PROCEEDINGS OF THE INTERNATIONAL SARUS CRANE WORKSHOP

12 January 2023

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Editor

Tran Triet

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Cover photo: Sarus Cranes at Tram Chim National Park, Vietnam, 2018.
Photo credit: Mr. Nguyen Truong Sinh, Ho Chi Minh City, Vietnam.

CONTENTS

PREFACE

The International Sarus Crane workshop was held online on 12 January 2023. There were 200 workshop registrants, many of whom were members of the Sarus Crane Conservation Group. The workshop began with a welcome speech from Dr. Richard Beilfuss, International Crane Foundation's President and CEO. The scientific program consisted of 7 presentations, covering most countries where Sarus Cranes are present.

The proceedings contain reports provided by the authors of the workshop presentations. The reports present detailed information about populations, habitats, threats and conservation strategies of Sarus Cranes in Australia, Cambodia, India, Myanmar, Nepal, Thailand and Vietnam. A study of crane movements in Cambodia was also included.

We thank Ms. Keren Becker and Ms. Sara Moore, International Crane foundation, for their help with English editing of the manuscripts.

Tran Triet, Ph.D
Southeast Asia Program Director, International Crane Foundation
December 2023.

OPENING REMARKS

Dr. Richard Beilfuss
President and CEO
International Crane Foundation
Baraboo, Wisconsin, USA

Dear Fellow Participants in this first meeting of the Sarus Crane Conservation Group:

It is an honor to welcome you today to this important meeting. I serve as President and CEO of the International Crane Foundation, and share in your passion for the iconic Sarus Crane, the world's tallest flying bird and flagship species for wetland conservation from South Asia to Australia.

I want to express my gratitude to Dr. Tran Triet for organizing this meeting. Dr. Tran Triet serves as Southeast Asia Program Director for the International Crane Foundation and has been a leader in Sarus Crane conservation in the Mekong Delta region for more than 20 years and a co-founder of the Mekong University Network.

This meeting is of great personal importance to me. My first work with the International Crane Foundation started in Vietnam during the 1980s, when we committed to securing the Sarus Crane and natural wetland conditions at Tram Chim nature reserve. I spent many years working at Tram Chim and came to love the wetland, the cranes, the surrounding communities, and the local champions who worked very hard to restore this wonderful place.

In 1990, we held an international Sarus Crane meeting at Tram Chim– including presentations from colleagues in India, Nepal, Vietnam, Cambodia, Thailand. At the time of that meeting, there were nearly 1000 Sarus Cranes in the wetlands of Tram Chim.

Over the 32 years since that time, the Sarus Crane situation has changed. Some of the changes are very worrying:

- The Southeast Asia population of Sarus Cranes in Cambodia and Vietnam has undergone a very rapid decline of more than 80% to fewer than 200 individuals today, with serious degradation of the Sarus Crane breeding grounds in northern Cambodia.
- The Southeast Asia population of Sarus Cranes in Myanmar is perhaps stable at about 500, but their breeding stronghold in the Ayeyarwady Delta is undergoing rapid transformation from traditional floating rice to industrialized rice production, the same transformation that led to the loss of more than a million hectares of Sarus Crane and waterbird habitat in the Mekong Delta during the 1980s and 1990s. The current political situation in Myanmar also makes it very difficult to advance the kinds of conservation efforts there that were successful in Vietnam.

- The Indian Sarus Crane population of India and Nepal remains the stronghold for the species, but we are increasingly concerned about impacts of climate change, wetland degradation, and other land use changes in the densely populated agricultural landscapes where they breed.
- The Australia Sarus Crane population status and trends are poorly known and range-wide research and monitoring is needed to determine if this secondary stronghold for the species is secure or in need of deeper conservation action.

We've also seen some amazing progress for Sarus Cranes over that past thirty year:

- In Vietnam, Tram Chim nature reserve is now Tram Chim National Park and the most significant wetland remnant protected in the Mekong Delta.
- The Phu My Lepironia Wetland Project is a global model for wetland conservation and sustainable livelihoods, linking Sarus conservation with wetland health, local income and employment, and natural wetland services.
- In Cambodia, several new protected areas are benefitting cranes and other wildlife. Many organizations are actively trying to secure the Sarus on their breeding grounds, testing innovative approaches.
- The Lumbini Crane Sanctuary was established in Nepal and supports several pairs of breeding Sarus Cranes and educational outreach to Buddhist pilgrims visiting Lumbini, the Birthplace of Buddha.
- Long-term research and monitoring in India indicate that diverse, productive farming landscapes even in very densely population human landscapes support large numbers of Sarus Cranes and many other species of conservation concern.
- The Sarus Crane reintroduction project in Thailand has been very successful. There is now a growing, self-sustaining population of Sarus Cranes in the wild. I am also excited that the successful Thai reintroduction effort can be now expanded to support Sarus Crane reintroductions in Vietnam to reestablish a breeding population in Vietnam that was lost during the war and bolster this declining population overall.
- The Mekong University Network is celebrating its 20th anniversary, with training in wetland management and research for many hundreds from government, universities, and NGOs.

I look forward to hearing all your presentations today, as you cover the key countries of the Sarus Crane range including India, Nepal, Australia, Myanmar, Cambodia, Vietnam, and Thailand. I hope that the presentations and discussions today will lead to better understanding of the population status, distribution, and trends of Sarus Cranes. I also hope new collaborations and ways forward will emerge to secure Sarus Cranes across their entire range, especially where urgent action is most needed in Cambodia and Vietnam. The International Crane Foundation is committed to providing technical expertise, conservation experience, and core funding towards ensuring a better future for Sarus Cranes throughout the region.

CURRENT KNOWLEDGE GAPS FOR CONSERVATION OF THE AUSTRALIAN SARUS CRANE

Timothy D. Nevard[1] & Elinor C. Scambler[2]

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1. Introduction

The Australian subspecies of Sarus Crane *Grus antigone gillae* differs significantly from extant Asian populations genetically and has a current unreliable population estimate of 5,000–10,000 birds (Mirande & Harris 2019, Nevard et al. 2021). The only reliably counted population of the Australian Sarus Crane (ASC), which winters on the Atherton Tablelands, is 826–3,255 birds (Scambler et al. 2020), constituting up to 19.5% of the estimated global population of 13,550–20,650 (Mirande & Harris 2019).

The ASC lives, forages and breeds in the same area and often alongside the much commoner Brolga *Grus rubicunda* (population estimate 50,000–100,000 birds: Mirande & Harris 2019) and its conservation therefore cannot be considered in isolation. Using genetic techniques, the current level of introgression between the species has been estimated at potentially 2.58% of the north Queensland population of ASCs and Brolgas (Nevard et al. 2020a: see Figure 8 below).

Figure 1: Australian Sarus Cranes (left) and Brolgas (right) at Kaban, on the Atherton Tablelands. (Photographer: TD Nevard).

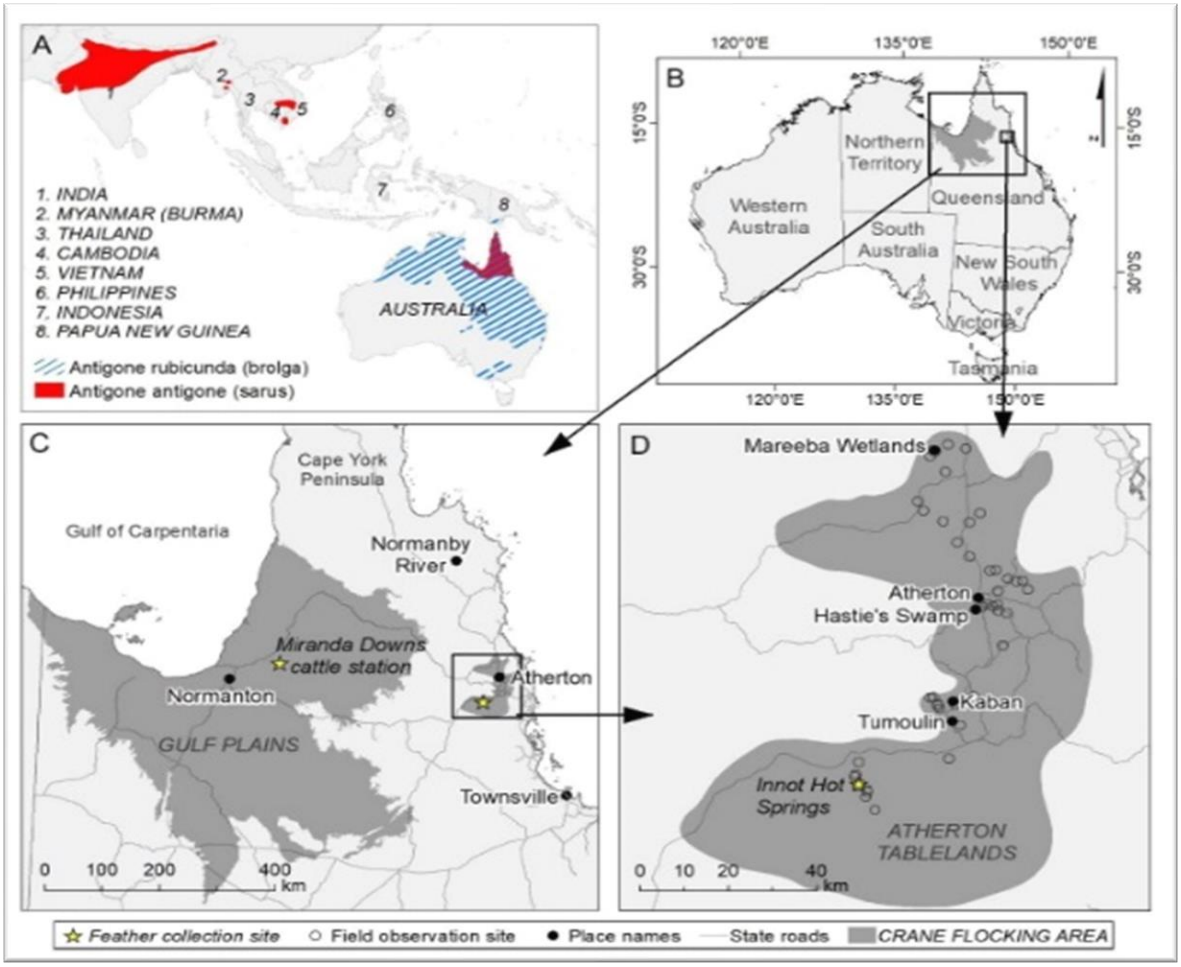

Figure 2: Distribution of Australian Sarus Cranes & Brolgas (A), with key localities in north Queensland (B, C & D) (Nevard et al. 2020a).

The currently accepted range of the ASC is shown in Figure 2 above (also Mirande & Harris 2019, p 324), with c.95% of this lying within north tropical Queensland. As can be seen, its range overlaps with that of the north Queensland distribution of Brolgas. Occasional outlier records of the ASC have also come from: (i) Kakadu, Northern Territory [c.7]; (ii) scattered on the northeast Queensland coast e.g., Townsville [c.10]; (iii) central Queensland [c.30]; and (iv) northern Western Australia [c.3] (Tanner & Jaensch 1988, Birdata 2023, eBird 2023).

2. Characteristics of Australian Sarus Crane

As indicated above, the ASC has a distinct genetic character, as well as certain phenotypic characteristics which distinguish it from Asian subspecies (see Figure 3 below). These include an often pronounced black 'beard' of filamentous feathers on its lower cheeks and throat; a variable length of red neck comb (sometimes barely extending below its throat); and is usually without any white plumage, which, if present, is not visually pronounced.

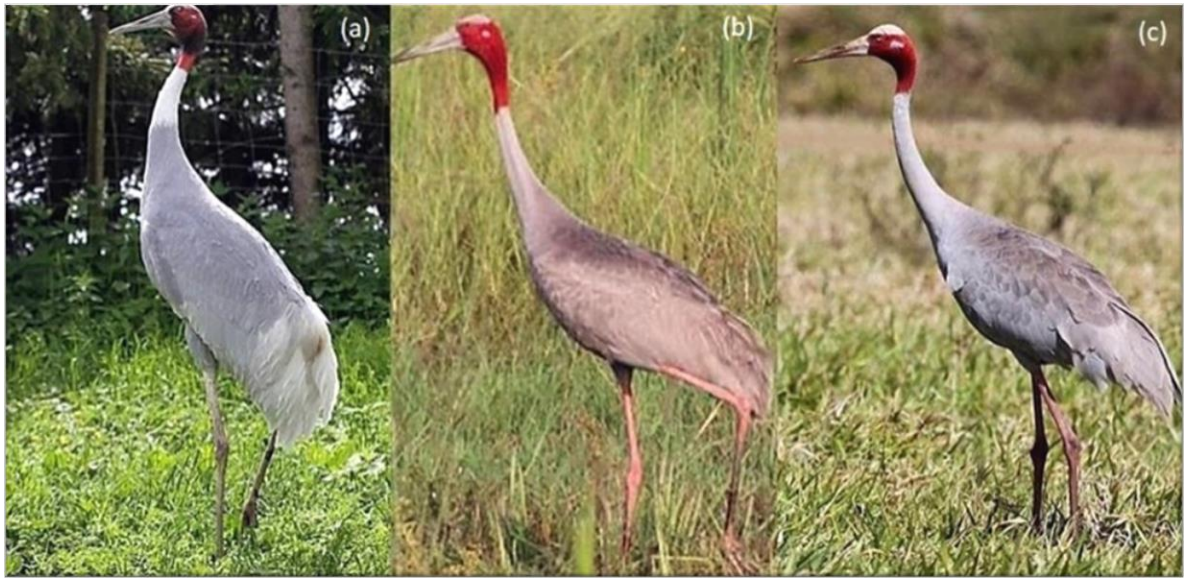

Figure 3: Extant Sarus Crane subspecies: (a) Grus antigone antigone South Asia; (b) G. a. sharpii Myanmar and Indochina; (c) G. a. gillae Australia. (Photographers: TD Nevard [a,c], R van Zalinge [b]).

Figure 4 below illustrates the genetic relationships between Sarus Crane subspecies (Nevard et al. 2020b). Samples are ordered by cluster, subspecies within clusters and a membership coefficient Q (y-axis). The diagram shows the marked genetic difference of the Australian *(gillae)* population from extant Asian subspecies and although only based on a single museum specimen (from the Smithsonian Institution) it shows potential evolutionary clustering with the extinct Philippine (*luzonica*) subspecies.

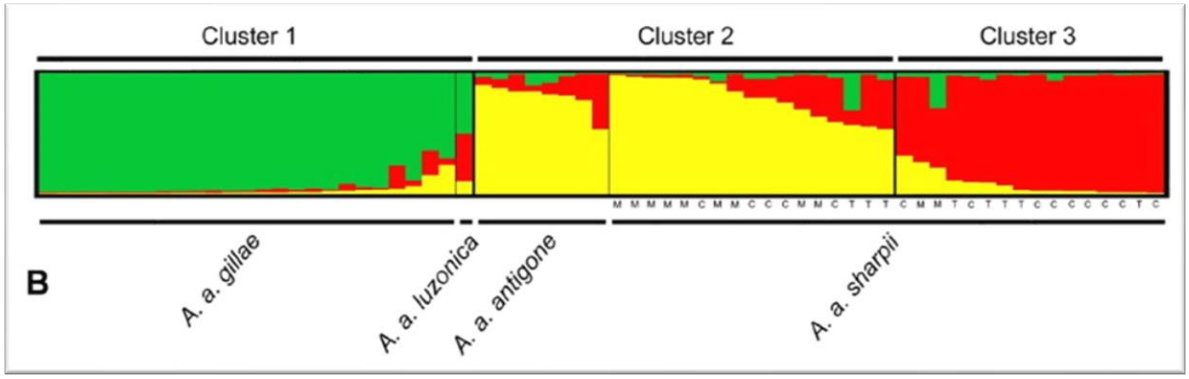

Figure 4: Bayesian cluster analyses of microsatellite data of Sarus Crane subspecies (Nevard et al. 2020b).

3. Key regions for the Australian Sarus Crane

As identified in Figure 2 above, two key areas for ASC conservation are the Atherton Tablelands (concentrated winter flocking) and Gulf Plains (breeding and dispersed winter flocking). The

Atherton Tablelands (see Figure 5 below) are just inland from Cairns and the Great Barrier Reef and are separated from the coast by the rainforest of the Wet Tropics World Heritage Area. The Tablelands form one of Australia's most biodiverse regions, as well as having its most diverse agricultural cropping (Nevard et al 2019b). The north, centre and extreme south of the region are characterised by irrigated agriculture, which is used by both ASCs and Brolgas for foraging and flocking during the post-breeding 'dry' season (June-December), mainly on waste maize, sorghum and peanuts following harvesting (Nevard et al. 2019a). Roosting of both species is principally in man-made wetlands, with only two – Hasties Swamp, a natural wetland, and the Mareeba Wetlands, man-made – with a conservation tenure (Scambler et al. 2020). The maximum number of roosts counted in the annual (since 1997) Birdlife Australia Atherton Tablelands Crane Count is 19 (Scambler et al. 2020) but it is likely that a few small roosts remain unknown in at least some years.

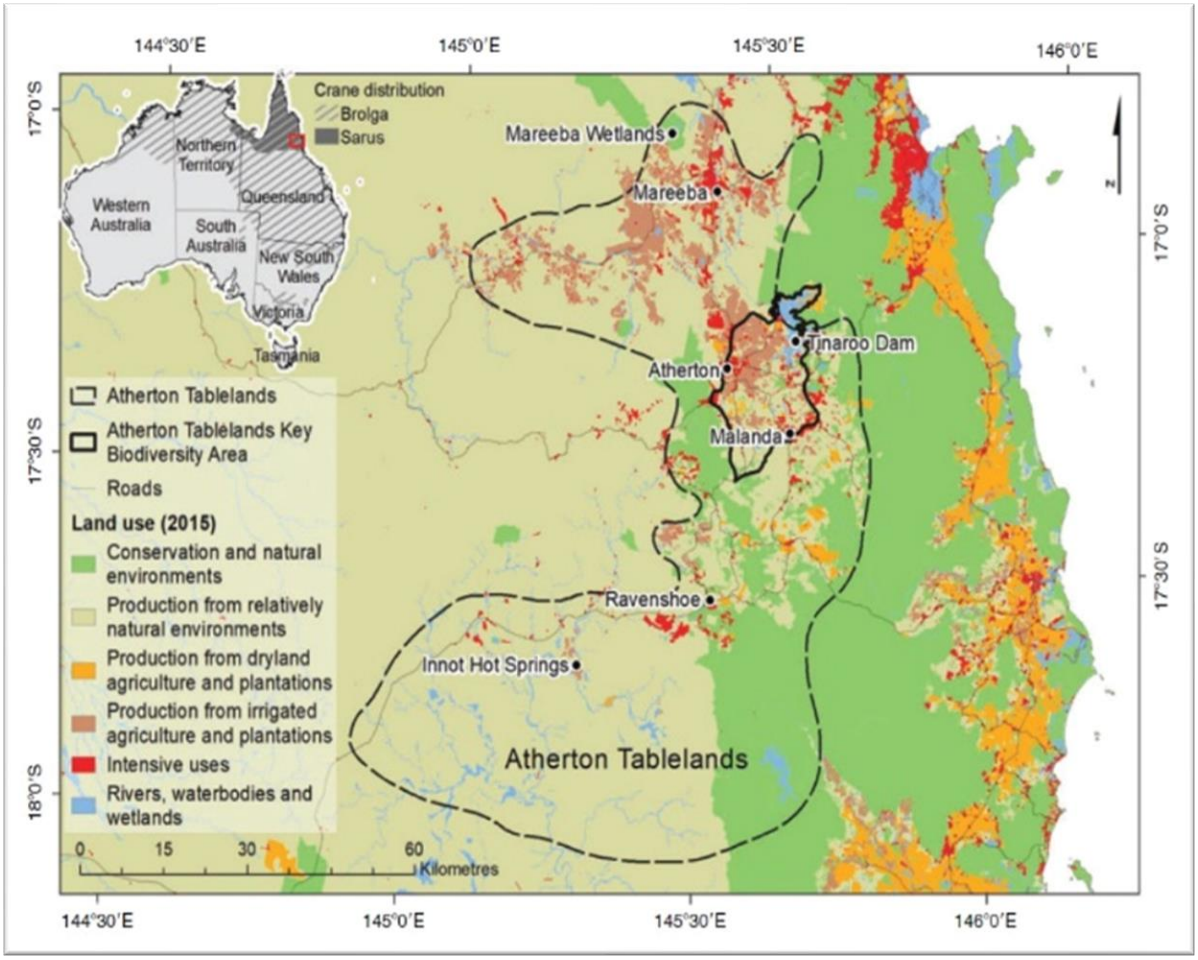

Figure 5: Land use on the Atherton Tablelands (Nevard et al. 2019a).

Figure 6 below is based on 44,554 visual observations over three years (Nevard et al. 2019b): 27,361 (61.4%) being Brolgas; 13,381 (30.0%) ASC; and 84 (0.2%) hybrids (3,728/8.4% of observations were unidentifiable to species). Brolgas are commoner on less fertile soils in the

south of the Atherton Tablelands and ASC commoner on the fertile, volcanic soils in the north (within the Atherton Tablelands KBA). Hybrids ('Sarolgas') are more common in areas where Brolgas dominate, especially in the far south of the Tablelands. However, a recent (2021/2022) factor to note is that cotton has replaced maize and peanuts in the far south of the Tablelands, and numbers of Brolgas wintering there have abruptly declined from almost 2,000 to as few as 45 and numbers of wintering Sarus Cranes have fallen from an average of 58 to as few as 4 (Scambler et al. 2020, TD Nevard unpublished data), although unpublished data from 2023 indicate that numbers may have picked-up with the reintroduction of grain cropping .

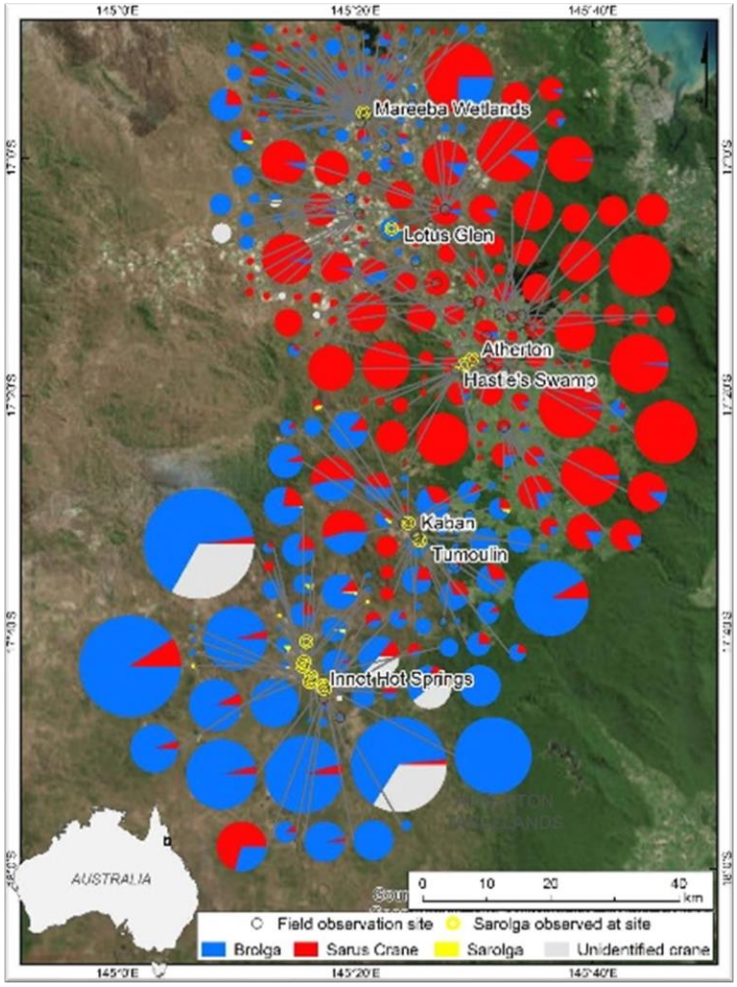

Figure 6: Visual observations of Australian Sarus Cranes and Brolgas and their hybrids (Sarolgas) on the Atherton Tablelands (based on Nevard et al. 2020a).

The other key region for the ASC is the Gulf Plains (see Figure 2 and Sundar et al. 2019), which abuts the Gulf of Carpentaria some 500 km west of the Atherton Tablelands. ASCs and Brolgas breed on the Gulf Plains (ASC are also suspected to breed in Cape York Peninsula) from January to March and remain with their fledged young until late May/early June, when they either

disperse within the Gulf Plains region or migrate to the Atherton Tablelands (Mirande & Harris 2019, Sundar et al. 2019, Nevard et al. 2020a). A key breeding location for both ASCs and Brolgas is Delta Downs cattle station on the coast of the Gulf of Carpentaria, north of Karumba and Normanton (see Figure 7 below), where survey work undertaken by George Archibald of ICF (Archibald & Swengel 1987), and others (TD Nevard unpublished data), indicates that ASC nest in thicker woodland and Brolgas in more open habitats (see also Sundar et al. 2019). Both appear to have a symbiotic relationship with cattle, which graze the margins of small wetlands, making them more suitable as nesting sites.

Figure 7: Nest locations of ASCs (red), Brolgas (blue), unidentified cranes (fawn) on c.100km² of Delta Downs cattle station, Gulf Plains. A further eight Brolga nests (no ASC nests) were located 10-30km to the NE of Karumba, in open swampy grassland habitat. (TD Nevard, from data collected during an ICF helicopter reconnaissance survey in 2019)

4. **Introgression**

Figure 8 below shows the degree of introgression identified in Brolgas and ASCs in north Queensland (Nevard et al 2020a). The black rectangle encloses 9 clear hybrids (Sarolgas) and the basal bar indicates the origin of the samples: green - Atherton Tablelands; orange - Gulf Plains; blue - captive Brolgas; magenta - captive Indian Sarus Cranes; and red - captive Australian Sarus Cranes.

Forty-one genotypes were encountered twice, in 11 cases in both the Gulf Plains and Atherton Tablelands, proving migration between these areas. Four 'Sarolgas' had pure Brolga allele combinations, so were back-crosses.

As indicated above, 2.58% of birds sampled were hybrids, which does not indicate a critical issue for conservation but maintaining a periodic watch on the regional crane population using shed feathers could be helpful in monitoring any change.

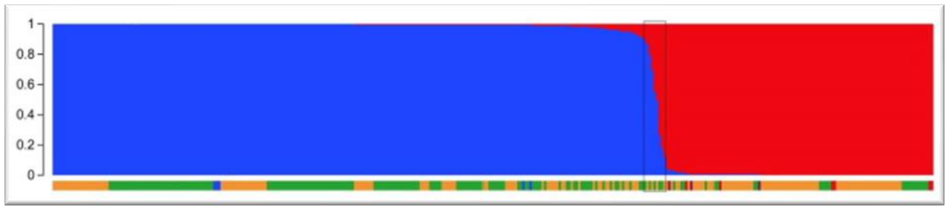

Figure 8: STRUCTURE plot of 348 Brolgas (blue) and Sarus Cranes (red) ordered according to decreasing Brolga membership coefficient (Q) (Nevard et al. 2020a).

5. Interactions between Australian Sarus Cranes and Brolgas

As ASCs and Brolgas occur in the same region and frequently alongside each other in the same habitat, understanding their behavioral and ecological relationships is important for ASC conservation. There has been little research around these relationships, especially in the vicinity of breeding locations, but it is important for the conservation of the ASC that its relationships with Brolgas are clarified.

Figure 9: ASCs and Brolgas are frequently together, with male Brolgas often dominant in pair-pair interactions. (a) At this dam in the Gulf Plains, the ASC pair retreated after being threatened by the male Brolga; (b) At the Mareeba Wetlands on the Atherton Tablelands, both species roost together and almost always avoid aggressive interaction. (Photographer: TD Nevard).

6. New Guinea

Brolgas are well-known in southern New Guinea (both in Papua New Guinea and Indonesia) and the presence of Sarus Cranes has been suggested for some years, but no direct photographic evidence yet exists. Figure 10 below shows the former Lake Carpentaria (bigger than current Lakes Victoria or Superior) and indicates the former geographic and ecological connection between northern Australia and southern New Guinea (Joseph et al. 2019). It is possible that both Sarus Cranes and Brolgas could have occupied Lake Carpentaria's northern (Papuan) shores as they do now on its former southern shoreline of the Australian Gulf Plains.

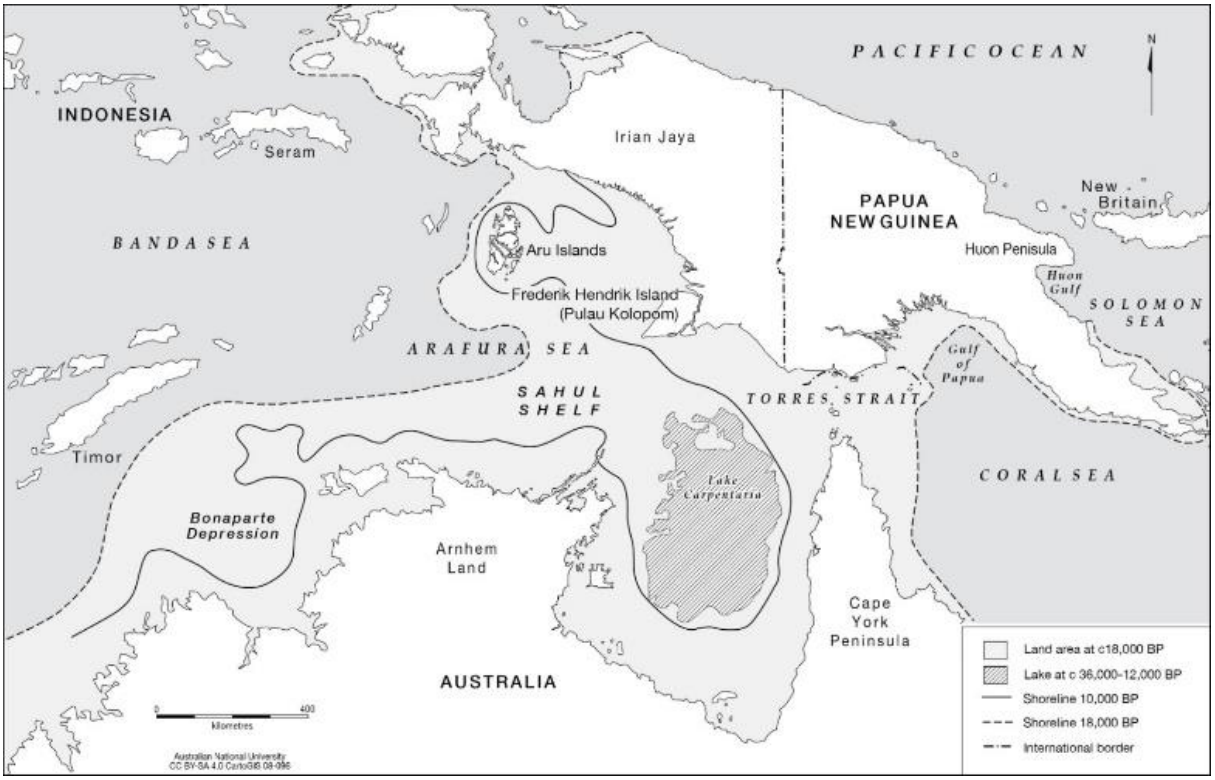

Figure 10: Shorelines of 'Lake Carpentaria', the Gulf of Carpentaria, Arafura Sea and Torres Strait 36,000-10,000 BP (CartoGIS Services, College of Asia and the Pacific, Australian National University, used under an Attribution-ShareAlike 4.0 International (CC BY-SA 4.0) licence).

Anecdotal statements by local people in some villages in the lower River Fly floodplain were made supporting the presence of both Brolgas and Sarus Cranes during a 2020 survey undertaken on behalf of the Ok Tedi Development Foundation (OTDF) and The Cairns Institute. Further fieldwork in October 2022 was again supported by OTDF and The Cairns Institute but three years of extreme flooding caused by La Niña conditions thwarted crane observations (although local people at Suki reconfirmed their belief in the presence of Sarus Cranes). An indication of the paucity of western ornithological knowledge in New Guinea is indicated by Figure 11 below. Local people know that Australian Pelicans *Pelicanus conspicillatus* nest in New Guinea, but the latest bird guides say they don't!

Figure 11: Australian Pelican Pelicanus conspicillatus eggshell in southern Trans-Fly region (Bensbach River floodplain), proving breeding occurs (Photographer: TD Nevard).

7. Key knowledge gaps for the conservation of Australian Sarus Cranes

1. Confirm ASC* population size in Australia.
2. Investigate ASC* breeding and population ecology and behaviour in Australia.
3. Investigate Gulf Plains ASC* dry season social model.
4. Confirm ASC* regional range (presence/absence in New Guinea).
5. Establish current and future threats to ASC*.
6. Establish diet flexibility for ASC*.
7. Establish roost site characteristics for ASC*.

*Australian Sarus Crane

7.1. Confirm Sarus Crane population size in Australia

The most critical 'unknown' for Australian Sarus Cranes (ASC) is the number remaining in the Gulf Plains and in Cape York Peninsula during the non-breeding season (rather than migrating to the Atherton Tablelands). The annual (early September) Atherton Tablelands roost count gives a reliable minimum estimate in the counted (wintering) area. However large numbers of cranes are known to remain in the Gulf Plains breeding areas and potentially Cape York Peninsula all year. A simultaneous or near-simultaneous survey, as widespread as possible, would give an additive estimate /number and greatly improve the overall population estimate. It would also add some data to the scarce information on precise wintering habitats. (e.g., Regional Ecosystems).

Conventional aerial surveys are not effective for Sarus Cranes in tropical Australia, as their presence is often obscured by vegetation and the problem of distinguishing them from Brolgas from the air is only possible in short-range surveys by helicopter (or ultralite). The Atherton Tablelands' (roost) survey technique is not applicable in the Gulf Plains and Cape York Peninsula, as: (i) few communal wintering roosts are known outside the Tablelands; (ii) there would be major resourcing issues across such a wide area; and (iii) there are access problems and dangers in isolated wetlands, especially from numerous Estuarine Crocodiles *Crocodylus porosus*.

