

1. INTRODUCTION

1.1 Background

There are 19 species of storks found in the world that belong to the Ciconiidae (del Hoyo *et al.* 1992). In Nepal, 8 species of storks found, two of which are Lesser adjutant and both are listed as globally threatened species (Inskipp and Inskipp 1991; Grimmett *et al.* 2000; Birdlife International 2001). Lesser Adjutant Stork is one of the largest breeding birds found in Nepal. It is listed as Vulnerable (Birdlife International 2004).

The Lesser Adjutant Stork ranges from India in the west through Nepal, Bangladesh, Myanmar, Thailand, Southern China to Laos, Cambodia, Vietnam, Peninsular, Malaysia, Brunei to several parts of Indonesia (Birdlife International 2001). The range is large but currently, most of its populations seems to have confined in the Indian subcontinent with India the most important country for its population (Choudhury 2000).

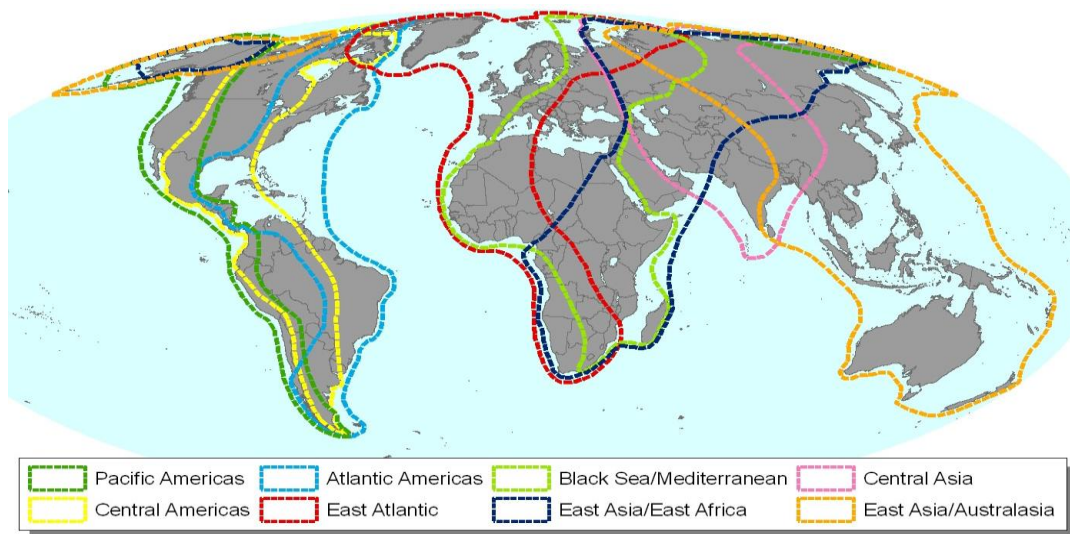


Fig 1 Major global flyways for Stork.

Sources: (http://www.birdlife.org/flyways/africa_eurasia/soaringbirds/index.html)

In the past, the Lesser Adjutant Stork was commonly found in the southern part of Nepal. Due to habitat loss, alteration and human disturbance, this species is now mainly restricted to some isolated pockets of lowland Nepal (Birdlife International 2001). Available literature

indicates that the wetland in Koshi Tappu Wildlife Reserve and adjacent areas in the east Nepal, are good territories of storks (Flemming *et al.* 1984; Pokharel, 1998). Though Koshi Wildlife Reserve is a good habitat for many wetland birds, including Lesser Adjutant Stork, the annual waterbird count indicates that bird population is declining. It was listed as nationally threatened by Bird Conservation Nepal (Baral *et al.* 1996).

Apart from studies in Chitwan National Park (Gyawli 2003; Hungden and Clarkson 2003; Choudhary 2004), systematic survey of the species has not been carried out to find its population status, breeding success and habitat preference. Therefore, it was essential to study the current population status, breeding success and habitat utilization of Lesser Adjutant Stork that would be helpful in developing management plans to conserve this threatened species in its natural habitat. Oriental Bird Club has funded three proposals on this species more or less at the same period covering eastern (this survey), central and western Nepal with an aim to generate complete status of species in Nepal (Carol Inskipp pre. Comm. 2011). This study focused to the eastern Nepal.

Lesser Adjutant Stork is local resident in the terai, below 250m below. Formerly much widespread in the terai, occurring almost from west to east Nepal, and more common in the east estimated 250 individuals and located 61 nests in Morang, Saptari and Siraha Districts; half of the nests were at Urlabari, Morang District (Baral 2004). They feed generally in wet fields; also in marshes and pools. Chiefly feeds outside protected areas and in the east where its main population is concentrated, also nests are unprotected sites. Habitat loss, disturbance, pesticide use in croplands, poisoning of wetlands for fishing, water pollution by factory effluents and development activities are the main threats (Gyawali 2003a; Baral 2004).

Lesser Adjutant Stork is water wading bird reside in lowland of terai below 75m-250m is distributed in India, Indonesia, Cambodia, Nepal, Sri Lanka, Bangladesh, Myanmar, Malaysia, Brunei, Vietnam, Thailand and Bhutan (BirdLife International 2009). In Nepal, particularly in the terai; it is noted that Chitwan National Park, especially on the Dhungre, Rapti, Reu, Khageri, Budhi Rapti and Narayani rivers. The species is also recorded from different sites of Nepal such as Butwal (Fleming 1959), Hetauda (Inskipp *et al.* 1971), Royal Bardia National Park, (Bolton 1976b; Dinerstein 1979; Tamaspur (Mills and Preston; 1981), Kanchanpur district (Suwal and Shrestha 1992), Nepalgunj (Van Riessen 1989), Mahotari,

Sarlahi, Parsa, Dhanusha, Sunsari, Morang, Jhapa, Nawalparasi and Rupandehi districts (Suwal and Shrestha 1992a), Between Koshi Barrage and Koshi Tappu Wildlife Reserve (Zerning and Braasch 1995), Chitwan National Park, Kasara, Gaida Wildlife Camp, Tiger Tops and along the Rapti river (Baral 1997), Ghodaghodi areas and Chulachuli range Ilam district (Chalise 1999) and in Lumbini reported by (Suwal 1999b), etc.

1.2 Objectives of the study

The main aims of this research were to assess the present status of Lesser Adjutant and provide an outline management prescription to ensure long-term survival in its natural habitat.

Specific objectives of research are:

- To estimate population Size in the KTWR.
- To study the habitat preferences and distribution of Lesser Adjutant Stork in KTWR.
- To Study the Breeding Success in the KTWR.

1.3 Rational of the study

The Lesser Adjutant Stork is globally threatened bird and they are in declining number. Their numbers are now on decreasing rate throughout whole world due to various reasons. Illegal hunting, lack of suitable habitat due to habitat destruction and modification, scarcity of food, water and shelter and other various disturbances (especially man made disturbances of artificial disturbances) make them difficult to survive. Moreover Nepal is suffering from the same events too and ultimately their numbers are on decreasing rate.

There are only a few areas in Nepal where this species is still inhabit. As they are aquatic birds i. e. water dependent birds, they like to inhabit nearer the aquatic bodies for their survival. So, Koshi Tappu Wildlife Reserve, is one of the important habitat of Nepal, which provides the habitat for species. Thus to acquire current information of Koshi Tappu Wildlife Reserve for Lesser Adjutant Storks , this research was chosen.

2. LITERATURE REVIEW

2.1 Population Status

Lesser Adjutant Stork (*Leptoptilos javanicus*) is a colonial tree nesting species with a world population about 6500-8000 individuals (Birdlife International 2009). In Nepal estimated population of Lesser Adjutant varied 100 to 500 individuals (Baral 1993a and 1998). Although the majority of birds reside within protected areas, a significant proportion of them venture outside to breed, feed and rest (e.g. in Morang, Sunsari, Saptari, Kailali and Kanchanpur districts) with a minority remaining permanently outside protected areas. In all cases, the population appears to be slowly declining (Baral 1998).

Koshi barrage and Koshi Tappu Wildlife Reserve contain the largest number of individuals and highest density per unit area, with as many as 15 were recorded daily (Wheeldon 1995). In 1989, a total of 13 nests were counted along the Rapti river near Charara, 8km west of Sauraha, Chitwan National Park (Baral 1998). In the entire country, 29 nests with 12 fledglings were counted in 1990-1992 (Suwal and Shrestha 1992a). It is listed as a vulnerable in the IUCN Red List (IUCN 2010) and Endangered in the Nepal Red Data Book (Baral and Inskipp 2004) because of its declining population due to habitat loss and degradation, hunting and disturbances (BirdLife International 2001).

