STATUS OF TIGERS IN THE SUNDARBAN LANDSCAPE OF BANGLADESH AND INDIA

Status of Tigers in the Sundarban Landscape Bangladesh and India

Principal Investigators
T. K. Dey, Md. J. Kabir, Q. Qureshi & Y. V. Jhala

Bangladesh Forest Department
T.K. Dey, M. J. Kabir, M. M. Ahsan,
M. M. Islam, M. M. R. Chowdhury & S. Hassan.

National Tiger Conservation Authority
S. P. Yadav, Himmat S. Negi, B. S. Bonal
& Rajesh Gopal

World Wide Fund for Nature - India
Debmalya Roy Chowdhury, Pankaj Sarkar,
Ratul Saha, Sunit Kumar Das & Jimmy Bora

West Bengal Forest Department
Soumitra Dasgupta & Pradeep Shukla

Wildlife Institute of India
Manjari Roy, Dipanjan Naha, Ahana Dutta, Bhaskar J Bora, Manendra
Kaneria, Rahul K Talegaonkar, Sougata Sadhukan, Urjit M Bhatt,
Ujjwal Sinha, Q. Qureshi & Y. V. Jhala

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प्रकाश जावडेकर
Prakash Javadekar

राज्य मंत्री (स्वतंत्र प्रभार)
MINISTER OF STATE (INDEPENDENT CHARGE)
पर्यावरण, वन एवं जलवायु परिवर्तन
ENVIRONMENT, FOREST & CLIMATE CHANGE
भारत सरकार/GOVERNMENT OF INDIA

सत्यमेव जयते

Message

Sundarbans is the last unexplored mystical home of the tiger. Here the tiger is dreaded and worshipped. It serves as a guardian of these majestic forests and has saved them from human overexploitation. For the first time, the joint assessment of tiger status by Bangladesh and India using a common standard scientific protocol, has unraveled the ecological aspects of this unique and little known tiger population that will be of immense value for its conservation.

I compliment officials of both the countries to have coordinated and conducted the first scientific assessment of status of the tiger in the undivided Sundarbans. Tiger knows no boundaries and to conserve this uniquely adapted tiger population, governments of the two countries need to work together and implement a conservation strategy that addresses threats outlined in this report. The Government of India will extend all support to ensure the smooth implementation of recommendations presented in this report.

(Prakash Javadekar)

Paryavaran Bhawan, Jor Bagh Road, New Delhi-110 003
Tel. : 011-24695136, 24695132, Fax : 011-24695329
www.youtube.com/prakashjavadekar www.facebook.com/prakashjavadekar
www.twitter.com/prakashjavadekar e-mail : mefcc@gov.in
website : www.prakashjavadekar.com

Anwar Hossain Manju
Minister

Ministry of Environment and Forest
Government of the People's
Republic of Bangladesh

Message

Tigers of Sundarban evolved with the unique morphological characteristics across the mangrove swamps of Bangladesh and India is one of the largest surviving tiger populations in the world. This majestic animal nicely adapted with the mud and tides in mangroves and become an important component of global tiger recovery program. Sundarban tiger due to its size and contiguity of habitat holds a promise of long term conservation.

Tiger is our national animal and conserving tiger is our national priority. The Global Tiger Summit held in St. Petersburg of Russia in.2010, marked as milestone in tiger conservation where our Honorable Prime Minister H.E. Sheikh Hasina expressed her all out support for tiger conservation. Bangladesh is working to achieve TXZ target through the implementation of Bangladesh Tiger Action Plan and National Tiger Recovery Program. Being a trans-boundary tiger habitat with India, I believe that strengthening trans-boundary law enforcement, monitoring, research and sharing of knowledge and information shall ensure long term survival of the species. Implementation of the Protocol signed with the Government of India will expedite tiger conservation in Sundarban landscape.

I am happy to know that Bangladesh Forest Department and West Bengal Forest Department did this joint survey in their respective part with the technical assistance of Wildlife Institute of India and overall guidance from National Tiger Conservation Authority of the Government of India. I would like to express my sincere thanks to the officers and staffs of Bangladesh Forest Department for doing tedious field work, data processing and report writing. Wildlife Institute of, India, National Tiger Conservation Authority "and the World Bank deserve special thanks for their support. This is the first robust scientific tiger estimation in Bangladesh Sundarban and will be of immense help in assessing conservation policy and management strategies for effective conservation of the species for future generation of Bangladesh, India and the world community.

(Anwar Hossain Manju, M.P.)

Bangladesh Secretariat, Dhaka. **Phone :** 9540587,9573303, **Fax :** 9545166, **e-mail :** minister@moef,gov.bd

Bishan Singh Bonal

Additional Director General (Project Tiger)
& Member Secretary
National Tiger Conservation Authority
Government of India

Message

Many of our tiger populations extend across international boundaries. Conserving these populations can be only be achieved by unified trans-boundary policies, monitoring and law enforcement. The Sundarban is home to a unique tiger that was speculated to constitute one of the world's largest population for the species. By bringing science into a robust monitoring programme the governments of India and Bangladesh have used a common protocol for the first time to assess tiger status across Sundarbans. The population estimate of 182 tigers is a laudable population of Global importance.

Now the onus lies on the wildlife managers of both countries to ensure the recovery and persistence of this population in the face of development and Global climate change. The National Tiger Conservation Authority will provide all the necessary assistance to safeguard this population through trans-boundary collaboration and cooperation.

(Bishan Singh Bonal)

Md. Yunus Ali

Chief Conservator
Of Forests Bangladesh

Message

Tiger population estimation is a difficult task as they are nocturnal, solitary, elusive and cryptic in nature . It becomes more difficult in Sundarban where tiger do not move in definite tracks. Absence of appropriate scientific method for monitoring tigers, prey and their habitats in the mangrove forests of India and Bangladesh was major drawback of tiger conservation. Wildlife Institute of India devised double sampling approach of spatially explicit capture mark-recapture, using camera traps and covariates of prey, tiger sign and human impacts, seems to be statistically robust for Sundarbans landscape. We feel comfort to adopt this method, and have tiger status that is accepted by the world community.

Bangladesh Forest Department, as a custodian of Sundarbans and the majestic royal Bengal tiger, has taken various steps for conservation of the species. SMART patrolling in the Sundarban West Sanctuary has claimed as effective law enforcement monitoring tools to spread all over the Sundarbans. Community involvement in tiger conservation gets momentum with the activation of community patrolling group (CPG) and Village Tiger Response Team (VTRT), now in a process to incorporate into legal framework. No tiger poaching incidences have been recorded in last six months. The MOU and the PROTOCOL signed with the Government of India for the protection of Sundarbans and the Bengal Tiger shall be a landmark for conservation.

I must appreciate the initiative of Wildlife Institute of India and National Tiger Conservation Authority of the Government of India to publish joint tiger status report for the entire Sundarbans. Officers and staffs of Bangladesh Forest Department involved in this study deserves special thanks and I hope this learning will unveil the way to all scientific research and monitoring of tigers, prey and their habitats in Sundarban.

10.3.2016

(Md. Yunus Ali)

Bana Bhaban, Agargaon, Sher-E-Bangla Nagar, Dhaka-1207
Phone Office : 88-02-8181737, Residence : 88-02-9021244, Telegram : FORESTS,
Fax : 88-02-8181741, Web : www.bforest.gov.bd, E-mail : ccf-fd@bforest.gov.bd

V. B. Mathur

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

Director
Wildlife Institute of India

Message

There has been a rapid stride in the process of assessment of tiger populations in India and with the application of modern tools and statistical rigour these estimates have now become more robust and reliable. Nevertheless, the Sundarban landscape presents a formidable challenge to address since traditional methodologies of tiger abundance estimation cannot be applied directly. I am very pleased to say that the scientists of this institute have now been able to standardize a robust and scientific protocol for the Sundarban landscape and have worked closely with the Forest Departments of Bangladesh and India to implement it. The outcomes of the present collaborative studies provide a much better estimate of tigers in this unique ecosystem.

My sincere compliments to the Forest Departments of West Bengal and Bangladesh for establishing the new benchmark for tiger population status, which also is a fine example of transboundary cooperation. The Institute would continue to provide professional inputs for effective management of Sundarbans - the nature's jewel.

V. B. Mathur, D.Phil. (Oxon)

Wildlife Institute of India, Chandrabani, Dehradun-248001, India.
Phone : 91 135 2646112, E-mail : dwii@wii.gov.in, Website : wii.gov.in

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The maps depicted in this report are indicative and relative. The authors are not to be held responsible for their accuracy.

Introduction

During the Eocene epoch, about 34 Ma, the Indian plate collided with the Eurasian landmass (Aitchison et al. 2007). This led to the formation of the Himalaya in the north and the subsidence of the Bengal basin region to the south-east (Uddin & Lundberg 2004). Copious amount of sediments, washed down by rivers formed by the developing mountains eventually led to the formation of the tidal mangrove halophytic forest called Sundarban (Das 2015). Located at the delta of Ganga, Brahmaputra and Meghna river system, Sundarban is the world's largest contiguous mangrove forest (Chaudhuri and Choudhury 1994). The name Sundarban literally means "beautiful forest" and in all likelihood is named after the 'Sundari' trees (*Heritiera fomes*) found in these mangroves. This mangrove forest spread across Bangladesh and India covers an area of approximately 10,000 sq.km. of which 62% lies in Bangladesh between 21°30'-22°30' N latitudes and 89°00'-89°55' E longitudes (Khan 2004, Barlow 2009) while 38% lies in India, situated within 21°40'04"N and 22°09'21"N latitude, and 88°01'56"E and 89°06'01"E longitude (Chaudhuri and Choudhury 1994) (Figure 1).