Instead, we recommend a straightforward, well-structured, wide-scale roadside survey to be undertaken over a week to10 days by volunteer teams based out of Normanton (trialling the methodology in its first year, potentially extending subsequently to Cape York Peninsula). Timing would be immediately following the Atherton Tablelands' count in September, to ensure that no migration movement results in 'double counting'. We envisage the count being undertaken annually, for a minimum of three years.

7.2. Increase knowledge of breeding and population ecology of ASC

Surveys in six catchments in the Gulf Plains during fledging in 2017 (Sundar et al. 2019) found 60% of ASC pairs with chicks, an exceptional year with the highest breeding success of any crane species in the world. The long-term average is likely to be much lower: between 2013-16, Atherton Tablelands' Brolga flocks included 9.1% first year juveniles and ASC flocks 9.8% (Nevard et al. 2020a). Ironically however, nests and eggs of the ASC are very little known, with many features such as site selection, incubation period and time to fledging based mainly on overseas data; and (ii) although concentrated in the Gulf Plains, ASC breeding is strongly suspected but not yet proven on eastern and western Cape York Peninsula, such as Rinyirru (Lakefield) National Park and New Mapoon. Also unknown, are the limiting factors to population growth. Pre-fledging mortality is unknown. There is no perceptible attrition in first-year birds while wintering on the Atherton Tablelands (JDA Grant unpublished data 1997–2022) so we presume that unknown (possibly multiple) factors occur after juveniles separate from their parents in the following breeding season. Some of these factors must be significant, but the Gulf Plains (not including Cape York Peninsula) covers over 220,000 km^2 of tropical savanna and woodland, a vast area to survey and very sparsely settled.

We acknowledge that these are serious gaps in ASC conservation knowledge, but there are major safety and logistics issues in accessing Wet Season floodplains for ground-based surveys, including flooded roads and danger from Estuarine Crocodiles. Helicopter-based surveys are feasible but expensive. We therefore suggest that this work (or widespread Dry Season surveys of risks to immatures) should only become a priority if a major threat to ASC nesting, or immature survival, were to be become apparent. At this stage, unless land use radically alters, we see no immediate threats warranting such major investment.

7.3. Confirm dry season social models/flocking areas for ASC

There are two social models for ASC populations in the non-breeding/Dry Season: (i) birds spread out widely across a region in pairs, family parties or small groups; and (ii) concentrated in specific areas, with foraging flocks and communal night roosts. Thus far, the only documented Dry Season flocking concentration of ASC is on the Atherton Tablelands.
It is important for ASC conservation that all flocking areas/sites are identified, and unpublished records published. Identification should be relatively straightforward, as the Gulf Plains and Cape York Peninsula are visited by significant numbers of birders, and local Indigenous rangers and conservation organisations now cover large parts of both areas and contact should be straightforward. Scambler (2022) identifies ways in which eBird volunteers can contribute to this knowledge.

7.4. Confirm presence/absence of Sarus Cranes in New Guinea

Rumours of the presence of Sarus Cranes in New Guinea have existed for some years. Recent surveys of potential range in the River Fly floodplain (Trans-Fly) have yielded no direct evidence but cause for optimism. Local hunters distinguish between Sarus and Brolga (which are well-recorded in New Guinea) and floodplain habitat is comparable to Australia (TD Nevard, pers. obs)., but no photographs or specimens have yet to emerge (efforts are in hand).
The Ok Tedi Development Foundation and its subsidiary, WestAgro Holdings are developing agricultural projects to replace mining income for local communities and are keen to partner with ICF and other conservation bodies to establish conservation-led branding for their produce in a similar way to 'Ibis Rice' and other initiatives (TD Nevard pers. obs.). Should Sarus Cranes be found in the Trans-Fly region, opportunities for the establishment of sustainable conservation measures should therefore be possible (as already intended for Brolgas). In the meantime, a genetic investigation of New Guinea Brolgas, potentially using shed feathers (as recently used successfully in Australia), could establish the extent of any differences with the Australian population and whether there has been introgression with Sarus Cranes.

7.5. Identify current and emerging threats for ASC

Threats include invasive weeds *Cryptostegia* and *Mimosa pigra are* affecting Gulf Plains wetlands e.g., Delta Downs (G. Archibald and TD Nevard pers. obs.). There are ongoing rumours of persecution of cranes in cropping areas but only one prosecution and conviction for poisoning (of Brolgas: Scambler 2015). Changes to cropping regimes are occurring in ASC range, with an accelerating move from arable to perennial crops (in which cranes do not forage) on the Atherton Tablelands, but extensive development of cropping in the Gulf Plains & Cape York Peninsula. Introgression with Brolgas is not yet at a critical level but should be monitored. The effects of nationally significant (200+ turbines) wind infrastructure development on the periphery of the ASC-listed Atherton Tablelands Key Biodiversity Area (KBA) have yet to be understood but could

be severe. Climate change-related sea level rise could also be a factor on the Gulf Plains. Egg collection has been flagged as an issue on Indigenous land, but no published data exists.

Given its extensive land range, current and emerging threats for Australian Sarus Cranes (ASC) are, as yet, unlikely to cause significant issues for the Australian population. However, the combined impact of nationally significant wind infrastructure development, climate change and cropping shifts on the Atherton Tablelands could be significant for the ASC's only currently recognised (and likely largest) Dry Season flocking area and ASC-led KBA. This could precipitate a relocation of flocking away from the Atherton Tablelands and towards newly cropped areas in the Gulf Plains and Cape York Peninsula, where crane/agriculture conflicts are already rumoured to be occurring.
Climate change-related sea level rise in the very flat Gulf Plains could eventually prove to be a significant factor for ASC, as the currently positive land level balance is tipped in favour of salt water encroachment. This could lead to the apparent symbiosis between extensive cattle grazing and crane occupancy being adversely affected by significantly diminishing access to flat, seasonally freshwater-inundated grazing land.

7.6. Investigate ASC diet and dietary flexibility

Dietary studies for both species of Australasian cranes are minimal. Brolgas can tolerate saline forage by excreting salts via a special gland but salinity tolerance in ASC food and nesting is unknown. Following on from Section 5 on Threats, the issue of ASC salinity tolerance is highly relevant if climate-related sea level rise occurs in the Gulf Plains, extensively affecting ASC breeding sites and feeding sites. The use of natural versus agricultural forage is also significant, as arable crop residues on the Atherton Tablelands, on which a very significant proportion [~50%] of the ASC population relies in the Dry Season, decline to unsustainable levels due to cropping shifts – especially if newly-developing alternative cropping areas prove unsuitable for cranes.

7.7. Identify ASC roost site characteristics

Differential characteristics of known roost sites on the Atherton Tablelands selected by Australian Sarus Cranes (ASC), as compared to those selected by or shared with Brolgas, are not understood. Without a much better understanding of this major crane distributional factor, appropriate conservation decisions cannot be properly made.
Identification of the key factors in crane roost configuration and location would require dedicated research, including the collection of data on roost features when actually in use e.g. water depth, extent, configuration, actual disturbance (not just proximity to dwellings or roads), proximity to cropping, adjacent land use, riparian and aquatic vegetation, etc. As only two roosts on the Atherton Tablelands are in a conservation tenure, voluntary protection by private landholders is hence a key element for the future of cranes on the Atherton Tablelands and probably across tropical Australia.

ACKNOWLEDGEMENTS, FUNDING & SELECTED REFERENCES

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SARUS CRANE (GRUS ANTIGONE) POPULATION, HABITAT, THREATS AND CONSERVATION STRATEGIES IN INDIA

Jatinder Kaur
UPL Sarus Conservation

1. Distribution Range of Sarus Crane

The Indian Sarus Crane Grus antigone is mainly found in north, northwest and central India, and as we go south, its population decreases. It is found in Punjab, Haryana, Uttar Pradesh, Western Bihar, Jharkhand, Rajasthan, Gujarat, Madhya Pradesh, Chhattisgarh and northern Maharashtra. The largest numbers of Sarus are found in and Uttar Pradesh, Gujarat and Rajasthan. Highest resident and breeding populations in Uttar Pradesh, Gujarat and Rajasthan in North and North West India (Gole 1989).

Outside India, it is still found in the terai of Nepal, but has become extinct in Pakistan and Bangladesh due to hunting (Rahmani et.al 2019). Sarus is the largest bird of India, and the tallest flying bird of the world. Like most crane species, Sarus is also dependent on marshes and lakes for foraging, resting and nesting, but being adaptable, it frequently uses flooded agricultural fields for foraging and nesting. These fields are surrogate marshes for Sarus. It is not found in large deep wetlands. It is a bird of floodplain shallow seasonal marshes, either developed due to flooding of large rivers or/and created by monsoonal deposition in depressions. most of these marshes are now more or less taken over by humans for agricultural or industrial purposes, therefore, Sarus has no choice but to live in crop fields. As Sarus is basically a bird of open marshes and jheels with good submerged vegetation and some emergent vegetation, it is, however, frequently found in paddy and wheat fields, particularly when they are irrigated. It is also found in harvested paddy/wheat fields to feed on fallen grains. It is also seen in wet grasslands, particularly found on the edges of drying up shallow jheels and lakes (Rahmani et.al 2019).

Historical distribution range of this species from the year 1890 (Murray, 1888-1890) to 1980s (Gole, 1989) to the year 2000 (Sundar et al. 2000) the Sarus had always been abundant in the state of Uttar Pradesh. The state is considered a stronghold of the Sarus Crane population since it supports the highest population of this species in country. The Wildlife Institute of India's countrywide Sarus census conducted during the years 1999 to 2001 had revealed the state of Uttar Pradesh to support the largest population as compared the other states in its distribution range. Distribution range has contracted towards the north and west of the Indian subcontinent (Sundar et al. 2000) and its population is considered under declining trend (Archibald et al. 2003). Once common and widespread in several north western states of India, the distribution and concentration of the Sarus Crane is now restricted to few states like Assam, Gujarat, Haryana,

Madhya Pradesh, Maharashtra, Rajasthan, and Uttar Pradesh (Gole, 1989, Singh and Tatu, 2000; Sundar et al. 2000) (Fig1.).

Sarus Cranes are primarily concentrated along the Gangetic floodplains in Uttar Pradesh state in India (~150000). Significant populations also occur in Gujarat and Rajasthan states in western India (~3,000), and small, scattered populations are known from Madhya Pradesh, Maharashtra, and Bihar states (~500) in central India (Mirande & Harris 2019).

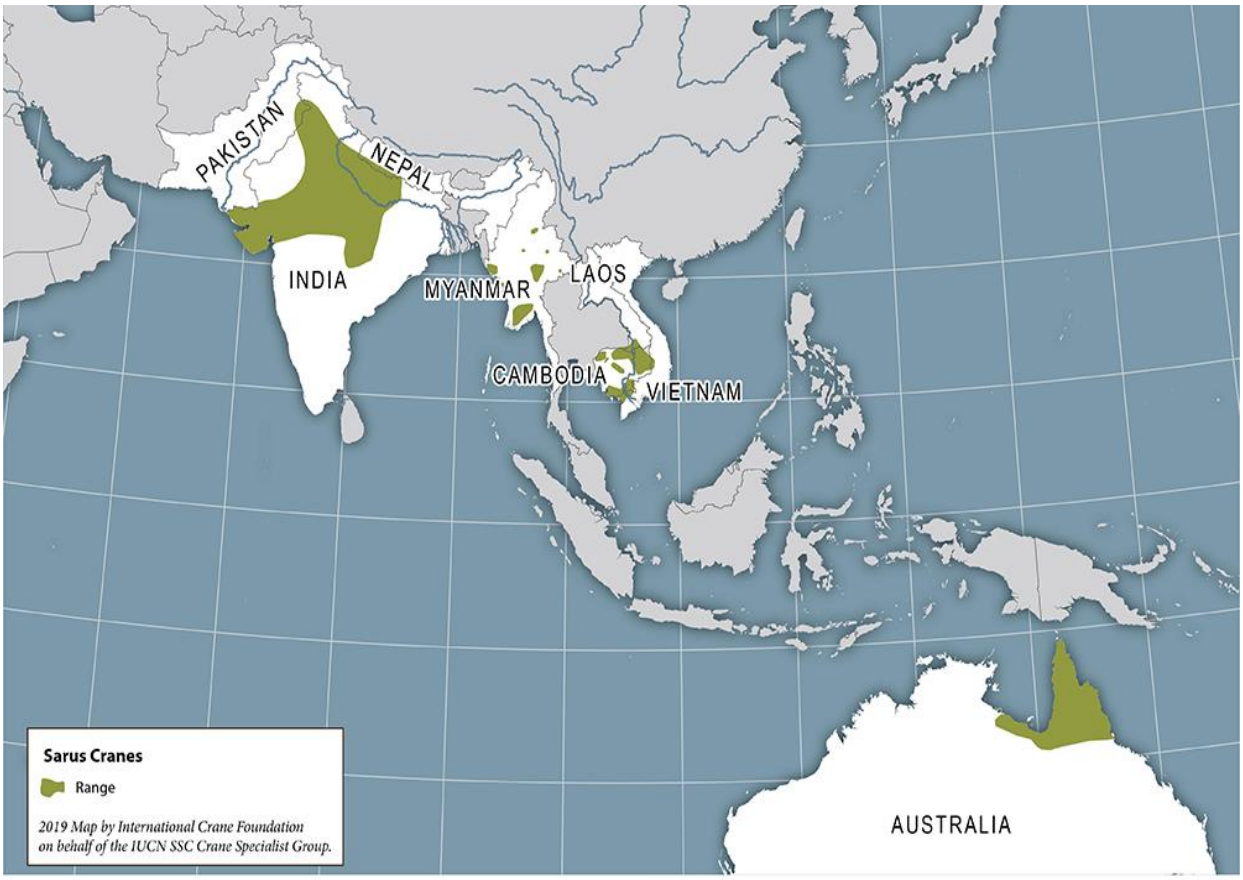

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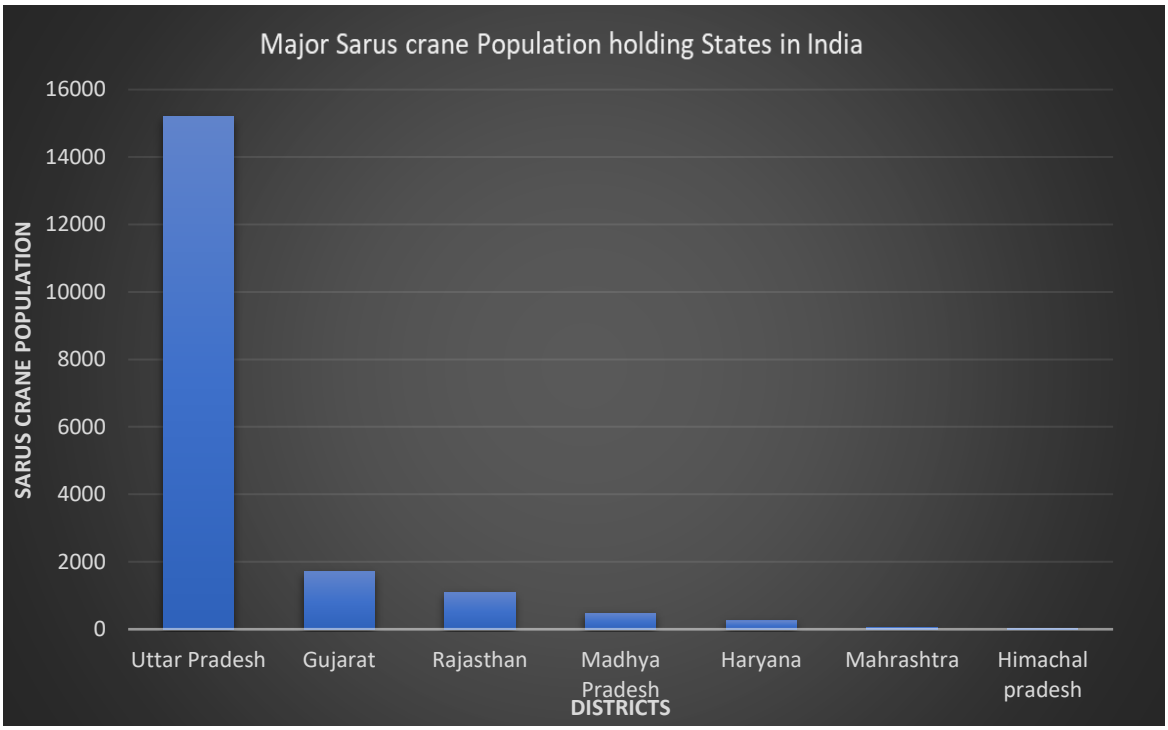
Fig:1. Distribution Range 2019 (IUCN SSC Crane Specialist Group)

Mahendiran et al. 2020 showed the population of Sarus Crane in Uttar Pradesh was estimated at 15,193 ± 2,905 (mean±SE) individuals (Coefficient of Variation (CV) of 0.191, while Lower Confidence Interval (LCI) was 10465, Upper Confidence Interval (UCI) was 22055, (df = 340.23). Rahmani et al.2019 locate Sarus in more than 1,000 sites in seven districts of Central Uttar Pradesh. A total of 1,384 Sarus were seen. However, this figure should be taken with caution as many sightings could be duplicate, and these surveys were not done simultaneously. Community based sarus population estimation conducted in Eastern Uttar Pradesh by Wildlife Trust of India (WTI). In 10 district of eastern monitoring Sarus crane since 2017 onwards and counted approx. 2550 Sarus.

Gujarat is the second most important State as far as the global population of the Sarus crane is concerned the first being Uttar Pradesh. (Annex 1).



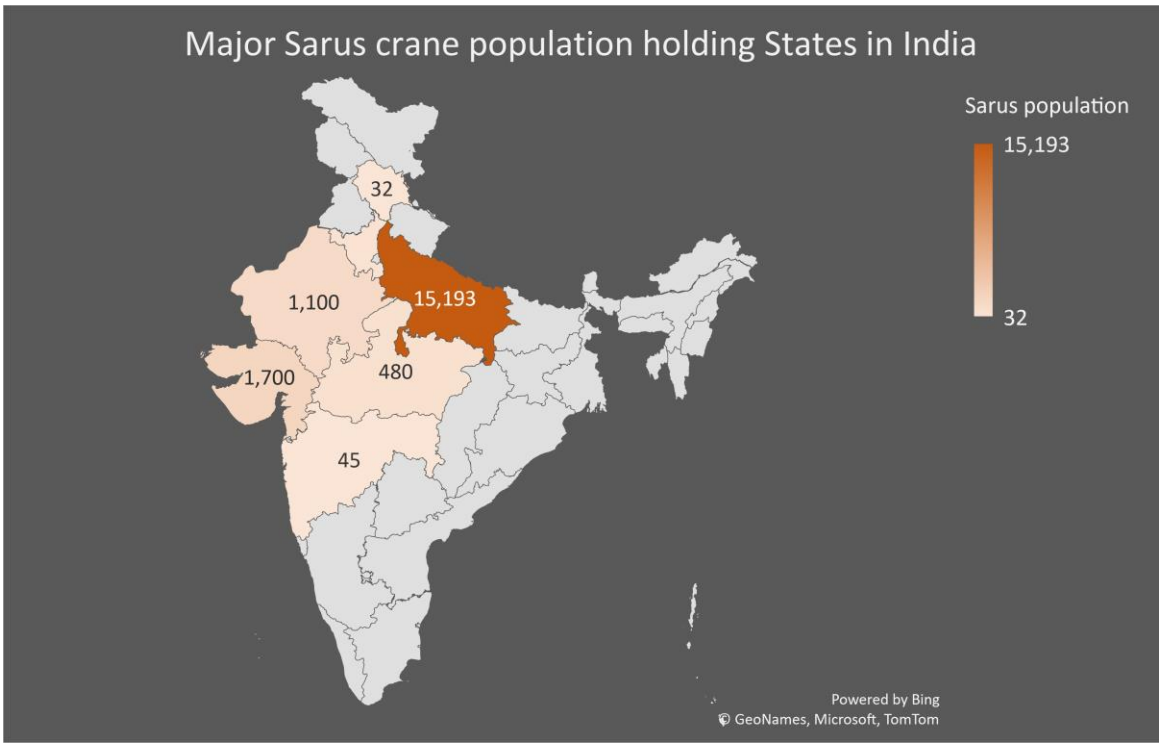


Fig:2. Major Sarus crane Population holding States in India.

2. Sarus Habitat

Sarus is the largest bird of India, and the tallest flying bird of the world. Sarus optimal habitat includes a combination of marshes, ponds, fallow lands, and cultivated lands. Sarus is basically a bird of open marshes and lakes with good submerged vegetation and some emergent vegetation. Adult pairs use cultivated fields, fallow land, and other drier habitats, as well as flooded fields, rice paddies. Across the landscape, Sarus nesting in fields, along canals and irrigation ditches, beside village ponds, and in shallow marshes, rice paddies, jheels, and reed beds. These fields are surrogate marshes for Sarus. Sarus Cranes utilize a wide variety of landscapes, depending on the food availability, cropping pattern and other seasonal factors. Increasing human demands on India's wetlands may be contributing to the decline of the Sarus Crane by reducing the recruitment rate within the population.

That is important for Sarus is a small shallow undisturbed lakes of 5-10 ha where it can nest and raise its chicks. The normal pattern of rainfall for 3-4 months is also important. neither are these lakes safe from human overuse nor do we expect that normal rainfall pattern will remain, due to climate change. it will be an understatement to say that most wetlands are under severe stress and some may not even survive the next few years, leaving Sarus with sub-marginal habitats such as paddy fields to nest(Rahmani et al.2019).

The Indo-Gangetic region consist of the massive flood-plain of the river Ganges and the associated wetlands (moist grasslands, ponds, lakes and agricultural fields. Nesting Locations of Sarus Crane recorded by researchers. Number of nests in paddy fields in Kheda district, Gujarat: Most preferred habitat by Sarus Crane. In Uttar Pradesh maximum number of nests recorded in wetlands of Uttar Pradesh. Habitat selection by Sarus crane for nesting: Preference of nesting is in agriculture field is more in Gujarat as compared Uttar Pradesh (Rahmani et al 2019).

3. Threats

Sarus Crane lives in human-dominated landscape, increasing human population, changes in the crop pattern, and rapid industrialization are putting subtle stresses on the Sarus populations. Sarus needs small shallow wetlands to breed, raise chicks and forage. The electrocution or injury after collision with powerlines becoming a major threat to Sarus. Rahamani et.al 2019 studied 30 wetlands and given emphasis to find out the presence/absence of powerlines and their distance from the wetlands. They suggested wetlands should be included by the State Wetland Authority, and some may be included in the national Wetland Conservation Programme of the MoEFCC.

Kaur et.al studying the threats and mortalities of the Sarus Crane in the landscape, between April 2016 and January 2023, total 37 causalities of Sarus Crane were recorded from Kheda and Anand districts of Gujarat. Out of which 20 were found injured and 17 were found dead due to electrocution and other unknown reasons. Of these the highest number of injured birds were found in the years 2020 and 2021 whereas highest number of dead birds were found in the years 2016 and 2022. On an average two birds are found injured or dead each year and electrocution is the major reason for mortalities 54%.

Habitat destruction and modification

Wetlands: Wetlands are under tremendous pressure of human use, drainage and conversion to agriculture, housing colonies, etc. Protection of small village wetlands. Survey to be done to find out the status of natural floodplain wetlands. Natural and also man-made wetlands should be mapped, demarcated and protected from encroachment. Numerous shallow lakes with Water Chestnut cultivated: Sarus generally abandons such wetlands during the singhara cultivation period. (Dr. Rahmani Pers.comm.). As per published report 97% of natural wetlands are less than 50 ha and these are the wetlands that are suitable for the Sarus crane. Natural habitat loss (marshes/wetlands), drainage of wetlands for paddy cultivation. Man -made habitat loss (dam/canal siltation, canal seepage). Open -wire electrification in Sarus dominant landscape. Increasing stray dog populations.

Egg stealing, Linear infrastructures (roads, bridges, railways) Kaur et al. 2008, Kaur et al. 2017, Rahmani et al. 2019). To alert the authorities that pesticides could be one the major threats to Sarus. Long-term study on this aspect in accredited government and non-government laboratories. Stealing or destruction of nests is a big problem in some areas of Sarus distribution. While studying the breeding biology of Sarus crane in Kota district from February 2000 to October 2001, Kaur and Choudhury (2003) found a total of 49 nests, out of which eggs were stolen from 13 nests. In 2017, out of 16 nests monitored, eggs disappeared from five nests, and in another six the fate was not known – some may have been preyed upon. Kaur and Choudhury (2003) mention that most of the stealing of eggs was done by migrant labourers who had come to repair the canal or to work in the crop fields. They found that there was not much damage done by the local people. It was found that during paddy-sowing, eggs were removed for diet supplement. egg shells were also used for curing seasonal fever, for eye treatment and childhood diseases. Some farmers removed the eggs to destroy the nest in the agricultural field (Kaur and Choudhury 2003).

The landscapes of India can be learning grounds for how to improve conditions for crane and wetland survival in other parts of the world where development and burgeoning human populations are Sarus Cranes and Indian farmers: Such coexistence can be continued if conservation interventions are able to incorporate local traditions alongside needs of the cranes increasing, necessitating very expensive conservation intervention strategies. Persisting ancient farming methods and deep-rooted cultural practices offer novel advantages to conservation practitioners. Conservation interventions tuned to these conditions will best serve the coexistence of farmers and cranes here

4. Conservation Strategies

4.1 Regional level

a. Expand network of rural volunteers/Sarus Mitra

Conservation of wildlife species especially those who live in conjunction with humans pose the biggest challenge of conserving their population and habitat in highly populated landscapes. The project adopted the community participatory approach wherein through the various awareness

and sensitization programs people were connected with the project for sharing information on the presence and distribution of the Sarus Crane in the landscape which was further expanded to informing, protecting and monitoring of nesting sites and juveniles till they fledge. The project through various outreach programs created a network of volunteers which were named the "Rural Sarus Protection Group (RSPG)". A network of 88 RSPGs are formed in 40 villages, comprising individuals or groups of individuals from the same village or locality. The group works on a voluntary basis and shares information on nesting, eggs, hatching and injured/dead birds. Out of the 88 RSPGs, 68% (n = 77) are actively involved in regular conservation activities in and around their villages.

b. Implement a financial incentive scheme for farmers who secure Sarus habitats.
Capacity building of volunteers on population and breeding monitoring (documentation, count, first aid, habitat conservation): The volunteers should be given annual trainings on documentation and identification of other bird species found in the agriculture fields and nearby wetlands. One of study being conducted in Kheda district of Gujarat district, 26 of the volunteers were given trainings on providing first aid to the injured birds found in the wild. To encourage and motivate the unpaid volunteers the project annually recognizes the volunteers who had performed exemplary during the year in a function. These recognitions help in raising the social stature of the volunteer in their village which helps in further expanding the volunteer network.
Formation of village level Sarus Mitre societies in each forest range with support from the Sarus Protection Society and organise their capacity building training programmes through organizations like the Wildlife Trust of India (WTI is already conducting such programmes in eastern Uttar Pradesh).

c. Liaise with the electricity transmission agencies for installing bird diverters/insulation of open wires in important Sarus crane congregation/breeding areas identified.

d. Increase outreach through - posters, pamphlets, billboards and sensitization programs with rural schools and villagers/ farmers for enhancing positive attitude of people towards the species. An envisaged an awareness campaign for Sarus Crane conservation, with the involvement of local communities and NGOs. Pamphlets and posters were printed in local languages for distribution in schools and villages, and wall paintings/sign boards were installed in important villages to spread awareness among the masses and to gather information. The pamphlets and postcards helped us to obtain information on Sarus Crane congregation sites, nesting, juveniles and injured/dead birds. Information's are received through phone calls and during personal visits. Audio-visual shows and lectures are held on the species, explaining its breeding period, habitat, fledging of chicks and ecological importance of the species. The programmes helped to dispel misconceptions regarding the crane's supposed destruction of crops, and the futile use of eggshells for various health problems. Activities like drawing and painting, rangoli, elocution, quiz contests, field visits, and celebration of conservation days like World Wetlands Day, Wildlife Week, and World Environment Day are held in coordination with schools and the local people near breeding or congregation areas. Include important wetlands under regional wetland conservation and management department for protection.

4.2 National level

a. Organize Sarus Crane conservation, management and research seminar involving all stakeholders, tri-annually. Compilation of research work being done in India and by looking the publications and involving stakeholders for organizing workshops, seminars at National level and State level.
b. Uniform population count methodology at country level, twice in a year; December (for new juvenile recruitment/late breeding) and June (total population count). Every year summer dusk monitoring of Sarus crane in Gujarat. UPL Sarus conservation project conduct. Annual Sarus count every year on 21 st June, it should be done across India on same day.Twice a year monitoring by the Forest staff should continue as this gives a sense of engagement in Sarus protection, but we need to develop robust and

doable Sarus monitoring protocol. Researchers with interest in field work and good knowledge of biostatistics should be used for such project. Such intensive monitoring should be done every three-four year and for more than 15-20 years. Only then we will be able to get good population trend data. This will give a good idea of the population trend.

5. Research Recommendation

a. Study the movement and dispersal of Sarus through satellite tracking and colour bands. Studies being done in India tthrough satellite tracking, geolocators and colour bands study to be conducted on movement and dispersal. Recommendation from Dr. Asad Rahmani that at least 15-20 adult Sarus and similar number of juveniles should be tracked. Only then we will get meaningful data.
b. Monitoring of the emerging cropping patterns, both at micro (village) and macro (region/ district) levels that might impact the Sarus crane population. Breeding success study in different crop types. Continuous studies to be conducted for at least five years because 2-3 years data will not give good results.

Note: The recommendations were written by study different reports, scientific papers at regional level and nation level work being done in India.

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Annex1. Population of Sarus Crane in different States of India.

S.no.	State	Reference work by	Population (Year)
1	**Uttar Pradesh**	SACON 2020, Rahmani et.al 2019, WTI, Eastern UP	15,193
2	**Gujarat**	Kaur et.al 2017, GEER foundation, Bird Conservation Society, Gujarat (BCSG)2021	1700
3	**Rajasthan**	Vyas, WII,1999-2000, Sundar etal. 2000	1100
4	**Haryana**	Print ISSN: 2278-3296 Online ISSN: 2349-4441 RNI No. HARBIL/2012/ An International Refereed Research Journal Vol. 10. No. 2. December 2021	250
5	**Himachal**	Breeding of Sarus Crane recorded in Punjab and Himachal Monday, 23 November 2020 Nishu Mahajan | Chandigarh	32
6	**Madhya Pradesh**	RAP project WTI, Rajesh Shan (Phd submitted)	480
7	**Maharashtra**	Sarus crane action plan, Gondia district2021	45
	Jammu& Kashmir	Tahir Shawl Published on: 3 Oct, 2020,	3
	G. Total		**18,803**

NEPAL SARUS CRANE REPORT 2023

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1. Introduction

Sarus Cranes are revered due to their monogamous character, shared parental care, elaborate courtship dances, and social interaction and tolerance to human beings earned a great respect worldwide. It holds a sacred symbol as the Sarus was once saved by Lord Buddha. The birthplace of Buddha is designated as the World Heritage Site, Buddha's message of living in harmony with nature is widespread, now the bird saved by Buddha is in peril. Sarus Cranes are sacred, revered, and protected by the indigenous people of Great Gangetic Plains.

Sarus cranes *Grus antigone antigone* are the tallest flying birds in the world. This sub species is non migratory, lives in wetlands and farmlands of Gangetic plains and beyond. It is an IUCN Vulnerable species. It is a protected species by Nepal Government NPWC Act 1973. Sarus Crane is the mascot of Lumbini Cultural Municipality.

Keystone species sharing wetland and human dominated open farmland of Lumbini along with Sarus Cranes are Lesser Adjutant Stork, Wooly-necked Stork, Open-billed Stork, Black-necked Stork, Black Stork, Painted Stork, Black Ibis, White Ibis, and Eurasian Spoonbill. And mammal species including Blue Bull Antelope, Hog Deer, Golden Jackal, Wild Boar, and Fishing Cats.

2. Distribution

They live in harmony with the farmers community in open and flat lands of Terai in Nepal. Currently they are thriving in Rupandehi and Kapilvastu districts. They are sparsely distributed in the districts of Kanchanpur, Kailali, Bardia, Banke Dang, Nawalparasi and Chitwan. They have been locally extirpated from Eastern Terai extending from Makwanpur and Parsa districts towards Jhapa District.

3. Population

The population estimation is based on the nationwide field research in April May of 2023 during dry period of pre monsoon count conducted by Nepal Zoological Society and Central Department of Zoology, Tribhuvan University with support from WWF Nepal and International Crane Foundation. This nationwide count confirmed 690 individuals in 2023 (Sharma, H.P., Bhattarai, B.P., and Katuwal H.B., 2023). The district wise population of Sarus count suggests highest in Rupandehi is 382, followed by 200 in Kapilvastu District and 70 in Nawalparasi, 33 in

Banke and only five in Kanchanpur District. No Sarus were reported from Chitwan, Dang and Kailali District during this count period.

Eleven major roosting sites have been identified during this count across Banke, Kapilvastu, Rupandehi and Nawalparasi districts. Bhagwanpur area of Banke, Bajhaha lake, Jagdishpur Bird Sanctuary, of Kapilvastu, clusters of roosting wetland sites in Rupandehi along the lower Danob and Tinau River flood plain and Nandan Lake of West Nawalpur Districts are major roosting sites. This number could be supported by observing a flock of 50 roosting Sarus counted in the wetland of Lumbini Crane Sanctuary on May 30, 2022. About 200 Sarus individual were counted in Tulsidihawa, a transboundary wetland of Mayadevi Rural Municipality, by Kumar Poudel on 2022 July 19th (TKP, 2022). Similarly, high counts of Sarus congregation of 153 Sarus while roosting at Jagdishpur Bird Sanctuary a Ramsar Site in Kapilvastu District, in April, 2023. Previous high counts of 104 Sarus were observed in the downstream of Danob river flood plains in 2004 by Ramond and Giri (pers comm) and during several other occasions along the Danob River Floodplains of Aama and Sipuwa Village of Rupandehi District.