2.2 Population Distribution

Lesser Adjutant is water wading bird reside in lowland of terai below 75m-250m is distributed in India, Indonesia, Cambodia, Nepal, Sri Lanka, Bangladesh, Myanmar, Malaysia, Brunei, Vietnam, Thailand and Bhutan (BirdLife International 2009). In Nepal, particularly in the terai; it is noted that Chitwan National Park, especially on the Dhunge, Rapti, Reu, Khageri, Budhi Rapti and Narayani rivers. The species is also recorded from different sites of Nepal such as Butwal (Fleming, 1959), Hetauda (Inskipp *et al.* 1971), Bardia National Park, (Bolton 1976; Dinerstein 1979; Tamaspur (Mills and Preston 1981), Kanchanpur district (Suwal and Shrestha 1992), Nepalgunj (Van Riessen 1989), Mahotari, Sarlahi, Parsa, Dhanusha, Sunsari, Morang, Jhapa, Nawalparasi and Rupandehi districts (Suwal and Shrestha 1992a), Between Koshi Barrage and Koshi Tappu Wildlife Reserve (Zerning and Braasch 1995), Chitwan National Park, Kasara, Gaida Wildlife Camp, Tiger

Tops and along the Rapti river (Baral 1997), Ghodaghodi areas and Chulachuli range Ilam district (Chalise 1999) and in Lumbini reported by (Suwal 1999) etc.

2.3 Habit and Habitat

The species is about 122cm (3.5-4ft) in length when it is measured up to top or standing. The species is Iris white, bill is dull yellow, the tip of which is whitish and base becomes tinged red in the breeding season. Bare skin of crown is generally greenish brown. Face and neck is yellow, tinged with brick red in the breeding season. Legs and feet may be greenish brown or almost black (Baker 1982).

The foods of Lesser Adjutant Storks are varied, fishes, frogs, reptiles, crustaceans and locusts etc are used as food (Ali and Ripley 1968). The species usually feed solitarily, well scattered over foraging sites, three or four individuals often forage in the same area but usually 10-100m apart (Saikia 1995), often around 50m apart (del Hoyo *et al.* 1992). In some cases, during the feeding period, the head and even most of the neck are inserted into mud when foraging (del Hoyo *et al.* 1992). After capturing large prey items, particularly frogs, fish, reptiles and occasionally molluscs, the individuals raise their head (Saikia, 1995). The food items of nestlings prefer amphibians (49%), molluscs (29%), fish (10%) and reptiles (2%) respectively (Saikia 1995). Rotten or long dead fish or meat is apparently never offered, either in the wild or captivity (Saikia 1998). during the parental care the stork is regularly regurgitated water onto nestlings apparently to keep them cool, (Saikia 1995).

The Lesser Adjutant Stork is an inhabitant of fresh and saltwater wetlands including riverbeds, floodplains, flooded fields and marshes, swamps, forest pools, lakes and paddyfields (especially in monsoon months), sandy islands, extensive areas of wet seepage, and less frequently of drier grasslands and pasture; from Bangladesh to Indonesia it is particularly closely associated with coastal mangroves and associated mudflats (Robinson and Kloss 1921–1924; Baker 1932–1935; Ripley 1982; Wells 1999, Hancock *et al.* 1992; del Hoyo *et al.* 1992; Saikia 1995; U Aye Hlaing *per* Khin Ma Ma Thwin 1997; Baral 1998; Thompson 1999).

2.4 Breeding Season

The timing of breeding events varies geographically and fluctuates annually but tends to coincide with the beginning of the dry season. In north-east India and Nepal, the main period of activity occurs in November to January (Baker 1922-1930; Saikia 1995; Baral 1998), although courtship begins as early as July as (Kahl 1971; Saikia, 1995; Choudhury 2000c). In Nepal, they were built nest on the *Bombax ceiba* species except one that was placed in *Adina cardifolia*, at Koshi Barrage and Chitwan National Park, the bird nests on *B. Ceiba*, in the former in tall grassland, in the later along the edge of the Rapti river and usually without any tall grasses or understory (Suwal; Shrestha,; 1992a Baral 1998).

2.5 Courtship and Nest Structure

In Assam, pair formation sometimes starts in July (3 months before egg-laying) with the male selecting the nest site prior to pair formation, apparently by carrying twigs to the chosen site (Saikia 1995). Out of 17 different varieties of plant materials used in construction of nests, *Bombax ceiba* (18%), *Ficus religiosa* (15%), and Bamboos (13%) were most frequent. In India, a full clutch contains 2-4 eggs, with an average clutch size of 2.62 (n=620) calculated by (Saikia 1998). The incubation period generally lasts 28-30 days, during this time, both adults share parental duties almost equally (Hancock *et al.* 1992; Saikia 1995). During the rainy days incubating birds regularly changed their orientation by 90° after each 15-30 minutes (occasionally remaining immobile for up to one hour) (Saikia 1998).

2.6 Migration

In Context to Nepal

In Nepal, at Koshi Barrage and Koshi Tappu Wildlife Reserve, immigrants from adjacent localities the population in winter (Baral 1998). During spring season stork spreads for a long period, the birds cover a short distance because of the worst weather conditions. They will return in January to April to their breeding habitats or areas. The Lesser Adjutant Storks i.e. from the Kutch to east Bangladesh, south Tamilnadu and are most regularly seen in the Eastern and middle (especially Chitwan) areas of Nepal (Inskipp and Inskipp 1985). In Nepal, they are frequently seen in Morang, Sunsari, Siraha, Dhanusa, Mahottari, Parsa,

Chitwan Rupandehi, Kapilvastu and Kanchanpur districts and especially in flooded fields, marshes and pools, as they are aquatic bird (Suwal and Shrestha 1992).

In Context to International

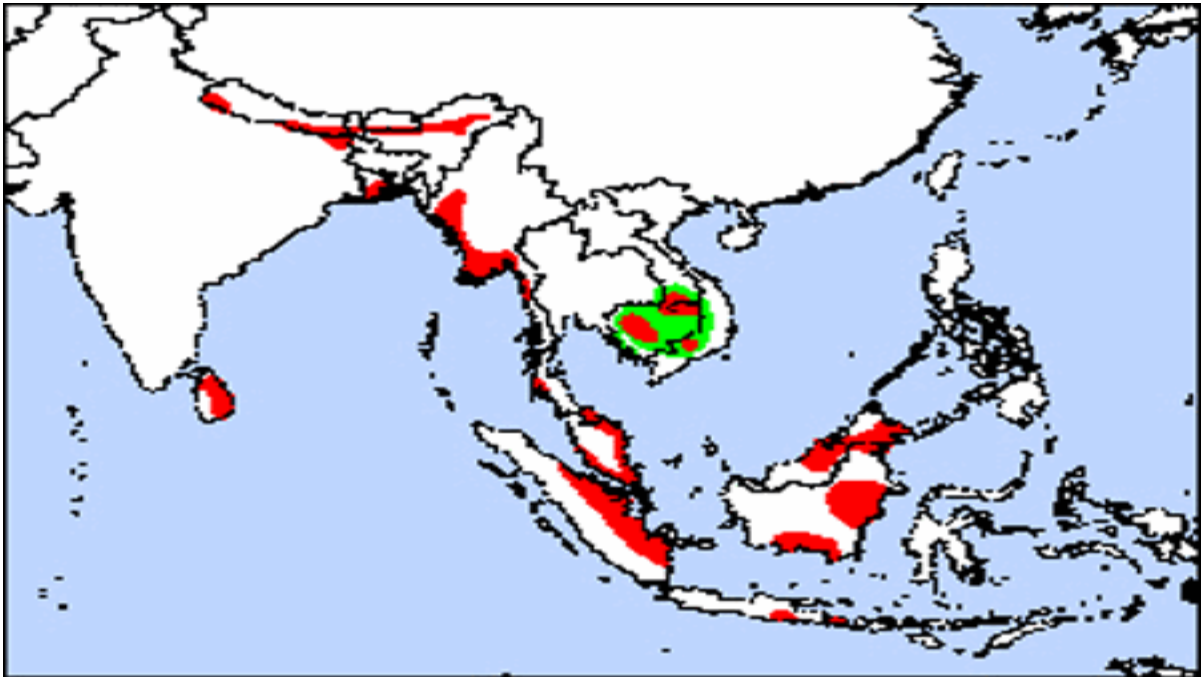


Fig 2 Globally Distribution of LAS Stork.

Lesser Adjutant Stork has an extensive range across South and South-East Asia. Substantial Populations remain migrate only in India (mostly in Assam, with c. 2,000 birds, West Bengal and Bihar where 42 nests were confirmed breeding in 2004), Indonesia (c.2,000 in 1993, the majority on Sumatra) and Cambodia (1000 Individuals or >300 pairs). Sri Lanka, Bangladesh, Myanmar, Laos, Malaysia (c. 500 Individuals), Brunei, Vietnam and Thailand. It has been recorded in Bhutan, but it is thought to be extinct in China and in Singapore.

