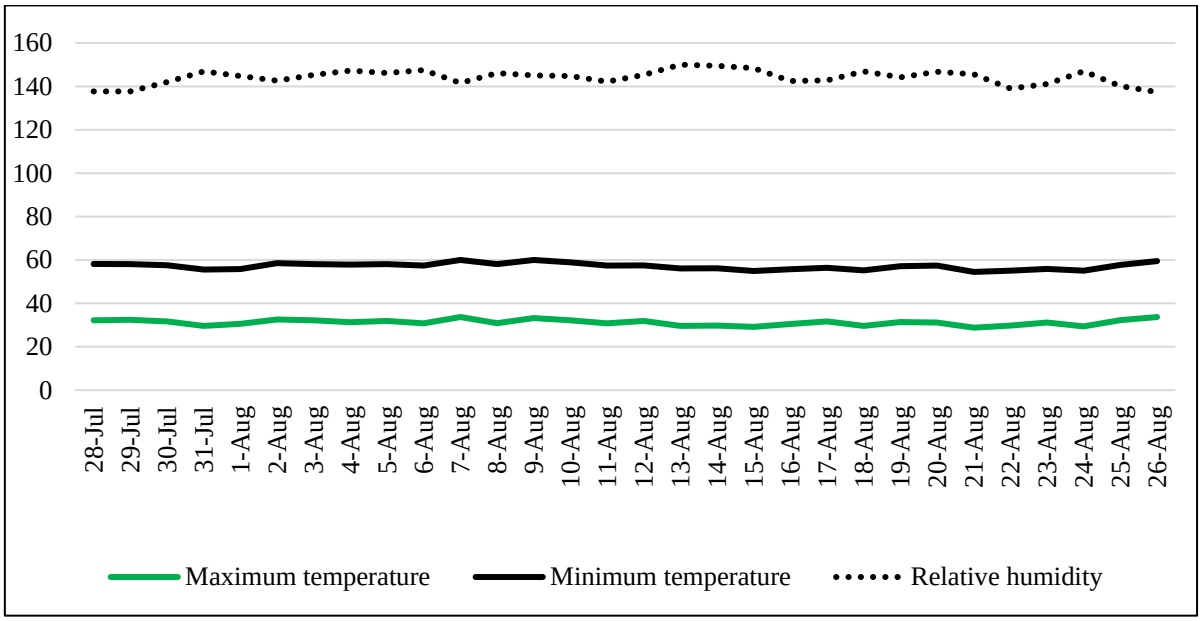

Figure 10: Climatic condition of study area

4.3 Behavior of Sarus Crane

The behavior of two Sarus Crane pairs was observed for 48 hours, two days for each pair. One nesting pair was selected from cropland and other pair was from wetland to observe the behavior, total 2331 different events were noted and categorized in 29 different activities (Annex 10).

Majority of Sarus Crane pairs were seen sitting on nest, feeding, standing, preening, headshaking, neck stretching and wing flapping (Figure 11). Male (12.00%) spent more time in nest in cropland and female (15.69%) in wetland. No significance difference (F-value=0.091,

d.f.= 1, 56; p-value= 0.765) was observed between activities of male and female on cropland as well as no significance difference (F-value=0.011, d.f.= 1, 56; p-value= 0.916) in wetland.

Sarus Cranes were observed flying up to nearby cropland from nesting site of wetland for foraging and they returned within one hour to one and half hour in average. After returning to the nesting site from foraging, the Crane in the nest produced loud sound and followed by the next one. Both the partner involved in nest maintenance.

Chasing, running, washing beak, dancing and aggressive were less observed during breeding period. Aggressiveness and alert behaviour of Sarus Crane were varied with the presence or absence of people, they didn't show any alertness with known people but they displayed more alertness with new person. Cranes showed aggressiveness due to chasing by Black drongos.

