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Impact of climate change on seasonal aggregation of Cattle Egret (*Bubulcus ibis*) in Koshi region of Bihar

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Abstract : Climate change and its impact on animals are well documented and related studies are being organized mostly around the hot-spots and conserved areas. The studies related to the abiotic factors on birds in the river Koshi is scarce. The river Koshi is famous for its mega-fan and dynamism in flow patterns in Bihar. In the present study, sensitivity to climatic fluctuations like weather events. Documentation on roosting behaviour in relation to the population size, roosting occupancy, roost gathering and rate of arrival on specific site in both winter and summer season. the bad weather lowered the number of flock size of roosters, and when compared with other variables have explicit significant effects and impulse the change of roosting site during postponed and extreme winter invents. A proportionate change was also observed with rainfall and summer months too. This suggests that prolonged cold waves in winter depress the Cattle Egret population while rainfall and humidity have shown moderate effect. Our results are alarming, the future alteration in climatic conditions may change the collective behaviour of the native as well as migratory birds in particular and an add space for invasive species in general.

Index Terms **- Cattle egret, climate change, river Koshi, roosting.**

I. INTRODUCTION

Understanding the impact of climate change using biological organisms is an established practice world over. Among the terrestrial animals, birds are most suitable indicators of climate change similar to fishes in aquatic ecosystem. Bird are more sensitive to the abiotic factors including other associated causes like habitat loss and impending its alterations (Panuccio et al., 2019). They are found to be susceptible to ability of adaptation, variation in rainfall, seasonal shift in weather events including cold waves, heat spells, longer humid days, etc. Besides these, using birds as an indicators, has several advantages like their wide range of availability, popularity and visibility, and above all tracking by birdwatchers (Hafner, et al., 1992; Panuccio et al., 2011). Their arrival and departure i.e. migrating phenomena are providing the best clues of seasonal climatic change or variations. These facts are well studied among the environmentalists and climatologists to link the impact of climate change.

Additionally, species interaction and synergistic impact of climate change associated with other factors viz., habitat loss, emerging disease, gap fill or canopy occupancy by other passerine or invasive species, may exacerbate the effects on domestic birds. The climatic change, alters the configuration of habitat and that lead to extrication of the birds species. In toto, 3.5oC surface temperature may increased by the year 2100 results in mass extinction of birds (Hafner, et al., 1992). The development of protected areas may get valued than ever, but still their design and objectives are need to be aligned with effects of climate change. Contrarily, most of the protected areas are climatically unstable and studies on fine scales has not been conducted thoroughly. Studying the extremes of weather which regulated by the long term climate change effects, the response of animals to these extremes allows for greater understanding and management of populations, as extremes can pose greater threats or benefits to various taxa at localized and short term conditions (Naveda-Rodríguez and Rush, 2023).

Among the gregarian birds in the world, Cattle egret (*Bubulcus ibis*) are widely spread. They have shown a rapid shift in the deteriorated climate of urban and rural settlement in the world. They are remarkably divers in the habitat and diet preferences, that made them popularised among the environmentalists. They roost in large flocks near water bodies and big canopy trees in the fringe of human settlement. Their collective behaviour has driven the attention due to unique roosting pattern which focused various evolutionary questions (Chiaradia et al., 2007; Kirsch et al., 2015). In the current study, climate change has kept in center and tried to put focus on roosting site alterations in different seasons.

It was aimed to understand the effect of weather variation on physiological and behavioral actions of individuals, for that we established hypothesis that weather or climate change does not change the number of individuals in flock and their migration. It

may also impact directly to the physiology of the bird that change the ecosystem linkages in general and birds availability in particular.

II. METHODOLOGY

2.1 Description of Study Area

The study was conducted in four major aggregation points in different directions in all the sites namely Saharsha, Madhepura, Supaul and Purnea districts. The sampling sites i.e. mostly roosting sites are near to the city towns within range of 3 km radius. In the present study, none of the sampling points were falling within the Important Bird Area (IBA) or conservation prioritized area. All the sites are influenced with the agriculture as well as urbanization impacts which have major contribution in maintenance of micro-climatic conditions. These areas made matrix of local and winter visiting migrant birds.