3. MATERIALS AND METHODS

3.1 STUDY AREA

3.1.1 Physiography and Location

Koshi Tappu Wildlife Reserve (26°35'N-87°05'E) occupies 17,500 ha of the Sapta Koshi River floodplain at the most north-easterly extension of the Gangetic Plain. It ranges in altitude from 75-81 m. The reserve is located between two flood control embankments and is subject to annual flooding. Approximately 70% of the reserve's land area is covered by grasslands (Heinen 1993) although during high flood years a large area of grassland is destroyed and replaced by new alluvial deposits. *Typha* and *Saccharum* are major grassland species found here, although patches of *Imperata* and *Phragmites* are often seen (Peet *et al.*,1999). Medium size *phantas* interspersed with young *Acacia* trees are found in sandy islands. Riverine vegetation with *Acacia catechu*/*Dalbergia sissoo* forest dominates on the islands and edges of the reserve. Mostly young trees grow inside and on the edges of the reserve within embankments, the old mature trees being swept away by annual floods. South of Koshi Tappu Wildlife Reserve lies the Koshi Barrage area. The area is 7 km from north to south and nearly 5 km breadth from east to west. More than 50% of the land area of the barrage is covered by water, and the remaining land area is subject to intensive agriculture. The barrage gates are regulated by the Indian Government according to a 99 year lease agreement between Nepal and India. A large number of bird species (485) has been recorded in the Koshi Tappu and Barrage area (Baral 2005). Koshi is by far the most important wetland staging post for migrating waders and waterfowl in Nepal (Inskipp & Inskipp 1991) and have been considered one of the most important in Asia (Scott 1989). Koshi Tappu also has the largest heronry in Nepal where as many as 25,730 nests belonging to 12 species of medium to large waders have been reported in 1996 (Choudhary 1996). As many as 20 globally threatened bird species have been recorded in the Koshi Tappu and Koshi Barrage area and eleven of these occur regularly. This area is an Important Bird Area especially for some wetland and grassland species, notably Swamp Francolin *Francolinus gularis*, Lesser Adjutant Stork *Leptoptilos javanicus*, and Bristled Grassbird *Chaetornis striatus* (Baral & Inskipp 2005). It holds the largest population of the globally threatened Swamp Francolin in Nepal (Baral 1998; Dahal *et al.* 2007), and also supports a good population of the Bristled

Grassbird (Baral & Inskipp 2005). The site is also important for Nepal's nearthreatened birds; 13 of the country's total of 23 occur and eight of these are wetland birds (Baral & Inskipp 2005). Only two restricted-range species have been recorded and both are rare visitors. Besides these, a number of nationally threatened species of birds occur in Koshi area (BCN & DNPWC 2011). The reserve contains Nepal's last population of Asian Buffalo *Bubalus bubalis arnee*, a globally threatened species (IUCN 2012). Other globally threatened species include South Asian River Dolphin *Platanista gangetica*, Hog Deer *Axis porcinus*, Smooth-coated Otter *Lutrogale perspicillata*, Gharial *Gavialis gangeticus* and Mugger Crocodile *Crocodylus palustris* (Baral & Inskipp 2005; IUCN 2012).

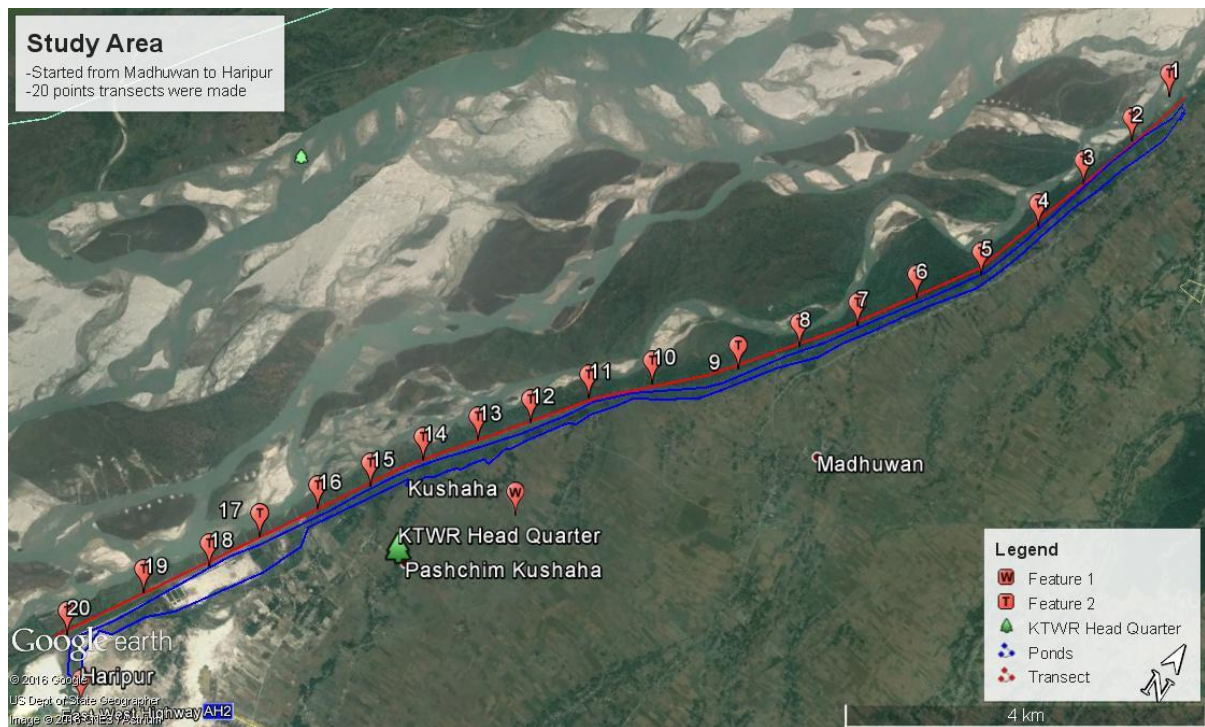


Fig. 3 Study area (Source: Google earth map)

3.2 Climate

The reserve experiences three distinct seasons. Summer (February through May) is intensely hot with minimum precipitation. Shade temperatures can reach 40°C. The monsoon starts in late may / early june and last until september bringing heavy frequent rainfalls. The rainfall is greatest during july but high humidity and temperatures are experienced throughout the

season. Winter (october through january) is characterized by clear sky and moderate temperatures, but can still get quite cold.

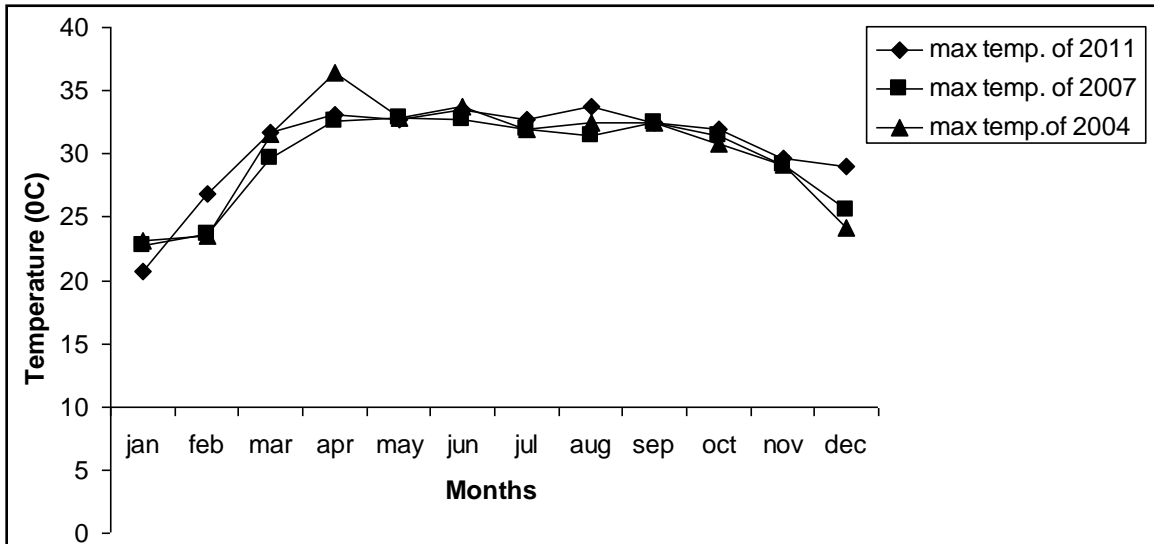


Figure 4 A Comparison of maximum Temperature of the study area in (2011,2007 and 2004)