About 20+ pairs nest in the farmland and wetland of Rupandehi District. The number could increase if a systematic count is carried out. Lumbini Development Trust's estate spreading over 7.6 square kilometers (about the area of Philadelphia Airport) campus accommodated 7 pairs of Sarus Cranes in 2021. That includes 4 pairs nesting inside the Lumbini Crane Sanctuary (within 100 ha). A total of 10 Wetlands with a capacity to collect over 100 million liters (about 26417200 gal) of monsoon rain impoundments were made for Sarus Conservation in partnership with Lumbini Development Trust, International Crane Foundation and supported by WWF Nepal. Vagrant Sarus Cranes have been reports from Rapti River flood plains of Dang, Rapti River Flood Plains and Dorangi farmlands of Chitwan District. There have been no recent records of Sarus from Eastern Terai, East of Parsa District. They have been recorded breeding in Kalikitch wetlands of Shuklaphanta National Park, the Lamkauli Phanta of Bardia National Park, and the Purainee Wetlands of Nepalgunj Municipality in Banke Districts. Whilst other large waders e.g., storks, Ibises and spoonbills occurs in the eastern Nepal, perhaps their nesting niche on the tree was the reason for their existence.

5. Habitat conditions

The whole of Nepal's lowland the northern Gangetic flood plains, with alluvial deposits, lying between 67 meters to 300 meters is defined as Terai Physiographic zone, is potential habitat for Sarus.

Much of the Kapilvastu, Rupandehi and Nawalparasi Districts lie under 300 meters (about 984.25 ft) above mean sea level. Two thirds of the area of these three districts are under farming system with river drainage system originating in Churia Hill Range and dotted with lakes and oxbow

lakes. Sarus has adopted to living in proximity of human settlements since eons, now paddy fields provide habitat for nesting, feeding and raising chicks.

The network of roads and electric powerlines transformed rural farmlands into peri urban, urban and industrial areas. The human population boom augmented by the linear structure fragmented their habitat. The vertical structures of power cables are hindrance for the birds in flight. The earlier Sarus friendly tranquil rural farmlands and wetland of Terai farmlands are now transforming into an unfavorable for Sarus Crane existence. The road networks, transmission lines and industrial pollution are major threats for crane existence.

6. Conservation threats

There is a wide spread of encroachment of their habitat by conversion of wetland and oxbow lakes into farmlands. Sixty percent of land is dominated by farmlands of Kapilvastu and Rupandehi District. Very few areas are covered by water surface namely, ponds, wetlands and rivers. The existing ponds and wetlands are also subject to encroachment. This is a water stressed area for eight months of the year.

Disturbances on nesting cranes by livestock, wild boars, jackals and feral dogs is a major concern. There are plenty of feral dogs in this area. Feral dogs hunt in packs. The less water regime enables these dogs and jackals to attack Sarus, raid eggs and the hatchlings and fledglings. There is an influx of Wild boars in the farmlands. Wild boar could be a nuisance to nesting cranes by depredating on eggs or fledglings.

More than 60% populace of Nepal live in the Terai Region, perhaps a seven-fold increase in the last seven decades. There are about 400 people per square kilometers living in Kapilvastu (total population 686,739) and over 720 people per square km in Rupandehi Districts (total population 880,196). The influx of population due to the available facility of access roads and energy and livelihood opportunities is transforming vast rural farmlands turning into peri urban, urban settlements and industrial areas (Nepal District Profile 2022). Cranes are in constant move and are flocking frequently perhaps due to many anthropogenic activities in their prime habitat, this behavior could be observed around Rupandehi District.

Linear Infrastructure development including highways, rural roads, irrigation canals, power lines, regional airport, and trade hubs. There are over 343 km (about 213.13 mi) road access in Kapilvastu in 2072/73 FY and 659 kms (about 409.48 mi) roads in Rupandehi District (facilitating over 88% of populace).

There are perhaps over 150 large, medium and small industries operating in Kapilvastu and Rupandehi Districts. They are the source of pollution of rivers, wetlands, air and soil from industries. The unmanaged waste of municipalities, and agrochemicals run off to water bodies are a serious concern. The discharge of untreated effluents from industries into river and wetland

polluted available freshwater accelerate of killing aquatic species. Living planet reports estimated over 86% loss of aquatic life by population volume.

There are no concrete plan and program to manage solid and liquid waste of municipalities and settlements in Nepal. Kapilvastu, Rupandehi and Nawalparasi West District and its municipalities are no different. Occasional burning of waste material, depositing solid waste near roadside, forest and wetland and riverbank is a common phenomenon. This has a negative effect on the health of people, ecosystem of wetland and Sarus Cranes. Open organic garbage is a food for scavengers including dogs and crows. Besides dogs, crows are a constant threat and harassment to the nesting cranes (predation of eggs and hatchlings).

Several hatchlings and fledgling succumbed to predation by feral dogs and other predators on hatchlings and fledglings' cranes (perhaps Jackals too). The lack of deep water gives easy mobility to dogs to chase and predate upon hatchlings and fledglings.

The riverbanks of Tinau, Danob, Kothi and Banganga are the social gathering and roost sites of Sarus during dry season. The constant river mining by employing trucks and tractors, backhoe loaders, excavators and bulldozers for river mining for sand and gravel poses threats to cranes.

Occasionally there are reports of crane casualties due to powerline collision in the rural electric transmission. 42 Sarus casualties have been recorded between 2010 and 2022 (Katuwal, Bhattarai and Sharma 2023). The access road, augmented by the laying of rural electrification powerlines over the farmlands is direct cause of death of Sarus. Annually three to four crane deaths are reported by citizens of Rupandehi.

Perhaps none of the municipalities in these three districts have a garbage management system. Open disposal of Garbage and non-biodegradable solid waste have been observed along the Danob, Tinau, Telar, and other riverbanks, forest and wetland of urban and peri urban areas and along the highways.

Application of Agro-chemical including organochlorines and pesticide such as Thiodan, malathions infested insects and grains are poisonous to Sarus.

The recent employment of mechanized harvest of rice is leading to killing of Sarus juveniles as reported by Kailash Jaisawal (pers comm). The left-over stubbles of rice and wheat fields are burnt in the farmlands causing air pollution and loss of insects and invertebrates, primary food for Sarus.

Climate related causes– less water regime due to long drought with intense temperature measuring 40-degree Celsius during pre-monsoon season, intense rainfall causing flooding of nests and destroying of eggs during monsoon season, or less rainfall, decreased water regime is depriving safe nesting condition on several occasion. 2022 experienced less rainfall during monsoon, perhaps resulting in less nesting. Lumbini garden hosted over seven pairs of nesting cranes in 2021 monsoon, but none nesting in 2022 monsoon. Perhaps the sudden heavy downpour in mid-October may have harmed nesting cranes in other locations. The periodic long

cold spell during January and February in Terai minimizes the visibility, lower temperature, is also perhaps a climatic factor affecting cranes foraging activity.

Adolescent herders are a constant anthropogenic threat to cranes are they are known to be involved in killing juvenile and adults and, egg stealing and nest destroying.

7. Conservation challenges

Influx of population turning farmlands into peri urban and urbanization is depriving safe habitat for Sarus.

Increase in Linear Infrastructure development in the Sarus range is a grave concern.

Limited knowledge and understanding of Sarus Crane conservation by central, provincial and municipal authorities is a hindrance for their conservation.

The low level of awareness for crane and wetland conservation amongst new settlers is a serious concern.

Insufficient coordination among major stakeholders for nature conservation and environmental protection is keeping crane conservation issues in the shadow.

Lack of understanding, and ownership of Sarus Cranes and farmland biodiversity conservation amongst authorities is also a primary reason for not getting attention for conservation.

Lack of resources and commitment from the authorities for Sarus Conservation.

No institutional arrangement for farmland biodiversity conservation or beyond the protected areas and forested areas.

Lack of open water regime for 8 months of a year is a serious challenge to overcome.

8. Opportunities for Sarus Crane Conservation

Research and population monitoring and population dispersal and movement of Sarus Cranes.

Agrobiodiversity management includes enhancing insects' eaters, birds of prey, pollinators, carrions eaters and rodent eaters.

Habitat enhancement and increment with civil works to provide qualitative and quantitative climate resilient wetland habitat with a number of shallow islands and shorelines by harvesting 100 billion liters of monsoon rain.

Initiate transboundary wetland conservation approach like the Terai Arc Landscape's in the transboundary farmlands and wetlands of Nepal and India including Bajhawa Lake and Ajingara Lakes and other river flood plains and wetland sites adjoining terai districts.

Promoting nature based and Sarus Crane watching tourism in the farmlands and wetlands to provide green economy to the local community.

Operation of Nature Interactive Center in Lumbini Crane Sanctuary for Sarus Crane Conservation and Natural resource management engaging the local farmer and communities, Buddha's birthplace visitors, including students and locals.

Demonstration sites for wise use of wetlands practices and awareness programs in Lumbini Crane Sanctuary and Jagadishpur Bird Sanctuary, Gaindahawa Lake and other major wetlands sites.

Sensitizing, capacitating and engaging municipalities and rural municipalities for Sarus Crane Conservation initiatives.

Sensitizing authorities and developers to have green linear infrastructure, especially the powerlines with reflectors and wind chimes to warn the incoming birds in flight.

Encourage, awareness campaigns and incentives for organic farming practices.

9. Interventions carried out for Sarus Crane Conservation in Lumbini since 1988

Study of Sarus Crane was initiated in 1988 by Rajendra N Suwal with support from Gaida Wildlife Camp, International Crane Foundation, National Trust for Nature Conservation and US Fish and Wildlife Services.

Established Lumbini Crane Sanctuary in 1994 as a demonstration site for Sarus Crane Habitat conservation by International Crane Foundation by leasing 100 ha land from Lumbini Development Trust for enhancing wetland habitat and Sarus Crane conservation awareness program.

Birdlife International declared Lumbini Garden and farmlands as Important Bird and Biodiversity Area (Birdlife 2005).

One million tree plantation campaign by WWF Nepal in partnership with Lumbini Development Trust in 2010 to fight climate change (WWF Nepal, 2011).

Habitat enhanced by making rain-water impoundments with support by WWF Nepal with a total of 20 ha wetland inside Lumbini Crane Foundation that could accumulate over 100 million liters (about 26417200 gal) of monsoon precipitation annually.

Lumbini Cultural Municipality declared Sarus Crane as their mascot in 2018 (THT, 2018).

Mobilized Green Youth Lumbini and Lumbini Social Service Foundation for Sarus conservation outreach program and Kalanamak Rice plantation with support from WWF Nepal.

Initiated Adopt a Wetland by Eco Clubs of Lumbini Schools under the Green Lumbini Initiative.

Sarus Crane Conservation Action Plan (2021 – 2025) endorsed by Nepal Government (DNPWC and DoFSC, 2021)

Fenced Lumbini Crane Sanctuary by mesh wire and live fence of thorny cane and shikakai plants to secure nesting cranes.

Nepal Government declaration of Jagdishpur Bird Sanctuary, a Ramsar Site (2003) in 2022 (The Nepal Weekly 2022) a major roosting site of Sarus Cranes.

Lumbini, the birthplace of Buddha is a beacon for compassion, Sarus Crane conservation, and pilgrimage destination. The Lumbini garden became a haven for birds, mammals, and reptiles. This sacred area shall remain in perpetuity as a protected and as a World Heritage Site. Buddha's principle of compassionate way of living in harmony with nature is acknowledged worldwide. Buddha's message "after my death, people with faith shall visit the place I was born, where I was enlightened, where I first preached and where I attained Mahaparinirvana" is a protocol for the disciples to visit these four sacred places.

WWF's mission is to build a future in which humans live in harmony with nature, WWF envisioned a deep connection in Lumbini in helping promote conservation principles to a wider audience.

Vision: To develop Greater Lumbini as a model site where Buddhist philosophy of interconnectedness and interdependence is ingrained in a human dominated landscape, for Sarus Crane conservation and sustainable development.

Sarus Conservation Goals– Increase population to 2000 + Sarus Cranes by 2030, by managing the existing wetlands and increasing their associated habitat including organic and safe farming practices in Lumbini province and make water impoundments to collect monsoon rains and engage government, communities, and private sectors and transboundary conservation initiatives for Sarus Crane Conservation.

10. Conservation strategies for next five years for the Sarus Crane Conservation Action Plan (2021-2025)

The Department of National Parks and Wildlife Conservation, and Department of Forest and Soil Conservation (DNPWC and DoFSC 2021) identified the following strategies for Sarus Crane conservation in Nepal for the period of 2021-2025.

Objective 1: Enhance the quality and quantity of healthy farmland and make water impoundments.

Ensure healthy farming practices (organic farming) in prime Sarus habitat.
Protect the Chure hill watersheds for ground water recharge, enhance and upscale the existing wetlands and oxbow lakes of protected areas, divisional forests, municipalities/rural municipalities, and irrigation authorities.

Encourage to construct water impoundments to collect water to make climate resilient wetland habitat with islands for safe nesting and climate resilient farming.
Facilitate to declare safe Sarus nesting wetland sites.
Facilitate to sensitize, capacitate, and engage Law Enforcement Agencies (LEA) to control industrial and municipal pollution, and stop wetland habitat encroachment.

Objective 2: Increase knowledge and understanding of Sarus Cranes population, movements, and its nesting status.
Facilitate to standardize monitoring protocols for population census, roost site and nest count protocols.
Conduct study to determine population dynamics of Sarus, roosting sites, nesting sites and its habitat status.
Advocate for the study of their movements by application of latest technology including satellite technology, tags, vocal identification, and drone for nest monitoring.
Encourage to disseminate research result information of Sarus conservation with all the stake holders and general populace.
Transboundary conservation monitoring and sharing of Data with India counter parts in selected wetlands of bordering Nepal including Nawalparasi, Rupandehi, Kapilvastu and Banke Districts.

Objective 3: Reduce Direct mortality of Sarus Cranes.
Raise awareness to control illegal hunting, chick and egg stealing and sensitizing and capacitating Law Enforcement Agencies.
Advocate to reduce power cable collision through research and application of deterrents and paints and chimes.
Coordinate with municipalities to reduce stray dog control to prevent predation by feral dogs and other predators.
Support to establish a captive management center to rehabilitate orphan and injured cranes.

Objective 4: Capacity building
Sensitize Municipal authorities and personnel on garbage, management, natural area protection and designation of safe Sarus habitat.
Involve Divisional Forest personnel for transboundary conservation and protection of Sarus Cranes.
Ministry of Forest and Environment, Provincial Line Ministries for wetland conservation policies and farmland biodiversity conservation policies.
Institutionalize Farmland Biodiversity conservation in Province and Municipal government.
Lumbini Development Trust, and Banganga Irrigation Office authorities on best use of natural resources management.
Agricultural Ministries for safe farming practices and promoted indigenous farming practices.

Involve CBOSs, NGO's and Farmers cooperatives for organic farming practices including growing Kalanamak rice varieties.
Initiate Sarus and Wetland conservation awareness campaigns among farmers Students and Youth in partnership with schools, universities and citizen scientists.

Objective 5: Transboundary and regional conservation
Engage Terai Arc Landscape in the farmland dominated by farmers and transboundary wetland and Sarus Conservation in partnership with Indian Government involving WWF India and other partners.
Engage with other Sarus range countries for sharing and exposure to the conservation policies and practices.

Objective 6: Partnerships building.
Networking with all the national stakeholders under one umbrella to address and initiate dialogue conservation cranes and other farmland biodiversity conservation, and management.
Networking with Global birds, large waders, Cranes Conservation specialist groups to exchange conservation and research information.

Objective 7: Awareness Campaign and Sensitization
Central, Provincial and Local level government to prioritize crane and wetland conservation.
Students and academic institutions as a means for conservation education awareness.
Local community for sensitizing the crane conservation initiatives.
Market Sarus and birdwatching and farmhouse tourism as a link to Buddha, Kalanamak farming in the Buddhist landscape among the domestic, Regional and Foreigners.
Collaborate for the Regional Cooperation amongst the Sarus crane conservation groups.

8: Objective Ex situ Conservation
Manage orphan and injured cranes recovered from the wild.
Rehabilitate the healthy cranes back to the wild.
Manage captive breeding facility for restocking from the disabled cranes in Lumbini Crane Sanctuary.
Plan to reintroduce Sarus Cranes in their former range in Nepal.
Make Lumbini Crane Sanctuary a beacon of cranes and wetlands conservation awareness center.

11. Discussion

Nepalese had the freedom to leave their natal area only after 1950's after the fall of Rana dictatorship regime. It coincided with the eradication of malarial mosquitoes, encouraging mountain people to settle in the southern plains of Terai by clearing forests. The infrastructure development including the construction of Mahendra East West Highway gave easy access to

clear forests and settle for farming. It triggered the habitat loss, habitat fragmentation and decline of megafauna including Tiges, Rhinos, Elephants and other large vertebrates at a rapid scale. The shock and stress of the highway spared the farmlands of Rupandehi and Kapilvastu District, it is because the highway followed the foothills of Churia Hill. While these two districts lost much of its forest cover and megafauna, Sarus Cranes survived in the farmlands amidst the protection of indigenous populace. It could be contributed to Lord Gautam Buddha saving a Sarus Crane shot by his cousin Dev Dutta. Perhaps since then, the locals protected and revered the Sarus.

The indigenous people specially the vegetarian Yadav community detest killing animals. They consider Sarus as the King of the Wetland (Siwan ki Raja). They also signify monogamous, and happy conjugal life. They are given the human status of Mama (maternal uncle), spared from crop damage in exchange for elaborate dance. For them nesting cranes indicate bumper harvest and pair of cranes signifies happy conjugal life. The influx of new settlers that have no respect and traditional belief of protecting cranes decimated their population in much of the Eastern Terai. It is followed by intensive agriculture including mechanized farming, infrastructure development including laying of powerlines in rural areas, and peri urbanization. Though their distribution overlaps with the presence of National Parks and Buffer zone of Terai Arc Landscape they are found in nominal number inside the protected area. This could be due to the unfavorable habitat with tall grasslands, dense forest coverage and absence of large open wetland, marshes, and pastures. And perhaps could not survive and protect their chicks from predators sharing same habitat.

The Sarus Crane today occupies a place of important symbolism in the hearts of the people of Lumbini. The journey that we have been undertaking over thirty years to protect the very bird once saved by Lord Buddha, has helped to forge a deep connection and a sense of responsibility that will sustain our efforts to nurture Lumbini's wilderness. Lumbini Crane Sanctuary has emerged as an important instrument in doing so and must be preserved in perpetuity.

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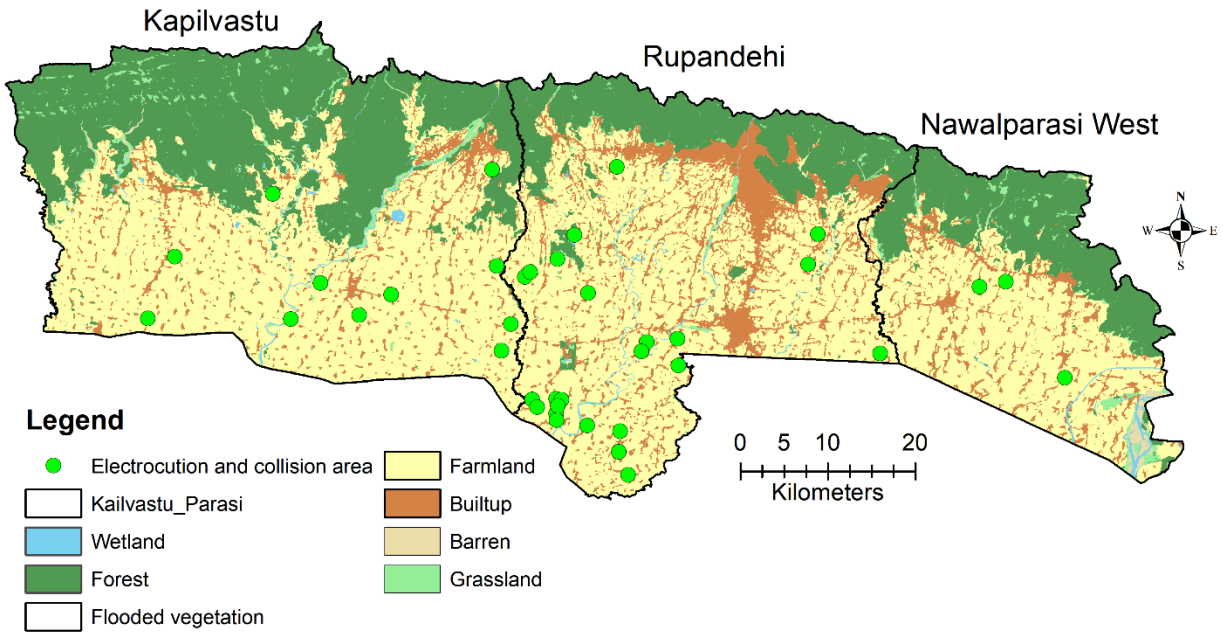
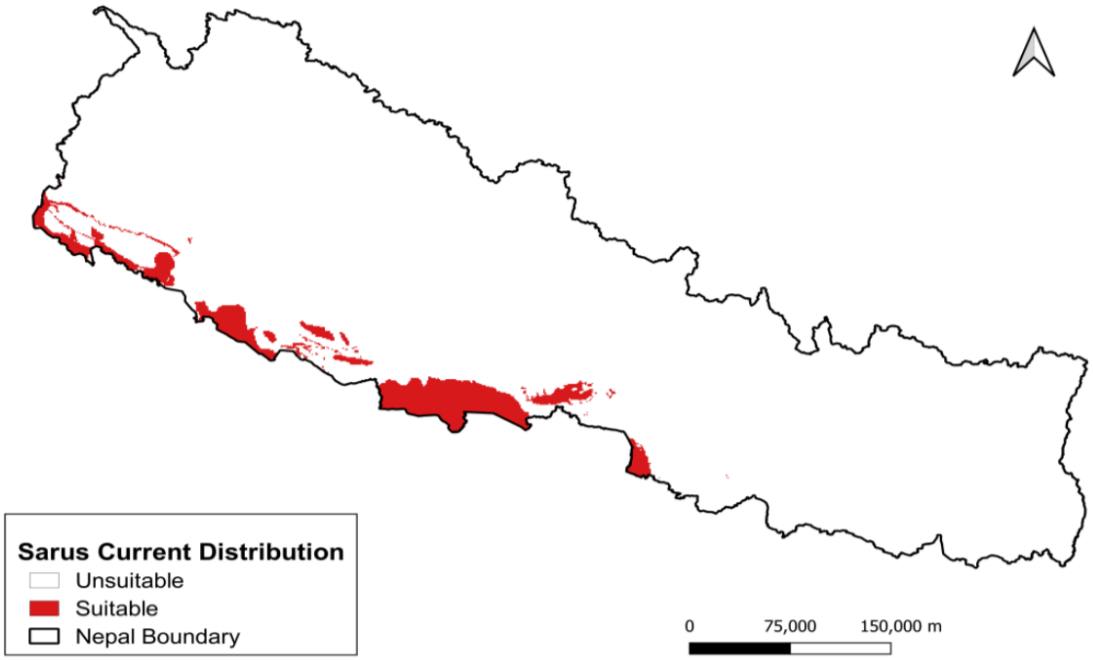
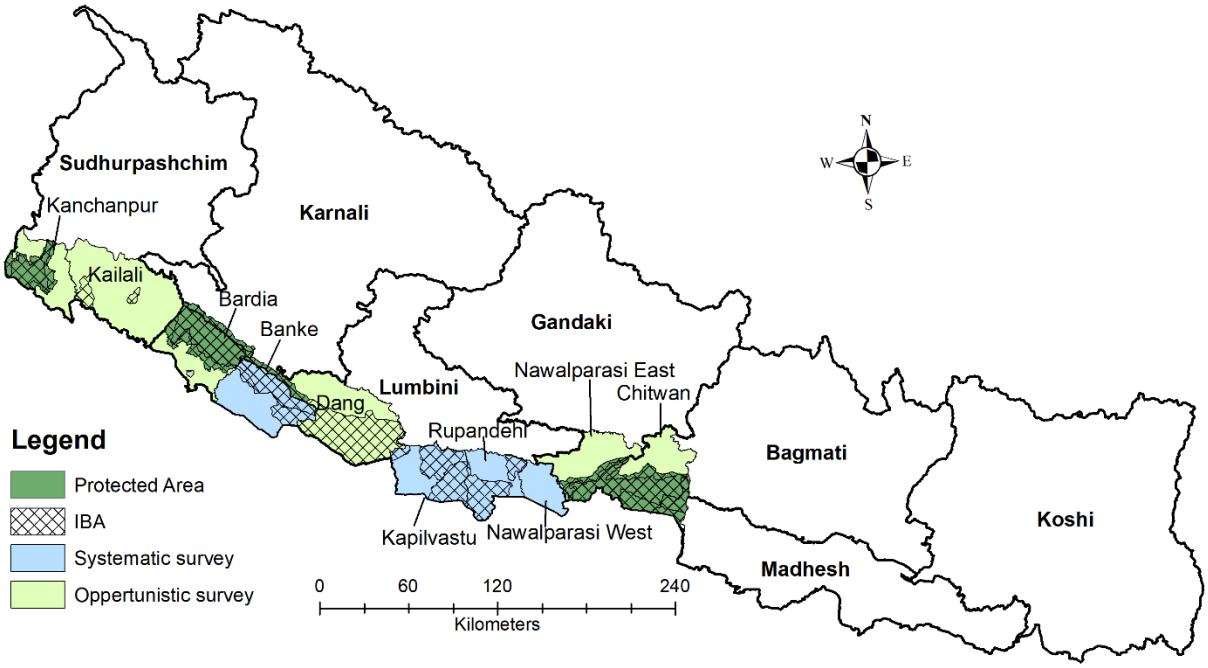
ANNEXES: MAPS and Figures:



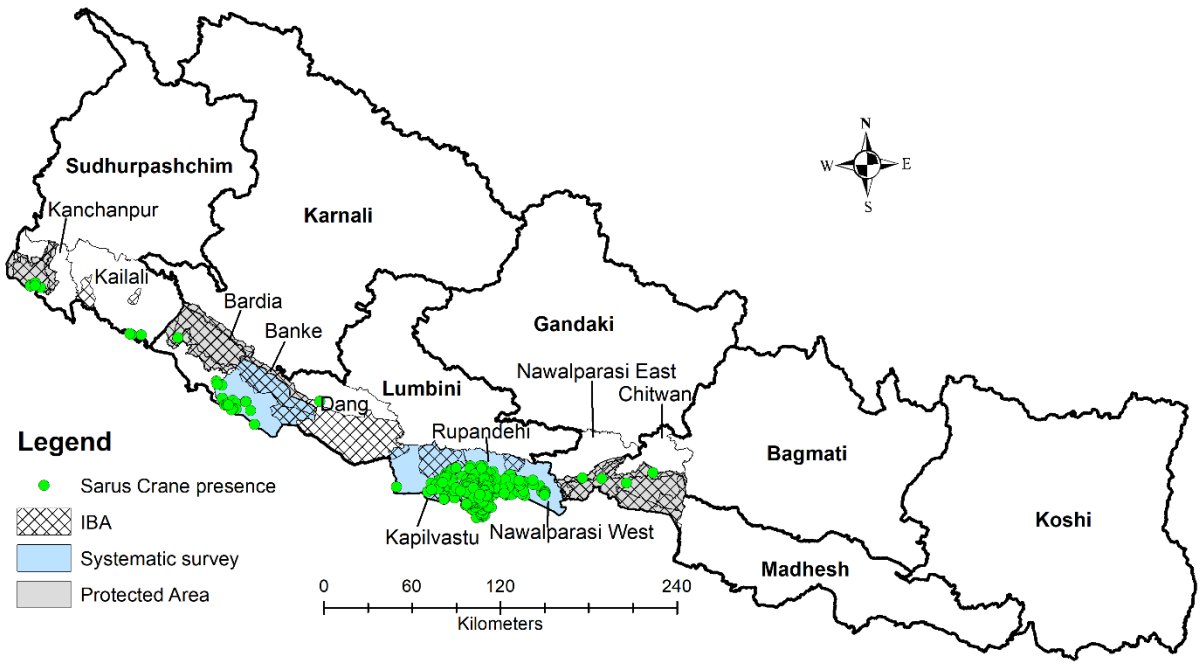
1Sarus Crane Electrocution and collision area. Source: Sharma, H.P., Bhattarai, B.P., and Katuwal H.B., 2023



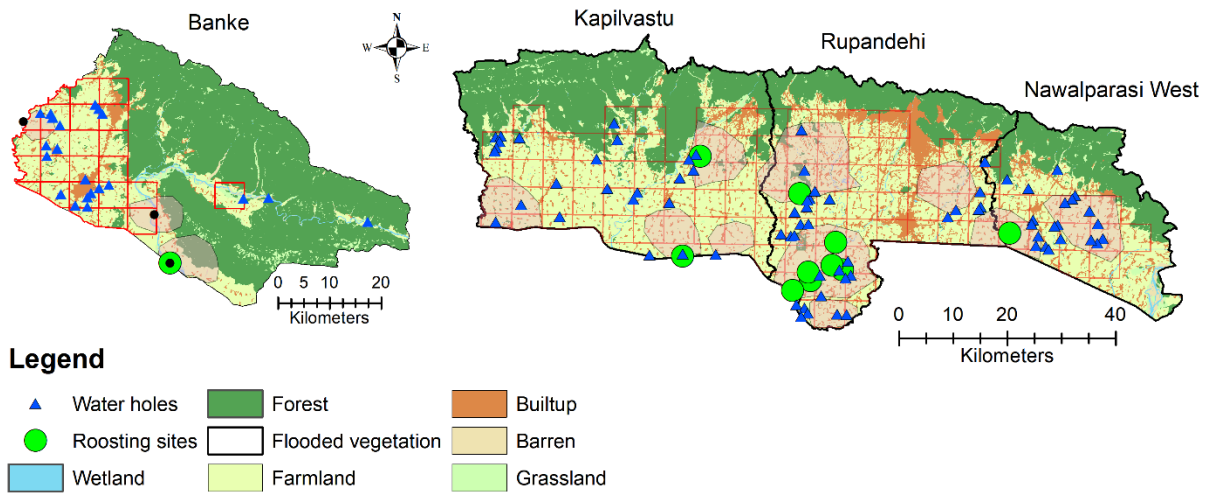
2 Sarus Crane Current Distribution. Source: Sharma, H.P., Bhattarai, B.P., and Katuwal H.B., 2023



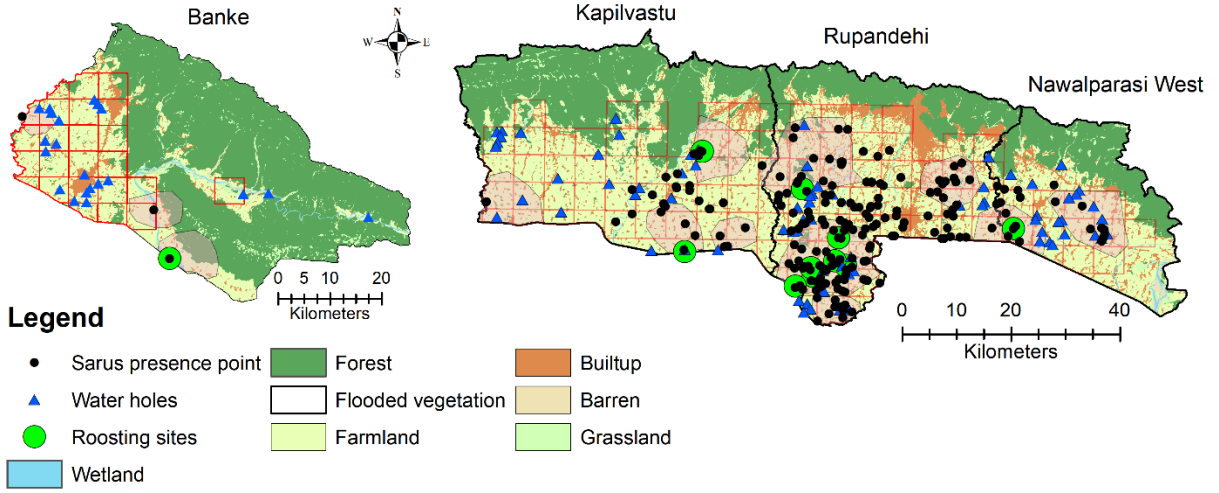
3 Sarus Crane systematic survey districts. Source: Sharma, H.P., Bhattarai, B.P., and Katuwal H.B., 2023



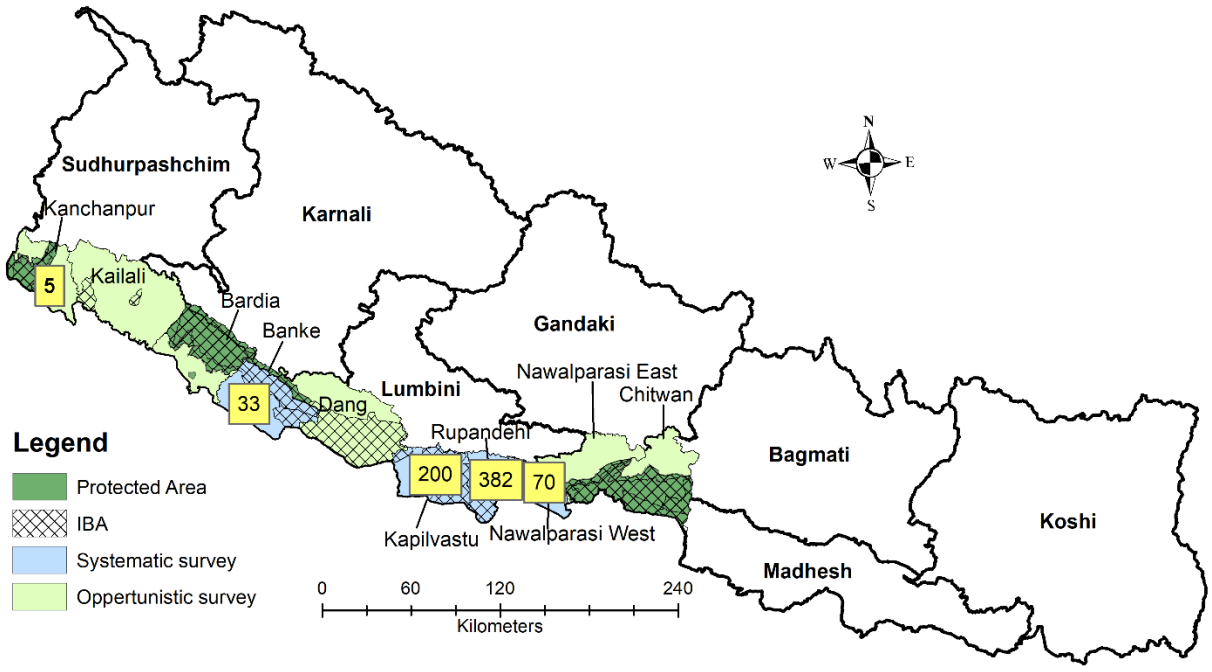
4 Sarus Crane presence area: Source: Sharma, H.P., Bhattarai, B.P., and Katuwal H.B., 2023