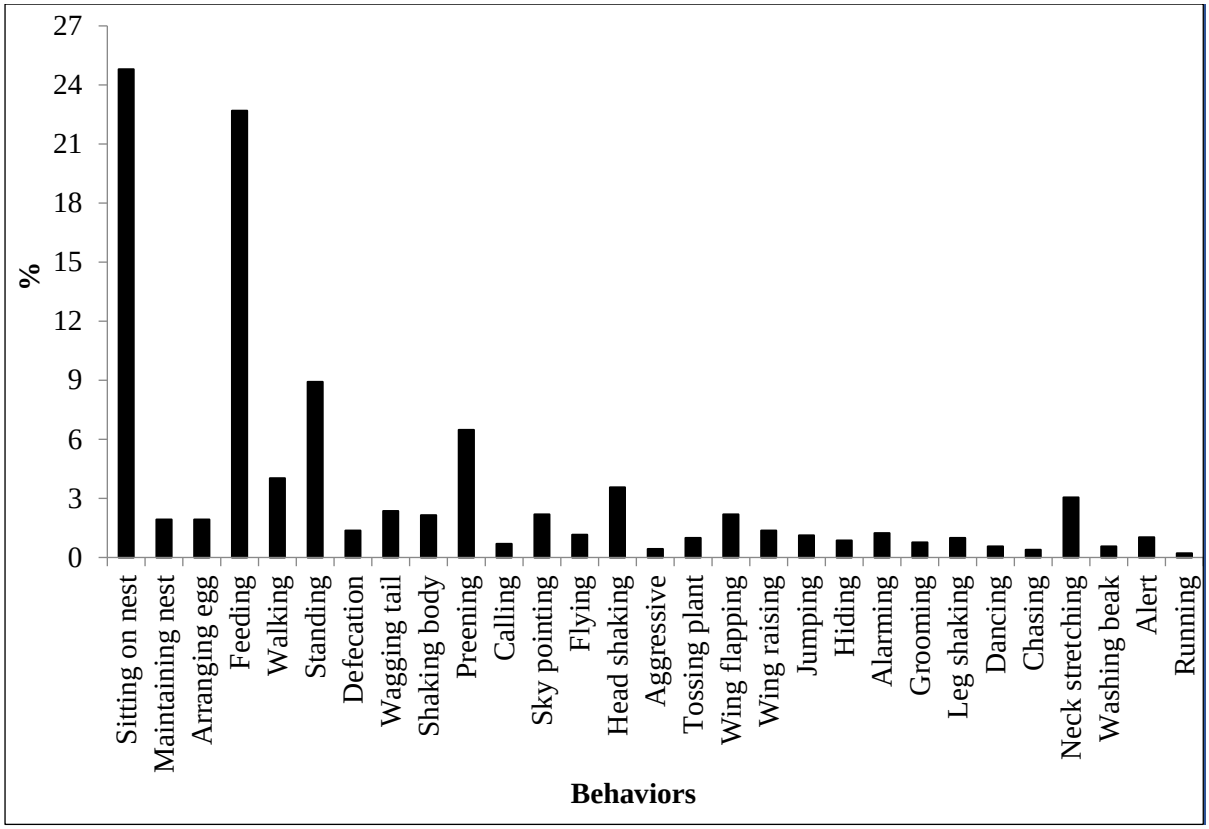

Figure 11: Total diurnal behavior of Sarus Cranein Lumbini IBA

Different activities were observed in cropland and wetland. Total 1294 posture were observed in cropland (Annex 11) and 1037 different posture in wetland (Annex 12). The predominant activities during the nesting period were sitting on nest (21.79%), feeding (19.71%), and standing (9.66%) which holds 51.16% of total activities in cropland. Similarly sitting on nest, feeding and standing were also predominant which holds 62.96% of total activities in wetland. Out of 29 activities of Sarus Crane, chasing and running were not found in wetland (Figure 12). No significance difference (F_{ratio}=1.1658, d.f.=1, 27; P-value=0.344) was found in activities of Sarus Crane on the both wetland and cropland.

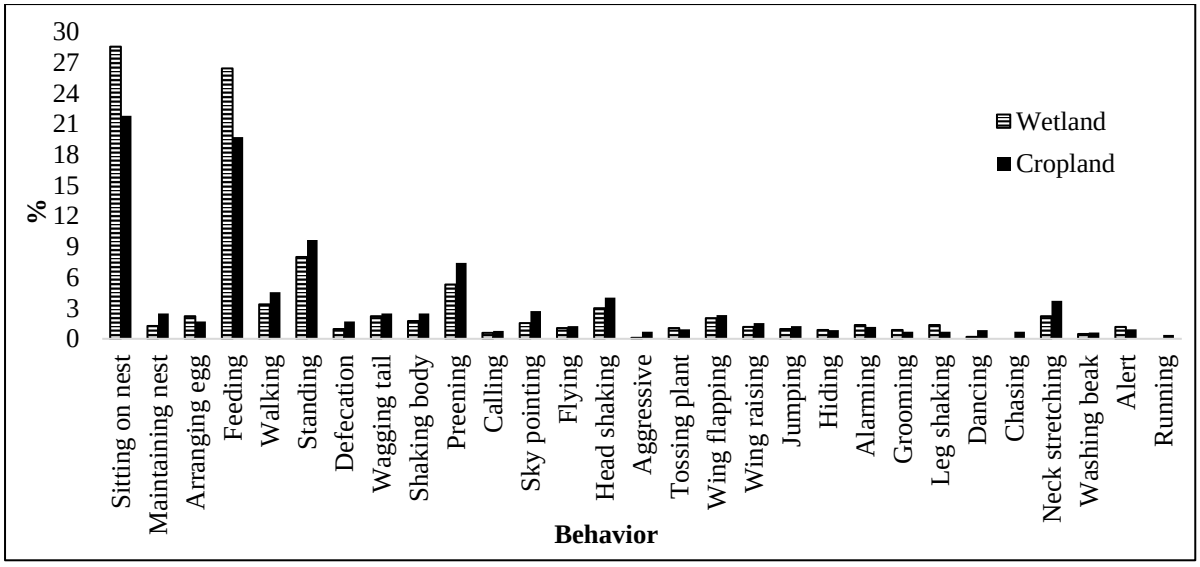

Figure 12: Diurnal behavior of Sarus Crane in cropland and wetland

Total 1219 events were recorded in male (Annex 13) and 1112 events in female (Annex 14). Sitting on nest, feeding and standing were dominant activities in both male and female. Least (0.16%) running behavior was observed in male while as least 0.09% chasing behavior was observed in female (Figure 13). Positive correlation was found between behavior pattern of male and female (Pearson correlation coefficient, r = 0.99) (Annex 15).

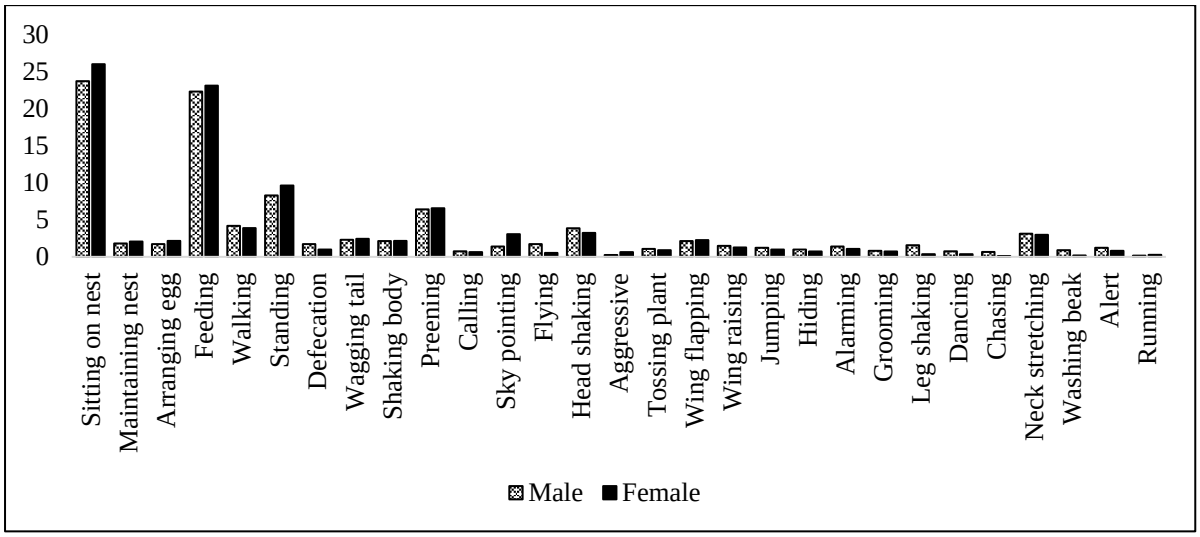

Figure 13: Diurnal behavior of male and female Sarus Crane

4.4 Conservation practices of Sarus Crane in study area

For the conservation of Sarus Crane, this study observed that the District Forest Office of Rupandehi, Lumbini Development Trust, Sarus Crane Sanctuary and Wetland User Groups managing wetlands by investing, providing trainings and technical support for wetland management. Wetland were constructed by them in the Sanctuary to attract nesting Crane and other wild animals. Annual activities such as Crane conservation education camps, art exhibitions, and crane festivals were organized by them to generate awareness amongst local people.