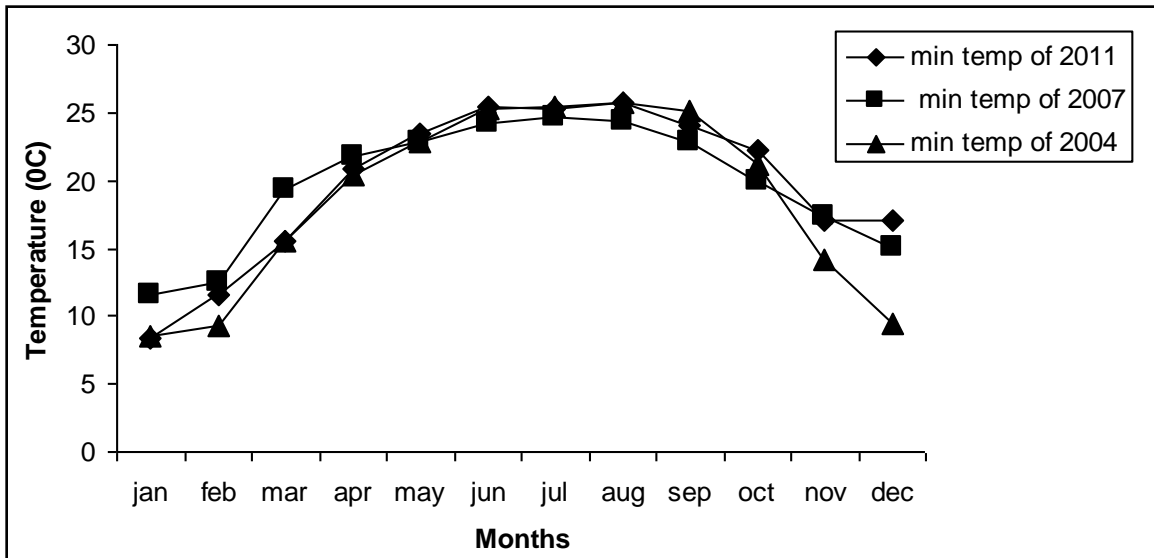


Figure 5: A Comparison of minimum Temperature of the study area in (2011, 2007 and 2004)

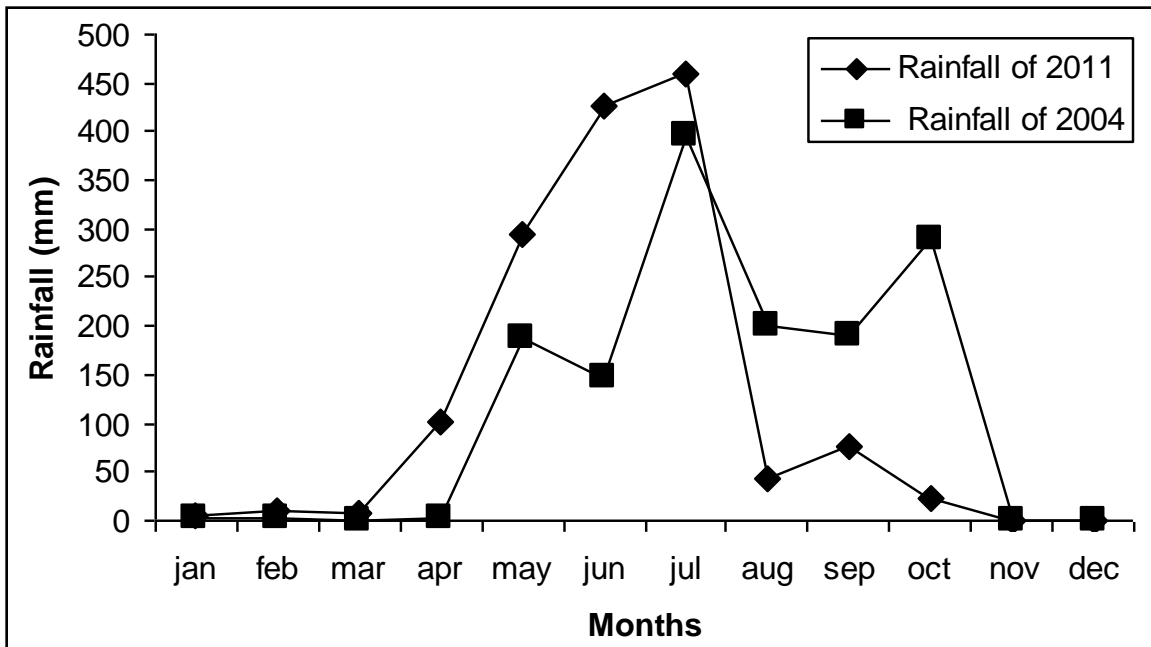


Figure 6: A Comparison of Rainfall of the study area in (2011 and 2004)

Source: Biratnagar Sub-metropolitan Office

3.3 Research Methods

3.3.1 Pilot Survey

A Pilot survey was conducted before doing the main observation. It was done in Jan-Feb. Months 2010. It was carried out by collecting the information about population status of Lesser Adjutant Stork, habitat types, suitable breeding place, current threats, flora and fauna found around it. Survey was done by questioning the park staffs, elephant drivers and local peoples and other relevant offices. For the study purposes the whole study area was categorised into four different habitat sites i.e. Agricultural field, Grassland, Wetland and Mixed forest respectively. And for this line transect method was used for census of Lesser Adjutant Stork population. (Subba 2001)

i) Agriculture field (AGF) habitat

It is actually a type of ecotone lies in between fields of villagers that lived in buffer zone and grassland habitat. agricultural land of about 100 hectare in the western side of KTWR. Some parts of that area covered by wooded grassland habitat.

During my study period, the field was covered with paddies and at one time, it was devoid of crops. As it was a field, small aquatic bodies in a few numbers were found within this area. In this field some trees like *Dalbergia sissoo*, *Bombax ceiba*, *Acacia catechu*. Grasses species like *Typha* and *Saccharum spontaneum* were dominant in this field, although patches of *Imperata cylindrica* and *Phragmites* were often seen. Notable shrubs species like *Asparagus racemosus* (Kurilo), *Lantana camara* and *Butea minor* were present (Subba 2001).

ii) Grassland (GL) habitat

it is the area where the grasses were dominant. *Cynodon dactylon* was the dominant among other grasses. *Imperata cylindrica* and *thema caudate* were other sps. found in grassland habitat. Approximately 70% of reserve's land area is covered by grassland (Heinen 1993) although during high flood year a large area of grasslands were destroyed and replaced by a new alluvial deposits. Small marshes were also found within the grassland habitat. The grassland habitats were surrounded by riverine forest which *Dalbergia sissoo* was dominant than other sps. this habitat for food of Lesser Adjutant Storks were found in high amount (Baral 2001).

iii) Wetland (WL) habitat

More than 50% of the land area was covered by water. There were also permanent and temporary water bodies present in the protected area. it has low level in dry season but the level is high in rainy season. Here, the many waterbodies were covered by aquatic weeds, thus causes declined water level. During the study period, Kamalpur Daha which is suitable habitat for many water wading birds and aquatic creatures. But the lack of proper management and yearly flooding caused wetland gets turned to agricultured land (Baral 2004).

In wetland habitat, hydrophytes of common emergent species were *Acorus calamus*, *Cyperus pilosus*, *Ipomoea aquatica*, *Ludwigia adscendens*, *Oryza rufipogon* and *Typha sps.* common submerged species were *Hydrilla verticillata*, *Ottelia alismoides* and *Ceratophyllum demersum*, like wise common floating-leafed species were *Nymphaea pubescens*, *Nymphoides hydrophyllum* and *Trapa quadrispinosa*. Whereas notable, free-floating species were *Azolla imbricata*, *Eichhornia crassipes*, *Pistia stratiotes* and *Spirodela polyrhiza* found in water bodies. Few marshes and pools were also found in east-south to the KTWR office, plenty of foods for Lesser Adjutant Storks such as molluscs, crustaceans and fishes were found in high amount, thus LAS prefer to forage these place than other habitat sites or number of individuals of LAS was high in amount (Baral 2004).

iv) Mixed forest (MF) habitat

Mixed forest habitats were represented by those habitats where the combination of forest and grassland occurred. This means the floor and understory of habitat was covered by grasses and shrubs and from this understory, trees made main role. These habitats were dry in nature i.e. no aquatic or water was available.

Actually, there were the intermixing of trees and grasses in about equal manner while least shrubs were also present. During my study period, tree species were observed *Dalbergia sissoo*, *Acacia catechu*, *Bombx ceiba*, shrubs and bushes were Siru, Bhati, and *Colebroohea oppositifolia*, like wise grasses were *Cynodon dactylon*, *Imperata cylidrica* and *Themada caudates* etc were present (Subba 2001).

3.3.2 Line Transect Method

For the census of Lesser Adjutant Stork population to different habitat sites, line transect method was used. For this, the imaginary line transect was sketched on the dam of Sapta Koshi River within the study area. The first point fixed on dam in Madhuban and last point in Sripur. Total distance from Madhuban to Sripur about 10km was measured and divided the points by the help of measuring tape. 20 points had fixed; each point was made every 500m, both side on each point having an area of 100×100m² in such way that direct observation (both naked eye and binocular) was count the Lesser Adjutant Stork and see the activities on every points. Binocular (Olympus 7×35) helped in identification of species and seeing of

soaring activities of storks. The observation in different habitat sites were conducted in the morning between (07h30- 10h30), in the midnight (01h-3h30) and in the late evening (04h-05h30) from December 2010 to November 2011.

3.3.3 Jacknife Technique

For the calculation of Population size of Lesser Adjutant Stork at different sites , Jacknife technique (Rodgers 1991) was used to estimate population size assuming that with repeated counts theoretically there is probability of counting all the animals in the area at one time. This method uses the difference between the highest count n_{max} and second highest count n_{max-1} to calculate N , the estimated total number $N = 2n_{max} - n_{max-1}$ (Rodger 1991).