The Cattle Egret (*Bubulcus ibis*) population is best indicator of good agriculture productivity and shown a rapid decline in many agriculture and urban areas. They aggregates in these fringed areas and breeds extensively on tall patchy trees with big canopies (10–15 m hight) specially Pepal and Banyan. None other species of birds were found in the communal roosting sites during the present study.

2.2 Sampling and Data Collection

The arrival and departure of the individuals at point of time in same site were recorded in the identified roosting sites from 6.00 am to 8.00 am in the morning and 5:00 pm to 7:00 pm during 24 consecutive months between 2021 and 2023. Total 24 sampling occasions were attempted to get a fair average individual numbers in flocks and their movement in both winter and summer seasons. The observations of the roosting sites were recorded from a distance of about 50m from the roosting trees. The number of individual cattle egret was easy to encounter by naked eyes since they are large enough in size to count in groups. The time of arrival of first group and gathering of all the groups was also recorded to estimate the total time of the gathering in the roost site.

Total time taken for gathering/ aggregation = Time of the last arrival – Time of the first arrival

Latterly, the rate of aggregation of roosts at different sites were calculated to understand the climate effect on roots.
The seasonal variation was calculated on summer and winter months by sub-categorizing the weather into three categories following the classification drown by Youcefi et al., 2019 are as follows:

- *Good weather condition - the clear sky with no significant clouds and wind,*
- *Cloudy weather condition - the cloudy sky with moderate wind action may drizzling and*
- *Bad weather condition - thundering & raining with high wind action.*

III. RESULTS AND DISCUSSION

Only 3–4 trees were used as roosts by the Cattle Egret and thus were surveyed in the present study. Despite the availability of other nearby patches of trees (100 m way) which could potentially be used as roosts, no other roosting sites were recorded in the proximity.

Weather clearly affects the occurrence and abundance of organisms at fine temporal and spatial scales. Very little is explored about the extreme weather events and their influence on birds spatial and temporal movements. Climatic change either in means of temperature, precipitation, visibility conditions, etc., or extreme weather events are highly influenced the movement of birds (Chiaradia et al., 2007; Kirsch et al., 2015). Among the sampling sites, average bird flock size was between 20 and 36 numbers whereas settlements reached maximum up to 85% at Madhepura (SII) in winter season (Table-1). The pattern was varied slightly in summer months (Table-2), site SIII has shown maximum aggregation up to 79% followed by site-SIV (72%) and Madhepura site was least (SII) with 65% settlement of birds. It was observed that during diurnal or seasonal movements birds show a high selectivity of weather factors (Newton, 2008).

In general, extreme weather events can pose serious demographic reduction in diurnal migration intensity under fog conditions in raptors and non-raptor birds. Prominently, clear skies, bright sunny days, tailwind assistance are facilitated the movements while adverse weather conditions like heat and cold waves, windy precipitation and events of thunderstorms hampered the movements. Low clouds and foggy days have significant negative impact the orientation as well as disrupting collecting behaviour of birds (Chiaradia et al., 2007).

Table 1: Average Roosting population aggregation pattern in Winter season at different sampling sites

Sampling sites	Flock size	Average no. of birds arrived	% settled individuals	Total Population
Saharsha (SI)	30	69.7	80%	209
Madhepura (SII)	25	75	85%	207
Supaul (SIII)	36	75	72%	225
Purnea (SIV)	20	75.3	79%	226

In the site SII, variation in flock size (maximum in summer and minimum in winter) was observed which indicates the impact of urbanization along with climatic conditions. As the anthropocentric change in climate has been observe, frequencies of extreme weather events may become often, resulting to change in distribution pattern of ecological communities. Herein, we ascribe to the definition of extreme weather events, as posited in Stephenson et al. (2008), that an extreme weather events are one that imbues meteorological values that exceed typical pre-existing conditions. Therefore, in the present study, the group of *B. ibis* have also found to avoid flying in foggy conditions because of the low visibility experiencing within fog that may challenge their navigation system (Naveda-Rodríguez and Rush, 2023). Optimal thermal conditions may posing a substantial burden in limiting their soaring flight.