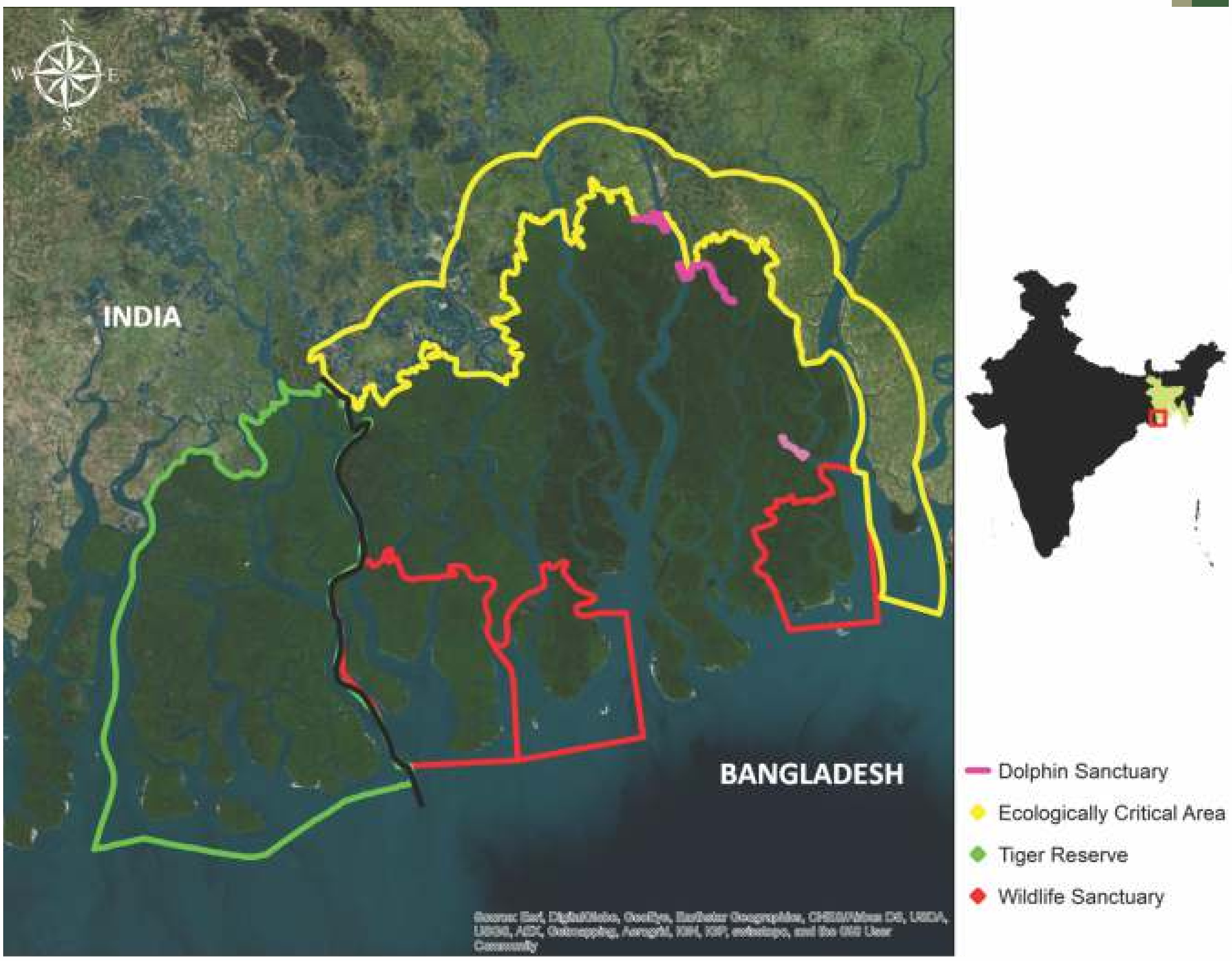

Figure 1. Network of protected areas across Sundarban landscape

Sundarban is the only exclusive mangrove habitat where the tiger exists giving it the status of Level I Tiger Conservation Unit (TCU) (Wikramanayake et al. 1998). Sundarban tigers differ morphologically from the mainland tigers (Barlow 2009) and are also genetically one of the most divergent groups amongst Bengal tigers (Singh et al 2015). Besides being a tiger habitat, these mangroves provide critical ecosystem services by buffering inlands from cyclones, stabilising sediments and aiding land maturation (Blasco et al. 1996), serving as a nursery for spawning by major fisheries of the Bay of Bengal, making it one of the globally important wetlands (Junk et al. 2006). It is recognised as a World Heritage Site and many local communities' subsistence and livelihood are dependent on harvest of natural produce like fish, giant tiger shrimp (*Penaeus monodon*) and honey (Blair 1990; Rahman 2000; Islam and Wahab 2005) and through eco-tourism.

Bangladesh Sundarban represents 44% of the total forested area in the country. Fifty percent of the total forest revenue is generated from this landscape, in the form of tourism, fishing, honey collection, nipa (*Nypa fruticans*) leaves for thatching, etc. (Khan, 2004). The wildlife sanctuaries viz. Sundarban East, Sundarban South and Sundarban West, comprising an area of 1,397 km^2, and a 10 km wide area surrounding the northern and eastern boundaries of Sundarban Reserve Forest designated as Ecologically Critical Area form the protected tracts in this forest.

Indian Sundarban cover an area of 4267 km^2 of mangrove forests which is within the jurisdiction of the two districts of 24 Parganas (South and North) of the state of West Bengal. The Indian Sundarban has been declared as 'Sundarban Biosphere Reserve' under the UNESCO Man and Biosphere Reserve (MAB) program. The biosphere reserve includes the core areas (declared as national park), the buffer zone and the wildlife sanctuary of the tiger reserve along with protected mangrove tracts in the South 24-Parganas. A part of the biosphere reserve includes the Sundarban Tiger Reserve (area 2585 km^2) which is further divided into the Sundarban National Park, Sajnekhali Wildlife Sanctuary and the Basirhat buffer zone.

Although the distribution of tigers throughout the Sundarban has been established, there has been no proper quantification of the tiger population. This dearth of rigorous scientific studies on their population dynamics, behaviour and conservation status is due to the logistic constraints imposed by the tidal forests coupled with the man-eating reputation of Sundarban tigers. In Sundarban, human-tiger conflicts are more frequent than in any other tiger habitat of the world (Neumann-Denzau and Helmut Denzau 2010). It has been estimated that on an average 36 people in Indian Sundarban and 22 people in Bangladesh Sundarban (Barlow et al. 2013) are killed each year. This in turn has impeded the assessment of any management success. Wildlife Institute of India had conducted a pilot study in 2010 (Jhala et al. 2011) on estimation of tiger population using camera traps in Sundarban which laid the groundwork for future similar studies. Over the years it has been demonstrated that the traditional camera trap-based mark-recapture exercise is possible provided it is tailored to the local conditions (Roy et al. 2016). Keeping this in mind, a collaborative study between Bangladesh Forest Department and Wildlife Institute of India was started in 2013-2015 to establish the first ever robust estimate of tiger density and abundance in Bangladesh Sundarban (Dey et al. 2015). At the same time, Wildlife Institute of India and World Wide Fund for Nature-India conducted camera trapping in 2013-14 to estimate tiger abundance across the entire Indian side of the Sundarban (Jhala et al. 2015).

Methodology

We determined the extent of tiger occurrence and relative abundance by khal surveys (Figure 2.) for tiger sign intensity across the entire Sundarban landmass.

Figure 2. Khal survey across Sundarban landscape

Simultaneously data on ecologically important covariates like prey species signs and sightings, and human disturbance indices were also recorded during khal surveys as per the established standardised protocols across the two countries (Jhala et al. 2014). Signs and sightings were computed as encounters per km of khal survey and were therefore comparable between areas and years. We estimated absolute tiger density through spatially explicit capture mark recapture (Efford 2004) using camera traps at three representative sample blocks covering an area of 1264 km^2 in Bangladesh Sundarban and five blocks (covering five ranges of Sundarban Biosphere Reserve) comprising an area of 1649 km^2 of Indian Sundarban.

Estimating tiger densities using camera trap based capture mark-recapture.

Camera trapping was carried out in eight blocks spread across Sundarban (Figure 3). The blocks were located in Sarankhola, Satkhira and Khulna ranges in Bangladesh while in India the blocks were located in Basirhat, Ramganga, East, West and Sajnekhali ranges. The