3.3.4 Direct Count Method for Nest Census

During the observation, nest searches were conducted during breeding season (September to December). A nest was counted as active or apparently occupied nest on one of the following two criteria, young one is seen in the nest or at least one adult present on the nest (Bibby *et al.* 1992). The direct counts method was used to count the nests and young present on the nest. This included counting of individuals by direct observation with the help of binocular. Because of the large size of the birds and relatively smaller colonies, this method was the most appropriate. To study breeding success; occupied, active and productive nests were counted based on (Postupalsky 1974), according to which an active nest is the one in which eggs had been laid, an occupied nest is the one in which eggs have not been laid but some nest building activity must have taken place and a nest from which a chick has fledged is termed as 'successful or productive nest'. The breeding success was calculated using following formula. Breeding success = Productive Nest / Active or Occupation Nest $\times 100$.

3.3.5 Questionnaire Survey

Questionnaire survey was done to the KTWR staffs, elephant drivers, KTWR Community forest staffs, BCN Officers and local peoples etc. Was carried out to know their view in order to get the status, distribution patterns and habitat preferences in the KTWR. The questionnaire surveys were conducted in Madhuban, Kushaha and Sripur. Total population of

these vdc's was 180 individuals. Among them 15% respondents were selected randomly for surveys.

3.4 Analysis of Data

The collected data were categorized and tabulated to determine status, distribution and habitat preferences of Lesser Adjutant.

3.4.1 Hypothesis setting

It was used to set following hypothesis for the distribution patterns and habitat preferences of Lesser Adjutant.

Null hypothesis H_0 : The number of Lesser Adjutant Stork should be uniformly distributed over 11 months. (Chi-Square Test)

Null hypothesis H_0 : The number of Lesser Adjutant Stork prefers all the suitable habitat types. (One- way anova)

Alternative hypothesis H_1 : The number of the Lesser Adjutant Stork should be clumped or random distributed over 11 months. (Chi-Square Test)

Alternative hypothesis H_1 : The number of Lesser Adjutant Stork doesn't prefer all the suitable habitat types. (One- way ANOVA)

3.4.2 Chi- Square χ^2 test for goodness of fit

A Chi- square goodness of fit test was carried to determine whether the individuals of Lesser Adjutant Stork were distributed according to months. The test was performed by setting the hypothesis that the number of Lesser Adjutant Stork should be distributed over 11 months in all habitat types. The hypothesis was tested at 1% and 5% level of significance. (Kothari 2004)

3.4.3 Analysis of variance (ANOVA)

It was used to test Analysis of variance whether the individuals of Lesser adjutant Storks were preferred all the suitable habitat types. the test was performed by setting the hypothesis that the number of Lesser Adjutant Stork prefers all the available habitat types. The hypothesis was tested at 5% level of significance.(Kothari, 2004).

3.4.4 Software Use

For analysis of data, R Console version 2.15.2 (R Development Core Team 2012), was used for box plot and one-way ANOVA.

4. RESULTS

4.1 Population Size

Populations of Lesser Adjutant Stork was found moderate. Their size ranged from 3 individuals in June and 21 individuals in February. The mean population was 8.64 individuals during the study period. The total number 95 individuals were found over the 11 months. Jackknife technique was used for the estimation of population size of Lesser Adjutant Storks in the study area was found 22 individuals. High frequency of LASs shown in February i.e. 21 individuals and low frequency of Lesser Adjutant Storks were found in June i.e. 3 individuals in my observation period (fig II). During my study period the number of Lesser Adjutant Storks were rise from December to March and again lowered down tremendously during breeding seasons viz., May, June and July. From the above data, the number of LAS according to different months were shown by line graph1.

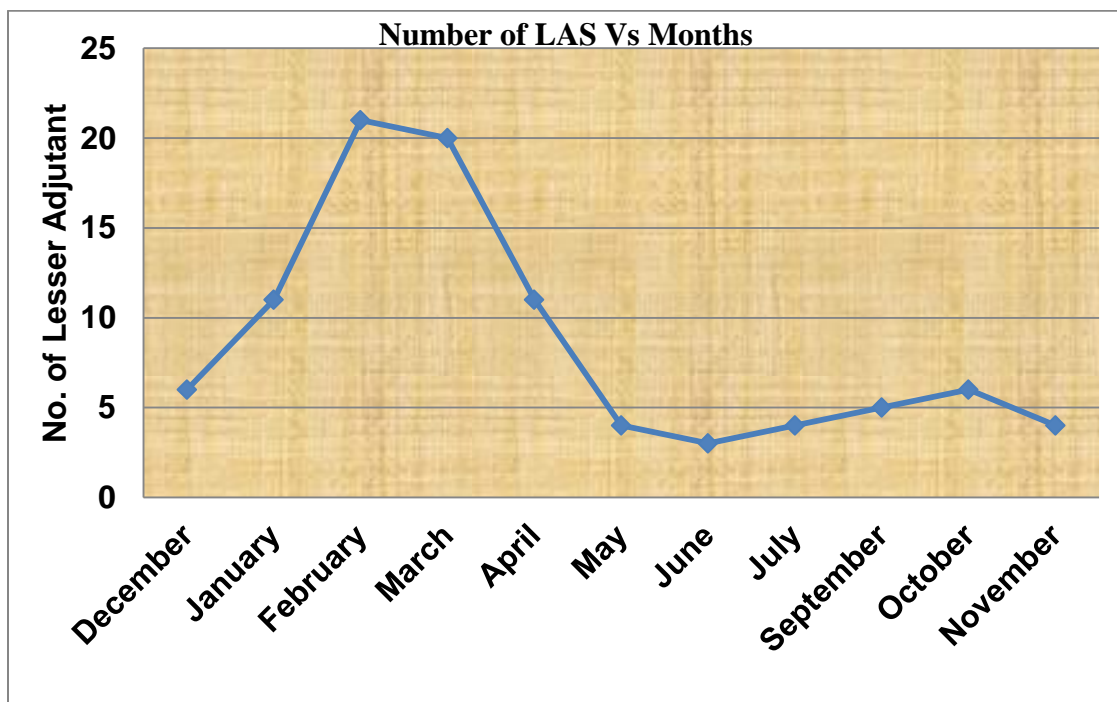


Fig 7 Number of Lesser Adjutant Storks recorded in different months

Note- The number of Lesser Adjutant Stork distributed over the 11 months. Among them, I found high number of LASs in february and least number in June i.e. 21 and 3 respectively during my research field.

During the Observation period, Lesser Adjutant Storks were observed in single, pair or families. Mostly Lesser Adjutant Storks observed in single i.e. 10 individuals during the pre nesting stage, 44 individuals observed in pair during the nesting stage and During the post nesting period, Lesser Adjutant Storks were observed in least pair i.e. 4 individuals. . From the above data, the number of LAS used different habitat at different nesting stage as shown in graph 2.