4.4.1 Respondents response on population trend of Sarus Crane

Among the 223 household surveys conducted in the Bishnupura region, maximum people agreed with the no change in Sarus Crane population in their area (Figure 14).

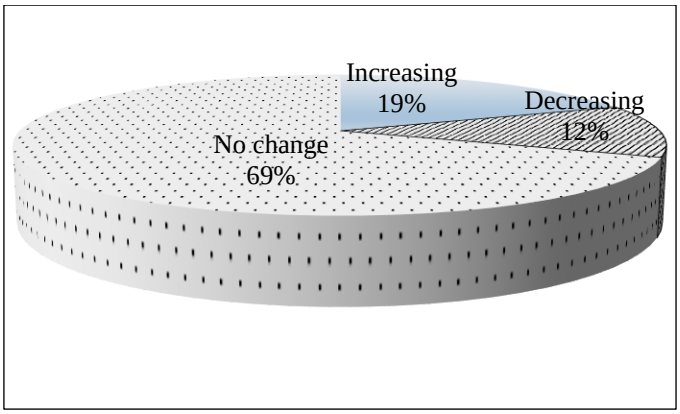

Figure 14: Respondents response on population trend

4.4.2 Respondents perception toward Sarus Crane

Among the 223 respondents of the Bishnupura region, majority of them showed positive perception towards Sarus Crane because they agreed with the Sarus Crane as not harmful creature. They agreed with existence of Sarus Crane in their farmland. They believed that Sarus Crane does not destroy the farmland and helpful for the increase in production, minority of respondent showed the negative attitude toward the Sarus Crane existence as they believed that Sarus Crane destroys their farmlands (Figure 15).

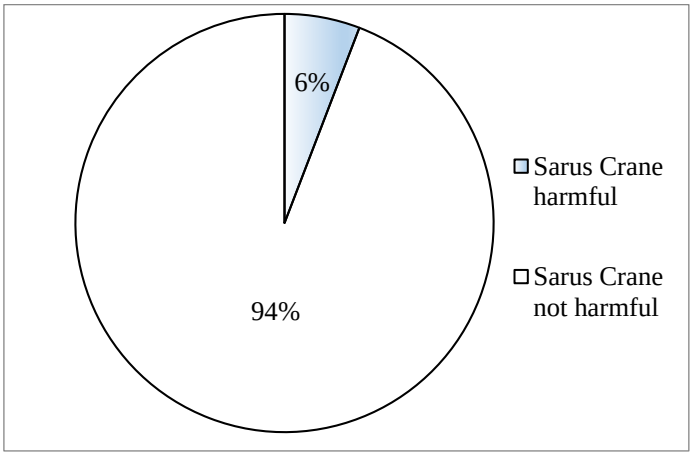

Figure 15: Respondents response on perception towards Sarus Crane

4.4.3 Respondents view on threats to Sarus Crane

According to respondent, destruction of wetland, destruction of nest, destruction of eggs, egg stolen and harassment were the threats to Sarus Crane (Figure 16).

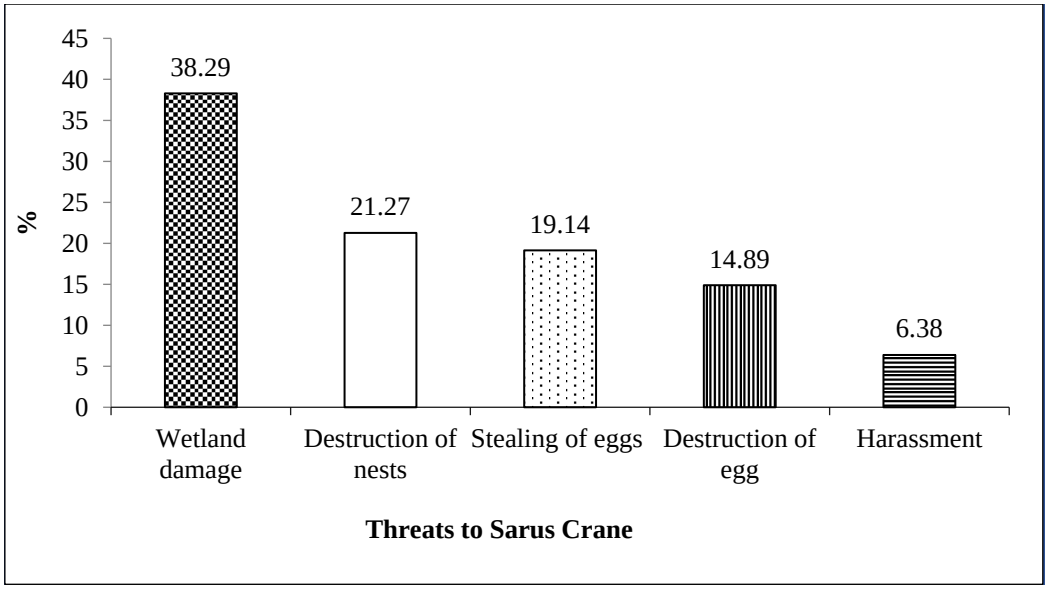

Figure 16: Respondents response on threats of Sarus Crane by animals and people

4.4.4 Respondents reaction on conservation practices on Sarus Crane

Among the respondents 40.36% of them agreed with need of conservation awareness campaigns for local people to increase their contribution on conservation of Sarus Crane habitat through possible ways. In addition, 26.91% respondents expressed conservation of wetland is supportive measure to conservation and 14% respondents, stated that the access to important nesting-grounds during the breeding season should be banned. On the other hand, 12.11% stated, local farmers must use minimize pesticide and seven percent voiced industrialists must stop industrial effluent disposal (Figure 17). Discussion among people have come up with the conclusion that all these mitigation measures play a crucial role in conservation of Sarus Crane.