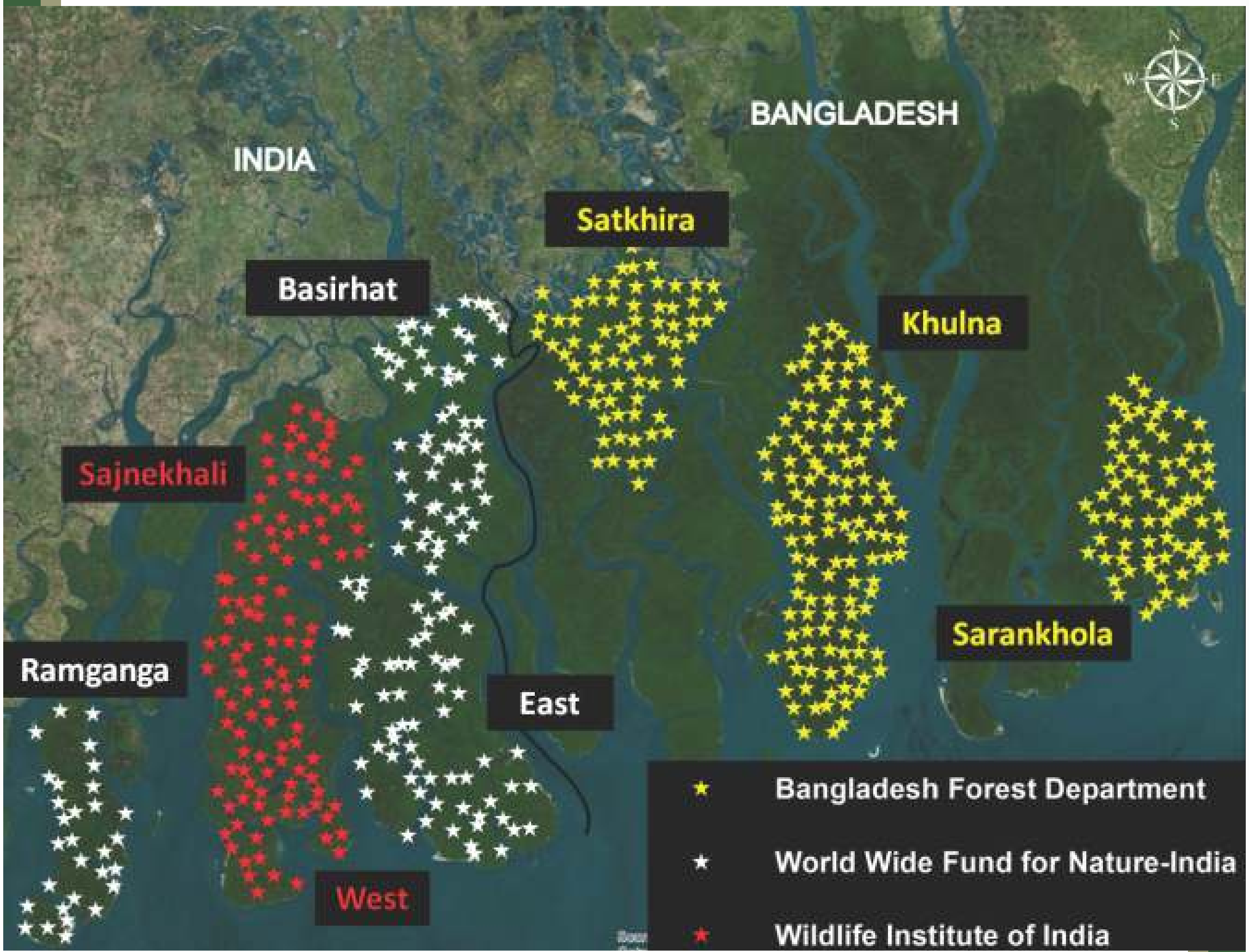

Figure 3. Camera trap blocks across Sundarban landscape

blocks selected were such that they were surrounded by wide water channels > 1 km on most sides as tigers have shown avoidance for the same (Naha et al. 2016 *In Review*). This was done to ensure geographic closure. Suitable camera trap locations were selected near brackish water holes, in elevated places, river bends, regular channel crossing paths frequented by tigers based on local knowledge of frontline forest staff and sign surveys to maximise photo capture and minimise chances of lethal encounters. We set up camera traps using baits and lures to attract tigers to our camera stations. Individual cameras were set 45 cm above ground and distance between the camera pair was 7-8 m. Inter-trap distances varied between 2 to 4 km. We used nylon nets and cut vegetation to orient the tigers to get proper flank photographs for identifying each individual from their stripe patterns (Roy et al. 2016). Trap stations were regularly monitored and constantly supplied with baits to minimize the spatio-temporal variation in photo captures between traps.

We identified individual tigers by their stripe patterns using a pattern recognition program Extract Compare (Hiby et al. 2009) specifically developed for tigers. Two matrices summarising photo-captured tigers' spatio-temporal detection-history and spatio-temporal camera trap layout were made. We then used this information in the spatially explicit capture-mark-recapture (package secr, Efford 2015) framework in Program R, to estimate tiger densities. SECR estimates densities directly from the spatial histories of individual animals by modelling two parameters – g0, the detection probability at the activity centre and sigma, the spatial movement parameter. Keeping detection function as half-normal, we modelled g0 as constant (null), behaviour (b) and behavioural response specific to trap-site (bk) and sigma as constant (null). The parameters were modelled separately for each block giving us the individual block densities. We used a habitat mask to demarcate non-habitats and buffered the camera trap minimum bounding polygon by 3 sigma to delineate the model inference space. We then selected the models with the lowest AIC as the best model.

Khal surveys

Khal survey was carried out across the entire Sundarban (Figure 2.) using a standardised sampling protocol established for the Sundarban (Jhala et al. 2014). This exercise was conducted alongside camera trapping study. During khal survey, direct sightings and signs of tiger, fishing cat, otters, estuarine crocodiles, monitor lizard, wild pig, spotted deer and human disturbance along with vegetation covariates were collected. GPS coordinates along with type of mangrove, slope of the bank and width of the upper and lower bank were noted for each sighting/sign encountered.

Relationship of covariates with camera-trap densities

Distribution of tiger sign at 100 km^2 grids was used to determine the naïve occupancy by tigers. Encounter rates for signs and sightings were computed for all data based on effort (kms of survey) invested in each 100 km^2 grid. Exploratory data analyses were used to evaluate the relationship between tiger density and covariates of prey abundance, human disturbance and tiger sign intensity (Figure 4a, b, c.). Covariates that showed a reasonably good relationship (linear and monotonic) were used in a multiple regression framework to model tiger density for 100 km^2 grids (Jhala et al. 2011).

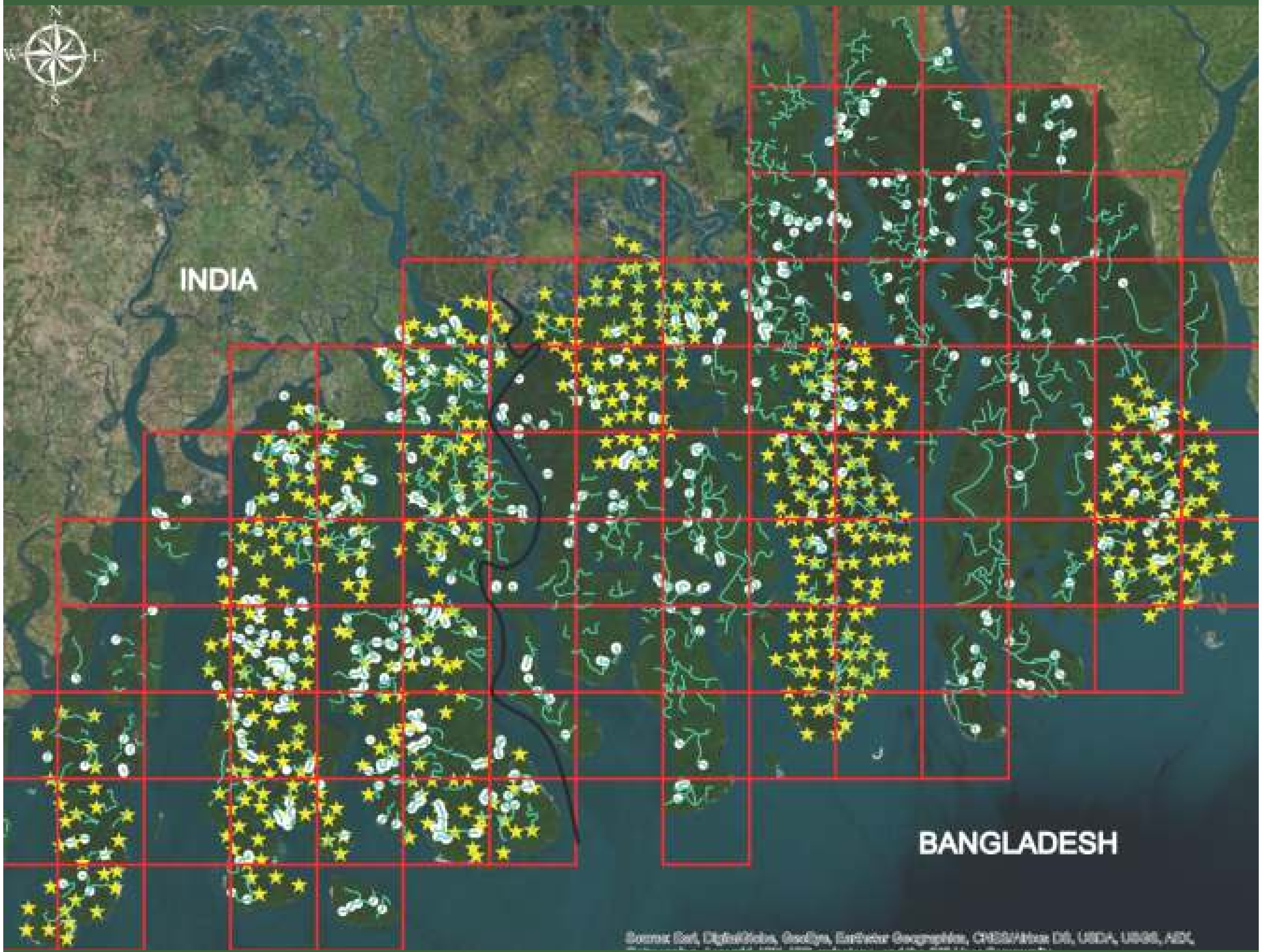

Figure 4a. Camera trap locations, khal survey track logs and tiger signs across Sundarban superimposed on 100 km^2 grids

Figure 4b. Grids (100 km^2) where SECR tiger density as well as covariate of prey, tiger sign intensity and human disturbance obtained from khal surveys were available to model relationships between tiger density and covariate

Figure 4c. Extrapolating tiger density to grids where camera trapping was not done

Results

Tiger density through camera trapping

The best models selected in most of the blocks included trap specific behavioural response in capture probability, which was expected since the trap sites were baited. The highest tiger density was recorded in Block VIII (Sajnekhali) while the lowest density was recorded from Block III (Khulna) (Table 1). The area weighted tiger density from all the eight camera trapped blocks was 2.85 (2.10-3.61) tigers/100 sq.km.

Table 1. Details and parameter estimates of spatially explicit capture recapture from camera trap sampling conducted in Sundarban. The model that described g0 as being a function of site specific behavioral response and sigma as constant was selected as best model for most of the blocks.