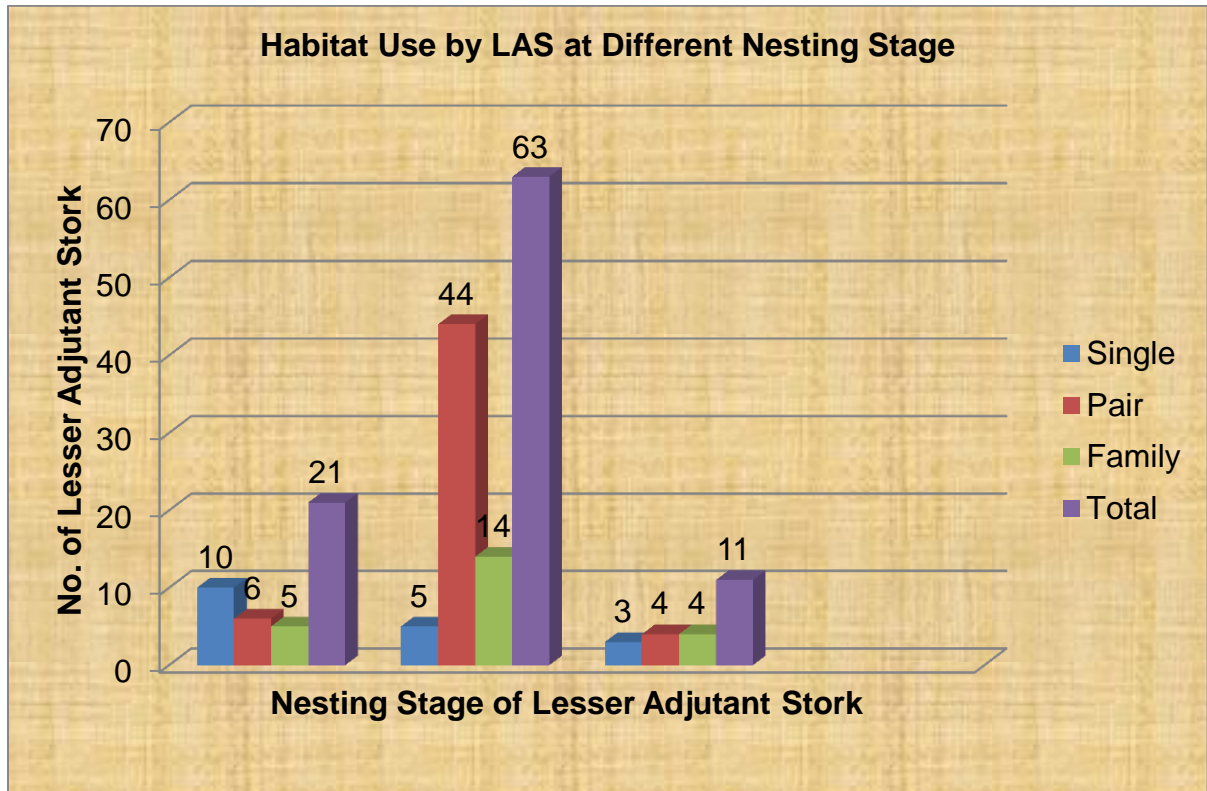


Fig 8 Habitat Use by Lesser Adjutant Stork at Different Nesting Stages

4.2 Habitat Preferences and Distribution

The population of Lesser Adjutant Storks were recorded from the Western part of the Sunsari district (eastern part of dam). LASs distributed in all VDCs of Sunsari, among them 3 VDCs Madhuban, Kusaha and Sripur etc, are most preferable habitat sites of Koshi Tappu Wildlife Reserve. Mostly Lesser Adjutant Stork occurred in winter season January to February and very low numbers of LASs recorded in August to September. From the calculation the value of chi-square χ^2 test was found 45.96. value of χ^2 for 10 d.f. at 1% and 5% level of significance were found 23.209 and 18.307 respectively, were very smaller than the calculated value 45.96. Significance difference showed ($P > F = 0.00000146$) and thus, null

hypothesis is rejected at 1% and 5% level of significance. Hence, It was concluded that the number of Lesser Adjutant Storks should be clumped or random distribution over the Different months. The habitat use of Lesser Adjutant Stork was based on the analysis of all the observation of the species, during 7 day visit of each month from December 2010 to November 2011. Lesser Adjutant Stork intensively used wetlands followed by agricultured field, grassland and mixed forests throughout year for foraging purpose. during my observation, There was found the habitat preference by LAS in Agricultured field 29 individuals, 24 individuals in Grassland, 57 individuals in Wetland and 15 individual in Mixed forest of all nesting stages viz., Prenesting, Nesting and Postnesting respectively.

Table 1 The Lesser Adjutant Stork prefers to forage at different Habitat Sites in the Study Area.

Nesting Stage	Habitat Sites				Total
	Agriculture field	Grassland	Mixed Forest	Wetland	
Prenesting	9	11	5	21	46
Nesting	8	6	4	17	35
Postnesting	12	7	6	19	44
Total	29	24	15	57	125

From the above data, the LAS mostly prefers to forage in wetland (WL) than other agricultural land (AGL), grassland (GL) and mixed forest (MF) respectively. The habitat use and preferences of Lesser Adjutant Stork at different habitat sites for foraging were shown by box plot.

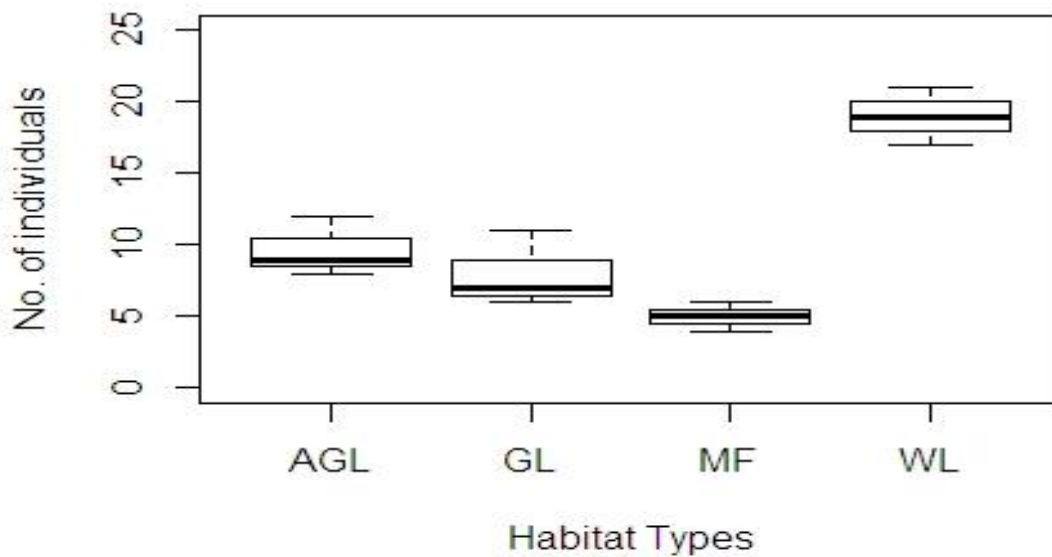


Fig 9 Box Plot for frequency of Habitat Use by Lesser Adjutant Stork in KTWR, 2010-2011

Note- The dark line in the box plot represents the median or mid value and its arm represents the quartile value of the species richness. There are outliers with the highest species richness at Wetland i.e. 57 and the lowest species richness at Mixed forest i.e. 15.

The ANOVA test was used to compare more than two samples in regarding to their homogeneity. Here, two samples were nesting stages viz; prenesting, nesting, post nesting and habitat sites i.e. Agricultural Land, Grass Land, Mixed Forest and Wetland. here, the test was used to find out all possible relation between the stages of LASs population in different habitats sites in Koshi Tappu Wildlife Reserve.

From the calculation, the Anova test was found 26.8 at 5% level of significance. Since the tabulated value of F- statistic for d.f.($v_1=3$, $v_2=8$) at 5% level of significance was 4.07. which was very less value than that of calculated value 26.8 at 5% level of significance. significance difference showed ($P>F=0.000159$). Hence null hypothesis H_0 at 5% was rejected and concluded that the number of LASs Stork doesn't prefer all suitable habitat or prefer wetland.

Table 2 One-way ANOVA table between the number of Lesser Adjutant Storks and different Habitat sites.

	Df	Sum of Sq	Mean Sq	F- Value	P(>F)	Remarks
LC	3	328.3	109.42	26.8	0.000159***	Significant
Residuals	8	32.7	4.08			

Significant code:***=0.001

4.3 Breeding Success

For breeding success nest searching programme was conducted september to December 2011, in Sunsari, Saptari and Udaypur. a total of 5 occupied nests of Lesser Adjutant Stork were observed in Kamalpur ward no. 3 and 4. Among these four nest were found on *Adina cardifolia* in Kamalpur-3, while 1 nest was found on *Bombax ceiba* in Kamalpur-4. In September 2011, only one nest was productive (i.e. 3 nestlings) were found on Karam Tree (*Adina cardifolia*) at Kamalpur ward no. 3. But in Sunsari and Udaypur were not seen any occupied or active nest.

Table 3 Nest Census of Lesser Adjutant Stork in the Study Area for field session 2010-2011

Location	No. of nests	Name of Tree	Altitude	State
Kamalpur-3, Saptari	4	Karam (<i>Adina cardifolia</i>)	45ft	2-incubating, 2-resting.
Kamalpur-4, Saptari	1	Simal (<i>Bombax ceiba</i>)	60ft	2-resting
Sunsari	*	*	*	*
Udaypur	*	*	*	*

Note- * Nests of Lesser Adjutant were not found.

From the above table, the breeding success in Koshi Tappu Wildlife Reserve was not found good. during the study period. There was seen very few number of Karam (*Adina cardifolia*) and Simal (*Bombax ceiba*) in the study area, branches of Simal tree was detached frequently for elephant food items. So, for resting, roosting and nesting purposes was disturbed. And they selected alternate habitat sites to breed resulted into very poor breeding success in KTWR. based on active nest as primary unit the breeding success was found 33% while based on occupied nest as primary unit the breeding success was found 20%. Out of 4 unsuccessful nests were failed during incubation period. this observed data shown in pie chart.