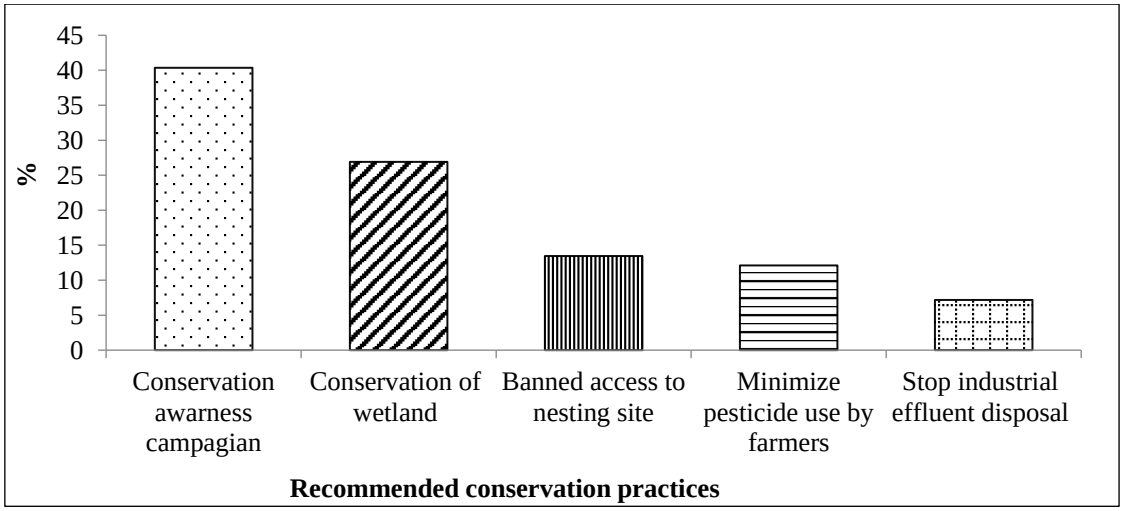

Figure 17: Respondents response on Conservation practices for Sarus Crane in Lumbini IBA

5 DISCUSSION

5.1 Population status and distribution

This study recorded total 180 Sarus Cranes in Lumbini IBA, which is higher than the study of Aryal (2004), which recorded 100 in Rupandehi and 68 in Kapilvastu; Manandhar (2014) that estimated 172 in Rupandehi, and 86 in Kapilvastu; Gyawali (2015) that observed 95 and the study of Gosai *et al*. (2016) which counted 143 in Rupandehi. Similarly, this study recorded lower number of Sarus Crane than the study conducted by Suwal (2008) which noted 200 and BCN and DNPWC (2011) which documented 504 in Rupandehi. This fluctuation of population might be due to change in area coverage in different studies. This study only focused on the areas of Lumbini IBA of Rupandehi and Kapilvastu districts.

Suwal (1999) observed Sarus crane 0.6 per square km and Paudel (2012) estimated 0.516 birds per square km in Rupandehi and Kapilvastu, which is similar with BCN and DNPWC (2011) that documented 0.516 birds per square km in Rupandehi. This study recorded only 0.285 birds per square km. Lower density might be due to the study concerned only in IBA parts of Rupandehi and Kapilvastu districts.

Sharma (2006) found clumped distribution pattern (variance/ mean= 8.86>1) in Nawalparasi, Tiwari (2017) also found clumped distribution pattern (Variance/mean = 2. 3>1) in Banke. This study determined the uniform distribution pattern (variance/mean=0.8635<1) in Lumbini IBA which might be due to availability of food throughout the study area.

5.2 Habitat assessment and preferences

Aryal *et al*. (2009) recorded 70% of Sarus Cranes using farmland and 30% using wetland as a regular habitat. Manandhar (2014) found 158 adult Sarus Cranes out of which 82% preferred agricultural land as their habitat and 18% preferred wetland in Rupandehi. Similarly, among 82 adults, 87% preferred agricultural land and 13% preferred wetland in Kapilvastu. Furthermore, among 30 adults, 13% preferred agricultural land and 87% preferred wetland in Nawalparasi. In Rupandehi, Gosain, *et al*. (2016) recorded 68.5% of Sarus Crane in agricultural land, 21.9% in wetland and 9.6% in mixed habitats. Panthi (2016) recorded 53% of these birds in wetland and 47% in cropland in Nawalparasi. Tiwari (2017) recorded 62.74% in farmlands, 31.37% in wetlands and 5.88% in grasslands. This study detected 86.36% (n=146) Sarus Cranes in cropland and 13.64% (n=34) in wetland which is similar with most of previous studies indicating cropland as preferred foraging habitat of Sarus Crane.

The use of agricultural land or cropland as their habitat is increasing. It might be due to the excessive utilization of wetland by local people for grazing their cattles and for fishing as well as destruction of wetland. Habitat used by the Sarus Crane depends upon the food availability. Most of the parts of Tarai is covered by farmland, which support fish, frog, snail and other insects, that are the food of the Sarus Crane that might be the reason behind congregation of Sarus Crane in farmlands.

5.2.1 Nesting sites, nests and eggs

Suwal (1999) found 38% nests in cropland and 62% in other habitat, Aryal (2004) recorded 79 nests in farmlands and 50 in wetlands, Manandhar (2014) observed 16 nests in agricultural land and seven in wetland in Rupandehi and Kapilvastu. Gyawali (2015) recorded eight nests in wetland, one in agricultural land 10 nests in the interface of wetland and agricultural land in Rupandehi, Gosain *et al.* (2016) counted 21 nests in Rupandehi. This study recorded 66.67% nests in cropland and 33.33% in wetland indicting the cropland as preferred nesting sites.

Sundar (2003) found nests constructed on water in natural wetlands or in inundated paddy fields in exposed positions that match with present study as majority of nest were found in wetland with short vegetation and in cropland. Most of the Sarus Cranes were found in pair; only four were found single which revels with finding of (Archibald *et al.*, 2003). Sitting on nest and feeding activities were high during study period.

Nest diameter and area

Suwal (1999) recorded mean diameter of nest 1.03m covering 0.833 square meters area. Aryal (2004) measured 1.45 square meters, Sharma (2006) found 0.126 square meters area, Gyawali (2015) estimated 2.76 square meters and Manandhar (2014) observed 2.81 square meters while this study recorded average diameter of the nest top 1.871m covering average 2.749 square meters area. This shows the average area coverage by the nest of Sarus Crane ranges from 0.126-2.81square meters.