Block Names	Country	Number of days sampled	Number of Camera locations	Number of individuals captured (Mt+1)	Minimum Bounding Polygon Area (sq.km)	Best Model with lowest AIC values in secr	Density (SE) in tigers/ 100sq.km	g0(SE)	Sigma (SE) in kms.
Block I (Sarankhola)	Bangladesh	74	71	18	309.18	D(.)g0(bk)σ(.)	3.70 (0.91)	0.01 (0.003)	3.37 (0.35)
Block II (Satkhira)	Bangladesh	68	71	13	366.44	D(.)g0(bk)σ(.)	2.77 (0.78)	0.01 (0.002)	4.27 (0.05)
Block III (Khulna)	Bangladesh	127	124	7	588.08	D(.)g0(bk)σ(.)	1.08 (0.04)	0.003 (0.0008)	8.98 (1.80)
Block IV (Basirhat)	India	31	56	14	325.4	D(.)g0(bk)σ(.)	3.43 (0.99)	0.01 (0.003)	3.07 (0.41)
Block V (Ramganga)	India	36	30	5	228.76	D(.)g0(.)σ(.)	1.57 (0.74)	0.01 (0.004)	9.06 (1.87)
Block VI (East)	India	31	60	20	485.45	D(.)g0(bk)σ(.)	3.77 (1.03)	0.003 (0.001)	5.84 (1.17)
Block VII (West)	India	32	76	14	420.33	D(.)g0(bk)σ(h2)	3.15 (0.88)	0.04 (0.007)	σ_1=1.89 (0.21) σ_2=4.24 (0.43) $pmix_1$= 0.71 (0.10)
Block VIII (Sajnekhali)	India	23	40	14	188.51	D(.)g0(bk)σ(h2)	4.79 (1.31)	0.04 (0.007)	σ_1=1.89 (0.21) σ_2=4.24 (0.43) $pmix_1$= 0.71(0.10)
Total			528	105 (including common tigers)					

Relationship between covariates obtained through khal survey and tiger densities generated through SECR.

Tiger density was found to have a positive relation with tiger sign intensity (r = 0.464; P = 0.008); and encounter rate of prey (r = 0.447, P = 0.012), while it had a negative relationship with encounter rate of human disturbance (r = -0.554, P = 0.0012). A multiple regression having all of the above three covariates had the best fit (P=0.007) and explanatory power (R^2 =0.4) to model tiger density (Table 2, Figure 5.).

Table 2. Model coefficients of covariates and tiger sign index for modelling tiger density in the Sundarban.

Parameters	Estimate	SE
(Intercept)	0.027	0.004
Tiger Sign Encounter Rate	12.21	6.15
Prey Encounter Rate	1.81	1.71
Human Disturbance ER	-10.97	4.86

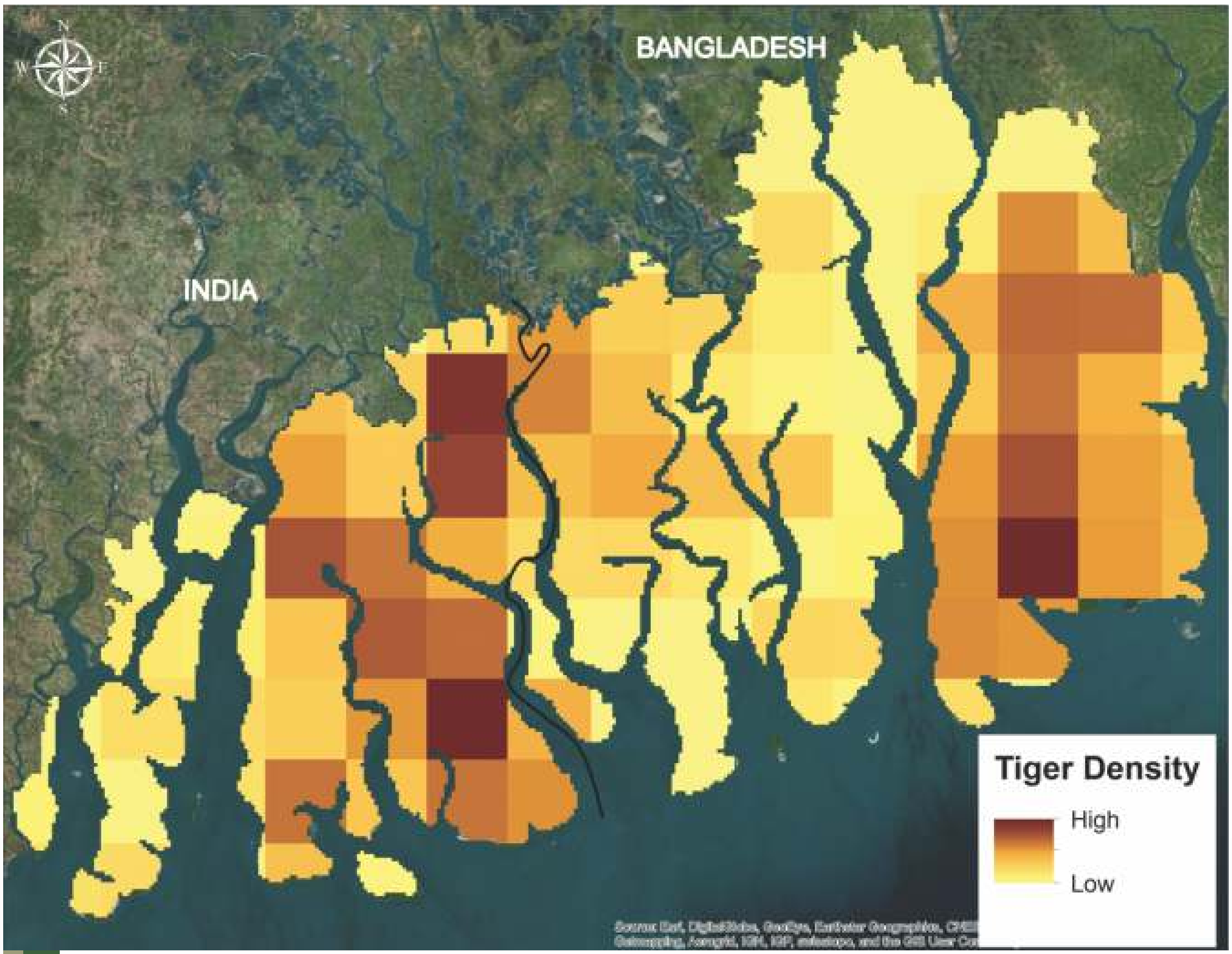

Figure 5. Tiger density across Sundarban obtained from camera trap based spatially explicit capture recapture and covariate based regression model

Tiger numbers, estimated by camera trapping using SECR within the minimum bounding camera trapped polygons and the multiple regression model for the remaining part, was 182 (145 to 226) in the total tiger occupied area of 6724 km2; with 106 (83 to 130) tigers on the Bangladesh side and 76 (62 to 96) tigers on the Indian side.

Species sign and human disturbance encounter rates

Encounter rates of species were plotted to depict relative abundance and distribution patterns across the entire Sundarban landscape (Figures 6 to 16).

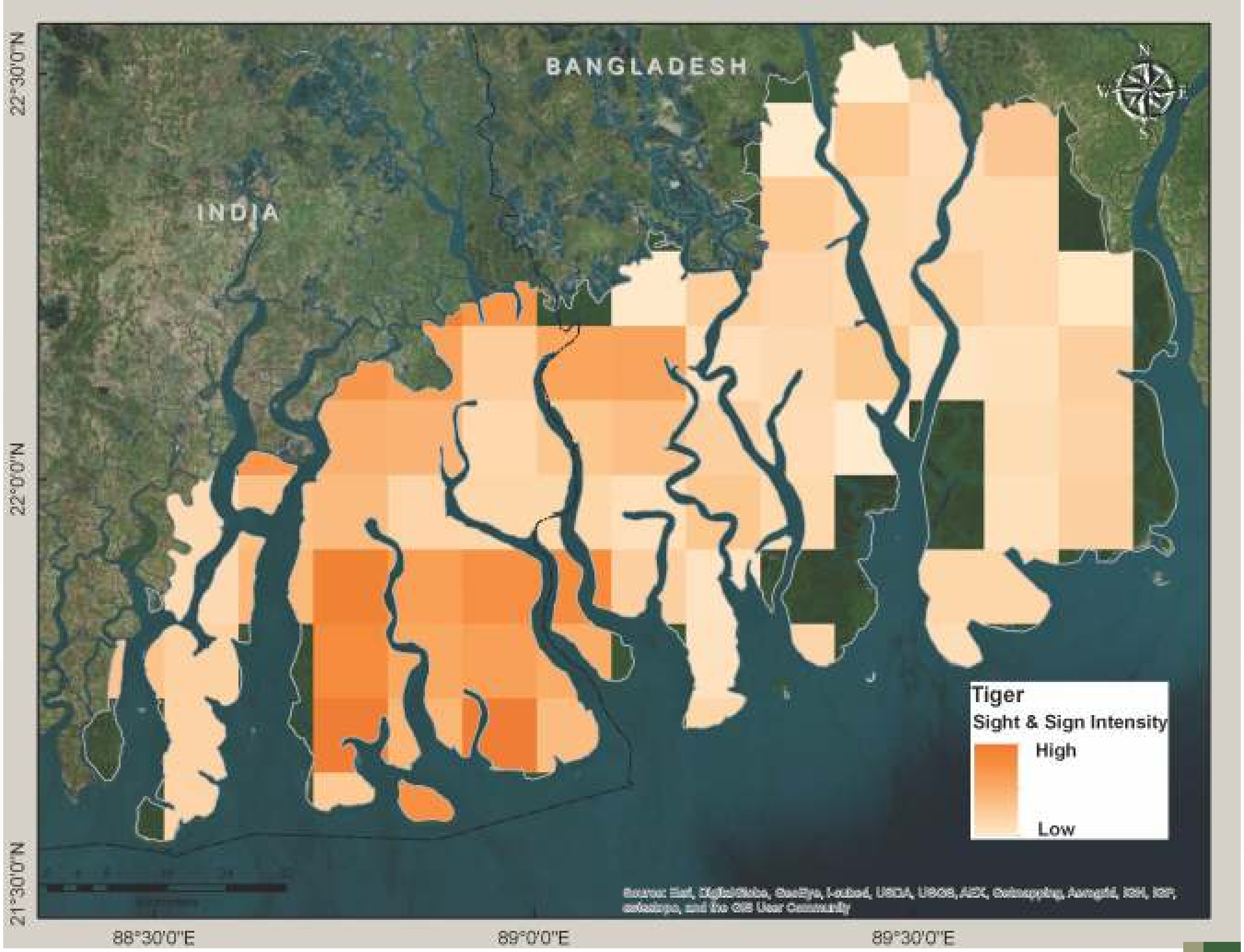

Figure 6. Intensity of tiger sign and sighting encounter rate across Sundarban

Tiger sign and sighting encounter rates were higher on the Indian side especially in the core zone of the national park as compared to other areas.