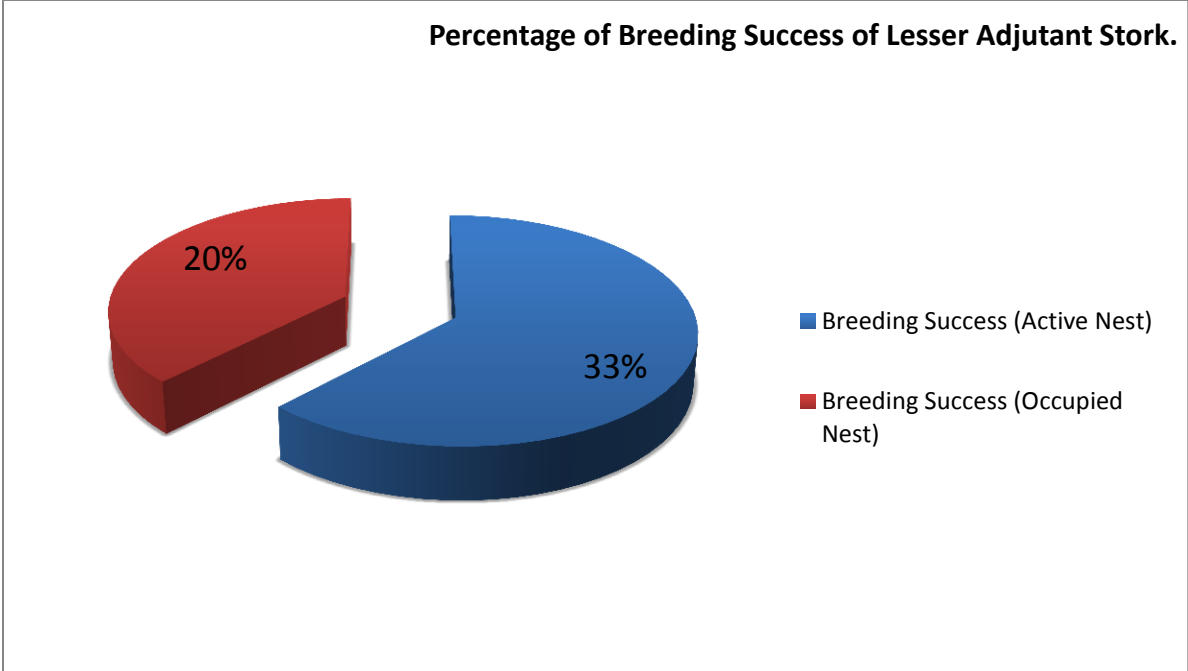


Fig- 10 Breeding Success of Lesser Adjutant Stork in Koshi Tappu Wildlife Reserve

5. DISCUSSION

Koshi Tappu Wildlife Reserve is one of the suitable habitat for many wetland birds including Lesser Adjutant Stork. There are 19 species of storks found in the world that belong to the Ciconiidae (del Hoyo *et al.* 1992). In Nepal, 8 species of storks found, two of which are adjutant Storks, are listed as globally threatened species (Inskipp and Inskipp 1991; Grimmett *et al.* 2000, Birdlife International 2000, 2001). Lesser Adjutant Stork is one of the largest breeding birds found in Nepal. It is listed as Vulnerable (Birdlife International 2004).

During the research period, population census was done by using Jackknife Technique. 22 individuals were observed over the different months (Feb-March) See Fig-6. In Koshi Tappu Wildlife Reserve of the Lesser Adjutant Stork was observed in Single, Pair and Family. It was used to compare population size varies accordance with different nesting stages. For this 10 individuals were observed in single, during prenesting stage, 44 individuals in pair, during nesting stage and last, 4 individuals observed during postnesting stage. (See Graph2).

Mostly the regular number of Stork observed in all VDCs of Sunsari. Among them 3 VDCs of Madhuban, Kushaha, Sripur are most preferable habitat site of KTWR. For the population distribution in the area used Chi-Square Test that the value of 10 df. at 1% and 5% level of significance. It was found 23.209 and 18.307 respectively. Significance difference showed ($P(F=0.00000140)$) and null hypothesis was rejected. Hence, it was concluded that number of Lesser Adjutant Stork should be clumped or random distribution over the different months.

Lesser Adjutant Stork was intensively preferred wetland followed by Agriculture field, Grassland and Mixed forest throughout the year. Habitat preference by LAS was observed in Agriculture field i.e. 29 24 individual was found in Grassland, 57 individuals found in Wetland and 15 individuals found in Mixed forest of all nesting stages viz., Prenesting, Nesting and Postnesting. For analysing the habitat types R-BoxPlot Software was used.

Among habitats, the wetland is the most favourable habitat for Lesser Adjutant. Wooded grassland habitat is least favourable habitat and other favourable habitat in decreasing order are Agricultured Land, Grass Land and Mixed forest habitats. This proves that the species choose such a place where the perfect combination of food, water and other shelter prevails. The Lesser Adjutant Storks most prefer the water bodies because it holds large amount of

invertebrates and other small vertebrates that are food of Lesser Adjutant and easily available to them also. Similarly, the temperature of such habitats are also somewhat less as compared to other habitats and always seen colonization in this habitat. The habitats Wetland, Agricultured field and Grassland have open space and more numbers of Simal (*Bombax ceiba*) trees in comparison to other habitats Mixed forest. As a result revealed that the Lesser Adjutant Storks favour open space and *Bombax ceiba* trees for nesting, resting and roosting. They confined to former type of habitats. Lesser Adjutant Stork doesn't prefer so hot , it favours humid environment. Therefore they are found near the aquatic bodies as compared to other type of habitats. In terms to biodiversity, these four habitat sites i.e. Wetland, Agricultured field, Grassland and Mixed forest differ to each other. So, it can be said that they are heterogeneous and insignificant to each another. This fact is also proved by Chi-square test and ANOVA test (Table 2) .

Lesser Adjutant Stork was water dependent bird, they were generally present in aquatic habitats than others. For this, It was compare between two samples i.e. Nesting Stages (Prenesting , Nesting and Postnesting) and habitat types. It was set the null hypothesis (One-way ANOVA), that Lesser Adjutant Stork prefers all the habitats. ANOVA was found 26.8 at 5% level of significance and Tabulated value of F- Statistic for d.f.($v_1=3$, $v_2=8$) was found 4.07. which was too less than calculated value. So null hypothesis was rejected. and it was concluded that the number of LAS doesnot prefer all the habitats or prefer wetland. See-Table 2.

In this study the numbers of Lesser Adjutant Storks were found moderate number in winter season than in summer season. This may be due to sufficient availability of food and due to migration of Lesser Adjutant Storks from Siberian part of Russia and other European countries to Nepal. The nestlings become adult in winter season, this may also be the reason that the numbers of Lesser Adjutant Stork are high in population than in summer season. Baral 2004 were found 61 nests at different localities in Morang, Saptari and Siraha districts. Among them localities five nest were found only in Karam tree (*Adina cardifolia*) in Kamalpur (Saptari). But 5 nests were observed in Kamalpur ward no. 3 and 4 (Saptari). Among them, four were in Karam tree (*Adina cardifolia*) and one in Simal tree (*Bombax ceiba*). in the study, the breeding success of Lesser Adjutant Stork in Koshi Tappu Wildlife Reserve were found 33% in active nest and 20% found in occupied nest respectively.

For Breeding Success, nest searching Programme was conducted in all the 3 Districts of KTWR 2011. 5 numbers of occupied nest only found in Saptari, among them 4 nest was observed in Kamalpur-3 and 1 nest in Kamalpur-4 of Karam Tree.

6. CONCLUSION AND RECOMMENDATIONS

Kohi Tappu Wildlife Reserve, a 'Ramsar' site is one of the outstanding important bird areas in the Indo-Gangetic grasslands. The research on the population status, habitat preferences and breeding success of Lesser Adjutant Storks in KTWR has given some important outputs. My study was conducted December 2010 to November 2011. During the study period, It was recorded 95 individuals from direct observation (Fig 1). This study suggests that the number of Lesser Adjutant Storks are more in winter than in summer season. They favour somewhat humid places where the perfect combination of food, water and shelter are available.

During the study, among four habitat sites viz. Agriculture field, Grassland, Mixed forest and wetland, the most preferable habitat i.e wetland while the least favourable or supportive habitat was mixed forest (Table 1). This study proves that the numbers of LASs favour differently to those four habitat sites. This may be due to differ in biodiversity, vegetation among habitats and other requirements needed to Lesser Adjutant Storks.

The Lesser Adjutant Stork prefers to make a nests in Karam (*Adina cardifolia*) and Simal tree (*Bombax ceiba*). during the observation, It was found 5 nests in kamalpur (Saptari). Among them four nests were observed in Karam trees (*Adina cardifolia*) and one in Simal tree (*Bombax ceiba*). So, this study suggests that the LASs prefers to make nest in karam trees than Simal trees, this may be due to large, strong and scattered branches. Breeding success of Lesser Adjutant Stork is very low. During the study period, breeding success of LAS that 33% (Active nest) was observed and 20% (Occupied nest) (fig iv).

The cleaning work done in KTWR helped in the prevention of succession of wetland at one side but decreased the activities of Lesser Adjutant Storks in wetland habitat and its peripheries for some months. The variation in number of Lesser Adjutant Stork in the study area It was observed time to time, this may be due to scarcity of food, climatic condition of habitats and different types of threats such as habitat loss and modifications, hunting, use of pesticide, poisoning and other disturbances.