5 Wetland regime and roosting sites of Sarus Crane. Source: Sharma, H.P., Bhattarai, B.P., and Katuwal H.B., 2023



6 Sarus presence sites and wetland regime and Sarus roosting sites. Source: Sharma, H.P., Bhattarai, B.P., and Katuwal H.B., 2023



7 Sarus Crane population in systematic survey and opportunistic survey districts: Source: Sharma, H.P., Bhattarai, B.P., and Katuwal H.B., 2023

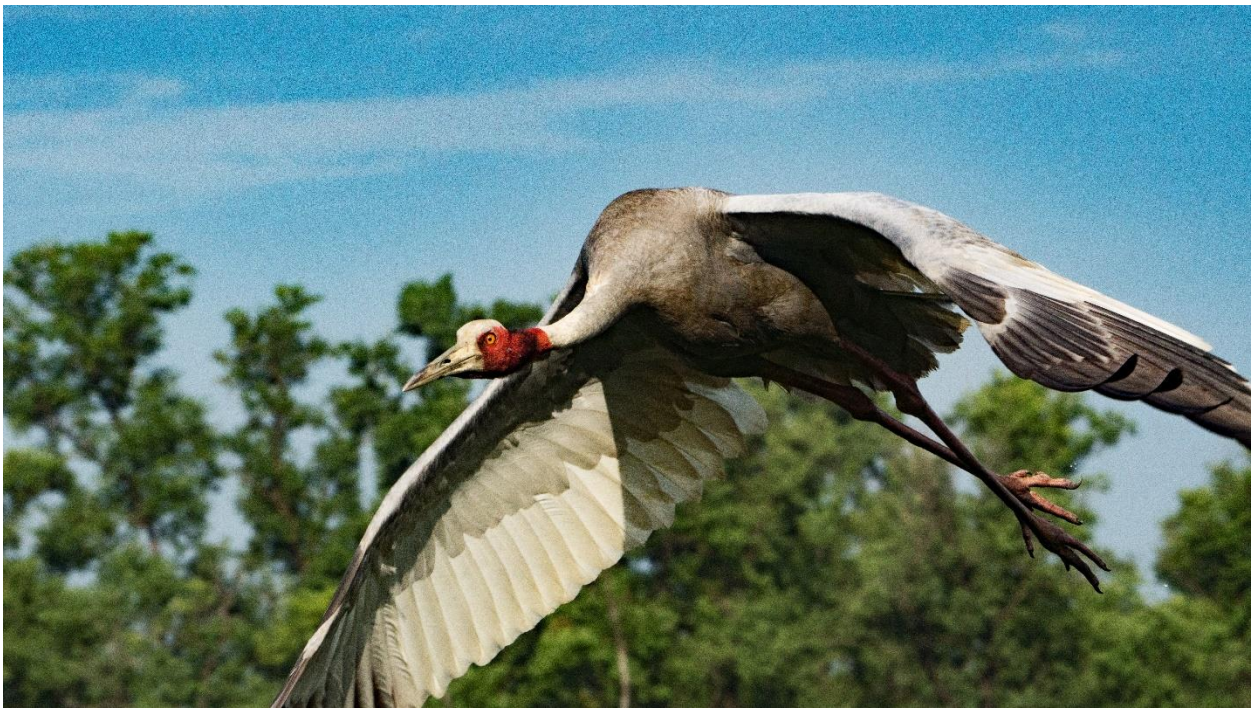
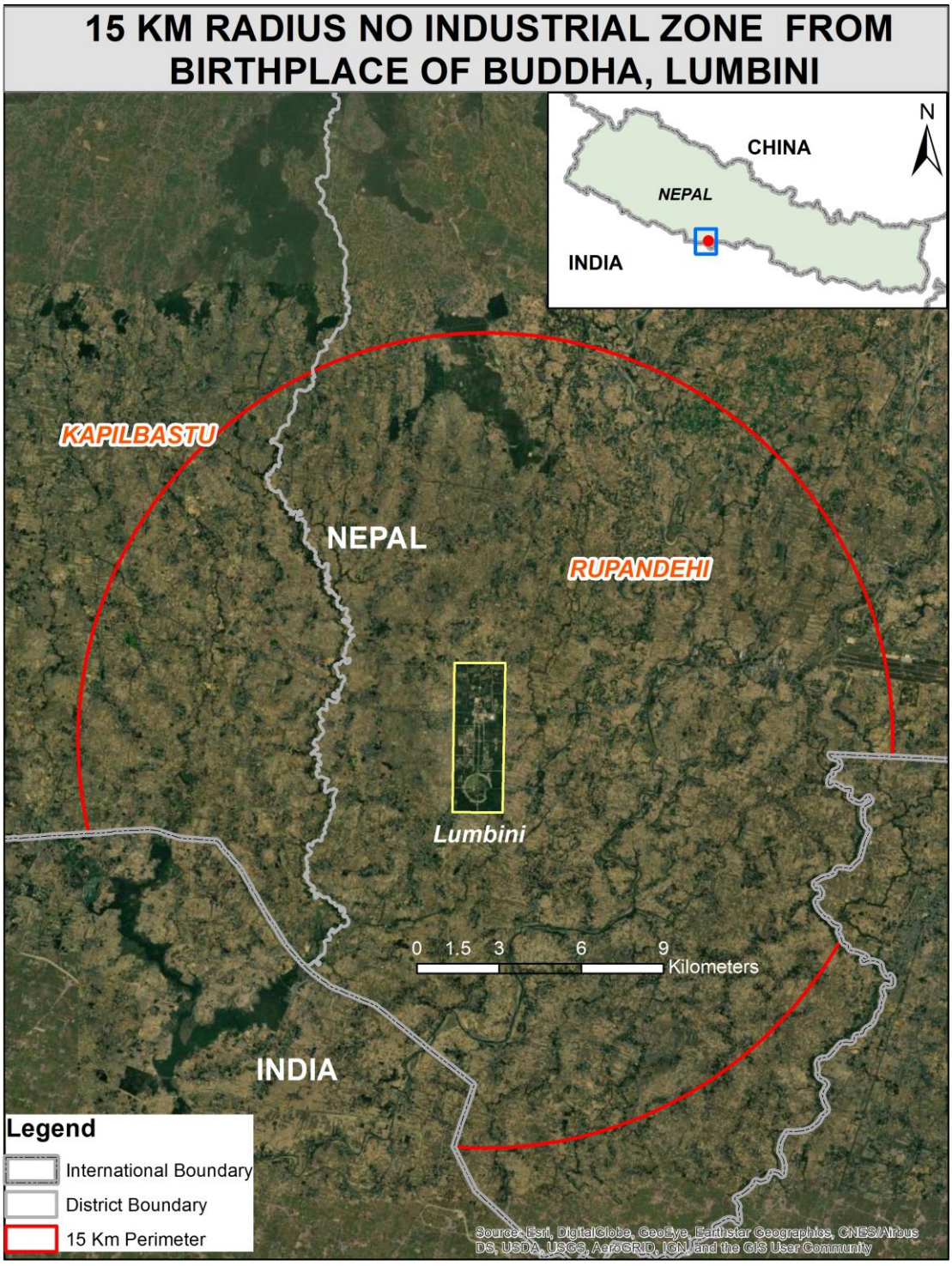


Photo credit: WWF Nepal/Rajendra Suwal



8Supreme Court of Nepal banned factories within 15 Kilometers of Mayadevi Temple, Lumbini, birthplace of Buddha, Source: My Republica, July 01, 2019 @RepublicaNepal

THE STATUS OF SARUS CRANES IN MYANMAR

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1. Introduction

Sarus crane (*Grus antigone*) has four disjunct populations: Indian Sarus, Australian Sarus and Eastern Sarus of which two populations exist - Southeast Asia (SEA) and China/Myanmar (Barzen and Seal, 2001). These populations were previously grouped into three subspecies (Meine & Archibald, 1996; Archibald et al., 2003) but recent population genetics study suggested that these morphotypes may represent a clinal genetic variation rather than distinct subspecies, although the genotypes of each population are distinct (Jones et al., 2005). As a species, Sarus Crane is listed "Vulnerable" (IUCN Red List, 2015). The two Eastern Sarus populations are the smallest and face serious threats, most importantly habitat loss.

The China/Myanmar population is distributed primarily in Myanmar, although a few individuals stray across the border into Yunnan Province, China; the SEA population occurs primarily in Cambodia and Vietnam. Small number of cranes occurred in southern Laos, but this flock has not been confirmed in recent years. There is no evidence of movement between the China/Myanmar and the SEA populations (Barzen et al., 1996; Barzen & Seal, 2001, Jones et al., 2005). The Sarus Crane is listed as a totally protected species in Myanmar under the Protection of Wildlife and Wild Plants and Conservation of Natural Area Law (Forest Department 2018). A small population of about 400 Sarus Cranes occurs in Myanmar, mostly in the Ayeyarwady River Delta. This population was poorly understood in 1996 (Claire and James, 2019). The current population and breeding status of Sarus Cranes in Ayeyarwdy Region, Myanmar is the subject of this report.

The objectives of this report are to:

(i) present the results of distribution, population, habitats, and breeding status of Sarus Cranes in Ayeyarwady Region by long term monitoring
(ii) observe the threats to Sarus Crane and habitats in Ayeyarwady Region
(iii) assess the status of Sarus Cranes in other areas of Myanmar by reviewing reports

2. Distribution and population status in Myanmar

Sarus Cranes are distributed throughout Myanmar, in five out of seven States (Kachin, Shan, Kayah, Rakhine and Mon) and five out of seven Regions (Ayeyawardy, Sagaing, Mandalay, Bago, and Yangon) (Latt, 2004). The Ayeyarwady Delta is the region where Sarus Cranes have been seen

most frequently and in highest numbers. Surveys conducted by the International Crane Foundation and Myanmar Forest Department in the Ayeyarwady Delta recorded 122 and 61 Sarus cranes in 1996 and 1998, respectively (Barzen et al., 1996; Meine 1999). Thet Zaw Naing (2005) recorded 88 Sarus Cranes in April 2004 and 128 in May 2005 at Tawntay Township, Ayeyarwady Delta. Most recently, a research team from Yangon University conducted a survey at three townships in the Ayeyarwady Delta during August - September 2015 and found 60 Sarus Cranes (Winn, 2015).

In northern Myanmar, Sarus Cranes were recorded in small numbers around Indawgyi Lake, Kachin State (Latt, 2001; van der Ven, 2003; Thet Zaw Naing & van der Ven, 2007; Aung Si, 2014). The highest count of 28 cranes was in February 1999 (Briggs & Latt, 1999). Interestingly, another crane species - the Eurasian crane (Grus grus) - was also frequently seen wintering in Kachin State, numbering more than 300 in 2007 (Thet Zaw Naing & Van der Ven, 2007). In Western Myanmar, Latt & Briggs (2003) reported 25 Sarus Cranes at several locations in Rakhine State. In Central Myanmar, Sarus Cranes have inhabited the Mandalay Region (MacDonald, 1906; Briggs & Latt, 1999). Sarus Cranes were also frequently observed in small numbers, but including breeding pairs, around Inle Lake (Shan State) and Moeyingyi Bird Sanctuary -- a Ramsar Site in Bago Region (Barzen et al., 1996; Meine 1999; Latt, 2004, Than Htay, 2002, Thein Lwin, 2012). Additional sightings of Sarus Cranes have been recorded at various locations in Sagaing Region (Briggs & Latt, 1999) and old, unconfirmed records from Mon State (Latt, 2004).

Previous field observations suggest that Sarus Cranes in the Ayeyarwady Delta appear to be non-migratory, often use paddy fields as breeding habitat, and are tolerant of the presence of humans in areas where Buddhist traditions are strong (Barzen et al., 1996; Meine, 1999; Winn, 2015). These sedentary behaviors are similar to those displayed by the Indian Sarus Cranes. Outside of the Ayeyarwady Delta and perhaps in the Rakhine area, Sarus Cranes in Myanmar may have seasonal movements between breeding and non-breeding seasons (Barzen et al., 1996, Barzen and Seal, 2001). These seasonal movements are similar to those of the Eastern Sarus cranes in SEA, which are very intolerant to humans, breed only in natural wetlands in remote deciduous Dipterocarp forests, and migrate seasonally between breeding and non-breeding habitats (Tran & van Zalinge, 2015).

According to historical occurrence results, Kenneth L. Jones, Jeb A. Barzen, Mary V. Ashley described that less than 100 cranes were recorded in 2004. Surveys conducted by the International Crane Foundation and Myanmar Forest Department in Ayeyarwady Delta recorded 122 and 61 Sarus Cranes in 1996 and 1998, respectively (Barzen *et al.,*1996). The unpublished report by Tin Nwe Latt, stated that 300-400 Sarus Cranes were recorded in Ayeyarwady Region. In a Summary report on a survey of breeding Sarus Cranes *Grus antigone* in Myanmar by Curt D. Meine in 1988 and follow up survey in 1999 in cooperation with the Myanmar Forestry Department and

Wildlife Conservation Society, surveys were performed in Maubin (7 villages), Wakema (3 villages), Einme and Labutta Township. In this report, over 100 Sarus Cranes were recorded in Ayeyarwady Region during the period of 8 days. One pair with nest recorded in Moe Yun Gyi Wildlife Sanctuary (Sai Wunna Kyi, 2014).

Curt D. Meine (1998) and their team surveyed in the Padu area, Saging region, and noted that Sarus Cranes were not observed in it during their survey period. J. A Sayer described in his letter, a pair of Sarus Crane were recorded in upper Chindwin near Mawleik, Saging Region by John Blower (1982).

Latt (1998, 2002, 2003 - unpublished report) and Curt D. Meine (1998) mentioned that Sarus Cranes were observed in Yangon Region. One of the bird survey team conducted fieldwork at sites where the Sarus Cranes was formerly recorded, including a site at Maubin where two nests were found in 2000 during the preliminary survey period (Thet Zaw Naing 2002) and the Payargyi Kwin area in Twantay township, where 88 and 128 Sarus Cranes were sighted in April 2004 and May 2005, respectively (Thet Zaw Naing 2005).

In The Birds of Burma by Smythies, Bertram E. 1953 mentioned that the Sarus Crane wasdistributed in Kachin State, northern Myanmar. According to the survey results by Curt D. Meine 1998 and their team, 28 Sarus Cranes were observed in near Indawgyi Lake. Sarus Cranes were observed in Lonton village (south of Indawgyi Lake), Chaungwa village and east of Indawgyi Lake. By the 1999-2000 expedition of Joost Vandervan, surveys were done in southwest, north and northeast of Bhamo, near Shwegu town, south of Myintkyina, south and north of Mogaung (west of Myintkyina) and Indawgyi Lake but Sarus Cranes were not seen during the survey trip. According to the interviews, local people said that Sarus Cranes were present in those areas. In a 2003 expedition report, the continuous annual surveys (2000 – 2003) showed thatSarus Cranes were observed in a small population (not more than 10 Cranes) in 2001, 2002 and not recorded in 2003. The author described in his report, other ornithologist had recorded Sarus Cranes with 2 or 3 juveniles in Indawgyi Lake in 2003.

In The Birds of Burma by Smythies, Bertram E. 1953 mentioned about the Sarus Cranes in Shan State. One pair with one juvenile was recorded in Tilaw village, Nyaung Shwe Township near Inlay Lake, described in a Summary report on a survey of breeding Sarus Cranes *Grus antigone* in Myanmar by Curt D. Meine in 1988 and follow up survey in 1999 in cooperation with the Myanmar Forestry Department and Wildlife Conservation Society.

According to the survey results by Curt D. Meine 1998 and their team, Sarus Crane was not recorded in their survey period and was last recorded in 1970 in Kayah State by interview surveys of local people. Information was gathered on a total of 9 specific sites of upper Rakhine State (Myanmar – Bangladesh border) where Sarus Cranes have been reported. These included both

breeding and wintering sites as well as historic and contemporary accounts of Sarus Crane use. Several Myanmar Forest Department (MFD) official state confidently that Sarus Cranes do not occur in the southern part of Rakhine State. The team surveyed in three Townships (Kyaukpyin, Myauk Oo and Rauthedaung). The survey results showed 2 pairs in Kyaukpyin, 9 Sarus Cranes in Myauk Oo in Suiyait chaung village and Seinhteingyi village and 3 pairs in Rauthedaung. Breeding was confirmed in Suiyait chaung village through the observation of juvenile. Sarus Cranes used brackish water habitat in Myauk Oo near the mangrove forest. According to their interview of local people, the population had declined in Rauthedaung, caused by the intrusion of salt water into the paddy field areas and paddy fields in that area converted into shrimp culture. Their report also described other threats such disturbance of nest sites in Rakhine State and Ayeyarwady Region.

Tin Nwe Latt (1996) studied the Cranes in Maubin Township, Ayeyarwady Region. She recorded a nesting site and five individual Sarus Cranes near Tha Htay Kone village and Hnget Taw Yoe village. Three Sarus Cranes were recorded in Nat Mu Gon village in Maubin Township. Thet Zaw Naing (2005) recorded two Sarus Cranes near Pain Chaung village. He also found two old nests near Pauk Kone village and three captive Cranes at Nyaung Pin Gayet monastery in January 2002.

Historically, of the seven States and seven Regions in Myanmar, the vulnerable species of Sarus Cranes were recorded in four States (Kachin, Rakhine, and Shan and Kayah)and four Regions(Ayeyarwady, Bago, Saging, and Yangon).. In the present time, there are no recorded data of Sarus Crane in Kayah since 1970. Currently, Sarus Cranes were observed in three States (Kachin, Rakhine, and Sahn) and four Regions (Ayeyarwady, Bago, Saging, and Yangon) (Figure 1) (Tin Aung Tun and Myo Sandar Winn, 2015 to 2022).

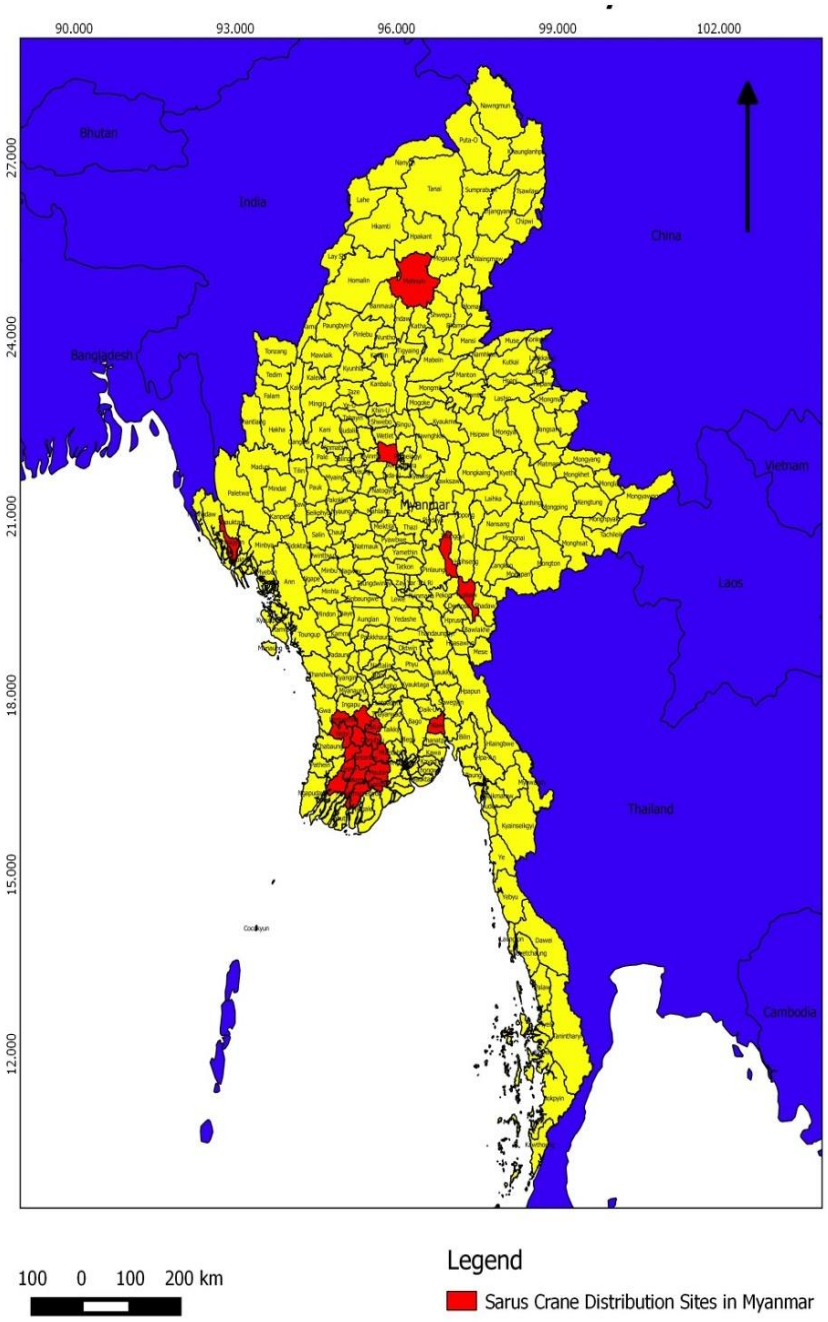

Figure 1. Distribution map of Sarus Cranes in Myanmar

3. Population status of Sarus Cranes in Ayeyarwady Region

3.1 Non-breeding season monitoring

The population of the Sarus Cranes were counted during the non – breeding season (December to May) yearly at four Districts (Maubin, Myaungmya, Pyapon and Labutta) in Ayeyarwady Region. Censuses were carried out six times per year. One five-day survey was performed at each of four sites. According to the survey results, the lowest population number of Sarus Cranes was recorded in earlier years, (2015 and 2016) and the team only surveyed in two sites. In 2017, 2018, 2019, 2021, and 2022, the team could survey in all four Districts. The differences in population numbers were not significant in yearly totals except in 2015 and 2016. The highest population numbers were observed in 2019 (306 individuals) followed by 2018 (299 individuals). Comparing four Districts, habitats of Myaungmya District (Wakema Township) and Maubin District (Maubin Township) were supporting the highest numbers of Sarus Cranes during the non-breeding season (Figure 2 and 3). By comparing the whole country population, 80% of populations were observed in Ayeyarwady Region.

Population status of Sarus Crane in 2015_2016

The survey was carried out in 15 villages that spanned across three Townships located in two different Districts within the Ayeyarwady Region. The survey results showed the presence of 59 Sarus Cranes, including eight juveniles, during the non-breeding season.

Population status of Sarus Crane in 2016_2017

This research encompassed 74 villages spread across nine Townships within four Districts located in the Ayeyarwady Region. The survey results showed the presence of 158 individual Sarus Cranes during the non-breeding season. Maubin District accounted for 104 individuals (including 20 juveniles), Myaungmya District hosted 49 individuals (including six juveniles), Pyapon District housed two individuals, and Labyutta District had three individuals (including one juvenile) within the overall population. It is noteworthy to mention that out of the total individuals recorded, 131 were classified as adults, while 27 were identified as juveniles.

Population status of Sarus Crane in 2017_2018

This study involved an investigation that covered 83 villages located across nine Townships within four Districts in the Ayeyarwady Region. The survey results revealed a significant presence of 222 individual Sarus Cranes during the non-breeding season. Maubin District exhibited 84 individuals (including 14 juveniles) of Sarus Cranes, Myaungmya District showcased a population of 131 individuals (including 26 juveniles). Pyapon District hosted a group of 5

individuals (including one juvenile), and Labyutta District accounted for two individuals. Among the recorded individuals, 181 were categorized as adults, while 41 were identified as juveniles.

Population status of Sarus Crane in 2018_2019

The study was conducted across 102 villages spanning 13 Townships within four Districts in Ayeyarwady Region. The findings of the survey revealed the presence of 299 individual Sarus Cranes during the non-breeding season. Maubin District accounted for 90 individuals (including 19 juveniles) of Sarus Cranes, Myaungmya District hosted 188 individuals (including 33 juveniles), Pyapon District housed 13 individuals (including two juveniles), and Labutta District had eight individuals. Among the total recorded individuals, 245 were classified as adults, while 54 were identified as juveniles.

Population status of Sarus Crane in 2019_2020

This study encompassed an investigation spanning 118 villages situated across 12 Townships within the Ayeyarwady Region's four Districts. The survey outcomes showed a notable presence of 306 individual Sarus Cranes during the non-breeding period. FMaubin District exhibited a count of 115 individuals (inclusive of 17 juveniles) of Sarus Cranes, while Myaungmya District showcased a population of 141 individuals (including 20 juveniles). Pyapon District hosted a group of 11 individuals, and Labutta District accounted for two individuals. Among the aggregated individuals recorded, 269 were categorized as adults, while 37 were discerned as juveniles.

Population status of Sarus Crane in 2020_2021

In 2020 and 2021, population surveys of Sarus Cranes were postponed due to the impact of the COVID-19 pandemic, resulting in a gap in census data during those years.

Population status of Sarus Crane in 2021_2022

This study involved an extensive investigation encompassing 68 villages distributed across three Townships within the two Districts in the Ayeyarwady Region. The survey outcomes effectively revealed 236 individual Sarus Cranes during their non-breeding phase. In Maubin District, a count of 105 Sarus Cranes was documented, inclusive of 19 juvenile individuals. Correspondingly, Myaungmya District demonstrated a population of 131 Sarus Cranes, encompassing 27 juveniles among them.

Population status of Sarus Crane in 2022_2023

The current study encompassed an extensive investigation that spanned across 83 villages, strategically situated within six Townships encompassing the four Districts of the Ayeyarwady Region. The outcomes of the comprehensive survey unveiled a substantial presence of 215

individual Sarus Cranes during their non-breeding phase. Within this context, Maubin District was marked by a count of 86 Sarus Cranes, including 11 juveniles. Myaungmya District possessed a population of 129 Sarus Cranes, of which 24 were juveniles. Neither Pyapon District nor Labutta District hosted any crane individuals during the study period.

3.2 Nesting monitoring in Ayeyarwady Region, Myanmar

Since 2015, Sarus Crane nesting sites were recorded in the unprotected area of Ayeyarwady Region. Nesting monitoring was performed in four Districts of Ayeyarwady Region. In the earlier nesting surveys of 2015 and 2016, the nests were recorded in the lowest numbers,caused by limited surveying. In 2017, 2018, 2019, the team surveyed and collected data in four Districts. The highest numbers of nests were recorded in 2019. In four Districts of Ayeyarwady Region, the highest population and nesting sites were recorded in Myaungmya (Wakema Township) and Maubin Districts (Maubin Township).

Breeding status of Sarus Crane in 2015_2016 in Ayeyarwady Region

Occurrences of 11 nests were recorded in nine villages within the designated study areas. Out of the total 11 nests documented, including 18 eggs across these nests, leading to the successful hatching of 18 chicks. After the breeding season, subsequent observations documented 11 fledgling individuals.

To evaluate the breeding status of Sarus Cranes, the Mayfield (1979) method was employed, yielding a hatching success rate of 100.0%, a fledging success rate of 61.1%, and a crude breeding success rate of 61.1%. The temporal distribution of nesting efforts indicated a significant peak in nest occurrences during the month of September.

Breeding status of Sarus Crane in 2016_2017 in Ayeyarwady Region

Occurrences of nests were documented in 17 villages within the designated study areas, totaling 23 observed nests. An analysis of the breeding data disclosed a count of 40 eggs distributed among these 23 nests, leading to the successful hatching of 40 chicks. Following the breeding season, subsequent observations recorded 29 fledgling individuals. To assess the breeding status of Sarus Cranes, the Mayfield (1979) method was employed, the outcomes indicated specific metrics: a hatching success rate of 100.00%, a fledging success rate of 72.50%, and a crude breeding success rate of 72.50%. The temporal distribution of nesting activities revealed a significant peak in nest occurrences during the month of August.

Breeding status of Sarus Crane in 2017_2018 in Ayeyarwady Region

Nest occurrences were carefully documented across 28 villages within the designated study areas, totaling 56 nests observed. 102 eggs were distributed among these 56 nests, resulting in the

successful hatching of 102 chicks. Beyond the breeding season, subsequent observations accounted for 54 fledgling individuals. Employing the Mayfield (1979) methodology to evaluate the breeding status of Sarus Cranes produced the following metrics: a hatching success rate of 100.00%, a fledging success rate of 52.94%, and a crude breeding success rate of 52.94%.

Breeding status of Sarus Crane in 2018_2019 in Ayeyarwady Region

Nest occurrences were documented across 32 villages within the designated study areas. Among the total of 78 nests, five nests experienced disturbance caused by human activities. The findings from the breeding data analysis revealed a count of 156 eggs distributed among 73 nests, resulting in a successful hatching of 125 chicks. Beyond the breeding season, a subsequent observation documented 87 fledgling individuals. Employing the Mayfield (1979) method to assess the breeding status of Sarus Cranes, the outcomes indicated hatching success at 80.1%, fledging success at 69.60% and crude breeding success at 55.70%. The temporal distribution of nesting endeavors indicated a peak in nest occurrences during the month of September.

Breeding status of Sarus Cranes in 2019_2020 in Ayeyarwady Region

Nest occurrences were documented across 25 villages situated within the designated study areas. Among the aggregate of 52 nests, 15 experienced disruptions caused by human activities. A74 eggs were distributed among 37 nests, culminating in the successful hatching of 69 chicks. Subsequent observations accounted for 34 fledgling individuals. Employing the Mayfield (1979) methodology to evaluate the breeding status of Sarus Cranes yielded a hatching success rate of 93.24%, fledging success concluded at 49.28% and crude breeding success stood at 45.95%.

Breeding status of Sarus Cranes in 2020_2021 in Ayeyarwady Region

In the years 2020 and 2021, the Sarus Crane breeding surveys were delayed because of the COVID-19 pandemic, leading to an absence of census data for those particular years.

Breeding status of Sarus Cranes in 2021_2022 in Ayeyarwady Region

Surveys were conducted across 31 villages within study areas. Among the 57 nests, 11 nests experienced disruptions attributed to human activities. Results showed 92 eggs distributed across 46 nests, culminating in the successful hatching of 83 chicks. Subsequent observations documented 46 fledgling individuals. Employing the Mayfield (1979) methodology, the hatching success demonstrated arate of 79.81%, the fledging success culminated at 55.42% and the crude breeding success was 42.23%.

Breeding status of Sarus Cranes in 2022_2023 in Ayeyarwady Region

Surveys were conducted across 27 villages in the study areas. Among the 56 nests, a subset of zero (0) nests experienced disruptions attributed to human activities. 101 eggs were distributed across

56 nests, culminating in the successful hatching of 70 chicks. Subsequent observations documented a total of 42 fledgling individuals. Employing the Mayfield (1979) methodology to assess the breeding status of Sarus Cranes yielded hatching success of 69.30%, the fledging success at 60% and the crude breeding success at 41.58%.

4. Habitats of Sarus Cranes in Myanmar

At each crane site, the survey team will conduct rapid assessment of crane habitats. We will follow the wetland habitat assessment protocol recommended in the Asian Wetland Inventory Handbook (Finlayson et al., 2002) and collect Level 4 data as detailed in the handbook, which is suitable for describing wetland habitats.

4.1 Breeding habitats

Information on Myanmar's breeding Sarus Cranes increasingly point to two main breeding areas. The main group of breeding birds is concentrated in a core area of the upper Ayeyarwady delta. These birds apparently remain in the region year-round. Lower Ayeyarwady delta is not being used and may be unsuitable as breeding habitat. This may be due to the higher salt content of the water, the difference in paddy management systems, the type and intensity of the human activity, the dispersal distance from existing crane populations, or a combination of these and other factors. The upper delta may contain additional breeding territories.

The relationship between the Sarus Crane'sbreeding behavior and the prevailing agricultural practices in the Ayeyarwady Region is delicate. Nesting success is likely a function of several interrelated factors. The remainder of Myanmar's breeding Cranes occur in smaller groups in the more mountainous interior valleys. These birds may be year-round residents near upland breeding territories (as in Shan State) or may sparsedispersed during the breeding season to scattered territories in the broader lowland valleys (as in Rakhine State) (Meine, 1998).

Documentation of nesting, including information on clutch size, egg survival and chicks of the Sarus Crane is limited and there have been no systematic surveys conducted to understand the breeding ecology of this species in Myanmar (Smith 1942, Sayer & U San Han 1983, Smythies 1986, Bird Life International 2001). The biology of the Sarus Crane on its breeding grounds has not been studied in detail (Archibald *et al.*, 2003). Some birds have been seen building nests in flooded rice-paddies in Myanmar (Latt 1998, Meine 1999, Archibald *et al.*, 2003).

Studies show that Sarus Cranes in India preferred paddy fields due to the openness of the landscape and shallow depth (<0.76m) of water, which is suitable for nesting and has high availability of food (Mukherjee *et al.*, 2000, Vyas 2002). Another nest with two eggs was recorded near Moyingyi Wetland Wildlife Sanctuary in 2019 but unfortunately both eggs were predated (Sai Wanna Kyi, 2019).

In current breeding habitats of Sarus Cranes were paddy fields (flooded or floating) and natural wetlands mingled with paddy fields and seasonal wetlands in the Ayeyarwady Region. Most of the floating rice fields and natural wetlands are suitable habitats for Sarus Cranes throughout the year in the Ayeyarwady Region. In recent results of 2015 to 2022 in the Ayeyarwady Region, designated in 13 townships were surveyed. Sarus Cranes were observed in all townships.