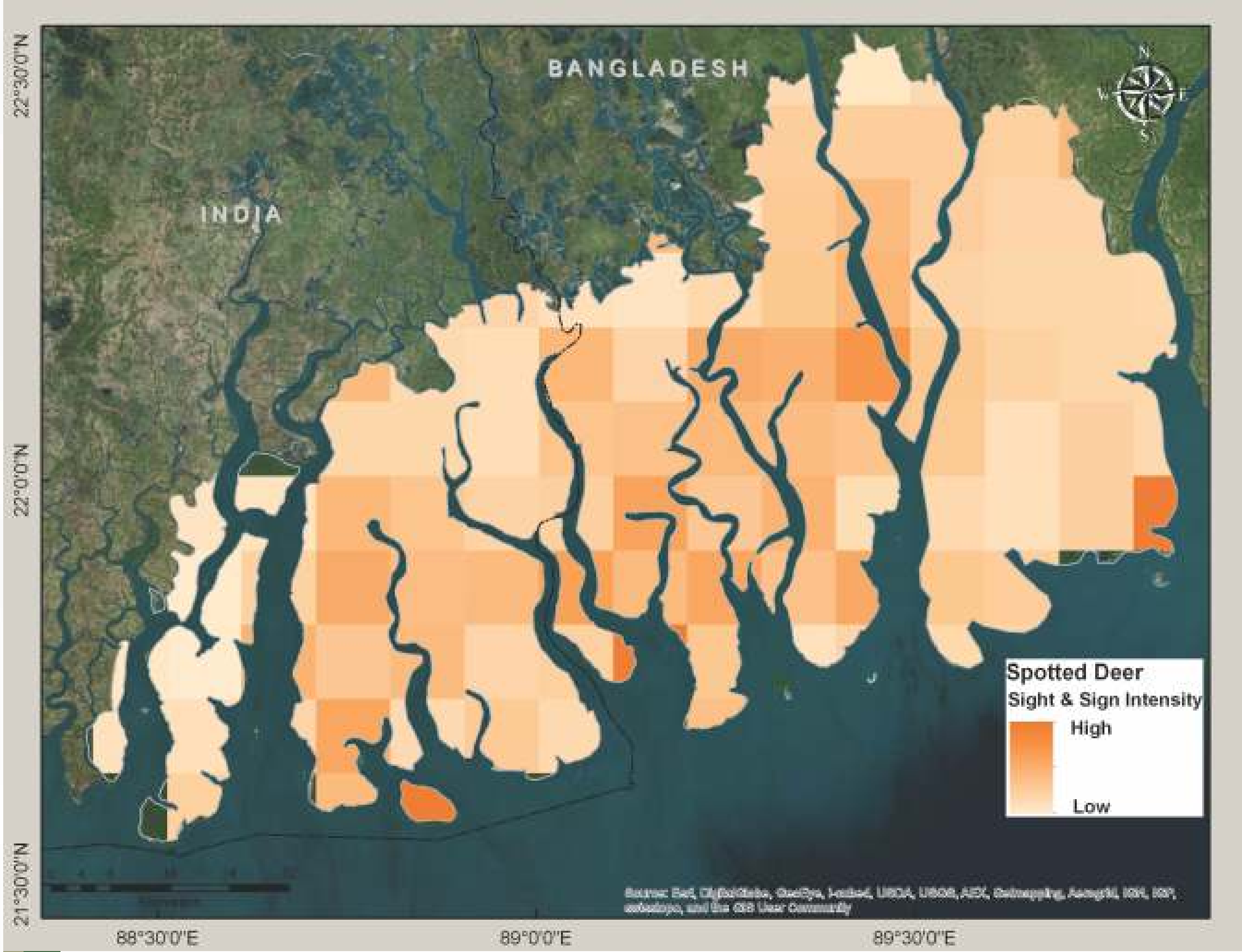

Figure 7. Intensity of spotted deer sign and sighting encounter rate across Sundarban

Spotted deer sign and sighting encounter rate was more or less uniform across the landscape with pockets of higher encounter rates in the Sarankhola and Khulna ranges of Bangladesh Sundarban.

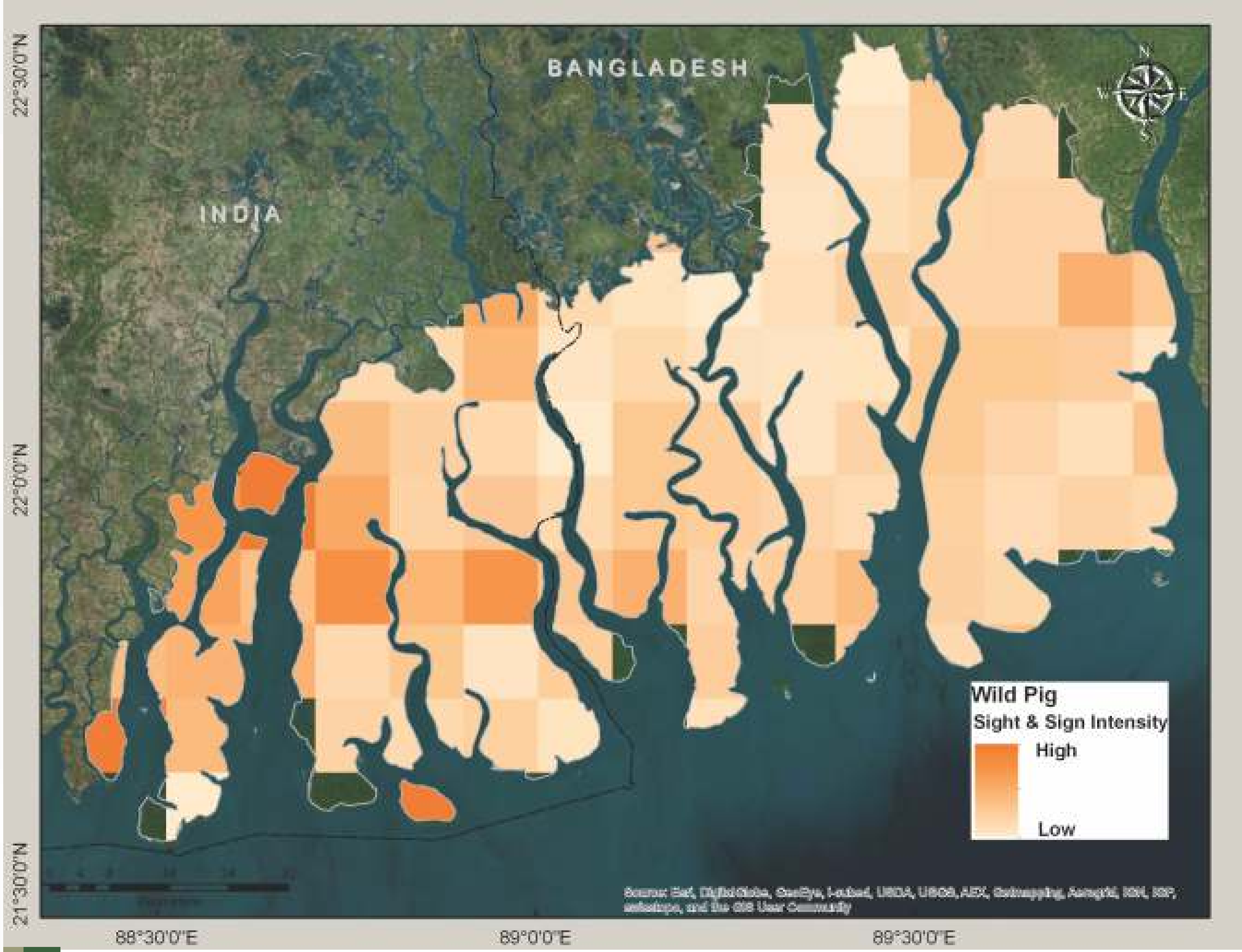

Figure 8. Intensity of wild pig sign and sighting encounter rate across Sundarban

Wild pig presence was recorded throughout the landscape with higher encounter rates on the Indian side.