Nest height and water depth

Aryal (2004) recorded average height of nest 20.3 cm ranging from 45cm to 12cm from the ground and water level, Manandhar (2014) found the maximum height of the nest 50 cm in wetland of Rupandehi and the minimum height 12 cm in agricultural land of Kapilvastu. The height of the nest ranges from 11 cm to 50 cm with the average of 29.78 cm. Whileas, this study recorded average height of nest form water level 11.525cm ranging from 5cm to 22cm and average height of nest from ground level 41.954cm ranging from 28.1cm to 56.9cm.

Suwal (1999) observed water depth at nest 24.75cm, Aryal (2004) measured 7.9 cm with maximum depth of 25cm, Manandhar (2014) found 13.78 cm water depth around the nest varying from 5cm in agricultural land and 28cm in wetland. This study recorded average 30.42cm water depth at nest ranging from 18.1cm to 42.3cm

Manandhar (2014) found the predominant nesting materials Thoti, Katarq Water hyacinth in wetlandls nest and Dubo, Gahachira, Rice, Thothi, Paspalum, Kerunga, Siru in agricultural nest by Sarus Crane, which is similar with this study.

Number of Eggs

Manandhar (2014) recorded 31 eggs, out of them 22 in Rupandehi and nine in Kapilvastu. Similarly Gyawali (2015) found 36 eggs and Gosain *et al.* (2016) counted 57 eggs in

Rupandehi. This study recorded 17 eggs among them five eggs in wetland and 12 eggs in cropland that might be due to availability of food in cropland and degradation of wetland. In five nests, two eggs were recorded whereas in seven nests only one egg was recorded which indicates that they lay one or two eggs in each breeding period.

5.2.2 Habitat parameters of nesting sites of Sarus Crane

The average distance of nests from nearest road, settlements, forest and river were 275.221m, 378.50m, 260.16m and 1787.86m respectively, which indicates the selection of nesting sites beneath 400m from road, settlements and forest.

5.2.3 Climatic parameters of habitat of Sarus Crane

The study showed temperature ranging from 25.2^{o}C-33.7^{o}C and relative humidity ranges from 77.9%-93.9% might be the preferred temperature and relative humidity for nesting by Sarus Crane.

5.3 Behaviors of Sarus Crane

Gosain *et al.* (2016) recorded feeding (39%), walking (17%), and standing (17%) as the predominant behaviors during the breeding season. Manandhar (2014) observed feeding, foraging walking, resting and preening as major behaviors that resembles with this study where sitting on nest (24.80%), feeding (22.69%), standing (8.92%), preening (6.48%), headshaking (3.56%), neck stretching (3.05%) and wing flapping (2.19%) were observed, indicating the sitting on the nests, feeding, standing and preening as preferred behavior of Sarus Crane.

Shrestha (1996) did not find any interactions between Sarus Cranes and local people or their livestock but they made alarming call soon after approaching of unfamiliar person and flew away. They returned to the nest and scanned around the nest producing calls. Gosain *et al,* (2016) observed varied behavior of Sarus Crane toward different people. The bird displayed offensive/defensive behavior when unfamiliar person approached to the nest, but showed normal behavior to the landowners. This study observed periodic alteration in parents Sarus Crane for guarding the nest. When one guards the nest, the next goes far for foraging. Similarly, Sarus Cranes were often observed close to local people and grazing livestock but frightened with the unknown people.

5.4 Conservation practices of Sarus Crane

Shrestha (1996), Panthi (2016) and Tiwari (2017) resulted need of awareness campaigns for local people, conservation of wetland, enforcement of strict rules and regulation for the conservation of Sarus Crane similar with this study, in addition this study recorded promotion of alternative of chemical pesticides and substituent disposal method of industrial effluent.

Beside these, current study also observed that the District forest office, LDT, Wetland User Group and Sarus Crane Sanctuary (SCS) playing vital role in Sarus Crane conservation by maintaining their habitat, conserving khayar, constructing water tanks, plantation and

allocating local staff for regular monitoring. Wetlands are leased from the Village Development Committees for an annual fee by wetland user groups for wetland management and the setting up of income generation schemes such as fisheries and duck farms which is supporting for biodiversity conservation as well as income generation for local people. The wise use of wetlands has been initiated wetlands in the district so far to make the user groups independent and the wetlands self-sustaining within few years .Lumbini IBA also includes the Lumbini Crane Sanctuary, which was established by International Crane Foundation in 1995. The sanctuary land covering 100ha is leased from the Lumbini Development Trust by the International Crane Foundation. This sanctuary demonstrates wetland management and conservation education, has an interactive centre and a conservation outreach programme which includes radio programmes on the environment. More recently, the Lumbini Development Trust has created wetlands within the core monastic zone promoting conservation of water birds

The Green Youth Lumbini is also playing significant role in conserving Sarus Crane by raising awareness in mass, rescuing the injured birds, plantation and extending wetlands in public barren lands.

Threats

Shrestha, (1996) mentioned the use of pesticides as major threat to Crane, Aryal, (2004), Sharma (2006), BCN and DNPWC (2011), Panthi (2016) and Tiwari (2017) also recorded conversion of wetlands into farmlands, hunting, stealing of eggs and chick, collisions in electrical cables and lack of awareness as the chief threats to these birds. Sundar (2009), Jha, and McKinley (2014), Manandhar (2014) and Gosain *et al.* (2016) observed the use of pesticides, chemical fertilizer, stealing eggs, habitat destruction, hunting for meat, electrocution, cattle grazing, major anthropogenic threats to Sarus Crane population which are similar with this study. In addition, this study also observed the regular flood as major natural threat that sweep away the nests of Sarus Crane.