Table 2: Average Roosting population aggregation pattern in Summer season at different sampling sites

Sampling sites	**Flock size**	**Average no. of birds arrived**	**% settled individuals**	**Total Population**
Saharsha (SI)	30	60.3	79%	181
Madhepura (SII)	35	47.3	65%	142
Supaul (SIII)	26	49.3	72%	148
Purnea (SIV)	20	59.7	69%	179

The temperature variation in summer and winter climatic conditions in the present study area is huge that characterized by wind actions. Some days of winters are extremely cold with minimum temperature range of ~5ºC whereas, average range was 9-11ºC. It is likely to be predictable conditions that affect the size of flocks to move for foraging or restrict their flight rather isolate them from other non-migratory populations. Extreme weather have immediate effects on local communities, cause behavioral changes and redistribution of plant and animals, as well as interaction that affect the human–wildlife interactions (Stephenson et al., 2008; Panuccio et al., 2019). Due to the relative isolation and small size, population of Cattle Egrets in Madhepura and Supaul in winter months whereas Madhepura and Purnea in summer months that may be counted very precisely. Their small population may be of local origin as their flight ranging recovery in aggregation time after diurnal movements are stable. Generally, small populations are at range of risk after extreme weather fluctuations causing starvation and other anthropological disturbances (air and sound pollution, urbanisation, cutting of big trees, etc.). Numbers of Cattle Egrets dropped with minimal temperatures in the beginning of January while maximum in just after the cold spells. However, recovery of population may take 2-3 year after a severe crash in weather has been recorded for Cattle Egrets in Texas, Grey Herons in Britain (Hafner et al., 1992).

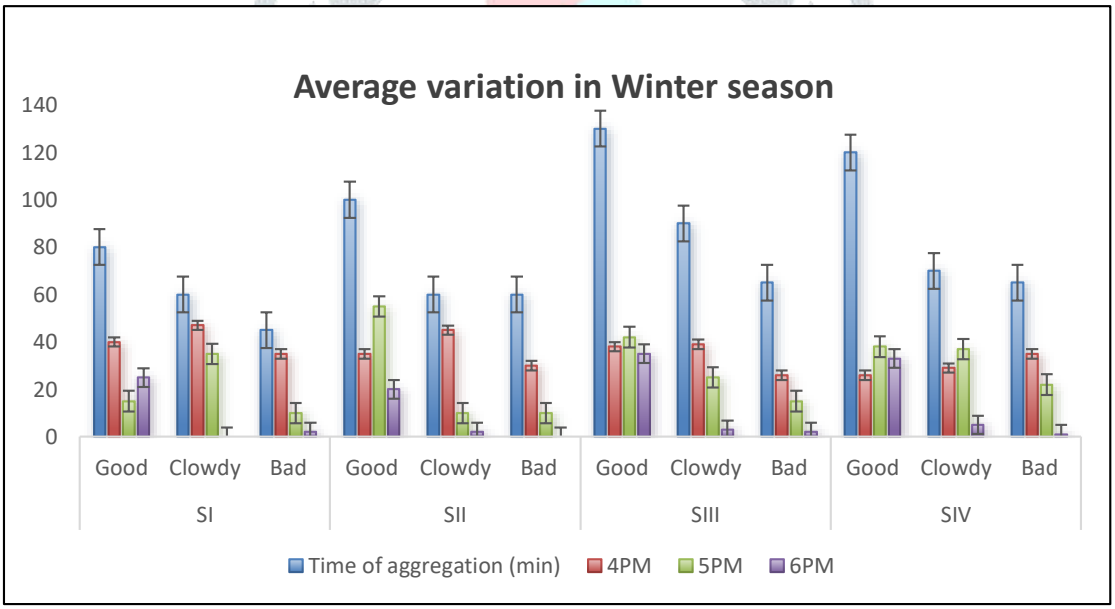

Figure 1: Total time of aggregation and maximum number of settlements in different time intervals (between 4 pm to 5 pm; 5 pm to 6 pm and 6 pm to 7 pm) estimates corresponding to climatic categorized conditions (Good, Cloudy and Bad weather) at all the sampling sites during the winter season between the year 2021-23