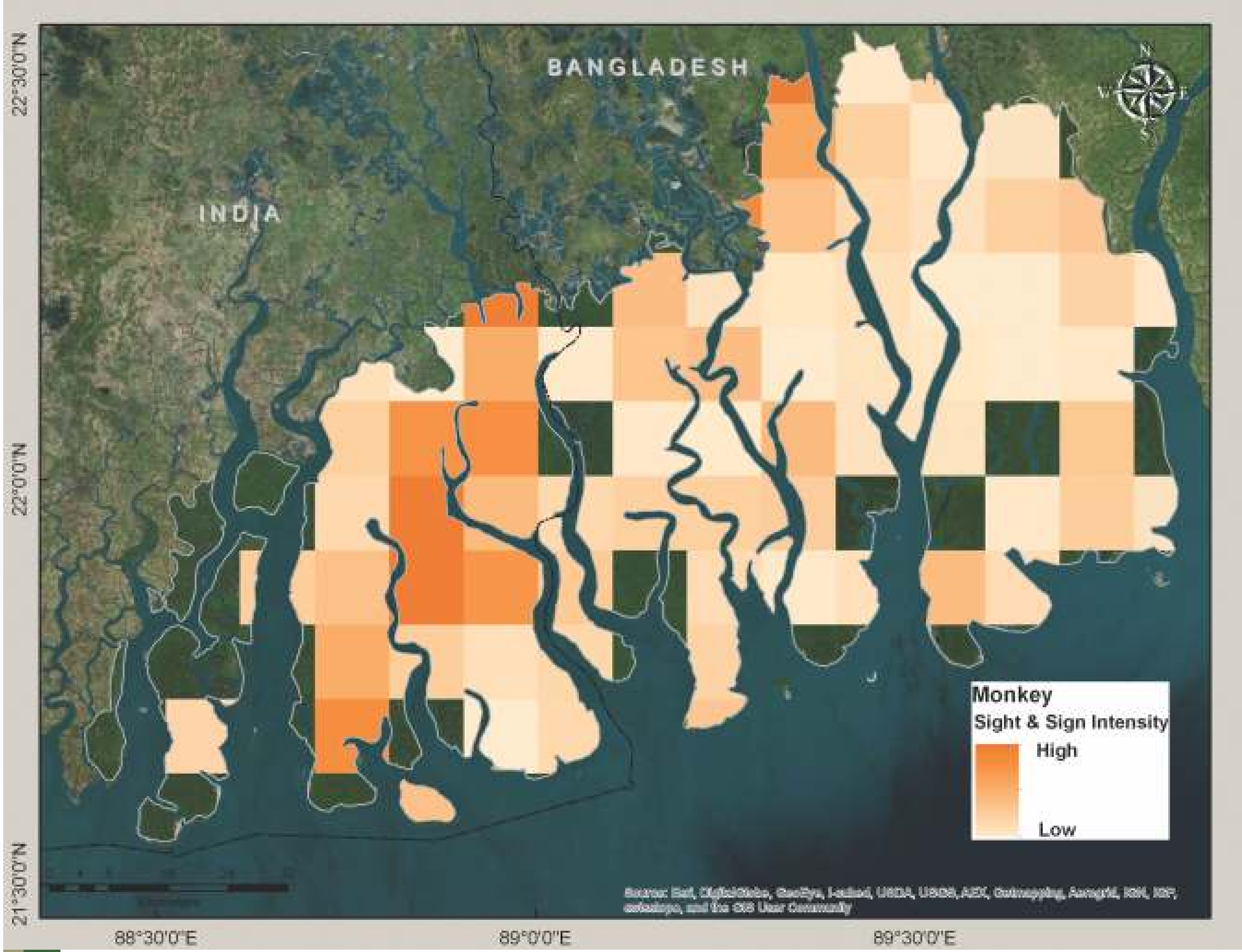

Figure 9. Intensity of Rhesus macaque sign and sighting encounter rate across Sundarban

Rhesus macaque sign and sighting encounter rate was higher in the East range of the Sundarban National Park as well as on the buffer zone of the Basirhat range in the Indian side.

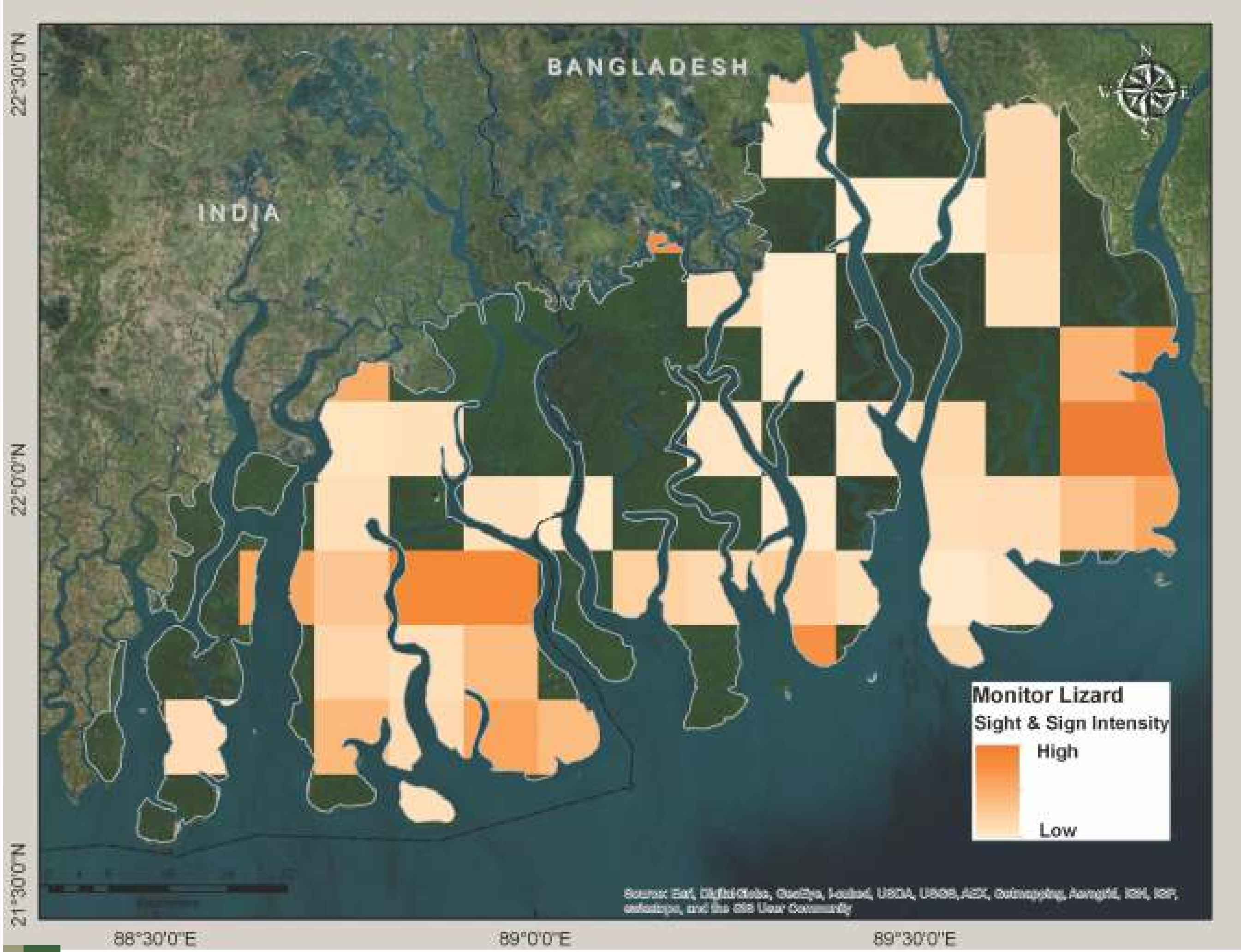

Figure 10. Intensity of monitor lizard sign and sighting encounter rate across Sundarban

Monitor lizard sign and sighting encounter rate was highest in the Chandpai-Sarankhola range of Bangladesh, while its presence was not recorded in many areas. Due to its large size and high abundance this species may form an important component of the tiger's diet in the Sundarbans.

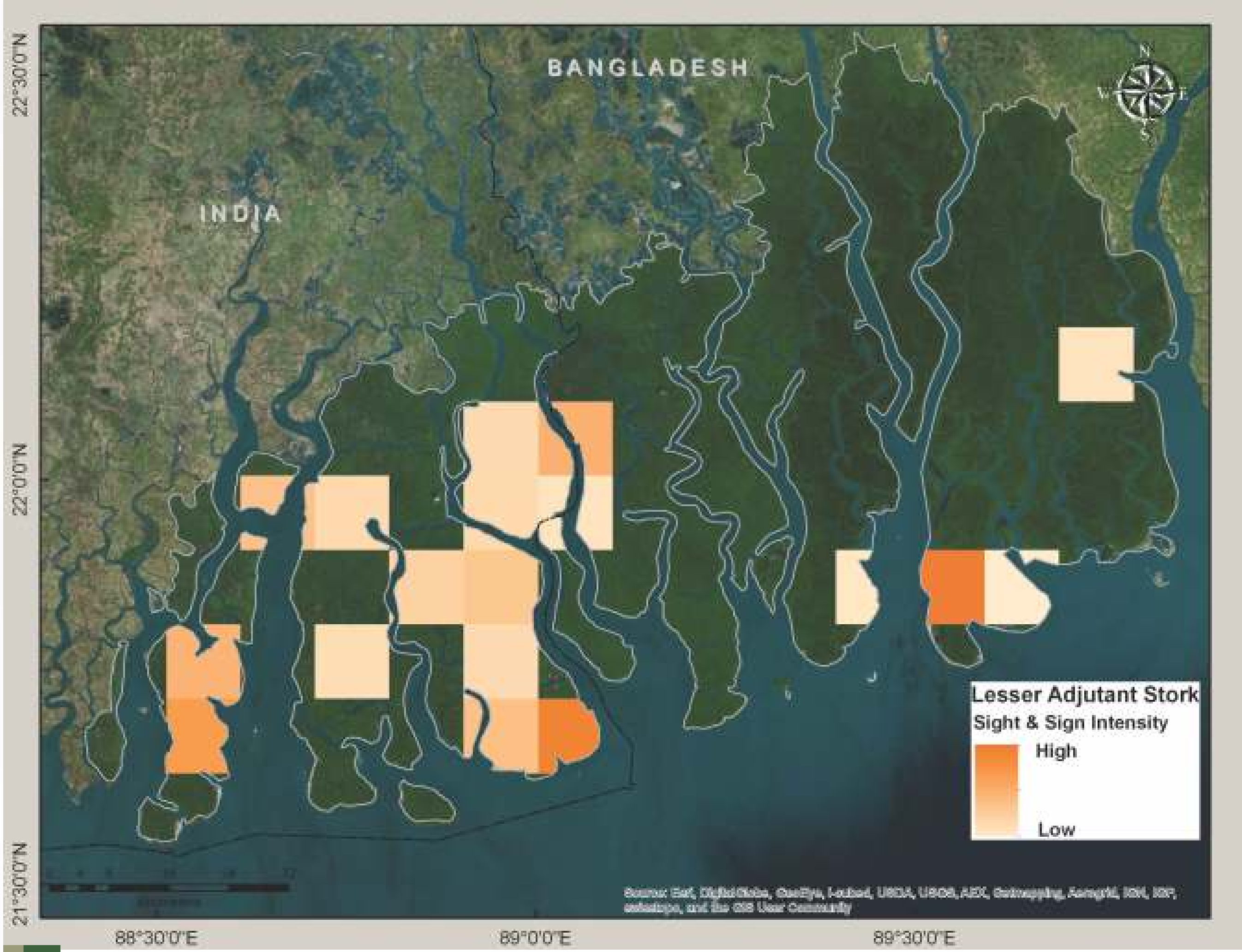

Figure 11. Intensity of lesser adjutant stork sign and sighting encounter rate across Sundarban

Lesser adjutant stork seemed to have more presence on in the Indian side rather than the Bangladesh Sundarban.