6 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

- There is fluctuating number of Sarus Crane in Rupandehi, Kapilvastu and Lumbini IBA. There are total 180 Sarus Crane in Lumbini IBA.
- In comparison to Rupandehi and Kapilvastu districts the density of Sarus Crane is lower in Lumbini IBA, which is 0.285 per square km and 1.417 per 5km line transect in Lumbini IBA.
- In Lumbini IBA, Sarus Cranes are in uniform distribution pattern.
- In the study area, 85.92% was agriculture land, 13.60% bare land, 0.31% builtup area, 0.1% wetland and 0.07% broadleaved closed forest.
- The preferred foraging habitat as well as nesting sites are croplands.
- The area coverage of nest of Sarus Crane ranges from 0.126-2.81 square meters.
- Height of nest from water level and ground level ranges from 5cm to 22cm and 28.1cm to 56.9cm respectively.
- The predominant nesting materials are Thoti, Katarq Water hyacinth in wetlands nest and Dubo, Gahachira, Rice, Thothi, Paspalum, Kerunga, Siru in agricultural nest.
- Sarus Crane lay one or two eggs in nest per year.
- Egg length of Sarus Crane varies from 3.2 inch to 4.6 inch.
- Water temperature and pH at nest ranges from 30.5 ^{o}C to 39 ^{o}C and 5.6 to 8.1 respectively.
- Nesting sites of Sarus Crane are beneath 400m from road, settlements and forest.
- During breeding season, most preferred behaviors are sitting on nest, standing on it, foraging, and preening.
- The major anthropogenic threats to Sarus Crane are destruction of wetland, stealing of eggs and chicks, destruction of egg and nests, collisions in electrical cables, use of pesticides, lack of awareness and natural threat is flood.
- The District Forest Office, LDT, Sarus Crane Santuary, Green Youth of Nepal, Green Youth of Lumbini are playing vital role in Sarus Crane conservation by maintaining their habitat, conserving khayar, constructing water tanks, expanding plantation, allocating local staff for regular monitoring, raising awareness in mass, rescuing injured birds and extending wetlands in public barren lands.

6.2 Recommendations

- Government, NGO and INGO and other conservation initiatives should propose the conservation action plan for their long-term conservation in and outside the protected areas.
- Regular detailed scientific studies on their ecology throughout the range applying cutting edge technology (e.g. Telemetry tagging, geographic information system) is highly recommended.
- Use of Insecticide/pesticide and chemical fertilizer should be reduced and bio pesticides should be promoted.
- Human encroachment inside the crane sanctuary having nesting sites of LDT should be stopped and the area must be logged with water.

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ANNEXES

Annex 1: Data Sheet

Sarus Crane Population Monitoring Form

Date: Location (Place, District): GPS: N: E: A:

SN	Date	North	East	Elevation	Time	Male	Female	Unknown	Cluster Size	Total	Place	Municipality	District	Cropland	Wetland	Nesting	Foraging	Flying	Resting	Dancing	Flapping	Preening	Sound Producing	Others Animals
1																								
2																								

Annex 2: Data Sheet

Sarus Crane Nest Monitoring Form

Date: Location (Place, District): GPS: N: E: A:

SN	Date	North	East	Elevation (m)	Time	Place	Road Distance	Distance from Settlement	Distance from Forest	Distance from River	Municipality/Gaunpalika	District	Cropland	Wetland	Egg Number	Egg Length	Nest Diameter (cm)	Nest Height From Water Level (cm)	Water Column (cm)	Nest height from ground level (cm)	Air Temperature	Nest Temperature	Nest Water Temperature	Nest Water Ph	Nesting Materials	Others Plants and Animal Around Nest
1																										
2																										

Annex 3: Data Sheet

Behavior Monitoring

Date: Habitat: Location (Place, District): GPS: N: E: A:

SN	Date	Time	Male Activities																											
			Sitting on Nest	Maintaining Nest	Arranging Egg	Feeding	Walking	Standing	Defecation	Wagging Tail	Shaking Body	Preening	Calling	Sky Pointing	Flying	Head Shaking	Aggressive	Tossing Plant	Wing Flapping	Wing Raising	Jumping	Hiding	Alarming	Grooming	Leg Shaking	Dancing	Chasing	Neck Stretching	Washing Beak	Alert	Running
1																														
2																														

SN	Date	Time	Female Activities																											
			Sitting on Nest	Maintaining Nest	Arranging Egg	Feeding	Walking	Standing	Defecation	Wagging Tail	Shaking Body	Preening	Calling	Sky Pointing	Flying	Head Shaking	Aggressive	Tossing Plant	Wing Flapping	Wing Raising	Jumping	Hiding	Alarming	Grooming	Leg Shaking	Dancing	Chasing	Neck Stretching	Washing Beak	Alert	Running
1																														
2																														

Annex 4: Recorded activities of Sarus Crane

S.No.	Activity	Definition
1	Sitting on nest	The process of brooding over eggs for hatching (Plate 1).
2	Maintaining nest	Rebuilding of nest by adding plants with their beak when their nest is sunk in water (Plate 11).
3	Arranging egg	Changing the position of eggs on their nests by beak (Plate 6).
4	Feeding	Taking food by beak (Plate 16).
5	Walking	Moving with the legs at the speed that is slower than running (Plate 7).
6	Standing	The position of staying upright on the feet (Plate 20).
7	Defecation	Discharging fecal matter from anus.
8	Wagging tail	The periodic shaking of tail (Plate 9).
9	Shaking body	The shivering of the whole body for quick and short periods.
10	Preening	Rearranging the barbs and barbules of feathers in the body (Plate 12)
11	Calling	Making a loud distinct sound so as to be heard at a distance for its partner (Plate 13).
12	Sky pointing	Pointing the beak towards the sky intentionally for short time
13	Flying	Moving through the air with wings (Plate 22)
14	Head shaking	The shivering of head for quick and short periods.
15	Aggressive	Ready to attack or pinch with beaks to unfamiliar people
16	Tossing plant	Lifting and throwing the plants with a quick, light or careless motion by beak.
17	Wing flapping	The continuous up and down movement of wings for short period. It is useful for aeration (Koju and Chalise, 2010) (Plate 10).
18	Wing raising	The spreading out of wings up by Sarus Crane for short time (Plate 27).
19	Jumping	Moving the body upward and forward leaving the ground suddenly (Plate 21).
20	Hiding	Remained out of sight seeking protection (Plate 8).
21	Alarming	Making loud sound for alertness in response to any disturbance (Plate 5).
22	Grooming	The process of cleaning body using beak (Koju and Chalise, 2010) (Plate 4).
23	Leg shaking	The movement of one of the legs in up and down positions (Plate 28).
24	Dancing	The movement of the body by jumping and flapping the wings (Plate 29).
25	Chasing	Crow attack Sarus Crane eggs (Plate 30) and Sarus Crane defend them by rushing them
26	Neck stretching	The extension of the neck length staying behind the paddy plants and khar plants (Plate 25).
27	Washing beak	The process of cleaning and rubbing the dirt of beak in stagnant water (Plate 19).
28	Alert	The state of careful watching especially for danger (Plate 2).
29	Running	Leaving the place by moving with the legs hurriedly (Plate 18).