The highest population numbers and nesting sites were recorded in Wakema and Maubin Township. In the breeding season, habitats of these two Townships are more favorable for foraging, nesting, resting, roosting, and rearing chicks than other Townships. Sarus Cranes are utilizing floating rice fields and natural wetlands in breeding season and non-breeding season. Nesting sites mostly occurred in floating rice fields than other habitats. Floating rice fields provide a vital habitat for Sarus Cranes during the monsoon season, offering food, nesting sites, and protection. (Tin Aung Tun and Myo Sandar Winn and Tran Triet, 2015 to 2022).

In the Ayeyarwady Delta of Myanmar, Sarus Cranes and many other waterbird species inhabit naturally flooded rice paddies intermixed with natural wetlands that are inundated for 5-6 months of the year. This wildlife-friendly land use is under increasing pressure for conversion to intensified agricultural systems that produce 2-3 rice crops per year through irrigation, wetland drainage, and increased application of fertilizers and pesticides. The rapid expansion of freshwater fish aquaculture, which converts deep-flooded rice paddies to fishponds, further reduces habitat for cranes and other wildlife in the Ayeyarwady Delta.

4.2 Non-breeding habitats

The Sarus Crane's ability to adapt is crucial for its survival in the arid landscapes of the Ayeyarwady Region during the sweltering dry season. In response to these challenging conditions, these majestic birds have made significant adjustments to their habitat and feeding patterns. They've sought refuge near dependable water sources, such as rivers, lakes, and irrigation canals, ensuring access to essential food and hydration.

During this time, the floating rice fields and natural wetlands undergo a dramatic transformation, with water levels receding and some areas even drying up entirely. Despite these changes, these habitats have found a unique purpose as non-breeding grounds for the Sarus Crane. Interestingly, certain paddy fields undergo a metamorphosis, transforming into agricultural plots cultivated with beans, chili, corn, and sunflowers.

In the non-breeding season, Sarus Cranes expertly navigate this altered landscape. They venture into these agricultural lands to forage for sustenance and, come evening, return to the shallow waters of floating rice fields and natural wetlands for roosting. Within these rich ecosystems, a variety of food awaits the Sarus Crane, including fish, snails, crabs, shrimp, and various

invertebrates. Their diverse diet supports their nutritional needs, ensuring their continued well-being.

A particularly noteworthy dietary adaptation occurs during the dry season when Sarus Cranes primarily feast on the tubers of *Eleocharis spp.* an aquatic plant variety. These tubers serve as a vital source of nutrition, providing the cranes with the energy and sustenance required to flourish in their ever-changing habitat.

In the landscape of the Ayeyarwady Region, not all areas are created equal for Sarus Cranes. The non-breeding habitats in Wakema and Maubin Township stand out as prime locations, offering ample space for foraging, resting, and roosting during the dry season. However, many other townships face the challenge of diminishing wetlands due to seasonal fluctuations. This scarcity of wetlands has a detrimental effect on the available food resources for Sarus Cranes during this critical period.

Consequently, during the non-breeding season, Sarus Cranes may find it necessary to travel in search of places with available water sources, ensuring their needs are met in the face of changing environmental conditions. The resilience and adaptability of these remarkable birds in the Ayeyarwady Region continue to inspire and highlight the importance of safeguarding their habitats for generations to come.

Table1. List of sites and habitat where Sarus Cranes were conducted in Ayeyarwady Region, Myanamar 2015-2022.

Site	Ecosystem	Country
Maubin District		
Maubin Township	Wetland	Myanmar
Nyaungdone Township	Wetland	Myanmar
Pantanaw Township	Wetland	Myanmar
Danuphyu Township	Wetland	Myanmar
Myaungmya District		
Myaungmya Township	Wetland	Myanmar
Einme Township	Wetland	Myanmar
Wakhema Township	Wetland	Myanmar
Pyapon District		
Kyaiklat Township	Wetland	Myanmar
Labutta District		
Mawlamyingkyun Township	Wetland	Myanmar

Table 2. Recorded population of Sarus Cranes in Ayeayarwady Region in 2015 – 2020 (except 2020)

Year	Month of maximum total count	Total	Maubin	Myaungmya	Pyapon	Labutta
2015	April	59	59	0	0	0
2016	March	158	104	49	2	3
2017	March	222	84	131	5	2
2018	May	299	90	188	13	8
2019	May	306	132	161	11	2
2021	May	169	63	106	7	0
2022	May	215	86	129	0	0

Table.3 Number of observed nests and hatched chick at four Districts in Ayeyarwady Region, 2015 – 2022.

Year	Maubin			Wakema			Pyapon			Labutta			Total		
	Nest	Chick	C/N	Nest	Chick	C/N	Nest	Chick	C/N	Nest	Chick	C/N	Nest	Chick	C/N
2015	11	18	1.6	0	0	0	0	0	0	0	0	0	11	18	1.6
2016	13	23	1.8	9	16	1.8	1	1	1	0	0	0	23	40	1.7
2017	17	31	1.8	36	67	1.9	2	2	1	1	2	2	56	102	1.8
2018	28	39	1.4	42	76	1.8	6	8	1.1	2	2	1	78	125	1.6
2019	22	28	1.3	28	39	1.3	1	1	1	1	1	1	52	69	1.3
2020	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2021	17	29	1.7	40	54	1.4	0	0	0	0	0	0	57	83	1.4
2022	17	18	1.1	39	52	1.3	0	0	0	0	0	0	56	70	1.3
Total	125	186	1.5	194	304	1.6	17	21	1.2	4	5	1.3	333	507	1.5

C/N: Number of chicks per nest

5. Threats on Sarus Cranes in Ayeyarwady Region, Myanmar

There are both direct and indirect threats to the well-being and survival of Sarus Cranes in Myanmar. Direct threats encompass activities like poaching, the removal of crane eggs, taking crane chicks and keeping them as pets, and predation by both wild and domestic animals. While the practice of taking crane chicks and raising them as pets is unfortunately common, poaching of adult cranes is exceedingly rare. This rarity can be attributed to the deeply rooted religious beliefs of local communities, who consider the Sarus Crane to be a sacred symbol. According to their religious traditions, it is believed that the Buddha once inhabited the body of a Sarus Crane in a past life. Consequently, harming or killing a Sarus Crane is viewed as an act that invites a curse upon oneself. This spiritual connection between the crane and the local population has proven to be a valuable tool in the conservation efforts aimed at protecting these magnificent birds in Myanmar.

Indirect threats primarily revolve around habitat loss, which poses a significant risk not only to Sarus Cranes but also to various other wildlife species. The conversion of natural wetlands and floating rice fields for alternative uses, such as fishponds and intensive rice cultivation, can result in the destruction of critical habitats for Sarus Cranes. This conversion not only diminishes the region's biodiversity but also contributes to water pollution.

Human encroachment into crane habitats is another indirect threat. Activities like agricultural expansion and urbanization can lead to the degradation and destruction of these habitats, reducing the availability of essential resources like food and shelter. Additionally, human presence can cause disturbances that disrupt the cranes' natural behavior and displacement from their preferred habitats.

The drying of natural wetlands is yet another perilous factor affecting crane survival. This drying out can be attributed to factors like prolonged droughts, hot weather, and the extraction of water from wetlands for agricultural purposes, such as draining for crop production. When wetlands dry up during the dry season, it results in reduced access to food and water for Sarus Cranes and other wildlife species. This situation has immediate consequences, including heat stress, limited water sources, and decreased forage availability. Such environmental conditions can lead to physiological stress, higher mortality rates, and reduced breeding success among Sarus Cranes.

The establishment of poultry farming near wetlands poses a risk of environmental pollution. The introduction of pollutants like pesticides and fertilizers into wetland ecosystems can lead to increased sedimentation, diminished water quality, and potential harm to local wildlife.

Furthermore, the excessive use of fertilizers and pesticides in agriculture practices can negatively impact both the Sarus Cranes and the local population. These chemicals can lead to the

elimination of natural wetland vegetation, poisoning of cranes and humans, and contribute to climate change. Overuse of pesticides can also result in infertility and unintentional poisoning of Sarus Cranes.

Finally, the development of urbanization, including the proliferation of power lines, is emerging as another threat to the survival of Sarus Cranes in Myanmar. These power lines can pose risks such as collisions and electrocutions, which can have detrimental effects on crane populations.

In summary, the well-being and continued existence of Sarus Cranes in Myanmar face a complex web of challenges, encompassing both direct and indirect threats, including poaching, habitat loss, human encroachment, wetland drying, pollution, and urban development. Conservation efforts are essential to mitigate these threats and safeguard the future of these magnificent birds.

6. Assessment of people's attitude towards Sarus Cranes conservation

Previous surveys suggest that at some places egg and chick removals are important threats to cranes (Meine, 1999; Winn, 2015). Farmers' tolerance of crop damage caused by cranes nesting in paddy fields also seemed to be different among different regions in Myanmar (Meine, 1999) and may be due to divergent religious beliefs (Barzen, 1997). We conducted assessment of people's attitude towards crane conservation at selected sites from different regions. The assessment will was one mainly by interviewing local people, and key informants such as Buddhist monks and village leaders. As influential figures in their communities, monks and village leaders can play important roles in crane and wetland conservation. Because cranes and people are living in close proximity in Myanmar, conservation by means of establishing sanctuaries or protected areas may not be applicable or necessary (Meine, 1999).

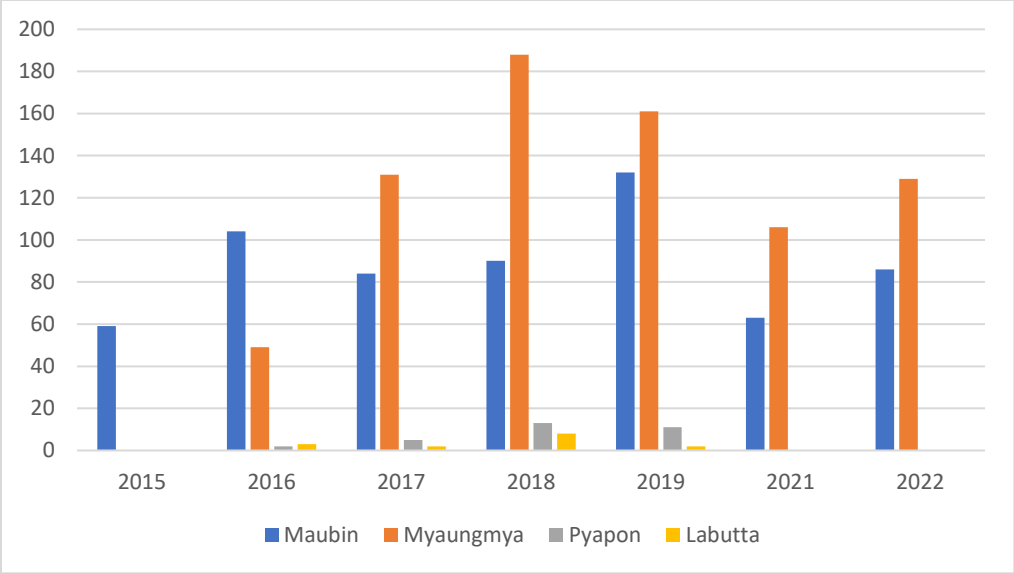

Figure 2. Recorded total number of Sarus Cranes during the non-breeding season in four Districts from 2015 to 2022.

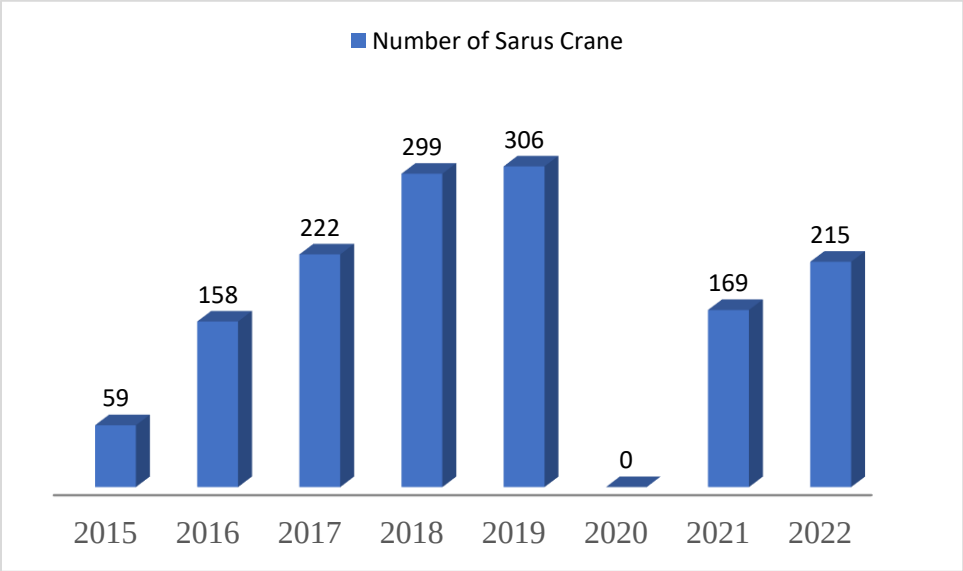

Figure 3. Total numbers of Sarus Cranes during the non-breeding season from 2015 to 2022.

7. Conclusion

The population status of Sarus Cranes in the Ayeyarwady Region of Myanmar has been meticulously monitored during both breeding and non-breeding seasons. This monitoring effort has revealed valuable insights into the dynamics of Sarus Crane populations in the region. Wakema and Maubin Townships stood out as key breeding areas, supporting high numbers of

Sarus Cranes and nesting sites. The survival rates of Sarus Crane chicks and juveniles can be influenced by various factors, including habitat quality, food availability, predation, and human activities. However, religious beliefs, especially the reverence of the crane as a sacred symbol, have contributed to the rarity of poaching adult cranes.

Assessments of people's attitudes towards Sarus Crane conservation have been conducted through interviews with local communities, Buddhist monks, and village leaders. These assessments provide insights into the varying levels of tolerance towards cranes, influenced by cultural and religious beliefs. It highlights the importance of engaging with local communities and influential figures in conservation efforts. The conservation of Sarus Cranes in the Ayeyarwady Region is a multifaceted challenge that requires a comprehensive approach. Monitoring, protection of habitats, community engagement, and awareness-raising are essential components of safeguarding the future of these iconic birds in Myanmar.

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SARUS CRANES IN THAILAND

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1. Introduction

The documentation of Eastern Sarus Cranes in Thailand has been recorded, albeit with uncertain specific locations, in 1973. Surprisingly, more than fifty years ago, the presence of these cranes in their native environment went unnoticed and they were not deemed extinct, despite Thailand's historical absence of a flourishing indigenous animal population. The Eastern Sarus crane holds significant recognition as one of the twenty species that are safeguarded under Thailand's Wildlife Conservation Act B.E. 2562 (2019). Between the years 1990 and 1997, the animal care staff at Nakhon Ratchasima Zoo, which is a part of the Zoological Park Organization (ZPOT), procured a total of 27 Eastern Sarus crane chicks. These chicks were acquired through generous donations made by villagers residing along the Thai-Cambodian border. These female birds were originally designated for the purpose of being utilized as breeding animals. Following this, there were extensive breeding efforts conducted within captive environments until the year 1997. During this particular time frame, the breeders were able to attain a satisfactory outcome by successfully raising Eastern Sarus crane chicks through natural reproductive mechanisms.

Since 2009, a significant conservation initiative has been in progress, encompassing the reintroduction of more than one hundred Eastern Sarus Cranes into the wetland ecosystems of Buri Ram Province, located in the northeastern region of Thailand. In 2016, a noteworthy achievement was attained with the auspicious occurrence of the inaugural hatching of a chick within its indigenous environment. It is worth noting that wetland habitats play a crucial role in sustaining biodiversity. However, there is a lack of sufficient protective measures for endangered species outside of designated conservation areas.

The main objective of the Sarus Crane reintroduction program is to incorporate the conservation of globally significant and threatened biodiversity into the management strategies of productive landscapes. The successful implementation of this integration is contingent upon the improvement of crucial habitat management practices. The comprehensive approach involves the preservation of species that are at risk of extinction, commonly referred to as endangered species (ES), as well as the protection of crucial habitats. This approach represents a shift in conservation practices and introduces a new framework for conservation efforts. The project functions as a paradigmatic model for the execution of conservation endeavors aimed at particular species. In 2017, a significant development took place when the classification of the Eastern Sarus Crane was revised from "extinct in the wild" (EW) to "critically endangered" (CR). The shift in status can be

directly attributed to the accomplishments attained by the project, underscoring its crucial role in reversing the declining prospects of this endangered species.

2. History of Sarus Cranes in Thailand

The Eastern Sarus Crane, an indigenous species in Thailand, has been extensively documented throughout the country, with historical records indicating its presence in both the northern and southern regions. Nevertheless, due to the Eastern Sarus crane's dependence on wetland habitats for breeding and foraging purposes, the significant reduction and deterioration of these habitats, along with grasslands, have directly resulted in a marked decrease in the population of this crane species. The ecological changes discussed are primarily attributed to transformations and modifications in agricultural environments, the application of chemical pesticides and insecticides, as well as various factors including hunting, utilization for sustenance, or the acquisition of raw materials for medicinal use. Undoubtedly, the historical documentation in Thailand provides ample evidence of multiple observations of the Sarus Crane. These sightings span from the period of King Thammathibet to the reign of King Rama IV. Notably, it was during the latter's rule that the initial mention of the "Crane Field" surfaced, referring to a specific location where the Sarus Crane was known to gather. The historical records presented valuable information that questioned the prevailing belief that the Sarus Crane was solely native to Thailand, thereby uncovering the existence of a substantial migratory community.

In the year 1961, Thailand initiated a comprehensive national economic and social development plan with the primary aim of improving agricultural productivity and increasing crop yield. This undertaking resulted in a significant alteration of natural environments, resulting in the conversion of approximately 60 million rai (equivalent to approximately 24 million acres) of natural habitats into cultivated fields. Simultaneously, the Sarus Crane population in Thailand underwent a precipitous and significant decrease. The Sarus Crane population, which was previously abundant and easily observable, has significantly declined and become a rare and infrequently observed species. In the year 1968, a mere two offspring of the Sarus Crane species were discovered in close proximity to the border shared by Thailand and Cambodia within the geographical region known as Surin province. One of the juvenile birds was placed under the care of Mr. Thawal Bunsi, a forestry official, who provided it with care and support at the Royal Chai Nat Bird Park located in Phrae Province. Unfortunately, the bird passed away at the age of 16 on October 27, 1984. The status of the other chick's fate remains unconfirmed. Following this incident, observations of the Sarus Crane in its native environment became increasingly infrequent. As a result, the Eastern Sarus Crane was officially classified as a protected wildlife species in compliance with the Wildlife Preservation and Protection Act, B.E. 2535.

Thailand received a total of three pairs of Sarus Crane offspring from the International Crane Foundation (ICF) in the year 1984 (B.E. 2527). These birds were enrolled in the care and rearing initiative at the Wildlife Breeding and Research Center, located in Bang Phra, Chonburi Province. As the progeny reached adulthood, the project underwent an expansion in its objectives, ultimately choosing the Kramang field located within the Phu Khew Wildlife Sanctuary in Chaiyaphum Province as the designated area for reintroducing the individuals into their natural habitat. The successful reintroduction of five Sarus Cranes into the natural habitat of Thailand took place on November 23, 1990 (B.E. 2533), marking a significant historical event.

Nevertheless, the decision to implement precautionary measures was made as a result of several factors. These factors include the limited quantity of cranes available and the uncertainties surrounding their lineage. Additionally, concerns arose from the observed disparities between the project-reared cranes and those obtained from the Nakhon Ratchasima Zoo. It is worth noting that the zoo had previously received Sarus Crane offspring of Thai origin from provinces located near the Cambodia-Thailand border. In order to conclusively address these uncertainties, blood samples from both the cranes that were raised as part of the project and those housed at Nakhon Ratchasima Zoo were sent to the International Crane Foundation (ICF) for a meticulous assessment of their genetic lineage. The project underwent a temporary suspension in the year 1994 (B.E. 2537) as a result of this significant genetic analysis.

In the latter part of July 2007 (B.E. 2550), a collaborative academic conference was organized involving three prominent entities: The Department of National Parks, Wildlife, and Plant Conservation; Kasetsart University; and various zoo organizations. The objective of this meeting was to engage in a comprehensive discussion regarding the strategic approach to wildlife conservation in Thailand. The accomplishments pertaining to the captive breeding of Eastern Sarus Cranes by zoo organizations have garnered significant attention and have become a prominent topic of discussion. A suggestion was put forth to develop a comprehensive action plan for the reintroduction of Eastern Sarus Cranes into their native environment.

Following this, a collaborative endeavor was commenced on September 8, 2007 (B.E. 2550), with the aim of securing backing from a range of public and private sector entities. Subsequently, the zoo organizations devised a strategic plan and subsequently submitted it to the National Research Council of Thailand. The commencement of this initiative signified the initiation of the project with the objective of making preparations for the reintroduction of Eastern Sarus Cranes into their natural habitat. The strategic plan serves as a crucial cornerstone in the continuous endeavor that has garnered notable accomplishments thus far. This undertaking has not only been instrumental in the preservation of the critically endangered Thai-origin Sarus Crane, but it has also played a part in improving its conservation status from a species that was dangerously close to extinction in its natural habitat in the year 2017.

3. The captive breeding and reintroduction program

Between the years 1989 and 1997 (B.E. 2532-2540), ZPOT received a donation of 32 Eastern Sarus cranes, comprising 19 males and 14 females. These birds were subsequently relocated to various breeding facilities, including Khao Khew Open Zoo (26 individuals), Chiang Mai Zoo (2 individuals), Dusit Zoo (2 individuals), and the Department of Forestry (4 individuals) at the time. Remarkably, successful breeding was achieved, with the first Thai-origin Sarus Crane offspring hatching in captivity in the year 1997 (B.E. 2540). Subsequently, breeding efforts continued to yield positive results, with an average population growth rate of 12.54±3.23% per year. Importantly, there was no statistically significant difference in population growth rates between males and females ($P>0.05$). The egg-laying patterns of Eastern Sarus Cranes exhibit a significant correlation with the duration of continuous rainfall, relative humidity, and monthly precipitation levels ($p<0.01$). Eastern Sarus Cranes tend to initiate nesting during the period of continuous rainfall, which lasts for approximately 5-22 days, with average monthly precipitation ranging from 28.30 to 319.70 millimeters.

The hatching rate of Eastern Sarus Cranes in their natural habitat is significantly impacted by the temperature conditions within the nest, exhibiting a strong correlation with the prevailing ambient environmental temperature. A significant correlation ($p<0.01$) has been noted between the hatching rate of Eastern Sarus Cranes and the average monthly temperature. Nevertheless, no statistically significant correlation has been observed between humidity, precipitation levels, and the frequency of rainy days. The Sarus Crane chick hatching process is most favorable within the temperature range of 31-37 degrees Celsius. There is a positive correlation between the rise in average temperature and the hatching rate of Eastern Sarus cranes. The temperature range that is considered most appropriate typically falls within the range of 36-37 degrees Celsius. Consequently, variations in precipitation patterns have the potential to influence the selection of habitats, nesting locations, and breeding timing for Eastern Sarus cranes.

Currently, as of the year 2022, the Khao Khew Open Zoo is home to a collection of 25 pairs of Eastern Sarus Cranes that are actively engaged in breeding. These pairs collectively produce an average annual yield of eggs, ranging from 40 to 60 eggs, which amounts to approximately 35 eggs per year. The annual hatching rate ranges from 20 to 25 chicks, while the survival rate of chicks per year is estimated to be between 12 and 15. The figures presented represent the population of Eastern Sarus Cranes designated for yearly reintroduction into their native environment.

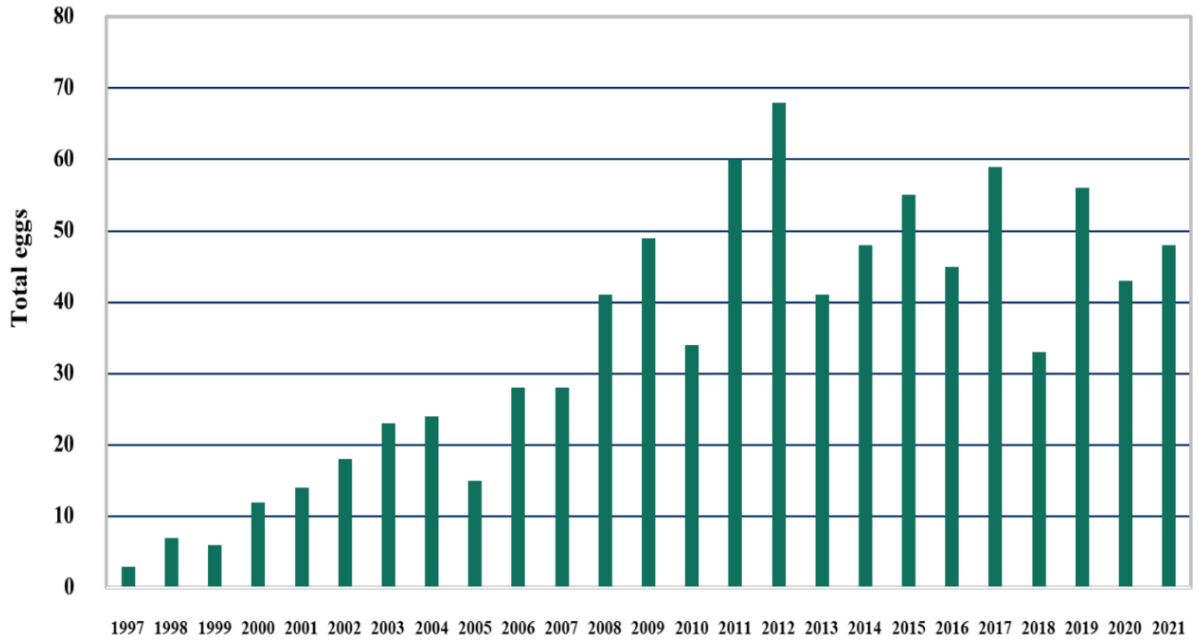


Figure 1 Egg laying patterns of East Sarus Cranes from the years 1997 to 2021.

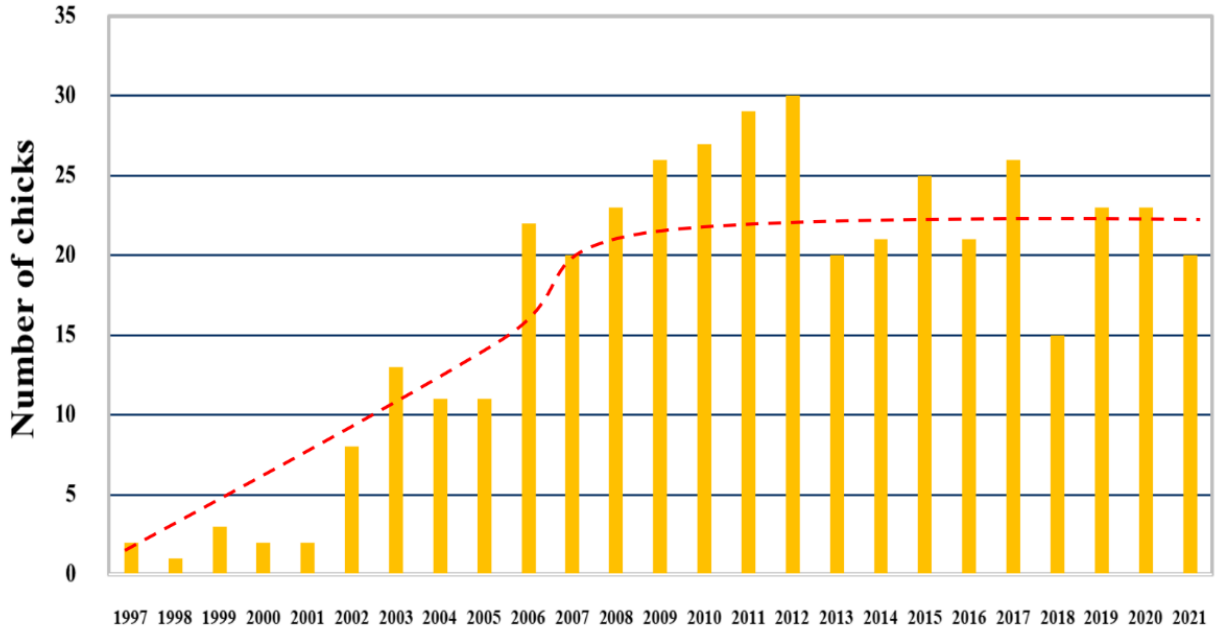


Figure 2 Hatching data of East Sarus Crane chicks from the year 1997 to 2021.

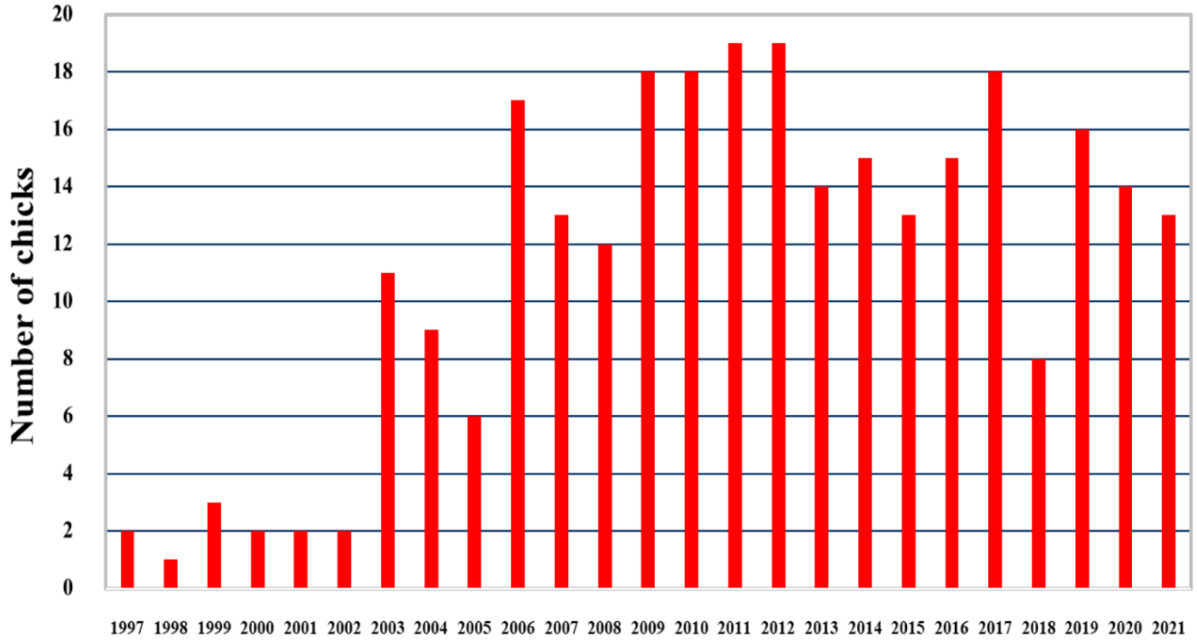


Figure 3. Data on the survival of juvenile individuals: specifically, the count of offspring that remain alive three months following their hatching.

The available data on juvenile survival reveals that there is a collective survival rate of 280 chicks, which corresponds to 66.04% of the overall chick population. Annually, the average survival rate of chicks was 11. The depicted trend in Figure 3 (2008 to 2021) has exhibited a relatively stable pattern, with an average annual range of approximately 12 to 15 chicks.

Figure 4. Initial captive breeding facility located at Nakhon Ratchasima Zoo is depicted.

4. The release of Sarus Cranes in natural wetlands

In 2011, ZPOT commenced the process of reintroducing Eastern Sarus Cranes back into their native environment. The aforementioned program has been implemented on an annual basis, maintaining a consistent trajectory through the current year, 2023. As a result, a cumulative total of 155 cranes have been successfully reintroduced into their natural habitat. Juvenile Eastern Sarus Cranes demonstrate gregarious tendencies in their native environment, as they congregate in social clusters, thereby augmenting their chances of survival and improving their foraging capabilities. In addition, social hierarchies predicated on gender and body size were observed by Kepler in 1976.

The preparation of juvenile Eastern Sarus Cranes for their release into their natural habitat by ZPOT involves the implementation of three distinct rearing methods: 1) parent rearing, 2) isolation or costume rearing, wherein caretakers don costumes that mimic crane parents, and 3) rearing by caretakers without the use of protective costumes. According to Swengel et al. (1996), juvenile cranes are typically separated from their parents when they are between 2 weeks and 4 months old. This separation is done in order to facilitate their upbringing and training in social behaviors, with the ultimate goal of integrating them into a wild flock. Upon reaching the age of 6 months, cranes have been observed to potentially exhibit aggressive behaviors towards other cranes or individuals of the same gender. Hence, it is imperative to ensure the provision of a suitable habitat, along with sufficient water and food resources, in order to mitigate conflicts and injuries that may compromise the suitability of reintroducing these animals back into their natural habitats.

At approximately 6 months of age, juvenile cranes are transferred to an acclimatization enclosure within the release area, allowing them to adapt to the natural environment gradually. The release process is carried out using a gentle release approach. These juveniles are reintroduced into their natural habitat when they reach around 1 year of age. The post-release survival rate of Eastern Sarus Cranes one year after their reintroduction averages at 78.6%. This survival rate is statistically significantly associated with the rearing method ($p<0.01$). Juveniles reared by crane parents exhibit the highest average post-release survival rate, reaching 100%. In contrast, cranes reared using the isolation rearing method have an average post-release survival rate of approximately 85%, while those reared by caregivers without protective costumes or those with close human contact have the lowest post-release survival rate, at 0%.

Consequently, since 2014, ZPOT has primarily adopted two rearing methods: parent rearing and isolation rearing. This choice stems from the understanding that cranes raised in close proximity to humans may exhibit reduced wariness, misplaced trust in humans, or stress-related behaviors, ultimately hindering their successful adaptation to the wild upon release. Furthermore, the pre-release acclimation period also plays a significant role in post-release survival rates, exhibiting a statistically significant correlation ($p<0.05$). It is noteworthy that an optimal acclimation period of at least 4 months in the actual release environment is advised before the cranes are reintroduced

into the wild. Additionally, with regard to the quantity and gender distribution of released cranes, there is no statistically significant correlation observed with post-release survival rates.