Figure 13. Dolphin sign and sighting encounter rate across Sundarban

Dolphin sign and sighting were in general low with higher presence recorded in the Bangladesh side especially within the declared protected areas for the species.

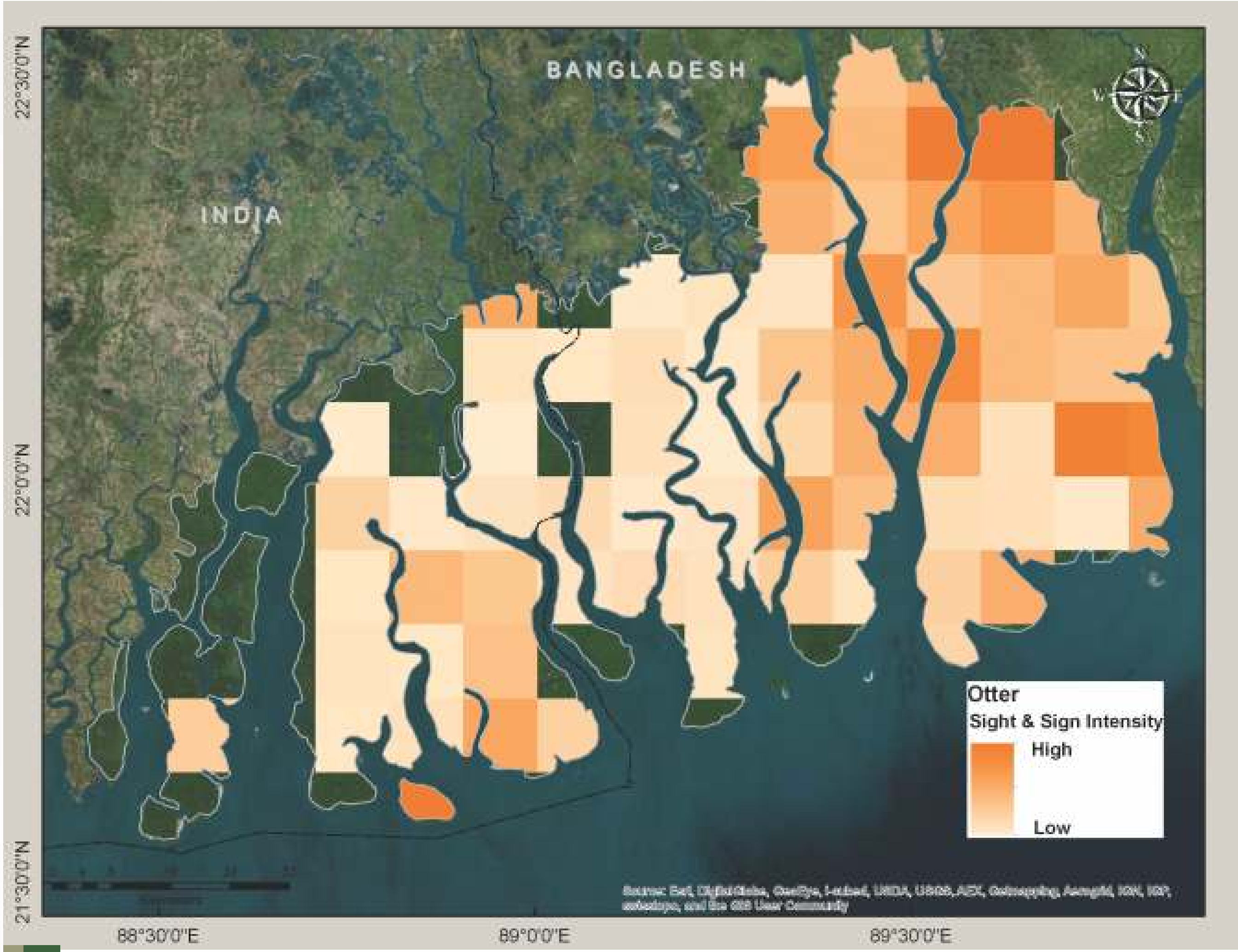

Figure 14. Intensity of otter sign and sighting encounter rate across Sundarban

Otter in general had a higher presence in the Bangladesh Sundarban as compared to the Indian side with ranges of Chandpai-Sarankhola and Khulna recording highest encounters.

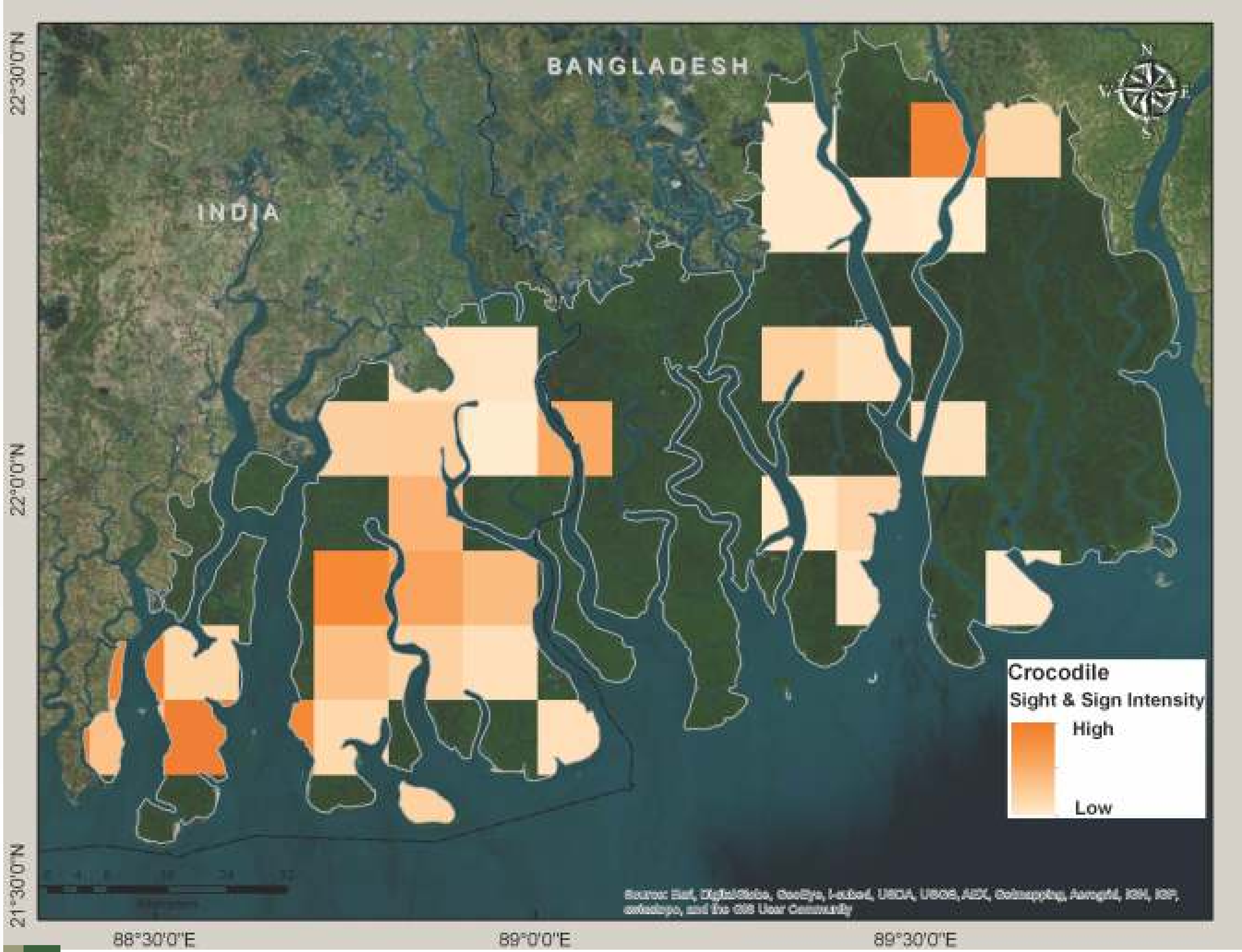

Figure 15. Intensity of crocodile sign and sighting encounter rate across Sundarban

Crocodile seemed to have a patchy distribution with more sign and sighting recorded on the Indian side.