Annex 5: Household Questionnaire for farmers

Respondents Name: Education:
Religion: Age: Place:

1. Do you know Sarus Crane? Y/N
2. How often do you see them in your farm? a.Rare b. Common
3. Do you consider Sarus Crane to be harmful? a. Yes b. No
   (If yes a. Crop damage b. Nuisance c. Other)
4. Do you think hunting of Sarus Crane should be allowed? a. Yes b. No
5. Is the population of Sarus Crane increasing or decreasing or as it was in recent year?
6. Have you seen people harming Sarus Crane?
   a. Hunting b.Harassment c. Damaging egg and nest
7. Do you use the pesticide or herbicide in your field? a. Yes b. No
8. Do you need compensation when crane damage your crop? Y/N
   If yes, what type of compensation? Money/Crop/Other
9. Do you know about trading of Sarus Crane? Y/N
   If yes, which part- eggs..... /body..... Live/Death.....
10. What will you do if you find egg of Crane in your field?

a. Take egg c. Do nothing

11. What will you do if you find wounded Crane?

a. Tell to responsible authority b. do nothing c. first aid d. send to sanctuary

b. kill it for meat b. heal the wound c. leave as it is d. others .....

12. Do you think Crane should exist in your area? Y/N
13. Do you know organizations working for the protection of Sarus Crane?
    Mention organization and its activities ……
    .....
14. Do you think tourism has affected Sarus Crane? Y/N
15. Do you have any idea for good management of it?

Annex 6: ANOVA test for site utilization between cropland and wetland by Sarus Crane

	Sum of Squares	d.f.	Mean Square	F	Sig.
Between Groups	11.5	1	11.5	5.198	0.026
Within Groups	141.591	64	2.21		
Total	153.09	65			

Annex 7: ANOVA test for site utilization for laying eggs between cropland and wetland by Sarus Crane

	Sum of Squares	d.f.	Mean Square	F	Sig.
Between Groups	.167	1	.167	.606	.454
Within Groups	2.750	10	.275		
Total	2.917	11			

Annex 8: Parameters of nesting sites, nests and eggs of Sarus Crane in Lumbini IBA

Habitat	Egg number	Egg length (inch)	Nest diameter (cm)	Nest height from water level (cm)	Water column (cm)	Nest height from ground level (cm)	Air temperature (ºC)	Nest temperature (ºC)	Nest water temperature (ºC)	Nest water Ph.
1	1	4.2	88.9	9	42	51	35	36	25.6	6
1	1	4	259.08	5	35.2	40.2	37	38	30.2	6.2
1	2	3.8	203.2	19	26.8	45.8	39	38.5	27.45	7.1
0	2	4.6	182.88	10	18.1	28.1	36	39	36.45	6.8
1	1	4.2	88.9	10	40.6	50.6	42	36.8	20.8	5.9
0	1	3.8	190.5	22	31	53	39	35.4	24.32	7.6
0	2	3.2	226.06	9	24.6	33.6	35	38.2	21.9	8.1
0	2	3.6	228.6	8	22.3	30.3	32	30.5	24.8	6.4
0	1	4	264.16	11	26	37	35	37.56	29.8	7.3
0	1	4.3	106.68	14.6	42.3	56.9	37	37	27.6	6.9
0	2	3.8	248.92	8.7	36.25	44.95	40	35.6	24.8	5.6
0	1	4.4	157.48	12	20	32	34	34	21	7.6
Mean	1.41	3.99	187.11	11.52	30.42	41.95	36.75	36.38	26.22	6.79
Std. Deviation	0.51	0.38	64.03	4.82	8.68	9.77	2.83	2.35	4.47	0.78
Variance	0.26	0.14	4100.09	23.26	75.34	95.45	8.02	5.56	20.00	0.61
Minimum	1	3.20	88.90	5	18.1	28.10	32	30.5	20.8	5.6
Maximum	2	4.60	264.16	22	42.3	56.90	42	39	36.45	8.1

1 = wetland,
0 = cropland

Annex 9: Habitat parameters and their descriptive statistics of nesting sites

Nesting sites	Distance (meters)				Egg number	Habitat
	from road	from Settlement	from forest	from river		
LDT	214.86	155.27	357.27	1003.6	1	wetland
LDT	587.51	528.25	136.48	473.39	1	wetland
LDT	590.6	585.36	137.21	478.5	2	wetland
Ramawapur	289.9	124.64	529.50	599.93	2	Cropland
Madhuwani	24.68	61.60	344.87	2011.13	1	wetland
Ekala	201.59	262.27	356.18	359.68	1	Cropland
Ekala	338.89	322.18	750.92	7606.68	2	Cropland
Aama	464.52	466.39	49.17	1068.58	2	Cropland
Aama	10.52	338.38	305.85	1767.90	1	Cropland
Bishnupura	209.09	942.98	28.26	2823.28	1	Cropland
Bishnupura	200.05	313.09	42.62	1965.13	2	Cropland
Sadi	170.45	441.70	83.60	1296.52	1	Cropland
Total	3302.66	4542.11	3121.93	21454.32		
Average	275.22	378.50	260.16	1787.86		

Annex 10: Frequency of events of activities of Sarus Crane

Activities	Events (N)	Percent (%)
Sitting on Nest	578	24.8
Maintaining Nest	45	1.93
Arranging Egg	45	1.93
Feeding	529	22.69
Walking	94	4.03
Standing	208	8.92
Defecation	32	1.37
Wagging Tail	55	2.36
Shaking Body	50	2.15
Preening	151	6.48
Calling	16	0.69
Sky Pointing	51	2.19
Flying	27	1.16
Head Shaking	83	3.56
Aggressive	10	0.43
Tossing Plant	23	0.99
Wing Flapping	51	2.19
Wing Raising	32	1.37
Jumping	26	1.12
Hiding	20	0.86
Alarming	29	1.24
Grooming	18	0.77
Leg Shaking	23	0.99
Dancing	13	0.56
Chasing	9	0.39
Neck Stretching	71	3.05
Washing Beak	13	0.56
Alert	24	1.03
Running	5	0.21
Total	2331	100