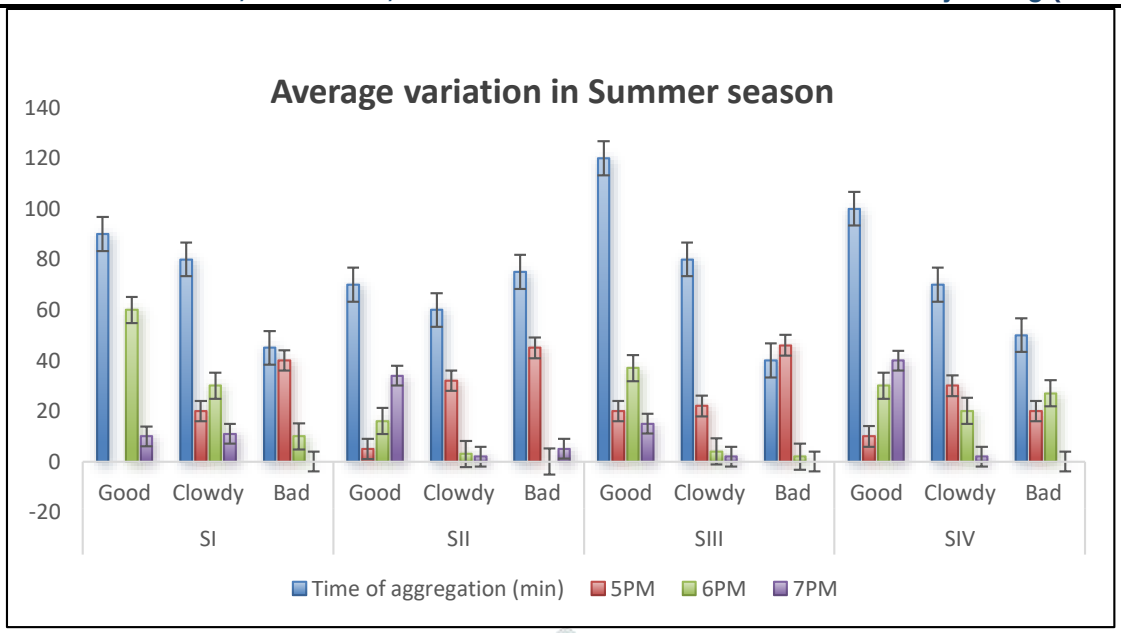

Figure 2: Total time of aggregation and maximum number of settlements in different time intervals (between 4 pm to 5 pm; 5 pm to 6 pm and 6 pm to 7 pm) estimates corresponding to climatic categorized conditions (Good, Cloudy and Bad weather) at all the sampling sites during the summer season between the year 2021-23

Cattle Egrets are ranged stable in all the sampling sites during study period despite the long cold spells and heat strokes waves, may be support of availability of food. These group are extremely adaptive to wide range of feeding habitats. A common winter food in the winter are earthworms, small insects from agriculture fields, when become inaccessible in summer months, becomes highly opportunistic, these birds switch to small rodents and aquatic fauna of near by water bodies (Youcefi et al., 2019; Panuccio et al., 2019). This was followed by a marked increase of the bird's lipid reserves until December and a progressive decline in January and February. Therefore, their poor body condition would compromise their breeding investment months after the weather event occurred (Schroeer and Kirchengast, 2018).

Besides their feeding behaviour, selectivity of big canopies, positioning against wind direction, availability of water bodies nearby in flying distance are the prerequisite of the site selection for roosting and resting sites. These fundamental requirements may be opted for the foresightedness of colonies possibly due to avoidance of predators, less resistance to wind action and optimal temperature near or above waters (Naveda-Rodríguez and Rush, 2023).

IV. CONCLUSION

We suggest directing future research on exploring the behavioural responses of soaring versus flapping migrants under different visibility conditions because these two groups may respond differently to these conditions due to the critical role of updrafts for soaring flight, possibly leading to differences in risks of collision with man-made structures. Future studies may also explore how specific movement and flight behaviour attributes such as altitude choice, flight speed and path tortuosity vary under different weather conditions.

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