The release of Eastern Sarus Cranes from enclosures into natural wetlands in the Buriram province, situated in northeastern Thailand, has been initiated by ZPOT since 2011. Between the years 2011 and 2022, a cumulative number of 155 male and 75 female cranes were successfully reintroduced into their natural habitat. ZPOT utilizes a range of tracking techniques, such as aluminum straps, colored straps, satellite, and radio transmitters, to effectively monitor the cranes. These methods enable the evaluation of their survival rates and the identification of their recently established habitats. In addition, there have been regional surveys undertaken to collect pertinent data. The post-release survival rate, on average, after one year of reintroduction is an impressive 78.6%. Additional information can be found in Table 1.

Table 1 Eastern Sarus Cranes that have been released in wetland habitats from the years 2011 to 2022.

Year	**Number of released Eastern Sarus Cranes** (unit=bird)			**Survival rate after released 1 year**
	Total	**Male**	**Female**	
2011	10	4	6	**6 (60%)**
2012	15	9	6	10 (67%)
2013	21	9	12	16 (76%)
2014	12	4	8	6 (50%)
2015	12	8	4	11 (85%)
2017	12	4	8	8 (67%)
2018	22	12	10	21 (95%)
2019	14	7	7	12 (86%)
2021	14	7	7	14 (100%)
2022	23	11	12	23 (100%)
Total	**155**	**75**	**8**	-
Average	-	-	-	78.6%

Figure 5. the implementation of the Eastern Sarus Cranes Release Program within wetlands.

5. Habitats

The feeding habits of Eastern Sarus Cranes are characterized by their omnivorous nature, as they consume a diverse range of both plant-based and animal-based foods. The dietary preferences of this organism encompass a diverse range of sources, which include an assortment of surplus seeds that are frequently encountered in agricultural regions. These seeds consist of essential crops such as wheat, rice, corn, beans, tubers, and sprouts. Moreover, Eastern Sarus Cranes engage in the consumption of aquatic vegetation, specifically focusing on plant stems and roots, in addition to terrestrial vegetation such as grass sprouts. Moreover, within aquatic ecosystems, the Eastern Sarus Cranes exhibit a dietary preference for various organisms, including clams, fish, and crabs. Notably, these cranes predominantly select water bodies with depths that do not surpass 30 centimeters.

Figure 6. The habitats of Eastern Sarus Cranes

6. Management program

ZPOT has been implementing a program since 2011 that involves the introduction of breeding cages into the natural wetlands of Buriram province. According to the Cabinet Resolution of 3 November 2000, which pertains to the Wetlands of International and National Significance in Thailand and their Conservation Measures, this particular region possesses significant international value as a wetland within Thailand. The area includes the adjacent wetlands, which are notable for their level topography, cultivation of rice, and presence of shallow bodies of water containing various types of aquatic vegetation such as reeds, lotuses, grasses, and other flora. However, the persistent pursuit of economic growth has resulted in the widespread exploitation of adjacent areas, with a particular emphasis on agricultural activities. This phenomenon involves the utilization of chemical substances such as insecticides, chemical fertilizers, and crop growth enhancers in order to satisfy market requirements, alongside the expansion of neighboring communities and the consequent release of waste into water bodies. As a result, the gradual degradation of the natural environment has been attributed to chemical contamination and the presence of harmful pathogens. This degradation is expected to have long-term repercussions for

the various organisms, including plants, animals, and humans, that depend on these wetlands. Notably, the Eastern Sarus Crane is particularly affected by these consequences. Therefore, it is crucial to develop a comprehensive strategy that considers all aspects for successful reintroduction, while also addressing the complex and interconnected obstacles and achieving a harmonious relationship between spatial utilization and sustainable cohabitation.

The Sarus Crane reintroduction program expresses significant apprehension regarding the persistent susceptibility of cranes to the toxic effects of agricultural chemicals, as well as the continuous degradation and depletion of their natural habitats. The main goals of the program encompass the execution of management and wetland conservation strategies for the crucial ecosystem services (ES) habitat, the creation of a sustainable financial plan for the long-term development of the ES habitat site, and the improvement of extension support to aid land users in adopting land use practices that promote biodiversity. The project has successfully facilitated the training of a substantial number of key stakeholders, including members of communities, farmers, local government officials, and rangers. This training initiative has been accomplished through the creation and implementation of a comprehensive curriculum consisting of more than ten distinct training modules. Capacity-building entails the process of identifying prevailing incentives and disincentives, with the aim of maximizing outcomes through the utilization of the accessible alternatives. The business plan is closely linked to capacity-building initiatives, which encompass the provision of technical support in key areas such as the establishment of organic rice farming cooperatives, business administration, and agricultural practices, including organic farming. In addition, the project incorporates wetland management planning that is in accordance with both national and international standards.

The implementation of this comprehensive approach facilitates the extensive integration of sustainable agricultural methods, thereby resulting in the augmentation of community revenues and the improvement of overall well-being. The financial support is derived from the revenue generated by important initiatives that promote biodiversity, such as organic rice production, products derived from wetlands, and innovative tourism activities that add value. The wetland management planning process incorporates the requirements of both ecosystem services (ES) and the local community, with an emphasis on facilitating community-driven tourism activities that center around the observation of Eastern Sarus Cranes and other avian species within the wetland areas. The Thailand Ramsar National Report COP 14 highlights the importance of recognizing the value of ecosystem services, specifically the economic benefits derived from community-based tourism activities in wetlands.

ZPOT has provided its assistance in facilitating the inclusion of organic farming communities within the conservation efforts targeting the preservation of the Eastern Sarus Cranes in Buri Ram province. The conservation program is inherently interconnected with both the rice paddy fields and the agrarian communities that inhabit these areas. Therefore, it is crucial to support the establishment of community-based organizations focused on organic rice farming. This support

will contribute to the advancement of knowledge and the promotion of innovation in this field. Additionally, it is important to utilize indigenous wisdom to enhance organic rice cultivation practices. By doing so, we can ensure the economic sustainability of organic rice farming and facilitate the transition of farmers from conventional chemical-dependent farming methods to more sustainable and environmentally friendly approaches. The pivotal role played by the establishment of exemplary community groups is assumed in the transformation of these communities into models for organic rice production, thereby aligning with the overarching goal of Thai Sarus Crane conservation.

ZPOT has successfully established the first-ever community organization, known as the 'Ban Sawai Sor' Organic Rice Community Group, led by Mr. Thongpoon Unjit, the head of Village No. 7, Sakae Prong Rong Sub-District, Mueang Buriram District. The community group comprises approximately 80 individuals who are actively involved in the cultivation of fragrant jasmine rice. The agricultural operation encompasses a land area of approximately 1,500 acres, situated in the upper portion of a wetland region that has been specifically designated as a conservation zone for Eastern Sarus cranes. Initially, Mr. Thongpoon Unjit undertook experiments with the objective of reducing the reliance on chemical inputs in his agricultural activities on his private farmland. Following this, he proceeded to market his rice products under the brand name 'Khao Unjit.' The 'Ban Sawai Sor Organic Rice Community Group' was formally established subsequent to the initiation and support provided by the ZPOT, resulting in its official registration. Furthermore, the organization established a Facebook page named 'Khao Unjit' in order to streamline sales processes and distribute relevant information regarding organic rice. The collaboration between the ZPOT and the Buriram Land Development Station aimed to enhance their engagement in the Participatory Guarantee System (PGS) for the purpose of certifying organic farming practices. The main aim of this initiative is to optimize the learning and development process by facilitating the acquisition of pertinent knowledge and advancements in the realm of organic rice cultivation. Furthermore, the objective is to establish efficient knowledge management systems and foster community experts who can provide consultation and facilitate the knowledge transfer in the field of organic rice production.

At present, the Ban Sawai Sor Organic Rice Community Group commercially promotes its aromatic jasmine rice offerings through the brand identity of 'SARUS RICE.' Concurrently, the local community has undergone a transformation into an eco-tourism village, utilizing the Thai Sarus Crane as its emblem, in order to promote the community as a sustainable tourism destination. The term "SARUS RICE" is derived from the local name given to the Eastern Sarus Crane, a species indigenous to Thailand. In the Thai language, the term "Khao Sa-rat" is used to designate this concept. The term "Sa-rat" generally encompasses notions of aesthetics, indispensability, and adherence to the principles outlined in the Royal Institute Dictionary, BE 2554. The term "Sa-rat" can be interpreted as a "beneficial substance." Consequently, "Khao Sa-rat" refers to rice that is cultivated through the collaborative and voluntary efforts of communities,

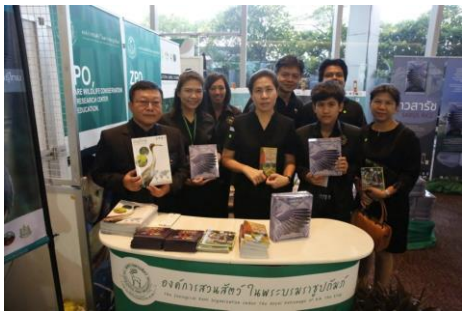
with the primary aim of preserving the long-term sustainability of the natural habitats of the Thai Sarus Crane and upholding ecological balance.

Furthermore, the ZPOT has provided its endorsement to two other commendable community organizations. One example of such a group is the "Organic Rice Community Group, Ban Kiat Jaroen," located in the Khok Ma sub-district of Prakhon Chai sub-district, within Buri Ram province. The collective consists of an estimated 100 individuals who are responsible for the management and supervision of rice fields that cover an area of approximately 2,300 rai. The area of interest is situated in the northern portion of the ecologically diverse flooded region known as the Buri Ram wetlands. The second community group is referred to as the "Large-Scale Agricultural Promotion Project" and is situated in the Sakae Sum sub-district within the Mueang, Buri Ram district. The community group comprises around 90 members who are actively involved in the cultivation of rice, spanning an area of approximately 1,500 rai. This site is located in the northern region of the flooded area of the Huai Talat Reservoir, which plays a vital role in providing water to the nearby vicinity. It is noteworthy that both regions have recorded instances of Eastern Sarus Cranes successfully establishing nests and occupying their respective environments following their reintroduction into their native habitats. Both community groups have taken steps to acquire organic farming certification through the Participatory Guarantee System (PGS), while concurrently enhancing their production techniques and establishing a self-sufficient network. The individuals in question have received extensive training, participated in knowledge exchange initiatives, and gained practical experience in the domain of organic farming methodologies. Furthermore, they have acquired knowledge in relation to the conservation of wetlands and the Thai Sarus Crane. The company is currently involved in the development of products that utilize aromatic rice as the primary ingredient, and these products will be commercially promoted under the brand name "SARUS RICE."

Currently, there is a group in Ban Raberd Kam, Samet sub-district, Mueang Buri Ram District which has received support from True Corporation Public Company Limited. This group is engaged in organic rice production in a wetland area where Eastern Sarus cranes have been released and has been selling their produce in department stores in Bangkok.

Figure 7. Organic Rice Community Group and SARUS RICE


SARUS
RICE

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SARUS RICE
Thank You


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SARUS CRANES IN CAMBODIA AND VIETNAM

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1. Introduction

Eastern Sarus Crane (*Grus antigone sharpii*) has the smallest population among the three subspecies of Sarus Crane. Within the Eastern Sarus Crane subspecies, there are now three non-overlapping populations: a reintroduced population in Thailand (Prentice and Siriaroonrat 2011; Sankhom et al. 2018) and two remnant populations; one in Myanmar and the other in both Cambodia and Vietnam. The reintroduced population, however, has remained relatively sedentary (Siriaroonrat et al. 2018) and has not likely mixed with cranes in Cambodia or Vietnam. The remnant Cambodia-Vietnam population of the Eastern Sarus Crane is the focus of this report.

The objectives of this report are to:

(i) present the results of long-term population monitoring, at both breeding and non-breeding habitats, that identify important population change
(ii) describe the habitats that cranes use, and
(iii) present an analysis of threats to Sarus Cranes that need to be addressed for the population to persist.

2. Distribution

The original distribution of Eastern Sarus Cranes occurred between Vietnam and Myanmar (Johnsgard 1983) in any appropriate habitat that could range from large seasonally inundated wetlands like the million-ha Plain of Reeds to small palustrine wetlands distributed in deciduous Dipterocarp forests (Barzen 2004, Barzen et al. 2019). In recent times, Eastern Sarus Cranes occurred primarily in Cambodia, southwestern China, Lao PDR (at least in the south), Malaysia (northern part), Myanmar, Thailand, and Vietnam (central and south). Within the last 30 years, Sarus Cranes were extirpated in China after 1990 and Lao PDR after 1996, the last years from which records exist in these two countries (Barzen and Seal 2001). Eastern Sarus Cranes were

extirpated in Thailand between 1968 and 1984 (Siriaroonrat et al. 2018) and from the Malay Peninsula prior to the 1990's (Wells 1999). The current distribution of the remnant Cambodia-Vietnam population is restricted to Cambodia (breeding and non-breeding) and Vietnam (non-breeding).

The distribution of known Eastern Sarus Cranes locations were restricted to dry (non-breeding) season habitats of the Mekong Delta 1985-1997, primarily from the Plain of Reeds at what is now Tram Chim National Park (Le 1987,1991; Beilfuss and Barzen 1994, Barzen and Seal 2001, Meynell et al. 2012). The next significant discovery of crane habitat during the dry season occurred at Ang Trapaeng Thmor reservoir (ATT) in 1998 (Sam 1998). In 2001, cranes were discovered using wetlands during the dry season in the Ha Tien Plain (Tran et al. 2000). Since 2005, Stoung Grasslands, adjacent to the north side of the Tonle Sap and part of the Tonle Sap Basin, have become important non-breeding habitat as well (van Zalinge et al. 2023a). With these discoveries, three primary wetland ecosystems were identified as important for the Cambodia-Vietnam population during the non-breeding season: 1) floodplains on the northern side of the Tonle Sap (including ATT), 2) the Mekong Delta (in both Cambodia and Vietnam) and 3) the open deciduous Dipterocarp forest in breeding areas where single family units, or non-territorial individuals, occupied permanent or a semi-permanent wetlands that retained water. The common denominator for among wetlands of the Tonle Sap, Mekong and open deciduous Dipterocarp forest was water presence during the dry season and water fluctuation between rainy and wet seasons.

Breeding locations were first documented in 1994 when crane nests were located during an aerial survey in and near the Lomphat Wildlife Sanctuary in northeastern Cambodia (Barzen 1994). From an aerial survey conducted in 2001, the known breeding distribution was expanded to include most of the northern plains in Cambodia (Barzen 2004) and subsequent ground surveys expanded the breeding range to include Yok Don National Park in Vietnam (Nguyen 2004).

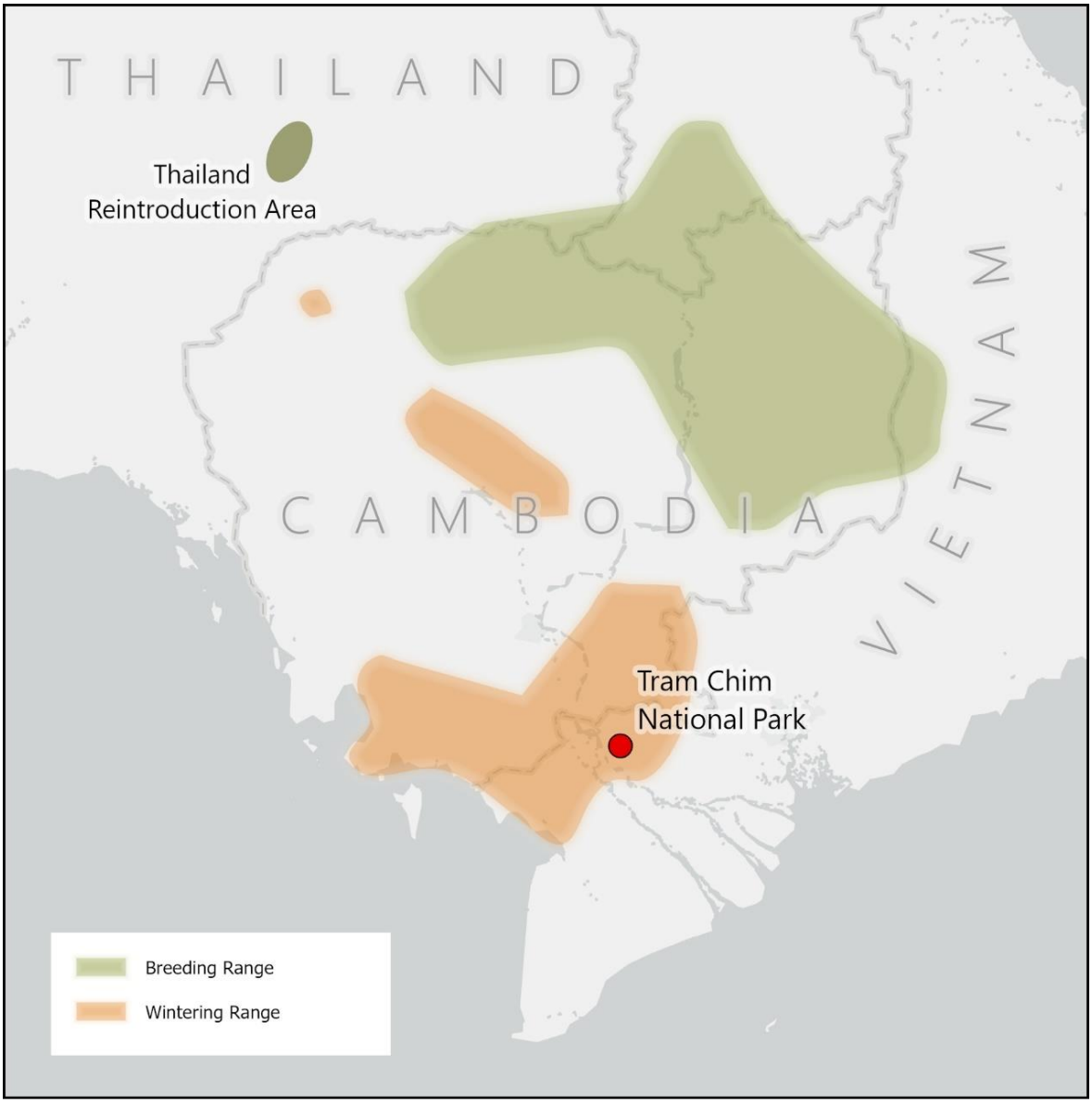

Figure 1: Current Eastern Sarus Crane range map in Cambodia and Vietnam, with the location of the reintroduced population in Thailand.

3. Habitats

3.1 Breeding habitats

Historically, though breeding cranes will use large, expansive wetlands to nest, breeding cranes often chose wetlands under 10 ha to construct their nests as well, even wetlands as small as a few hectares (Barzen 2004). The current distribution of nesting cranes occurs in these small, scattered wetlands that are dispersed throughout the dry deciduous forests, wetlands that are often not depicted on many maps or noted in wetland inventories due to their small size and numerous

occurrences (Barzen 2004). We now know that small seasonal, palustrian wetlands in the dry forests are unique ecosystems that have clear geo-morphological origins and do not occur randomly in the forest (Barzen et al. 2019). Within the broader region, the scattered wetlands that serve as crane nesting habitat occur in many, but not all, of the regions within the Central Indochina Dry Forest Ecosystem (Barzen et al. 2019) which is an ecosystem defined by dry, deciduous Dipterocarp forests (Rundel, 2007).

The current breeding distribution of the Cambodia-Vietnam population is entirely restricted to Cambodia with primary nesting areas occurring in two areas: 1) in the Northern Plains, consisting of deciduous forests extending from Beng Per Wildlife Sanctuary to Kulen Promtep Wildlife Sanctuary and eastwards to Chhaeb Wildlife Sanctuary and 2) in the Eastern Plains, in smaller scattered locations in the "three S" region of the Srae Pok, Sesan and Sekong Rivers with an area in Lomphat Wildlife Sanctuary and other adjacent deciduous forest areas in the region (Barzen 2004, van Zalinge et al. 2023b). Nests have been found as far north as Siem Pang WS. Nesting currently occurs in mostly small, usually temporarily inundated, wetlands during the rainy season (Barzen 2004, Harrison & Mao 2017) and individuals often disperse away from scattered nesting habitats in dry forests, dominated by species of deciduous Dipterocarp trees, as these seasonal wetlands dry out (Barzen, unpubl. data; van Zalinge et al. 2023b). Generally, it seems that nesting wetlands are less extensive (Barzen et al. 2019), and nesting density is lower, east of the Mekong River than what occurs west of the Mekong River (van Zalinge et al. 2023b).

3.2 Non-breeding habitats

Sarus Cranes successfully utilize rice fields in India (Sundar 2009) and Myanmar (Barzen and Seal 2001; Tin Aung Tun et al. 2023) during both breeding and non-breeding portions of the annual cycle. In Cambodia and Vietnam, some cranes were seen using rice fields for foraging but not for nesting. During the past two decades, the main non-breeding sites for Sarus Cranes in Cambodia include Ang Trapaeng Thmor (ATT) in Banteay Meanchey Province, several sites around the Tonle Sap Lake, Boeng Prek Lpov (BPL) in Takeo Province, and Anlung Pring (AP) in Kampot Province. Sarus Crane sites in Vietnam include Tram Chim National Park (TC) in Dong Thap Province, Lang Sen Wetland Reserve in Long An Province, and Phu My (PM), Hon Chong, Kien Luong and Hon Dat which all are all in Kien Giang Province. Sarus Cranes were also seen stopping at Lo Go Xa Mat National Park in Tay Ninh Province during their migration from breeding grounds in northern Cambodia to the Mekong Delta in Vietnam (Table 1).

In natural wetlands during the dry season, cranes prefer vegetation communities containing *Eleocharis dulcis* and *E. philippensis* at AP (Yav et al. 2015). At Tram Chim National Park the primary diet was thought to be tubers of *E. dulcis, E. ochrostachys* and *E. atropurpurea* but other prey items such as crab and fish were also adventitiously consumed (Meynell et al. 2012).

Wetlands used by cranes early in the dry season, like BPL and the Tonle Sap floodplains, are areas that dry completely in most years and become too dry to support large numbers of cranes by

January or February. Conversely, wetlands at AP, Phu My and ATT dry out later in the dry season so that cranes often flock to these protected areas more from February through April (Tran et al. 2022).

Daily crane movements during the dry season can be extensive, but flocks tend to use a preferred roost as long as possible if human disturbance is minimal and water conditions are good (van Zalinge et al. 2023a). At ATT, conditions are less predictable because water levels in the reservoir are managed primarily for rice irrigation and not for wetland productivity. Sarus Cranes also forage in harvested rice fields located near roosting wetlands at most sites. The Tonle Sap Basin now appears to provide key non-breeding season habitats for cranes in their entirety or as a stopping point between breeding areas and final non-breeding locations of ATT or the Mekong Delta.

4. Status of the Cambodia-Vietnam Sarus Crane population

4.1 Non-breeding season monitoring

In 2001, the International Crane Foundation established the cooperative Sarus Crane monitoring program throughout the three wetland ecoystems that comprise the non-breeding sites utilized by the Cambodia-Vietnam population. Annual censuses were carried out once a year on the last day of March (2001-2007), three times per year (January, February and March) 2008-2013 and five times a year, from December to May, since 2014 (Tran et al. 2022). Most counts were repeated on two consecutive days at the end of each month and the highest tally of consecutive counts was used for each site in each month.

Population monitoring data obtained prior to 2002 showed that the Cambodia-Vietnam population seemed to have remained stable or perhaps declined slightly from a high of 1,100 individuals in 1990 (Barzen and Seal 2001) to 878 birds by 2002 (Tran et al. 2022). Precision of counts prior to 2002 could not discern between interpretations of stable versus slowly declining populations. Coordinated counts of the Cambodia-Vietnam population began in 2001 where all known areas used by cranes during the dry (i.e. non-breeding) season were observed simultaneously. The population appeared stable at approximately 850 individuals during 2002-2013 (Tran et al. 2022) or declined at a rate of about 1% per year (van Zalinge 2021). Following 2013, the Cambodia-Vietnam population declined rapidly with over an 80% reduction in crane numbers between 2014 and 2021 (Table 2; Figure 2; Tran et al. 2022). The highest number of Sarus cranes recorded in the 2022 population census was 156 (in February 2022; Tran et al. 2022). The synchronized counts in 2022-2023 in Cambodia and Vietnam recorded a slight increase, with a maximum count of 180 birds in February 2023 (Gray-Reed et al. 2023). Compared to 2013, the population was reduced by 670 birds, or 79% of the population, averaging 7.9% per year during the past 10 years. Currently, Anlung Pring supports the largest numbers of cranes during the dry season in the Mekong Delta (Gray-Reed et al. 2023) (Figure 3). The trend is

likely biologically accurate, even if counts may miss an unknown percentage of the population each year (Figure 4).

Table 1: List of sites and dry season habitat where synchronized counts of Sarus Cranes were conducted in Cambodia and Vietnam 2001 – 2023.

Site	Ecosystem	Country
Tonle Sap Lake Basin		
Ang Trapaeng Thmor	Floodplain	Cambodia
Presh Neath Presh	Floodplain	Cambodia
Tonle Sap Grasslands (Kampong Thom)	Floodplain	Cambodia
Mekong River Delta		
Boeng Prek Lpov	Floodplain	Cambodia
Anlung Pring/Phu My	Floodplain	Cambodia/Vietnam
Koh Thom	Floodplain	Cambodia
Tram Chim	Floodplain	Vietnam
Lang Sen	Floodplain	Vietnam
Hon Chong	Floodplain	Vietnam
Kien Luong	Floodplain	Vietnam
Phnom Teuk/ Da Dung (Ha Tien)	Floodplain	Cambodia/Vietnam
Hon Dat	Floodplain	Vietnam
Northern/Eastern deciduous forests		
Preah Vihear Protected Forest	Isolated Wetland	Cambodia
Kulen Promtep Wildlife Sanctuary	Isolated Wetland	Cambodia
Siem Pang Wildlife Sanctuary	Isolated Wetland	Cambodia
Mondulkiri Protected Forest	Isolated Wetland	Cambodia
Lomphat Wildlife Sanctuary	Isolated Wetland	Cambodia
Lo Go Xa Mat	Isolated Wetland	Vietnam
Cardamoms		
Srae Ambel	Isolated Wetland	Cambodia

Table 2: Coordinated counts of Eastern Sarus Cranes during the non-breeding season in Cambodia and Vietnam 2001 – 2023. From 2001 to 2007 counts were done once a year (in March); during 2008 – 2009 three times a year (January to March); during 2010-2012 4 times a year (January to April); during 2013 - 2023, 6 times a year (December – May). This table shows the highest numbers of cranes recorded in a given year. Source: Tran et al. 2022))

Year	Month of max total count	Total	Mekong Delta	Tonle Sap Basin	Deciduous Forests
2001	March	650	411	228	11
2002	March	878	527	351	0
2003	March	837	494	339	4
2004	March	785	417	365	3
2005	March	721	366	334	21
2006	March	814	391	373	50
2007	March	692	276	402	14
2008	March	852	371	475	6
2009	March	747	365	367	15
2010	January	864	518	324	22
2011	February	869	562	295	12
2012	March	681	394	270	17
2013	March	850	513	322	15
2014	March	671	259	398	14
2015	March	572	343	201	28
2016	February	433	243	178	12
2017	January	360	200	140	20
2018	February	253	161	79	13
2019	January	234	121	76	37
2020	February	194	103	84	7
2021	February	164	91	71	2
2022	February	156	97	55	4
2023	February	180	97*	72	11

(*Number of cranes in the Mekong Delta sites for 2023 included 4 birds seen in Sre Ambel)

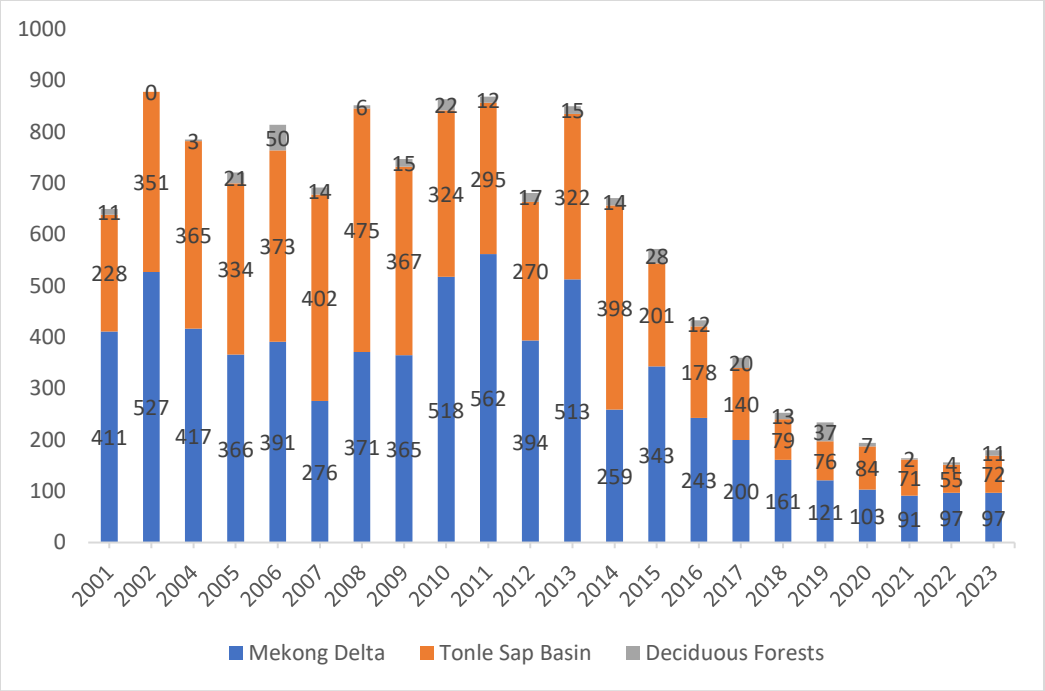

Figure 2: Total number of Sarus Cranes recorded during non-breeding season censuses grouped by regions, 2001 – 2023.

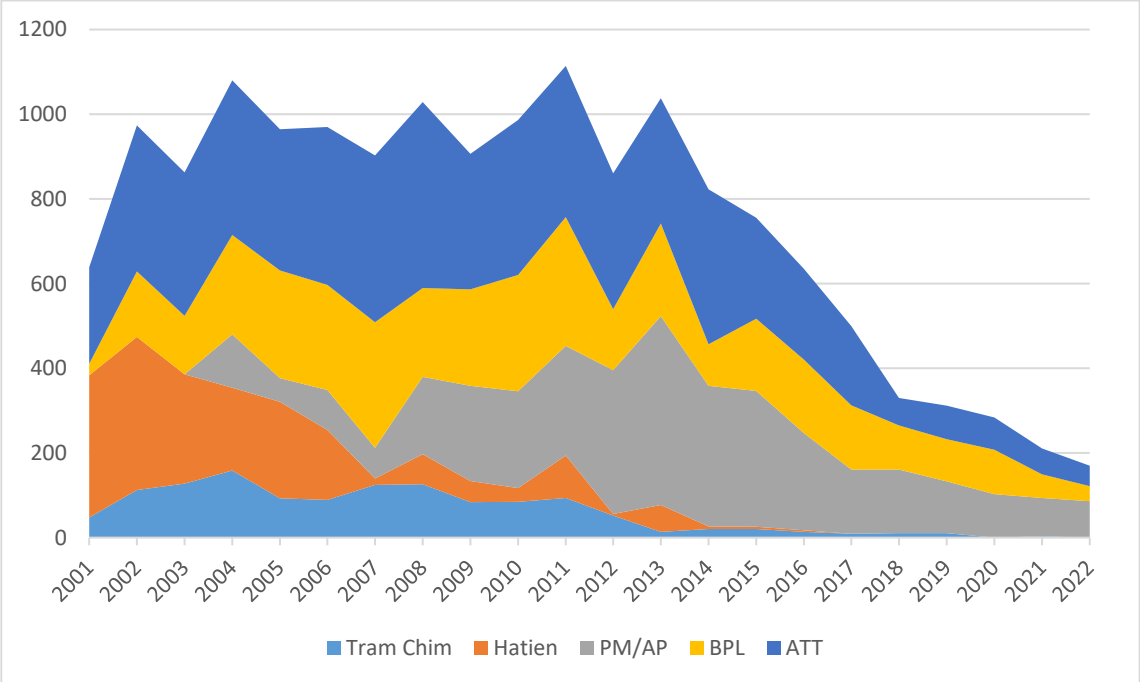

Figure 3: Numbers of Sarus Crane recorded at important crane sites in the dry seasons of 2001 – 2022. This graph shows the highest numbers of Sarus Cranes recorded at each site each year during 2001-2021. These numbers may be different from the census numbers for a given site in a

given year. Census data were recorded at set dates, usually the last day of the month, while crane count data from sites were recorded more frequently throughout the year.
Tram Chim: Tram Chim National Park, Vietnam
Hatien: Hon Chong and Ha Tien towns, Kien Giang Province, Vietnam
PM/AP: Phu My, Vietnam - Anlung Pring, Cambodia
BPL: Boeung Prek Lapouv, Takeo Province, Cambodia
ATT: Ang Trapaeng Thmaw, Bangtey Meanchey Province, Cambodia

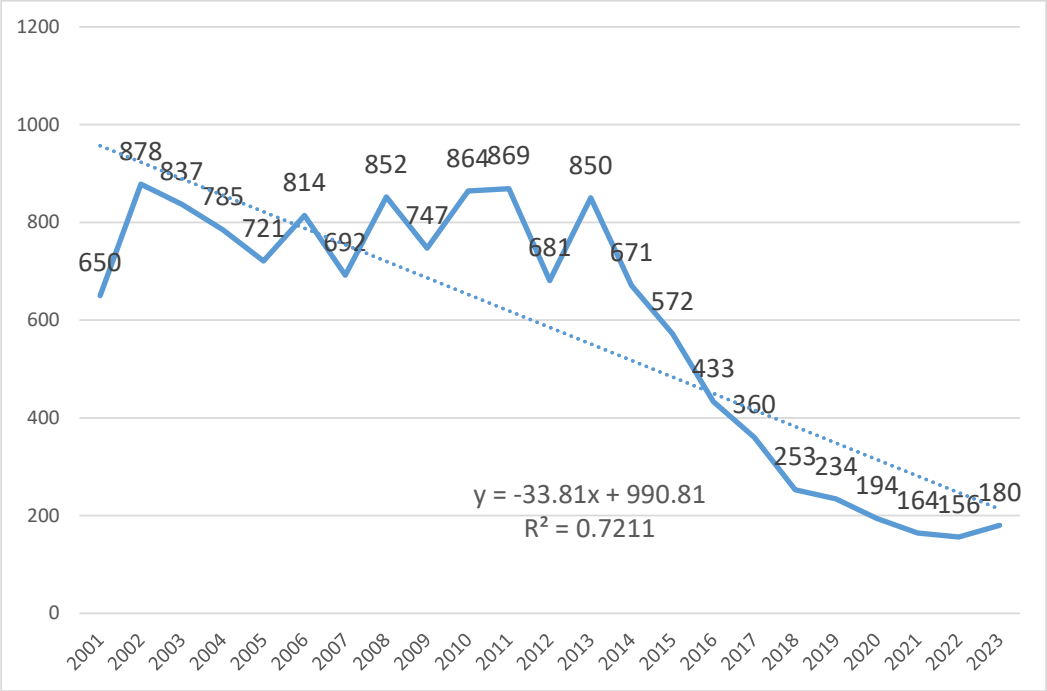

Figure 4: Trend of Sarus Crane population in Cambodia and Vietnam 2001-2023.