Annex 11: Frequency of events of activities in cropland by Sarus Crane

Cropland Activities	Events (N)	Percent (%)
Sitting on Nest	282	21.79
Maintaining Nest	32	2.47
Arranging Egg	22	1.7
Feeding	255	19.71
Walking	59	4.56
Standing	125	9.66
Defecation	22	1.7
Wagging Tail	32	2.47
Shaking Body	32	2.47
Preening	96	7.42
Calling	10	0.77
Sky Pointing	35	2.7
Flying	16	1.24
Head Shaking	52	4.02
Aggressive	9	0.7
Tossing Plant	12	0.93
Wing Flapping	30	2.32
Wing Raising	20	1.55
Jumping	16	1.24
Hiding	11	0.85
Alarming	15	1.16
Grooming	9	0.7
Leg Shaking	9	0.7
Dancing	11	0.85
Chasing	9	0.7
Neck Stretching	48	3.71
Washing Beak	8	0.62
Alert	12	0.93
Running	5	0.39
Total	1294	100

Annex 12: Frequency of events from 29 activities in wetland by Sarus Crane

Wetland Activities	N	Percent (%)
Sitting on Nest	296	28.54
Maintaining Nest	13	1.25
Arranging Egg	23	2.22
Feeding	274	26.42
Walking	35	3.38
Standing	83	8
Defecation	10	0.96
Wagging Tail	23	2.22
Shaking Body	18	1.74
Preening	55	5.3
Calling	6	0.58
Sky Pointing	16	1.54
Flying	11	1.06
Head Shaking	31	2.99
Aggressive	1	0.1
Tossing Plant	11	1.06
Wing Flapping	21	2.03
Wing Raising	12	1.16
Jumping	10	0.96
Hiding	9	0.87
Alarming	14	1.35
Grooming	9	0.87
Leg Shaking	14	1.35
Dancing	2	0.19
Chasing	0	0
Neck Stretching	23	2.22
Washing Beak	5	0.48
Alert	12	1.16
Running	0	0
Total	1037	100

Annex 13: Total events of male Sarus Crane

Activities	Events (N)	Percent (%)
Sitting on Nest	289	23.71
Maintaining Nest	22	1.8
Arranging Egg	21	1.72
Feeding	272	22.31
Walking	51	4.18
Standing	101	8.29
Defecation	21	1.72
Wagging Tail	28	2.3
Shaking Body	26	2.13
Preening	78	6.4
Calling	9	0.74
Sky Pointing	17	1.39
Flying	21	1.72
Head Shaking	47	3.86
Aggressive	3	0.25
Tossing Plant	13	1.07
Wing Flapping	26	2.13
Wing Raising	18	1.48
Jumping	15	1.23
Hiding	12	0.98
Alarming	17	1.39
Grooming	10	0.82
Leg Shaking	19	1.56
Dancing	9	0.74
Chasing	8	0.66
Neck Stretching	38	3.12
Washing Beak	11	0.9
Alert	15	1.23
Running	2	0.16
Total	1219	100

Annex 14: Total events of female Sarus Crane

Activities	Female events	Percent (%)
Sitting on Nest	289	25.99
Maintaining Nest	23	2.07
Arranging Egg	24	2.16
Feeding	257	23.11
Walking	43	3.87
Standing	107	9.62
Defecation	11	0.99
Wagging Tail	27	2.43
Shaking Body	24	2.16
Preening	73	6.56
Calling	7	0.63
Sky Pointing	34	3.06
Flying	6	0.54
Head Shaking	36	3.24
Aggressive	7	0.63
Tossing Plant	10	0.9
Wing Flapping	25	2.25
Wing Raising	14	1.26
Jumping	11	0.99
Hiding	8	0.72
Alarming	12	1.08
Grooming	8	0.72
Leg Shaking	4	0.36
Dancing	4	0.36
Chasing	1	0.09
Neck Stretching	33	2.97
Washing Beak	2	0.18
Alert	9	0.81
Running	3	0.27
Total	1112	100

Annex 15: Correlation between behavior pattern of male and female Sarus Crane

		Male	Female
Male	**Pearson Correlation**	1	.995**
	Sig. (2-tailed)		0
	N	29	29
Female	**Pearson Correlation**	.995**	1
	Sig. (2-tailed)	0	
	N	29	29
** Correlation is significant at the 0.01 level (2-tailed).			

PHOTO PLATES

Plate 1: Sarus Crane sitting on the nest

Plate 2: Alert behavior of Sarus Crane

Plate 3: Monitoring of egg and nest

Plate 4: Grooming

Plate 5: Alarming

Plate 6: Arranging egg

Plate 7: walking

Plate 8: Hiding

Plate 9: Wagging tail

Plate 10: Wing flapping

Plate 11:Maintaining nest

Plate 12: Preening

Plate 13:Calling

Plate 14: Nest measurement

Plate 15: Paddy plants used in nest

Plate 16: Feeding

Plate 17: GPS reading of nest

Plate 18: Running

Plate 19: Washing beak

Plate 20: Standing

Plate 21: Jumping

Plate 22: Flying

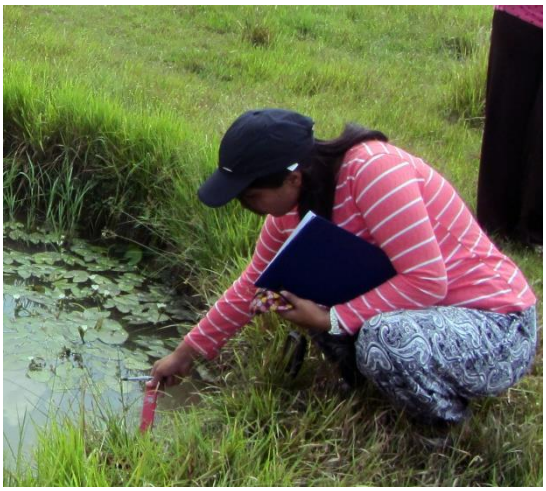

Plate 23: Taking pH of water

Plate 24: Questionnaire with local people

Plate 25: Neck stretching

Plate 26: Discussion with farmers

Plate 27: Wing raising

Plate 28: Leg Shaking

Plate 29: Dancing

Plate 30: Crow attacking eggs