Based on my whole research for the protection of Lesser Adjutant Stork following recommendations should be implemented:

- Potential habitats of Lesser Adjutant Stork in the study area should be protected and managed.
- The wetlands inside the protected area should be avoided from drying, artificial pumpig should be implemented.
- The water bodies in KTWR is being covered by water pollutant plants such as water hyacinth(Jalkumbhi), water lettuce, hydrilla and lotus. So , the food of wetland birds and reptiles to decreasing day by day. Proper management should be done to eliminate such invasive plants.
- Insecticide, pesticides and chemical fertilizers should be stopped to use in agricultureland.
- Illegal bird hunting and trafficking is totally prohibited in the protected area.
- Banned to cut those trees where the storks are generally use to make nest like Karam and Simal trees.
- The collection of firewood, fodder and livestock pressure inside the protected area should be controlled immediately. For this protected area, should develop good coordination with the local peoples live buffer zone. Protected area's staffs should motivate people by giving them alternative choices. Community forest should be made for the people for firewood and fodder.

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Source: <http://www.planetofbirds.com> 6 June , 2012.

8. APPENDIX-1

Number of Lesser Adjutant Storks obtained in different months.

Months	No. Of Lesser Adjutant Storks
December	6
January	11
February	21
March	20
April	11
May	4
June	3
July	4
September	5
October	6
November	4
Total	95
Mean	8.6

9. APPENDIX-2

Monthly Primary Data Obtained from my field Research (2010-2011).

Date	Lesser Adjutant Storks Prefer in Different Habitat Sites in the Study Area.						
	Wetland	Agricultured Field		Grassland		Mixed Forest	
		H1	H2	H1	H2	H1	H2
Dec25	1	0	0	2	0	0	0
Dec26	1	0	0	0	0	2	0
Dec27	2	0	2	0	0	2	0
Dec28	0	0	0	2	0	0	0
Dec29	1	0	0	0	0	0	0
Dec30	0	2	0	2	0	0	2
Dec31	1	0	0	0	3	2	0
Jan12	2	0	0	2	0	0	0
Jan13	1	0	0	0	0	3	4
Jan14	1	0	2	2	0	2	0
Jan15	2	2	0	0	0	2	0
Jan16	0	0	0	2	0	0	0
Jan 17	0	0	0	0	2	2	2
Feb1	2	2	0	0	2	2	0
Feb2	0	0	2	2	3	0	0
Feb3	1	0	0	0	3	2	2
Feb4	3	2	0	3	0	0	2
Feb5	1	0	0	3	2	0	2
Feb6	0	0	2	0	2	3	0
Feb7	0	0	2	0	2	5	0
Feb8	1	3	0	0	0	0	0
Feb9	4	2	0	2	0	0	3
Feb10	1	0	0	0	2	0	4
Mar3	0	2	0	2	2	2	2
Mar4	2	0	0	0	0	2	2
Mar5	1	2	0	0	3	3	0
Mar6	0	0	2	3	0	0	0
Mar7	1	0	0	0	0	0	2
Mar8	1	3	0	0	0	0	0
Apr17	2	0	0	2	0	0	0
Apr18	0	2	2	3	0	5	0
Apr19	1	0	0	2	0	3	5
Apr20	0	0	0	0	0	0	0

Apr21	0	0	0	0	3	0	0
Apr22	0	3	2	2	2	0	3
Apr23	1	0	0	0	0	0	2
Apr24	0	0	0	2	0	2	0
May12	1	2	0	3	2	0	0
May13	0	0	0	0	3	0	0
May14	2	0	2	2	0	2	0
May15	0	2	3	2	0	5	2
May16	0	0	2	3	0	0	3
May17	1	2	0	0	0	2	4
May18	1	2	0	0	0	0	0
May19	1	0	0	0	2	0	0
May20	1	0	2	2	0	0	2
May21	0	2	0	2	0	0	0
May22	0	0	2	3	0	0	4
May23	0	0	0	0	2	2	0
June17	0	0	0	0	0	0	0
June 18	0	0	0	2	0	0	0
June19	1	0	0	0	0	0	0
June20	0	0	0	0	0	0	0
June21	0	0	0	0	0	0	2
June22	0	0	0	0	2	3	0
June23	0	0	0	0	0	0	0
June24	0	0	0	0	0	0	0
June25	0	0	0	0	0	0	0
June26	0	0	0	0	2	0	2
June27	1	0	0	0	0	0	0
June28	0	0	0	0	0	0	0
June29	0	0	0	0	0	2	0
June30	1	0	0	0	0	0	2
July15	0	2	0	0	0	4	0
July16	0	0	0	0	2	0	0
July17	0	0	0	0	0	2	2
July18	0	0	0	2	0	0	0
July19	1	2	0	0	0	0	0
July20	0	0	0	0	0	0	3
July21	0	0	0	0	0	2	0
July22	0	0	2	0	0	0	0
July23	0	0	0	0	0	0	0
July24	1	0	0	0	0	0	2
July25	0	2	0	0	0	3	0
Sept11	2	2	0	2	0	3	3
Sept12	0	0	2	2	0	2	4
Sept13	0	2	0	0	2	0	0
Sept14	1	0	3	0	0	0	0

Sept15	1	0	0	2	2	2	2
Sept16	1	2	2	0	0	5	0
Sept17	0	0	0	0	0	0	3
Oct2	2	2	0	0	2	2	0
Oct3	1	0	0	0	0	3	0
Oct4	1	2	3	3	0	0	5
Oct5	0	0	0	0	0	0	0
Oct6	2	0	0	0	0	5	0
Oct7	3	2	0	0	2	0	3
Oct8	1	0	2	2	0	2	2
Nov3	2	0	0	0	2	5	0
Nov4	0	2	0	2	0	3	0
Nov5	1	0	0	2	0	5	2
Nov6	1	0	2	2	0	3	2
Nov7	2	0	3	0	0	0	0
Nov8	0	2	0	2	2	0	0
Nov9	0	0	3	0	0	3	0
Nov10	1	0	0	0	3	0	2
Nov11	0	0	0	0	0	0	0
Nov12	1	2	2	0	0	5	4

10. APPENDIX-3 Family Structure of Lesser Adjutant Stork in different Season.

S.N	Season	Single	Pair	Family	Total
1	Pre nesting	10	3(6)	2(5)	21
2	Nesting	5	22(44)	5(14)	63
3	Post nesting	3	2(4)	1(4)	11

11 APPENDIX-4 Data of Breeding Success of Lesser Adjutant Stork in Koshi Tappu Wildlir Reserve.

Location	Occupied Nests	Active Nests	Productive (Successful) Nest	Unproductive (Unsuccessful) Nest	Breeding Success (Active Nest as Primary Unit)	Breeding Success (Occupied Nest as Primary Unit)
Saptari Kamalpur	5	3	1(3 nestlings)	4	33%	20%

12 APPENDIX-5 Photoplates



I. LAS was standing at Sissoo Tree

Covered by *Micania micrantha*



II. LAS was resting at Sissoo Tree



III. Nest of LAS at *Adina cardifolia*



IV. Juveniles in nest of *Adina cardifolia* .



V. Sub adult standing at nest for food.



VI. Flying Posture of LAS at Madhuban for food



VII. Matured pair of LAS ready for mating near the nest at Karam Tree(*Adina cardifolia*)



VIII. Kamalpur Daha from the west post of Kamalpur of Koshi Tappu Wildlife Reserve, Saptari



IX. Aquatic weeds covered the whole water surface of pond at Madhuban



X. Group of LAS resting at Simal Tree after feeding



XI. Flooded area of Sapta Koshi from KTWR office, Paschim Kushaha



XII. Feeding Area of Lesser Adjutant Storks at Madhuban



XIII. Yearly fire event caused decline the habitat of LAS in KTWR (view west of kushaha)



XIV. Suitable feeding area of Lesser Adjutant Stork destroyed by yearly floodings, Haripur

13 APPENDIX-6

SAMPLE OF FORMAT OF QUESTIONNAIRE

QUESTIONNAIRE FOR POPULATION STATUS, HABITAT PREFERECES AND BREEDING SUCCESS OF LESSER ADJUTANT STORK (*Leptoptilos javanicus* Horsfield,1821) IN KOSHI TAPPU WILDLIFE RESERVE, NEPAL.

Date: Village: Ward no: District:

1. Name
2. Occupation
3. Age
4. Sex: M/F
4. Have you seen any Storks near the aquatic bodies? Yes...../ No.....
5. If yes, where? Wetland...../Agricultured field...../Mixed forest...../Grassland.....
6. When was last one seen? Month...../ Year.....
7. If you seen any Storks, how far from the village?..... in M/Km.
8. How many are seen?

i) one ii) Two iii) More than two.

9. How do you identify it?

i) by its appearance ii) by its voice iii) mode of flyings iv) others

10. Which months they are seen in maximum and minimum numbers?

Maxium months...../Minimum months.....

11. Why most of Storks were coming to KTWR for feeding?

i) Plenty of foods ii) Good habitats iii) Safety iv) Others

12. Have you seen any Storks that killed or Poached? Yes...../ No.....

13. Why the number of storks had seen low in breeding season?

i) Food scarsity ii) Habitat destruction iii) Poaching iv) Other