4.2 Nesting monitoring

In 2001, the International Crane Foundation conducted an aerial survey across most of the known breeding range of Eastern Sarus Cranes and found 82 nesting pairs (Barzen 2004). Fifty eight of 82 nesting territories (71%) were found within protected areas of Chhaeb, Kulen Promtep, and Lomphat wildlife sanctuaries. The remaining 24 nesting territories (29%) were located outside the boundaries of any current protected area (calculated from Barzen 2004).

The Wildlife Conservation Society – Cambodia Program initiated the Nest Protection Program in northern Cambodia in 2002 to protect several important bird species. The program included Sarus Cranes at Chhaeb Wildlife Sanctuary in 2004, and then extended to Kulen Promtep Wildlife Sanctuary in 2006 (Clements et al. 2009, Clements et al. 2013; Harrison and Mao 2017). From 2006-2021, the number of detected nests declined by 2.3 nests per year in these two wildlife sanctuaries (Table 3, Figure 4). If due to mortality of adults, the decline in nests indicates

a loss of 4.6 breeding adults per year (i.e. twice the number of nests). For the population level in 2021, the loss of breeding adults from just these two protected areas is approximately 2% of the population. In long-lived species with low fecundity, populations are sensitive to loss of breeding adults. Most modeled crane population would decline with this rate of loss in breeding pairs (Servanty et al. 2014, Wheeler et al. 2019, 2021).

Since Sarus Cranes are territorial on rainy season breeding sites, the decline in nests is likely due to mortality of individuals rather than movement of individuals to other nesting areas. Over the same period (2004-2021) dry season monitoring data showed that cranes declined by 46 birds per year, but the rate of decline was not constant, with most of the population decline occurring during 2014-2021 (Figure 2). Declining population estimated from both rainy season and dry season monitoring suggest that a real population decline is occurring rather than a drop in census numbers caused by dry season adults shifting their locations to some currently unknown location.

Our strongest hypothesis that explains the decline of cranes in the Cambodia-Vietnam population is, therefore, additive mortality, i.e. mortality that is abnormal and high enough to cause population decline. As such, the current population decline seriously threatens long-term viability of the remnant Cambodia-Vietnam population of Eastern Sarus Cranes. Reversing this trend is the top priority for any action taken.

Table 3: Number of detected nests and hatched birds recorded at Kulen Promtep, Chhaeb and Lomphat wildlife sanctuaries, 2003 – 2021.
KPWS: Kulen Promtep Wildlife Sanctuary, Cambodia
CWS: Chhaeb Wildlife Sanctuary, Cambodia
LPWS: Lomphat Wildlife Sanctuary, Cambodia
C/N: Number of chicks per net

Year	KPWS			CWS			LPWS			Total		
	Nest	Chick	C/N	Nest	Chick	C/N	Nest	Chick	C/N	Nest	Chick	C/N
2003	6	0	0.0							6	0	0.0
2004	3	3	1.0	16	19	1.2				19	22	1.2
2005	7	11	1.6	22	30	1.4				29	41	1.4
2006	9	12	1.3	28	39	1.4				37	51	1.4
2007	19	30	1.6	35	42	1.2				54	72	1.3
2008	24	36	1.5	33	54	1.6				57	90	1.6
2009	23	39	1.7	29	50	1.7				52	89	1.7
2010	24	37	1.5	20	33	1.7				44	70	1.6
2011	26	35	1.3	24	38	1.6				50	73	1.5
2012	11	16	1.5	14	23	1.6				25	39	1.6
2013	21	33	1.6	19	33	1.7				40	66	1.7

2014	21	35	1.7	19	28	1.5				40	63	1.6
2015	28	41	1.5	16	30	1.9				44	71	1.6
2016	14	25	1.8	13	24	1.8				27	49	1.8
2017	17	31	1.8	10	19	1.9				27	50	1.9
2018	17	30	1.8	12	22	1.8	1	2	2.0	29	52	1.8
2019	8	10	1.3	5	8	1.6	2	3	1.5	13	18	1.4
2020	6	7	1.2	7	10	1.4	0	0	0.0	13	17	1.3
2021	7	11	1.6	7	10	1.4	1	0	0.0	14	21	1.5
TOTAL	291	442	1.4	329	512	1.6	4	5	0.0	620	954	1.5

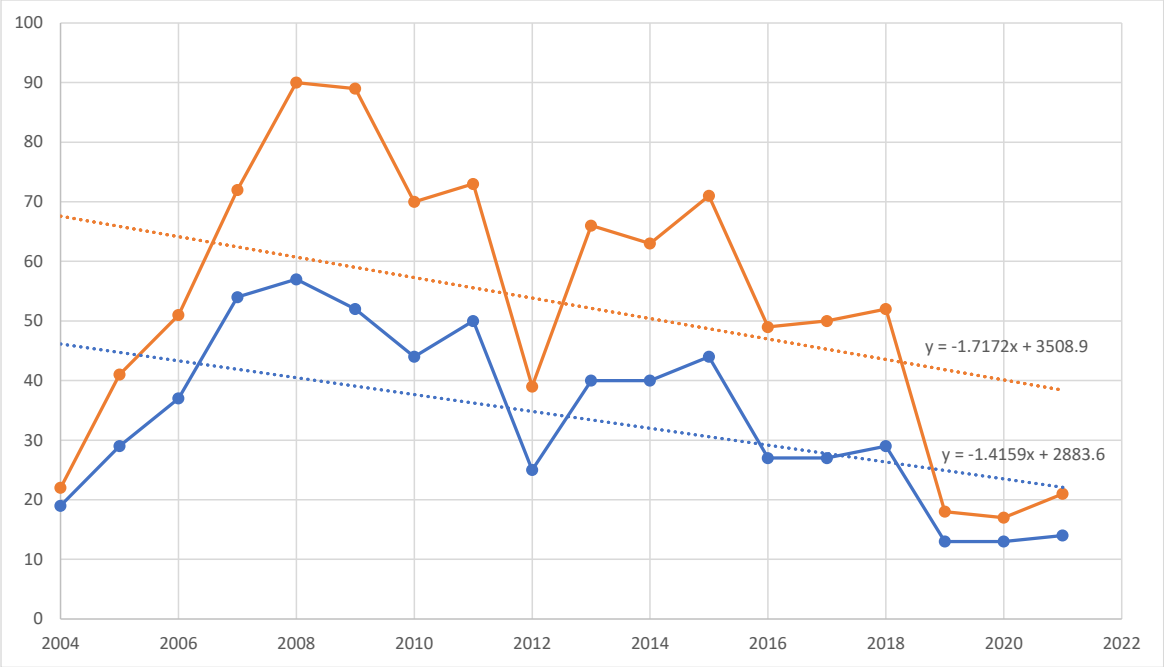

Figure 4: Trends in total numbers of Sarus crane nests (orange line) and chicks (blue line) recorded at Chhep and Kulen Promtep wildlife sanctuaries 2004 – 2021.

5. Mortality of cranes

Eastern Sarus Cranes are long-lived individuals. Mortality in egg and chick stages up to the period of arrival of juveniles with their parents on non-breeding grounds is unknown. The mortality of juveniles during their first wet season after recently being separated from their parents is currently high and is estimated at just under half of all juveniles that had survived up to this stage (van Zalinge 2021). This level of mortality is significantly higher than any other known crane population (Servanty et al. 2014, Wheeler et al. 2019). Based on only four ringed juveniles captured in 1998 (n=2) and 2001 (n=2), these individuals were re-sighted up to the ages of 12 and 15 years. The oldest of these was not re-sighted at AP after 2015. This gives an average age of 13.5

and approximately 10 reproductive years per individual (van Zalinge 2021). More re-sighting data from seven juvenile cranes caught and ringed in 2015 are needed to get current estimates of longevity for complete lifespans.

Current mortality of adults also appears to be much higher than known from other crane species (Servanty et al. 2014, Wheeler et al. 2019) and appears to be unsustainable (Figures 1, 2). Over similar time periods presumed mortality of adult cranes from the small population of ringed cranes captured in 2015 was almost 20% lower than for cranes captured in 1998 and 2001 (66.7% versus 85.7%, van Zalinge 2021). The annual mortality of breeding adult Eastern Sarus Cranes may be the largest factor causing the rapid decline observed in this population.

6. Threats and potential threats

We convened a three-day workshop in Phnom Penh, Cambodia, in 2016 to discuss threats that Sarus Cranes in Cambodia and Vietnam were facing. Forty-six participants representing non-governmental conservation organizations, protected areas, and governmental agencies who were involved with crane conservation attended the workshop. During the first day, participants identified all threats related to Sarus Cranes that they identified from their experience. Participants were then divided into four groups to facilitate discussion and asked to rank each of the threats according to scope (i.e. proportion of the Eastern Sarus Crane population impacted by each threat), severity (the amount of mortality likely caused to the Sarus Crane population) and certainty (certainty the group in their assessment of scope and severity). All three variables were ranked on a four-point scale with 1 relating to the highest scope, severity or certainty. Scores assigned to scope, severity and certainty by the four groups were then averaged and assigned an overall rank using the following equation: Scope x Severity x Certainty. The lowest scoring threats ranked highest.

Threats were listed in order of impact from highest (lowest score) to lowest impact (Table 3) and detailed in Appendix 1. In general, threats that related to habitat loss (at various scales) ranked higher than threats that related to hunting, which is unsurprising given the rapid loss of habitat taking place across Cambodia. Hunting (in its various forms) generally ranked lower than habitat loss, which in part might be due to a lack of information. Alternatively, there is still a considerable amount of superficially suitable habitat for Sarus Crane in Cambodia, especially when one considers that in Myanmar, Thailand and India cranes successfully fledge young from active rice paddies or in agricultural landscapes (Barzen and Seal 2001, Mukherjee et al. 2002, Sundar 2009, Siriaroonrat et al. 2018). This perhaps indicates that hunting (or more generally mortality) has, and is, playing a greater role in the decline of Sarus Crane than we currently perceive.

Many threats, however, are synergistic with one another and cannot be addressed in isolation. To simplify the process, the group-derived threats were organized into five broader categories: 1) crane mortality, 2) habitat conditions, 3) government policy/cooperation/enforcement, 4) lack of

knowledge and 5) lack of local support. These broad categories are listed below in their order of priority with the most important broad level of threat being listed first.

Crane Mortality (Critical)

Of the 26 threats listed, 9 (threats #8 mortality of eggs and chicks, #15 killing adults for food, #16 capture of adults, #18 accidental poisoning, #19 disease, #22 dogs killing cranes, #23 hunting of roosting birds, #25 killing cranes to protect crops, and #26 collision with power lines) involved mortality directly. Other threats (such as #3 lack of food, #24 disturbance by tourists or #14 disturbance by local people) could involve mortality indirectly. This is particularly true where disturbance increases the risk of mortality for eggs or chicks. Further, both non-breeding season and nest monitoring data and marked bird data suggest that the population of Eastern Sarus Cranes declined rapidly 2014-2021 (Harrison & Mao 2017; Tran et al. 2022, van Zalinge 2021) and population models of both Eastern Sarus Cranes and of similar crane species suggest that these rates of decline are not only unsustainable, they may result in extirpation of the population within five years (Barzen and Seal 2001, Servanty et al. 2014, Wheeler et al. 2019, 2021). The rapid population decline is also a new phenomenon as the population was relatively stable for three decades prior to 2014 (Figure 1). What has changed in the mortality threat is perhaps the most crucial issue that can be addressed.

The combination of mortality-related threats and the rapid rates of decline move mortality, as a broad threat category, to the highest priority with specific sources of mortality (e.g. #8 taking of eggs or chicks, #15 poisoning cranes and #19 disease) listed within this broader category to assist with targeting actions. Several participants also identified attacks by dogs as becoming a serious threat in breeding areas of the reintroduced population in Thailand (N. Purchkoon, per. com.) and in Cambodia (J. C. Eames, per. com.). Predation on crane eggs and chicks by domestic dogs was also recorded by WCS Nest Protection Program (Harrison & Mao 2017). Thai conservationists believed that they subsequently decreased the threat from uncontrolled domestic dogs by providing compensation to local farmers who had rice paddy damaged by nesting cranes (N. Purchkoon, per. com).

Except for 2019, the proportion of juvenile birds found in the non-breeding season flocks has been high. The high proportion of young would suggest that primary mortality factors occur after the chicks fledge such as during the first year of independence (van Zalinge 2021) or for adult breeding birds. Ibis Rice programs have successfully altered the behavior of local rice growers on breeding areas by the provision of various incentives (Clements et al. 2013, Clements and Milner-Gulland 2014) and *Lepironia* programs have strengthened conservation on non-breeding areas in the Mekong Delta (Tran et al. 2007). Care, however, should be taken because programs that aim to change attitudes can take a long time to develop successfully (Barzen 2018) and therefore need to be paired with direct actions that can provide results in the short-term.

Habitat Conditions (Critical)

Nine threats were related to habitat conditions (threats #1 Concessions, #3 Lack of food, #4 Small scale encroachment, #10 Poor water management, #11 Conversion to rice, #12 Drought via climate change, #13 Rice agriculture intensification, #20 Encroachment by shrimp farms, and #21 Invasive species). These threats relate to 1) encroachment by other land uses on natural lands used by cranes, such as agriculture or economic land concessions, 2) inappropriate management of conservation areas themselves and 3) increasing human population density which exacerbates other issues like various forms of natural resource extraction. Addressing the threat of land concessions was viewed as being especially important. In addition to converting crane habitat to agricultural land-use, such as with land concessions, non-natural water level management of wetlands used by non-breeding areas, for example, can also reduce food abundance or availability (threat #3) or create water levels that are too deep for crane use (threat #10). Though crane numbers have declined so precipitously that habitat may not directly be limiting population growth, they may be indirectly causing mortality. For example, if food conditions at ATT or Tram Chim are insufficient to allow cranes to forage within the protected area, cranes will fly out to rice fields to forage and that behavior may expose cranes to greater risk of mortality through poisoning, poaching or attack from dogs. The broad threat category of habitat condition is, therefore, listed as a priority of co-importance with factors influencing crane mortality. Suitable habitat, especially on breeding areas, currently includes only those places that have limited human disturbance. Habitat loss in at least three dry season habitats (ATT, Preah Net Preah, Stoung Grasslands and Ha Tien Plain) have been particularly severe and important (Packman et al. 2013, Funkenberg et al. 2014). Conservation efforts on behalf of cranes can be informed by recommendations for birds inhabiting these grasslands (Packman et al. 2014).

Government Policy, Cooperation and Enforcement (High)

Participants felt that a lack of support across all sectors of the society, and at all levels, was a major factor in causing the decline in Cambodia's Sarus Cranes. In this context, a broad-based awareness program that targets government, local community and general public alike is recommended. Specifically, the focus upon improving government support addresses threats #1 (concessions), #2 (weak enforcement), #5 (lack of support) and #9 (lack of collaboration). Management of protected areas to provide functioning native ecosystems and to reduce human disturbance from factors such as dogs, is partly related to government programs as well. No new policy can be successful if it is not enforceable.

Lack of knowledge (Medium)

Lack of knowledge, or the need for additional research, was addressed in only one specific threat (threat #7 Lack of knowledge regarding movements, foraging and breeding needs) but was implicit in most of the other threats. The inability to evaluate how much overfishing of wetlands (threat #17) affects habitat use by cranes, for example, identifies our inability to assess how much this threat could contribute to mortality. Since the lack of knowledge is implicit in most of the 26

threats identified, it would be important to simultaneously address threats of higher priority, such as mortality, while concurrently addressing a broad lack of knowledge.

Lack of local support (Medium)

The lack of local support was only specifically identified in threat #6 but was indirectly identified in threats #4 (small scale encroachment), #11 (conversion to rice), #13 (rice agriculture intensification), #14 (disturbance by local people), #17 (overfishing), #18 (accidental poisoning), #20 (encroachment by shrimp farms) and #22 (dogs killing cranes). Obtaining the cooperation of local people in the conservation of cranes has been successful in programs such as Ibis Rice (Clements and Milner-Gulland 2014), *Lepironia* products (Tran et al. 2007) and in crane reintroduction to places where local hunting pressure likely extirpated the original population but is no longer a problem due to education and outreach (Prentice and Siriaroonrat 2011). Programs that link addressing the needs of local people with crane conservation are critical in that they ultimately can cover broad areas. The primary cost of these programs is the long time-period that is required for their development to ecologically meaningful scales – scales that can affect the sustainability of critical crane habitat (Barzen 2018) or reverse declining populations.

Table 4. Threats to Sarus Crane in Cambodia, and their ranking, as determined by group participation at the Eastern Sarus Crane Workshop held July 26-27, 2016 (see Appendix 1 for details).

Rank	Threat	Scope	Severity	Certainty	Total
1	Large-scale forest loss	1.8	1.0	1.3	2.2
2	Weak law enforcement	1.3	1.3	1.5	2.3
3	Lack of food for cranes	2.0	1.5	1.5	4.5
4	Small-scale encroachment of *veals* (breeding wetlands)	1.8	1.5	1.8	4.6
5	Lack of government/public support for Sarus Crane	1.3	2.5	1.5	4.7
6	Lack of local support for Sarus Crane conservation	1.3	1.5	2.5	4.7
7	Lack of knowledge on movements, feeding and breeding requirements	1.3	2.0	2.0	5.0
8	Taking of eggs and chicks from nests for pets or trade	1.8	1.5	2.0	5.3
9	Lack of collaboration at national and regional level	2.0	2.5	1.3	6.3
10	Inappropriate wetland management	2.0	1.8	2.0	7.0
11	Large-scale conversion of grasslands and wetlands to irrigated dry-season rice	2.0	1.8	2.6	9.2
12	Drying of wetlands/climate	2.0	1.8	2.8	9.6
13	Intensification of rice cultivation	2.0	2.0	2.5	10.0
14	Disturbance by local people	1.8	2.5	2.5	10.9
15	Intentional poisoning for human food	2.5	2.5	2.5	15.6
16	Taking of birds for pets/zoos	3.0	2.3	2.3	16.3
17	Overfishing of wetlands	2.0	3.0	3.0	18.0
18	Accidental poisoning due to pesticide use	2.3	2.5	3.4	19.0

19	Disease and other pathogens	2.8	2.0	4.0	22.0
20	Encroachment due to shrimp farms and associated runoff	3.0	2.6	3.0	23.6
21	Invasive species esp. *Mimosa* spp.	3.0	3.0	2.7	24.0
22	Disturbance and killing by domestic dogs	3.0	3.0	2.8	24.8
23	Hunting of roosting birds	3.5	3.0	2.5	26.3
24	Disturbance from photographers/tourists	3.8	3.8	2.3	31.6
25	Intentional poisoning to protect crops	3.5	3.5	2.8	33.7
26	Collisions with power lines	3.3	3.8	3.3	39.6

7. Conservation priorities

7.1 Cambodia

Since 2021, Cambodia has established the "Cambodia Sarus Crane Working Group" (CSCWG), consisting of representatives from all NGOs and government agencies involved in crane conservation, to coordinate crane conservation activities in the country. The Group now has 40 members. CSCWG has identified the following priority activities for crane conservation in Cambodia:

a. Conduct a study to understand the causes of rapid population decline,
b. Improve law enforcement and strengthen patrol activities in protected areas utilized by cranes both dry and rainy seasons,
c. Expand nest protection programs to cover all Sarus Crane breeding areas in Northern Cambodia,
d. Prevent the conversion of crane-breeding wetlands, and surrounding uplands, to farmlands or other types of land use, and restore previously degraded habitats.

7.2 Vietnam

Vietnam has identified its main strategy in crane conservation over the next 5 years (2023-2028) is to restore the crane population at Tram Chim National Park, the country's most important historical crane site. Dong Thap Province, where Tram Chim National Park is located, is committed to supporting efforts to restore the Sarus Crane population at Tram Chim. Dong Thap Province and the Zoological Park Organization of Thailand (ZPOT) have reached a 5-year agreement by which ZPOT will annually send juvenile cranes raised in captivity at Nakhon Raschasima Zoo to Tram Chim for acclimation to the wild and release.

Currently ICF is assisting Dong Thap Province to develop a 10-year plan for the Sarus Crane restoration program at Tram Chim. The program includes 4 components:

a. Release of juvenile Sarus Cranes at Tram Chim,

b. Improve crane habitats in the core zone of Tram Chim through proper water management and other habitat enhancement methods,
c. Develop a wildlife-friendly, organic rice farming area in the buffer zone of Tram Chim to reduce environmental contamination in collaboration with farmers, and
d. Improve the livelihoods of local people through activities that are connected with the crane restoration program and promote the participation of the public in monitoring and safeguarding the released birds.

The goal of this ten-year program is to release a minimum of 50 Sarus Cranes to the wild with the reintroduced population successfully fledging chicks. The population will be reassessed in 5 and 10-year marks to determine progress toward self-sustainability against monitoring metrics (total number, number breeding pairs, recruitment of chicks born in wild).

Other crane conservation priorities for Vietnam are:

a. Improve crane habitat management at crane sites in the Mekong Delta,
b. Involve local communities in crane conservation in ways that help improve their livelihoods, and
c. Study the impacts of climate and economic development on crane sites and develop mitigation measures.

8. Conclusions

The Cambodia-Vietnam population of Eastern Sarus Cranes is the smallest among all populations of the Sarus Cranes across the species distribution range with less than 200 individuals recorded during the last population survey in 2023. Monitoring data documented a reduction of 79% of the population over the last 10 years, averaging 7.9%/year. The main reasons of population decline are likely (1) high adult mortality, and (2) habitat loss and degradation, especially breeding habitats. Sarus Cranes face different threats in Cambodia and Vietnam, the conservation strategies for each country for the next 5 years are also different. In Cambodia, crane conservation efforts will focus on (1) determining the causes of population decline to provide insight into developing threat mitigation programs, and (2) improve protection of major crane sites, especially nesting sites. Vietnam will invest in a Sarus Crane restoration program at Tram Chim National Park with a goal to establish a resident breeding population within the next 10 years.

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APPENDIX 1: Threats to Eastern Sarus Cranes identified at the Sarus Crane Conservation Workshop organized in Phnom Penh, Cambodia, July 26-27, 2016. Compiled by Simon Mahood, Wildlife Conservation Society – Cambodia Program.

Identified threats were listed in order of impact from highest (lowest score) to lowest impact (Table 2) and detailed below. Participants were then divided into four groups to facilitate discussion and asked to rank each of the threats according to scope (defined as an estimate of the proportion of the Eastern Sarus Crane population impacted by that threat), severity (a subjective judgment of the impact of that threat on the Eastern Sarus Crane population) and certainty (intended to be an honest indication of how certain the group were in their scope and severity assessments). All three variables were ranked on a four-point scale with 1 relating to the highest scope, severity and certainty, and 4 the lowest.

Despite clear instructions to groups there were some misunderstandings, particularly relating to the difference between scope and severity, and in the meaning of severity, with some participants judging it to refer to impact on individual Sarus Crane rather than impact on populations, such that any threat that could directly cause mortality of a Sarus Crane was judged to be of the highest severity, even if it had relatively minor population level impact. To reduce the impact of misunderstandings on the threat ranking exercise, the scores assigned to scope, severity and certainty by the four groups were averaged and then assigned an overall rank using the following equation: scope x severity x certainty, with the lowest scoring threats ranked highest.

Specific threats ranked from highest to lowest:

1. Large-scale forest loss (economic land concessions)

There was universal agreement, and a very high degree of certainty, that this was the most severe threat facing Cambodia's Sarus Cranes, and that it impacted most of the population. Cambodia has experienced one of the highest rates of forest loss of anywhere in the world over the last ten years. Conversion of lowland deciduous forest in Cambodia's northern and eastern plains to large-scale agro-industrial concessions is thought likely to have caused the destruction of Sarus Crane breeding habitat. It has also negatively impacted a range of other globally threatened species. This threat can only be dealt with through working with government agencies responsible for the protection of forest, namely the Forestry Administration of the Ministry of Environment and the Ministry of Agriculture, Forestry and Fisheries.

2. Weak law enforcement

It was universally agreed that weak law enforcement was the most significant indirect threat to Sarus Crane. This threat could have been re-worded as "lack of government support for Sarus Crane conservation", although the impacts of weak law enforcement (owing to incompetence, negligence, lack of motivation or more nefarious reasons) are felt throughout conservation and indeed other sectors. Where they are caused by a lack of capacity, deficiencies in law enforcement should be addressed through training. A suite of far-reaching measures is required to improve motivation of law enforcement agencies and individuals, and to address other possible causes of weak law enforcement.

3. Lack of food for foraging cranes

That this threat scored so highly might be in error, because only two of the four groups assigned it a score at all. Nonetheless, it was (tentatively) ranked as the second most important direct threat to Sarus Cranes, particularly by those familiar with the species on its non-breeding grounds. Some examples of crane mortality included emaciated, young cranes (van Zalinge 2021). Additional research is required to understand whether Sarus Cranes are indeed food limited in Cambodia, given the size of the population and the area of superficially suitable foraging habitat; and if so, what can be done about it.

4. Small-scale encroachment of breeding wetlands

Participants, particularly those with direct experience of conservation of Sarus Cranes in the breeding season, believed that the conversion of the relatively small wetlands within forested areas in which Sarus Cranes breed was a highly significant threat to the species. As human populations have grown within the northern and eastern plains, local people are increasingly encroaching on *veals*, *boengs*, or in forests surrounding these wetlands, to cultivate rice. This habitat conversion has led to a rapid loss of breeding habitat. Although there is evidence from Myanmar and India that Sarus Cranes can breed in rice paddies, this has never been recorded in Cambodia, perhaps because human disturbance (threat #14) is too high there.

5. Lack of government/public support for Sarus Crane

This threat, which describes how participants felt that there was a lack or deficiency of support for Sarus Crane conservation across government and by the general public, was identified as a highly significant indirect threat. Within the government it typically manifests itself in the approval of development projects or policies that might negatively affect Sarus Cranes or crane habitat, and a lack of enforcement of laws that pertain to hunting of Sarus Crane. Within the general public, a lack of support for Sarus Crane conservation might cause small stakeholders to convert habitat that is used by Sarus Cranes to other land uses. This threat can be addressed through a broad-reaching awareness campaign. Sarus Cranes are large, spectacular birds. They,

and other species of crane, are universally popular species around the world, and often serve as flagships for wider conservation initiatives. There is a precedent for improving public and government support for Sarus Crane conservation elsewhere, and methods that can be replicated in Cambodia to build pride in and support for the species.

6. Lack of local support for Sarus Crane conservation

This somewhat ambiguous indirect threat received almost universal recognition among participants as one of the most serious threats facing Sarus Crane. It is therefore generally agreed that support for Sarus Crane conservation among local communities is lacking, and that this is a serious impediment to their conservation. A lack of local support for Sarus Crane conservation typically manifests itself in general law breaking, such as hunting or destruction of Sarus Crane habitat. This threat would be best addressed through education and awareness raising at the local level to build pride in the species.

7. Lack of knowledge on movement, feeding and breeding requirements

This indirect threat resonated with many participants who felt that a lack of scientific information regarding Sarus Cranes in Cambodia was a significant threat to the Southeast Asia Population of Eastern Sarus Cranes because it impedes successful conservation by government, NGOs and local people. Scoring indicated that there were differences in perception among the participants in terms of how significant this threat impacts our collective ability to conserve Sarus Crane. Nonetheless, this threat is currently being addressed through a PhD conducted by Robert van Zalinge. Robert has attached satellite transmitters to Sarus Cranes to study their movements and has carried out detailed feeding and breeding studies. Robert's data will go a long way towards addressing this threat.

8. Taking of eggs and chicks from nests for pets or for sale

In long-lived birds, survival rates in the first two years of life have a particularly significant impact on the population. This threat scored consistently highly with all participants, in scope, severity, and their certainty that this was correct. Data from the Northern Plains indicates that paying community members to protect the nests of Sarus Crane significantly increases nest success. This is a clear indication that robbing of eggs or chicks by humans is indeed a major issue for Sarus Crane. It is also an indication of how the threat can be addressed, coupled with law enforcement to investigate, arrest and prosecute those who rob the nests of Sarus Crane. Increased nest success, however, does not mean that population recruitment (the adding of new breeding adults to the population) will increase. With the Eastern Migratory Population of Whooping Cranes, for example, though hatch success was increased the population still did not grow because juvenile chick mortality was also high (Barzen et al. 2018). With Eastern Sarus

Cranes, the recent dramatic population decline over three years (2014-2018; Tran et al. 2018, van Zalinge 2021) suggests an increase in adult mortality, a type of mortality to which crane populations are highly sensitive (Servanty et al. 2014, Wheeler et al. 2019, 2021).

9. Lack of collaboration at national and sub-national levels

This threat ranked highly because participants expressed a high degree of certainty in their opinions that it impacted Sarus Cranes, although there were differences of opinion in terms of the scope and severity of this threat. A lack of collaboration between NGOs and government at all levels is likely to lead to a lack of cohesion in policies and practices that might impact Sarus Cranes. As an indirect threat its impact on threats that directly impact Sarus Crane needs to be better understood before it can be addressed.

10. Inappropriate wetland management regimes

This threat would have ranked much more highly were it not for one group, who went against the opinions of the rest of the groups and felt that wetland management impacted very little of the Sarus Crane population and indeed had very little impact on the cranes (they also had a very low degree of certainty in their opinion). This threat is most pertinent in the non-breeding grounds, where there are no wetlands that are managed specifically for Sarus Cranes. For instance, at ATT, where half of Cambodia's Sarus Cranes spend the non-breeding season, the water level in the reserve is determined by the needs of the surrounding rice farmers, who use the water from the reservoir for irrigation: the reserve manager and the ministry responsible for the management of ATT do not even have an opportunity to express an opinion in the management of the water level. Management of water level is fundamental to wetland management. It determines the species of plant that can grow there and the potential for the site to be used by fauna at all tropic levels. Unless water levels in the wetlands used by Sarus Cranes can be managed by the agencies responsible for the management of those sites then we will continue to have to rely on luck to ensure that they persist at those sites. There is a need to lobby strongly for the agencies responsible for the management of sites that support Sarus Cranes in the non-breeding season to play a role in deciding water management regimes at those sites.

11. Large-scale conversion of grasslands and wetlands to irrigated dry-season rice

This threat impacts cranes in the non-breeding season. Most of the participants agreed that this was a significant threat to much of Cambodia's Sarus Crane population, and that it was having a severe impact on the species. There is a nationwide trend of conversion of wetlands and small-scale lowland paddy to large-scale agro-industrial rice cultivation, in line with the spread of irrigation infrastructure. Wetlands and grasslands that are frequently used by Sarus Cranes must be protected against conversion to large-scale agriculture.

12. Drying of wetlands due to changing weather or climatic conditions

This threat scored relatively highly, which is likely to reflect participants concerns about a lack of hands-on wetland management, and the likely impacts of impacts of basin development (hydropower dams on the Mekong and its tributaries, and water abstraction for irrigation) and the lowering of the water table due to expansion of water-hungry crops such as sugar and rubber. Ground water inflow may be an important factor in determining water permanence of small wetlands in the dry forest (Barzen et al. 2019). Participants felt that these factors were likely to be leading to changes in habitats where Sarus Cranes breed and feed, and therefore be causing a decline in their numbers.

13. Intensification of rice cultivation

This threat is similar to threats #4 and 11. The patterns of scoring these three threats were similar. Although Sarus Cranes often feed on fallow small-scale rice paddies, intensive cropping regimes reduce the amount of food available, owing to degradation of foraging habitat and increased use of pesticides. Farmers who grow rice in a way that is compatible with Sarus Crane conservation, and whose fields are frequently used by Sarus Crane, can be compensated for not intensifying their agricultural practices (Clements et al. 2013.

14. Disturbance by local people

This threat refers to non-lethal human activities that nonetheless cause disturbance to cranes and could contribute to, for instance, reduced reproductive success by disturbing nests or inadequate foraging by disturbing important foraging sites on habitats used by non-breeding cranes. There was considerable disagreement among participants in the scope and severity of this threat. This threat is likely to only be an issue where cranes view humans as a threat, which is typically the case in Cambodia, but not in some places in Myanmar (Barzen and Seal 2001) or India (Archibald et al. 2003) due to reduced rates of hunting in those countries. To counter this threat, people should be restricted from entering areas where Sarus Cranes typically breed or forage.

15. Intentional poisoning of cranes for use as human food

This threat describes the use of grain (or other bait) laced with poison (usually pesticides) to kill Sarus Cranes (and other species) for use as food by the hunter directly, or for sale to others for food. International participants commented that this is a problem that is more prevalent in Cambodia than in neighboring countries. Most of the groups agreed that this was likely to be a significant threat. This threat could be address through improved enforcement of the law (it is illegal both to miss-use pesticides and to intentionally kill Sarus Cranes) and a program of education, that should focus on the health issues associated with eating poisoned meat.

16. Capture of adult Sarus Cranes for use as pets or for display in zoos

Participants expressed diverse opinions in terms of the scope of this threat, the severity of its impact on the Sarus Crane population, and indeed the certainty of their opinions on these matters. This might reflect a lack of data, however, within the workshop the preliminary results from Robert van Zalinge's satellite tracking project were presented (van Zalinge 2021), and of his 10 tagged birds, one was caught by a wildlife trader "for sale to a zoo". Evidently, more research into this threat is necessary before it is accepted that illegal wildlife trade is a significant threat to Sarus Crane.

17. Overfishing of wetlands

This threat is something of a curious one, since Sarus Cranes are not principally piscivorous, although they do consume some fish, along with frogs, invertebrates, seeds and tubers. Nonetheless, excessive fishing of wetlands means that they are constantly occupied by people, and therefore cause undue disturbance to foraging cranes, even if the people do not significantly deplete the crane's food sources.

18. Accidental poisoning of cranes due to pesticide use

The groups were unanimous in their uncertainty over the scope and severity of this threat. There is a lack of data on the prevalence of secondary poisoning in Sarus Cranes, which manifests itself in a lack of action in addressing this potential threat. Promotion of good agricultural practices that minimize or even eliminate pesticide use would be a useful precautionary measure and improve the suitability of farmland for wildlife in general.

19. Disease and other pathogens

Although there is no actual evidence that disease or parasites are a threat to Cambodia's Sarus Crane population, it scored very highly in terms of scope and severity. Avian influenza, for example, is known from Southeast Asia and can potentially strike areas of rice agriculture (Gilbert et al. 2008) located near non-breeding areas in Cambodia (Figure 3). However, a lack of evidence meant that all groups rated their certainty of these assertions very low. More research is required into the prevalence of disease and pathogens in Sarus Cranes within Cambodia before any conservation action to address this potential threat is recommended.

20. Encroachment due to shrimp farms and associated run-off

This is a threat to Sarus Cranes in the non-breeding sites in south-east Cambodia and southwestern Vietnam. Consequently, it did not score highly in terms of scope, but might have a significant impact on the foraging habitat at sites such as An Long Pring Wildlife Sanctuary

(Cambodia) and Phu My Nature Reserve (Vietnam). Since these sites receive legal protection it is recommended to work with government agencies to prevent further encroachment from shrimp farms and eliminate run-off from existing shrimp farms entering water supplies.

21. Invasive species, especially Mimosa pigra

The prolific expansion of exotic species such as *Mimosa pigra* is a threat to the non-breeding habitat of Sarus Crane. *Mimosa* spp. have invaded sites in the south-east of Cambodia that are used in the non-breeding season, and are spreading within the Tonle Sap floodplain, destroying Sarus Crane foraging habitat. At Boung Prek Lapouv there are already programs underway to remove invasive plants, and although relatively expensive and labor intensive, these should be continued in order to prevent the loss of suitable foraging habitat. Similar scenarios of invasion by *Mimosa pigra* occurred at Tram Chim National Park but have since been controlled (Tran, pers. comm.).

22. Disturbance and killing of Sarus Crane by free-ranging domestic dogs

There was a lack of agreement among participants regarding the scope and severity of this threat, and in their level of certainty of their assertions. However, most participants have witnessed free-ranging domestic dogs chasing Sarus Cranes. It was been noted that dogs frequently follow people into areas used by Sarus Cranes. Although research would be useful to clarify the impact of this threat, domestic dogs should not be allowed within protected areas regardless of their potential impacts on cranes, since they are known to kill other threatened species that use the same sites.

23. Hunting of roosting birds

This threat refers to the practice of catching birds when they are roosting on the ground, often on wet or moonless nights. Often the species caught are relatively common species, such as Oriental Pratincole (*Glareola maldivarum*) or Open-billed Storks (*Anastomus oscitans*), but when they are encountered, other species may also be caught. The inclusion of the words "with sticks" confused many participants, who excluded other methods of hunting roosting birds (such as with nets) in their evaluation of this threat. The inclusion of the words "with sticks" was intended to clarify that this was actively hunting (killing) birds at night and to differentiate it from the capture of live birds for zoos or as pets or the poisoning of cranes for use as human food. This threat should be addressed through improved law enforcement and raising awareness of the conservation importance and legal status of Sarus Crane.

24. Disturbance from photographers and other tourists

Ecotourism is increasingly touted as a way to bring income to communities who use areas where Sarus Cranes spend the non-breeding season. Cranes are iconic, flagship species, which are attractive to birdwatchers, nature-lovers and general tourists alike. Some of these types of tourist do not understand that they will disturb the birds if they go to close, or do not care about the impact that they might have on the birds. The workshop participants did not think that this was a particularly serious threat to Sarus Cranes, because the number of tourists is currently very low. However, it is likely to increase, so a code of conduct for tourists, and some signage that communicates this clearly in multiple languages, is needed at the popular non-breeding sites such as An Long Pring Wildlife Sanctuary, Cambodia, or Tram Chim National Park, Vietnam.

25. Intentional poisoning of Sarus Crane to protect crops

This threat refers to the killing of cranes to prevent crop damage, not the killing of cranes (through poisoning) for food. However, participants stated that they would have ranked it higher if it referred to other lethal means of preventing cranes from damaging crops, rather than specifically the use of poisons to achieve this end. This threat is not thought to be significant, however, it could be reduced through general awareness raising about Sarus Crane, better law enforcement and mitigation of damage (Barzen and Ballinger 2018, Barzen et al. 2020).

26. Collisions with power transmission lines

This threat was ranked of least importance, largely due to the almost complete lack of power transmission lines in Cambodia. However, there are government plans to construct a network of power transmission lines throughout the country. A 350 km power transmission line is planned along the northern edge of the Tonle Sap floodplain, with additional lines passing through breeding areas in Preah Vihear, Kratie and Mondulkiri provinces. Cranes are highly susceptible to striking power lines, as has been demonstrated worldwide (Harris and Mirande 2013). Power lines that are to be constructed in areas that are used by Sarus Crane should be marked for effective deterrence of crane collision with lines (Dwyer et al. 2019).

A synthesis of tracking movements and modeling breeding areas, linking to the recent decline of the Sarus Crane population in Cambodia-Vietnam

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1. Introduction

As a general rule, the more reliant a crane species is on wetlands, the more threatened it is (Harris, 2010). Particularly the reliance on wetlands as refuges in the breeding season makes most cranes vulnerable. Of the 15 species, 11 are currently listed as threatened with extinction under the IUCN Red List (Archibald and Meine, 2019). However, most cranes have also proved to be adaptable in the face of landscape change and have responded to changes in human behavior, with the Sandhill Crane (*Grus canadensis*) population in Wisconsin, USA, nesting in increasingly smaller wetlands, down to one hectare in size (Barzen *et al.*, 2016), once stronger protection had been provided, and similarly, the Red-crowned Crane (*Grus japonensis*) only nesting in large, undisturbed wetlands on mainland Asia, but on Hokkaido, Japan where the species is strictly protected as a National Monument, using almost every available wetland (Harris, 2010). It seems therefore that safety in the breeding season is crucial to crane conservation, with wetland nesting species being more affected by persecution and disturbance than wetland size and condition.

The Indian Sarus Crane population (*Grus antigone antigone*) is known to breed in agricultural landscapes, favoring natural wetlands, but also nests in paddy fields (Sundar, 2009), something the Eastern Sarus Cranes of the Ayeyarwaddy Delta in Myanmar also do (Archibald *et al.*, 2003), however, as with the Red-crowned Cranes of Hokkaido, such close association with humans is only possible where cranes are not persecuted. In contrast, Sarus Cranes in Australia (*G.a. gilli*) and Cambodia (*G.a. sharpii*) nest in remote open forests (Archibald *et al.*, 2003), although the actual nest location is in clearings containing seasonal wetlands. The deciduous dipterocarp forests of northern Cambodia that are used by cranes in the breeding season (Barzen, 2003) for the most part have an open grassy understory and, in plains areas such as in the Kulen Promtep and Chep Wildlife Sanctuaries, many areas are shallowly inundated as long as the monsoon rains persist (Barzen *et al.*, 2019). The breeding season lasts from June to September (Clements et al. 2013) which overlaps with the monsoon period, a time of relative abundance for many wetland birds.

Little was known about breeding locations in Cambodia when the first nesting record in Southeast Asia was recorded in 1994 (Barzen, 1994). In 2001, aerial searches over deciduous dipterocarp forest in northern Cambodia located 82 nests, of which 71% were within protected areas (Barzen, 2003) and by 2011, around 50 pairs were known to have been breeding each year in two protected areas in northern Cambodia; Kulen Promtep- and Chep Wildlife Sanctuaries (Clements *et al.*, 2013), which subsequently have been considered the most important nesting areas for the population.

Despite breeding in more remote regions, the taking of eggs or flightless young by people has been consistently high and widespread and has been considered the principal threat to the persistence of Sarus Cranes and other globally threatened large waterbird species in the Northern Plains (Clements *et al.*, 2013). In 2002 a nest protection program was initiated as a conservation response at two of the main known breeding sites, Kulen Promtep and Chep Wildlife Sanctuaries, protecting as many nests as possible, of Sarus Cranes and other large-bodied bird species including ibises, storks and vultures, and is still ongoing with participation from up to 49 different villages (Clements *et al.*, 2013; Harrison and Mao, 2017).

However, the open deciduous dipterocarp forests cranes use in the breeding season have since become threatened by conversion to agriculture in Cambodia (Eames and Huong, 2013; Davis *et al.*, 2015; Harrison and Mao, 2017; Kong *et al.*, 2019; Riggs *et al.*, 2020), with similar habitat already having largely disappeared from Thailand and Vietnam due to the same processes (Wohlfart *et al.*, 2014). These processes in turn have a multiplier effect on hunting rates in nearby forests and it is this, more than logging or local deforestation, that can rapidly decimate wildlife populations over large areas (Robinson *et al.*, 1999; Wilkie *et al.*, 2000; Wilkie *et al.*, 2011; Brodie *et al.*, 2015; Harrison *et al.*, 2016).

From synchronized counts conducted annually in the dry season since 2001, across sites used by cranes in Cambodia and Vietnam, it became evident in 2016 that the number of Sarus Cranes was dropping year-on-year at a consistent and alarming rate since a high count of 850 cranes in 2013 (van Zalinge and Tran, 2016). This trend continued and in 2021 the highest count was only 164 cranes (Tran *et al.*, 2021). In this report we identify important breeding areas through a combination of tracking movements of individuals and modeling nest site selection based on nest locations from aerial survey. We also look at how deforestation and new roads impacted the suitability of breeding areas between 2001 and 2016, and hypothesize that any measured loss in nest site suitability as a result of changes in these factors is likely also an indicator of increased human intrusion in to breeding areas. A substantial measure of deterioration of breeding grounds could then be a factor behind the rapid decline in the population.

2. Tracking crane movements

This section on tracking crane movements in Cambodia and Vietnam gives an overview of selected information largely based on that from van Zalinge *et al.* (2023b). In March 1998 and March 2001 a total of seven battery-powered ARGOS satellite PTT transmitters manufactured by Microwave Telemetry www.microwavetelemetry.com were deployed. In January-February 2015, ten solar-powered GPRS-GSM transmitters were deployed. These devices were manufactured by e-obs www.e-obs.de. A total of 11 cranes were color-ringed in 1998 & 2001 and 16 in 2015. An overview of cranes tagged and ringed is given in Table 1, below. A juvenile crane (tag 4234/1) that was caught by a trader in the Stung Sen – Santuk area, died in August 2015. Its tag was transferred to a second juvenile (4234/2) that had been confiscated from the same trader. The juvenile with tag 4235 was captured by people near Boeung Prek Lapouv in late June 2015 and released with the other confiscated juvenile in September 2015.

Table 1. Cranes tagged and/or ringed: 1998, 2001 and 2015.

Family Unit - Age Class	Sex	Capture Location	Capture Year	Tag Number	Rings Left Leg*	Rings Right Leg*
1 - Adult	Female	Tram Chim	1998	5444	Metal	White/Red
2 - Adult	Female	Tram Chim	1998	5420	Metal	White/Blue
2 - Adult	Male	Tram Chim	1998	5418	Metal	White/Yellow
3 - Adult	Male	Tram Chim	1998	5437	Metal	Red/White
3 - Adult	Female	Tram Chim	1998	-	Metal	Red/Blue
3 - Juvenile	Unknown	Tram Chim	1998	-	Red/Green	Metal
3 - Juvenile	Unknown	Tram Chim	1998	-	Red/Yellow	Metal
4 - Adult	Female	Tram Chim	2001	19303	Yellow/Red	Metal
4 - Adult	Male	Tram Chim	2001	-	Metal	Red/Yellow
4 - Juvenile	Unknown	Tram Chim	2001	19298	Red/Black	Metal
4 - Juvenile	Unknown	Tram Chim	2001	19275	Yellow/Black	Metal

Family Unit - Age Class	Sex	Capture Location	Capture Year	Tag Number	Rings Left Leg*	Rings Right Leg*
5 - Adult	Male	Stoung-Chikraeng	2015	4233	Green/Red	Green/White/Metal
5 - Adult	Female	Stoung-Chikraeng	2015	-	Red/Red	Green/Green/Metal
5 - Juvenile	Unknown	Stoung-Chikraeng	2015	4234/1	Green/White	Green/White/Metal
5 - Juvenile	Unknown	Stoung-Chikraeng	2015	-	Green/Red	White/White/Metal
6 - Adult	Female	Anlung Pring	2015	-	Green/White	Green/Metal/Red
6 - Adult	Male	Anlung Pring	2015	4236	White/Red	Green/Metal/White
6 - Juvenile	Unknown	Anlung Pring	2015	4235	Green/Red	White/Metal/Red
7 - Adult	Female	Stoung-Chikraeng	2015	-	White/Metal/Red	White/Green
7 - Adult	Male	Stoung-Chikraeng	2015	4238	Green/Metal/Red	Red/White
7 - Juvenile	Unknown	Stoung-Chikraeng	2015	4237	White/Metal/White	Green/White
7 - Juvenile	Unknown	Stoung-Chikraeng	2015	-	White/Metal/White	White/Red
8 - Adult	Male	Ang Trapeang Thmor	2015	4239	Metal/White/White	White/White
8 - Juvenile	Unknown	Ang Trapeang Thmor	2015	4240	Metal/Green/Green	Green/White
9 - Adult	Female	Anlung Pring	2015	-	White/Red	Metal/White/White
9 - Adult	Male	Anlung Pring	2015	4241	Red/Red	Metal/Red/Red
9 - Juvenile	Unknown	Anlung Pring	17/2/15	4242	Green/White	Metal/White/White
10 - Juvenile	Unknown	Stung Sen-Santuk	12/8/15	4234/2	Red/White	Red/White

*Some color rings may no longer be attached or may have faded / changed color

Though ten adults were tagged, two adults (5418 and 5420) were members of the same pair and were expected to travel together so we had independent samples of movement from nine adults.

One tag on an adult (4241) failed within a month and provided too few data for home range analysis, making a total of eight adults providing independent samples. A total of seven juveniles were tagged, two in 2001 and five in 2015. The two juveniles captured in 2001 were siblings, remaining close together and following their tagged parent in both the dry season of capture and the subsequent wet season.

The overall movement pathways of tracked cranes are depicted in Figure 1 and areas moved to are described in Table 2. Three independent individuals or family groups caught in Tram Chim in 1998 and 2001 moved to the Lomphat area in the wet season, which corresponds with the breeding season, while one adult from 1998 moved to the eastern part of the Northern Plains, to forests south of Chep Wildlife Sanctuary. Departure for breeding grounds typically occurred around mid-April. Unfortunately, in 2015, only a single position was received in the wet season from one (4236) of two tagged adults from Anlung Pring, on 26 May. This position came from within Chep Wildlife Sanctuary and was likely in the general vicinity of its breeding territory. The juvenile (4235) belonging to this adult was also seen to use the same location, with a first record on 3 May, although it moved back and forth between Chep and the Stung-Sen Santuk area, which it used up to early June. The other 2015 juvenile (4242) moved to Lo Go Xa Mat and on to the western Seima – Phnom Prich area, then flying up and down to the Mekong Delta in May, before transmission abruptly ended in western Seima Wildlife Sanctuary. Both Lo Go Xa Mat and Seima – Phnom Prich were also used by the 2001 family when moving between Tram Chim and the Lomphat area.

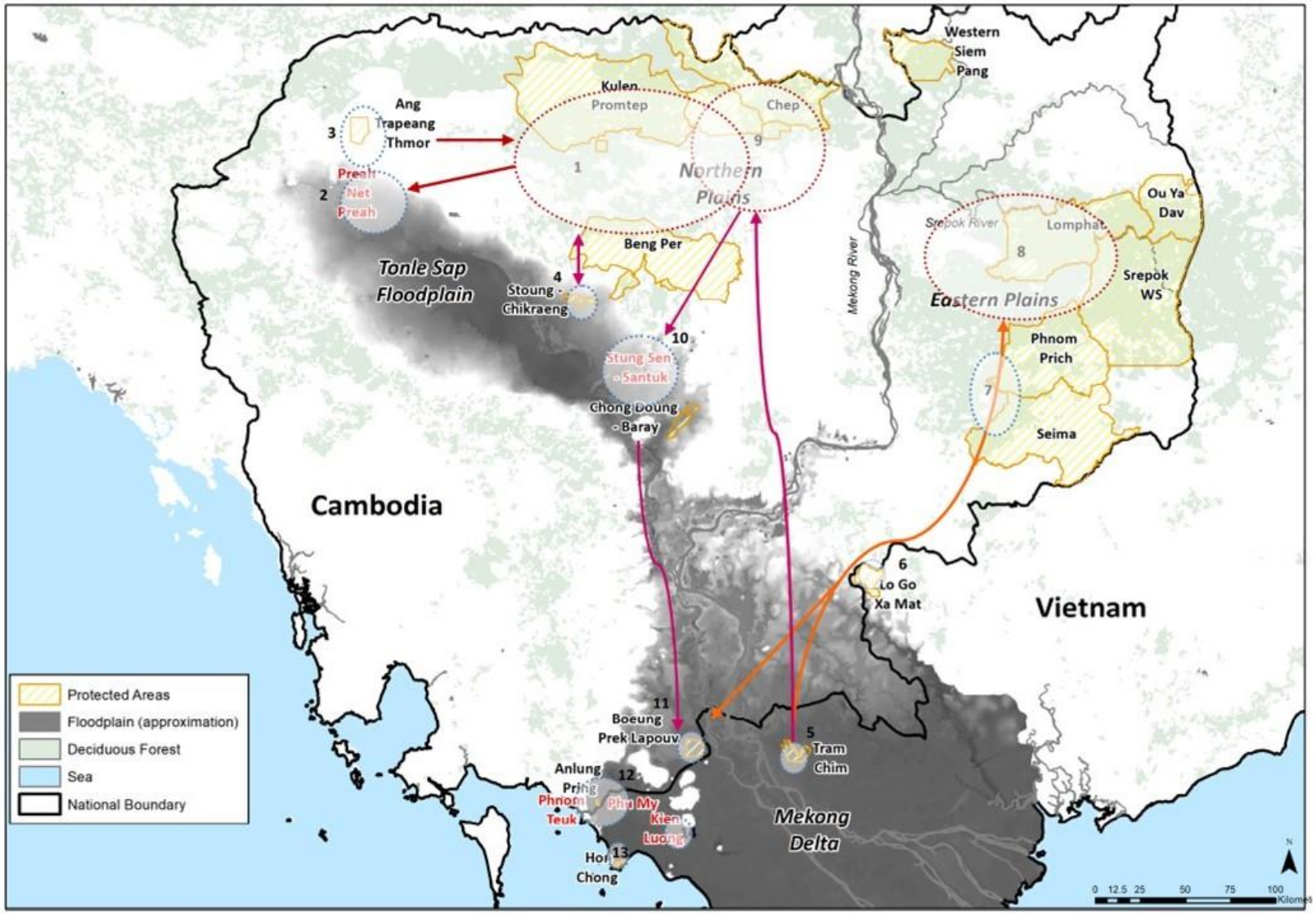

Figure 1. Pathways flown by cranes to and from Northern Plains (red lines) and Eastern Plains (orange lines). Red-rimmed circles represent clusters of points in breeding areas, blue-rimmed circles represent clusters of points in non-breeding and transition areas.

Table 2. Description of the areas used by tracked cranes, as shown in Figure 1.

Site # Fig. 1	Area used	Geographic region	Country	Season used	Habitat characteristics
1	Southern Kulen Promtep to Beng Per	Western Northern Plains	Cambodia	Breeding	Mix of open deciduous dipterocarp forest with scattered wetlands and denser forest types. Scattered ricefields in areas nearer to habitation.
2	Preah Net Preah	Tonle Sap floodplain	Cambodia	Non-breeding	Floodplain grasslands with scattered small wetlands and ponds, mixed with wet- and dry season cultivation areas. This area extends in to Kralanh district.
3	Ang ang Thmor	Tonle Sap floodplain	Cambodia	Non-breeding	Shallow water reservoir with wetland of predominantly wild Chinese water chestnut (*Eleocharis dulcis*), surrounded by ricefields.
4	Stoung - Chikraeng	Tonle Sap floodplain	Cambodia	Non-breeding	Floodplain grasslands with scattered small wetlands and ponds, mixed with wet- and dry season cultivation areas.
5	Tram Chim	Mekong delta	Vietnam	Non-breeding	Largely embanked freshwater wetland with scattered wild Chinese water chestnut and Water lily. Surrounded by ricefields.
6	Lo Go Xa Mat	Eastern Plains	Vietnam	Transition	Mix of open deciduous dipterocarp forest with scattered wetlands and areas of dense forest.
7	Western Seima to Western Phnom Prich	Eastern Plains	Cambodia	Transition	Mix of open deciduous dipterocarp forest with scattered wetlands and denser forest types.

8	Lomphat region	Eastern Plains	Cambodia	Breeding	Mix of open deciduous dipterocarp forest with scattered wetlands and denser forest types. Scattered ricefields in areas nearer to habitation.
9	Chep and forests to the south	Eastern Northern Plains	Cambodia	Breeding	Mix of open deciduous dipterocarp forest with scattered wetlands and denser forest types. Scattered ricefields in areas nearer to habitation.
10	Stung Sen – Santuk	Tonle Sap floodplain	Cambodia	Transition, Non-breeding	Floodplain grasslands with scattered small wetlands and ponds, mixed with wet- and dry season cultivation areas.
11	Boeung Prek Lapouv	Mekong delta	Cambodia	Non-breeding	Freshwater wetland with patches of wild Chinese water chestnut and Water lily (*Nymphaea* sp.), surrounded by dry-season, irrigated ricefields.
12	Anlung Pring, Phnom Teuk and Phu My	Mekong delta	Cambodia	Non-breeding	Wetlands of predominantly wild Chinese water chestnut and other spikerushes, surrounded by rice- and shrimp farms. Southern Anlung Pring is saline and tidal.
13	Hon Chong	Mekong delta	Vietnam	Non-breeding	Wetland that was used in 1998-2001, but has since been lost to development.
14	Kien Luong	Mekong delta	Vietnam	Non-breeding	Area of wetlands mixed with ricefields.

Cranes that were tracked returning to the Mekong Delta in 1998 and 2001 first arrived in Boeung Prek Lapouv (Dec/Jan) before moving on to Hon Chong and then Tram Chim. In 2015, one of the Anlung Pring families (including 4235 and 4236) would sometimes make brief foraging visits to Phnom Teuk and Phu My, other wetlands nearby, and also made an extended visit to Kien Luong, while the other family (4241 and 4242) moved to Phu My shortly after capture and release and remained there for the rest of the dry season.

Tagged adults from the Tonle Sap region (2015, Ang Trapeang Thmor and Stoung-Chikraeng) moved to the area covering southern Kulen Promtep WS south to northern Beng Per, in the

western part of the Northern Plains, where they held territories during the breeding season, with nesting confirmed for the adult from Ang Trapeang Thmor. This adult (4239) moved to the same area again in the 2016 breeding season. As mentioned earlier, one juvenile (4234/1) remained in the floodplain and was captured for the wildlife trade in August, the other juvenile from Stoung-Chikraeng (4237) eventually spent most of the 2015 wet season in the area south of Chep (Area 9 in Figure 1), while the juvenile from Ang Trapeang Thmor (4240) ended up using flooded ricefields with a failed crop for much of that wet season. In 2016 and 2017, as a sub-adult, 4237 switched to the southern Kulen Promtep area and this area was also used in 2016 by 4240. The juvenile (4234/2) confiscated from a trader and released in to the flooded ricefields 4240 was using in 2015, moved to the Chep area in 2016.

Although the one adult (4233) from Stoung-Chikreang whose tag was still transmitting in the 2016 non-breeding season, moved directly from its breeding territory back to Stoung-Chikraeng, the adult from Ang Trapeang Thmor (4239) first moved to Preah Net Preah, using this area in the early dry season months, before continuing to Ang Trapeang Thmor around early January. Its' offspring (4240) did the same as did the re-released sub-adults (4234/2 and 4235). The remaining sub-adult (4237) moved directly back to its 2015 site, Stoung-Chikraeng, in 2016, but switched to Preah Net Preah and Ang Trapeang Thmor in the 2017 non-breeding season.

3. Declining condition of breeding areas

This section on spatial modeling of nest site suitability in Cambodia and the decline in the condition of breeding areas is based on van Zalinge *et al.* (2023a). The locations of Sarus Crane nests found in an aerial survey of northern Cambodia, 3-12 September 2001, were used in combination with topographical parameters (elevation, slope, distance to rivers, roads and agricultural areas) and habitat type, to model nest site selection in 2001, and using this base model, to predict nest site suitability in 2016 after inclusion of updated spatial data on new roads and areas of habitat conversion.

Highly suitable conditions for nesting, where occupancy likelihood was more than 75%, were found mostly west of the Mekong River (Northern Plains), especially in eastern and central Chep and southern Kulen Promtep (both Wildlife Sanctuaries) and an area extending from Kulen Promtep to northern Beng Per (Figure 1) , which remains unprotected. East of the Mekong in the Eastern Plains, optimal nesting conditions are sparse, but such locations exist in western Lomphat, western and southern Srepok WS and in unprotected locations to the west of Ratanakiri provincial capital. Locations with a predicted occupancy likelihood of >75% shrank by 69% in the Northern Plains (66% inside protected areas and 79% outside) and 73% in the Eastern Plains (80% inside and 64% outside), between 2001 and 2016.

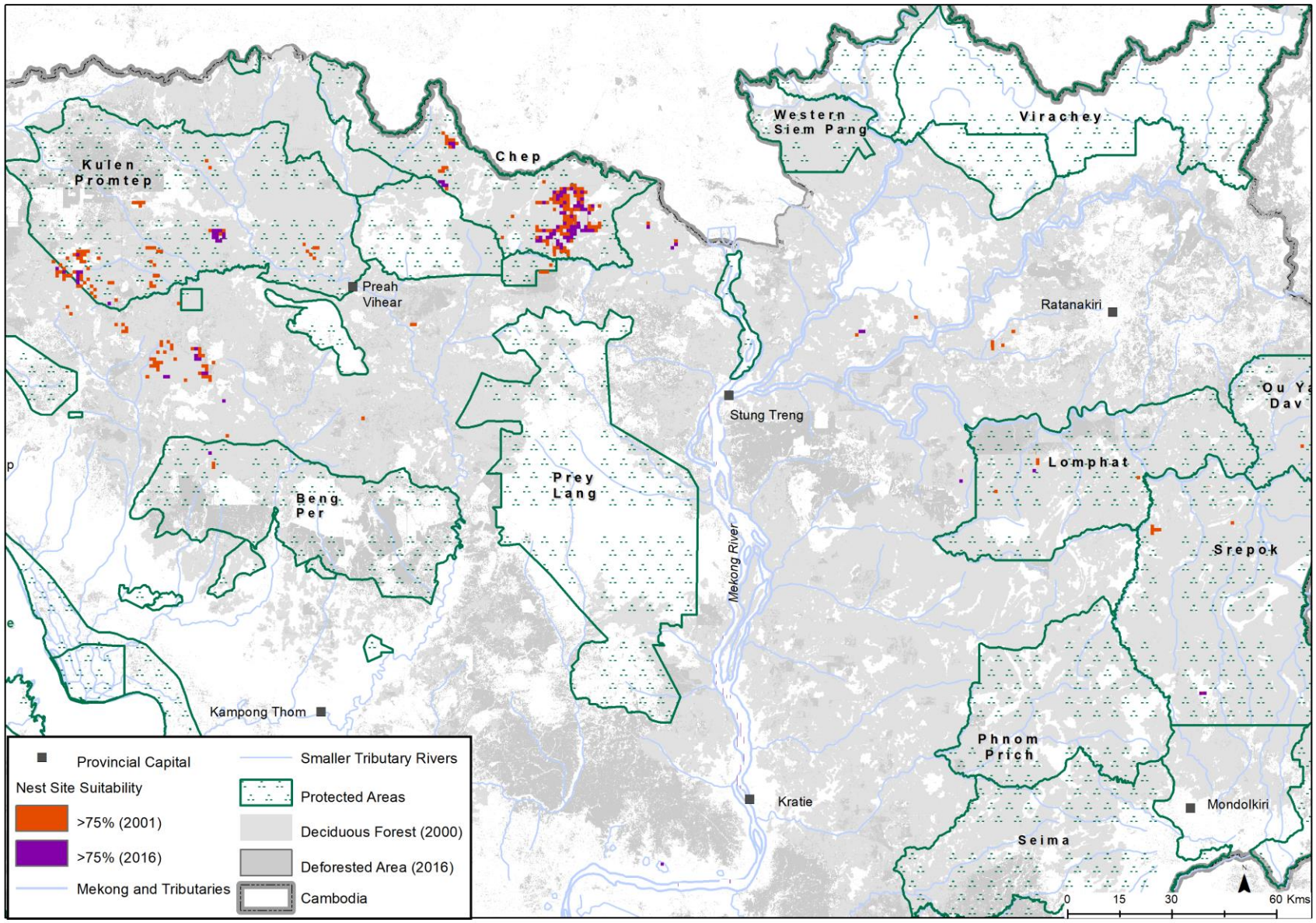

Figure 2. Areas with >75% predicted likelihood of nest occupancy (suitability) in 2001 and 2016.

4. Discussions

Adults tracked from non-breeding grounds in the Tonle Sap region held breeding grounds exclusively in the Northern Plains and more westerly than adults from the Mekong Delta, which held breeding grounds in both the Northern and Eastern Plains. In 1998 and 2001, with Tram Chim as capture site, one in four adults moved to the Northern Plains. In 2015, for cranes from Anlung Pring, one of two adults was confirmed to be in the Northern Plains at the start of the breeding season and the other likely had a breeding territory in the Eastern Plains; based on the movements of the juvenile. Given that annual synchronized crane counts conducted around this time across non-breeding grounds indicate that the population was more or less evenly distributed between the Tonle Sap and Mekong Delta regions (van Zalinge and Tran, 2016), a larger portion of the population must breed in the Northern- than in the Eastern Plains.

This preference for the Northern Plains is likely due to more suitable nesting habitat being available than in the Eastern Plains. Nevertheless, the tracking data indicates the importance of the area in and around Lomphat Wildlife Sanctuary, which is corroborated by findings from the aerial survey conducted by Barzen (2003), and which indicate that, at least at the time, an area including western and southern Lomphat extending in to western and northern Srepok and southern Ou Ya Dav was used by breeding cranes. One confirmed nest was also found in Yok Don National Park, Vietnam, which is located just east of Sre Pok Wildlife Sanctuary (Nguyen, 2004). Many of these areas do not fall in the highest predicted occupancy likelihood of >75%, but in lower categories. It is also known that small numbers breed in Western Siem Pang (see report on Sarus Cranes in Cambodia in this document). That they do breed the Eastern Plains despite better conditions in the Northern Plains is likely in part due to the deciduous forest tracts of the Eastern Plains starting almost adjacent to the Mekong Delta in Lo Go Xa Mat, which is used as a stopover site, and then extending northwards, via western Seima and Phnom Prich to suitable habitat around Lomphat.

Species of wildlife targeted by hunters in tropical forests are highly at risk even when the habitat is still intact, leading to what has been coined "the empty forest syndrome" (Redford, 1992; Wilkie *et al.*, 2011), while logging and habitat conversion can make natural habitats even more accessible and further increase the hunting pressure on wildlife populations (Robinson *et al.*, 1999). In 2001 the forests of northern Cambodia were very remote regions, but even then collection of eggs and chicks from nests by people was consistently high and widespread and was considered the principal threat to the persistence of Sarus Cranes and other globally threatened large waterbird species (Clements *et al.*, 2013). Hunting too has always been widespread in these regions (Loucks *et al.*, 2009) and wildlife populations have been kept far below carrying capacity (O'Kelly *et al.*, 2012).

By 2016, areas in the highest category of predicted nest occupancy declined by as much as 70%. This decline was modeled on measured conversion of habitat to agriculture and expansion of the road network, 2001-2016, and this measured deterioration in site condition can also be

considered as a measure of increased susceptibility to nest predation and hunting. Habitat conversion and expansion of the road network, including within protected areas, in turn leads to more in migration of people. Within Kulen Promtep and Chep Wildlife Sanctuaries the population increased by 27% between 2008 and 2016 (Harrison and Mao, 2017).

As described in other reports on the Cambodia-Vietnam Sarus Crane population in this document, the population has undergone a rapid decline since around 2013-2015. Although it is difficult to rule out the impact of other threats, the increased vulnerability of breeding areas likely plays a major role in this decline. Remaining breeding areas need to be safeguarded from further habitat loss, hunting and nest predation.

5. Recommendations

- Prevent further habitat degradation of Chep and Kulen Promtep as key breeding sites. Eradicate hunting.
- Strengthen nest protection program in Chep and Kulen Promtep and roll-out to other protected areas with breeding cranes.
- Use areas of >75% predicted nest occupancy as target for surveying for Sarus Crane presence in the breeding season and nesting activity, with the aim of protecting more important breeding areas.
- Initiate steps towards protecting and/or restoring floodplain habitat in Preah-Net-Preah and Stung Sen-Santuk.
- In current conservation areas in the Mekong Delta and Tonle Sap floodplain, improve water management to produce natural foods sufficient to allow foraging, and work with farmers in rice-growing areas used by cranes to prevent crane-human conflict.
- Regularly track (adults) and ring cranes (also juveniles) to collect more data on movements and mortality, under changing circumstances
- Distinguish juveniles from adults in annual crane counts

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