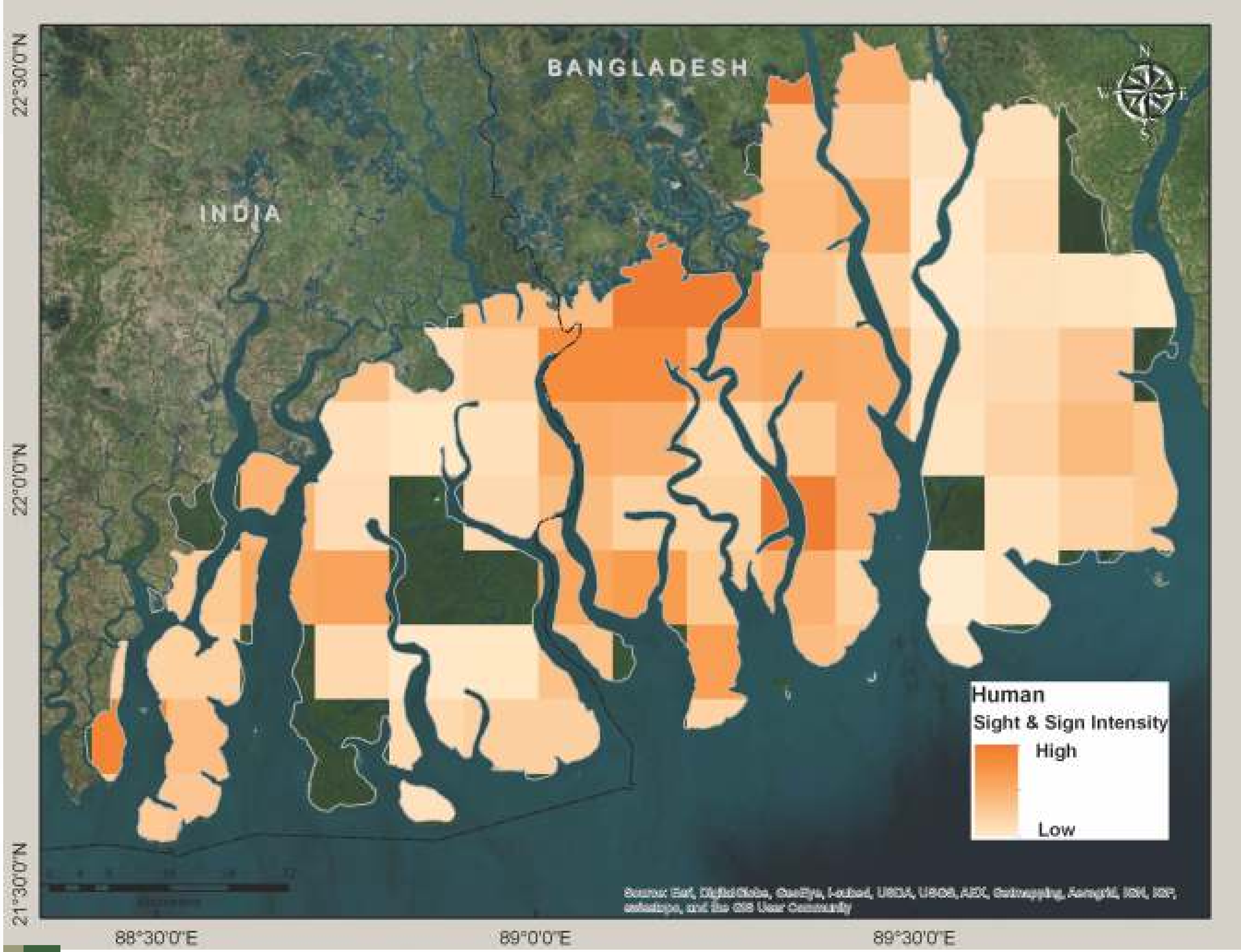

Figure 16. Intensity of human sign and sighting encounter rate across Sundarban

The encounter rate of human sign and sighting was higher near the edges of the forest and overall higher in Bangladesh Sundarban which is further exacerbated by the usage of river channels for transportation of commercial vehicles

Discussion

Earlier estimates based on less reliable methods using home range size of two tigresses (Barlow et al. 2008), pugmark, and khal surveys had estimated tiger abundance between 300 to 500 in Bangladesh Sundarban (Barlow et al. 2008, GTRP 2012). Khan (2004) provided a more reasonable estimate based on prey availability at about 200 tigers in Bangladesh Sundarban. Tiger density estimated using camera traps in the Indian Sundarban had estimated abundance at 76 tigers (62 to 96) (Jhala et al 2015).

This is the first ever effort to quantify tiger abundance in Bangladesh as well as the entire Sundarban based on a robust scientific protocol using camera traps in an SECR framework and double sampling approach. The current assessment covers a reasonably large area (2912.15 km^2) of the Sundarban by camera traps.

Low density of tigers in the Sundarban is an inherent attribute of the hostile mangrove habitat that supports low tiger prey densities. Management of this population for long-term survival is therefore more difficult and conservation strategies need to identify threats and seek to immediately minimise them.

The biggest peril to this landscape, given the comparatively lower risk of direct habitat destruction by humans, is the rising sea level due to climate change which threatens to submerge 96 % of the landmass (Loucks et al. 2010). This will not only lead to the loss of a unique landscape, but also increased salinity of the inner human dominated lands along with increased tiger movement into the surrounding villages leading to escalated human-animal conflict. Additionally, Rahman et al 2011 found that in the recent years the accretion rate has declined however, the erosion rate has been relatively high. A direct result of this is the loss of 170 km^2 of coastal land in 37 years (1973 to 2010). Enhanced protection of the remaining natural forests, practices of afforestation with salt-tolerant mangrove species and social forestry, construction of natural and man-made levee should be undertaken to prevent further loss of land.

Another threat to this landscape is the usage of water channels inside this forest as conduit for commercial boat traffic. Over 200 vessels ply everyday through the Sela river and Passur river located in and near the Chandpai-Sarankhola range of Bangladesh Sundarban respectively. This constant movement of boats can become potential barriers to dispersal between islands leading to fragmented and isolated tiger populations within Sundarban. The 1320 MW coal based thermal power plant at Rampal and proposed exclusive economic zone in Mongla which is a collaborative effort between India and Bangladesh along with the already established busy Mongla Port would only further exacerbate this problem (Figure 16.). Development is inevitable in this economically backward region, however, appropriate mitigation measures need to be planned and implemented simultaneously. This would buffer the negative impacts of development projects to some extent. Development in consonance with conservation objectives in mind should be the norm of this highly sensitive ecosystem.

Figure 17. Waterways used as conduit for commercial boat traffic in Bangladesh Sundarbans

Data from radio-collared tigers suggest that tigers in general show avoidance in crossing channels wider than 600m and also they are most active from 5 am to 10 am. Movement corridors that minimise crossings of wide water channels need to be identified so that the various islands harbouring tigers remain genetically connected. Boat traffic during the active phase of tigers needs to be regulated within these corridors to ensure that this does not become a barrier to tiger dispersal.

Pollution is also one of the major threats to this landscape. The vessels plying inside Sundarban often carry cargo like oil, fly-ash, cement, fertiliser etc. These vessels are veritable 'mobile bombs' as attested by the massive oil spillage in December 2014, when the ship Southern Star-7, ran aground and dumped 358,000 liters of Heavy Fuel Oil in the Sela river. Unfortunately this is not an isolated event, as two such ships before this incident and one ship after the incident had run aground and emptied their entire cargo in the highly sensitive mangrove system. Additionally, with Sundarban located at the estuarine phase of Ganga, Brahmaputra and Meghna, it becomes a veritable catchment area for the garbage of entire northern India and major parts of Bangladesh. In all likelihood, the only solution to this problem seems massive awareness programs along with regional collaboration between the two countries to clean the river system of sewage and industrial waste.

Last but not the least poaching of tigers and their prey are a major concern for tiger conservation globally, Sundarban being no exception. Law enforcement is especially difficult in the Sundarban due to its hostile habitat and porous borders. Smuggling of wildlife especially tiger parts and products becomes relatively easy. Considering density of tigers on the Indian side of the Sundarban to be about 4 tigers per 100 km, the Bangladesh population is below the potential carrying capacity of the habitat. Tiger density was negatively correlated with human disturbance which was relatively high in Bangladesh Sundarban. Strict law enforcement, enhanced community participation, strengthening Forest Department and efficient tiger human conflict management in Sundarban would help reverse this trend.

This study provides the first authentic baseline from which we need to work towards addressing commitments to the Global Tiger Recovery Program. It is possible to double the tiger numbers in Sundarban by investing in resources that promote tiger conservation. These include law enforcement activities (staff, patrol boats, arms and ammunition, and equipment); implementation of technology aided patrols and ecological monitoring programs like MSTrIPES/SMART; restricting development in the ecosensitive sensitive zone and investing in mitigation measures to minimize impacts; delineating corridors for tiger movement across Sundarban and managing these by controlling ship traffic and human disturbance.

The Sundarban tigers represent one of the top 5 largest global populations of the species and along with the unique adaptations of the Sundarban tigers for a life in the mangrove forests, it is evident that this population is extremely important for global recovery of the species and a pride for both Bangladesh and India.

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Bangladesh

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World ~~Wildlife~~ Fund for Nature (India)

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Wildlife Institute of India

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Appendix I – Tiger individuals photo-captured in Sundarban

Tiger individuals of Bangladesh Sundarban

No Right Flank Captured

SBB – 1 Left Flank only

No Right Flank Captured

SBB – 2 Left Flank only

No Right Flank Captured

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SBB – 48 Right Flank only

Tiger individuals of Indian Sundarban –

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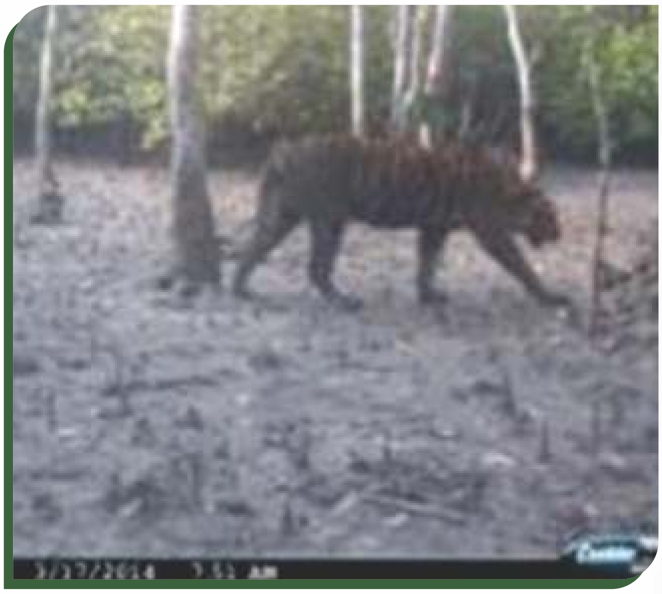

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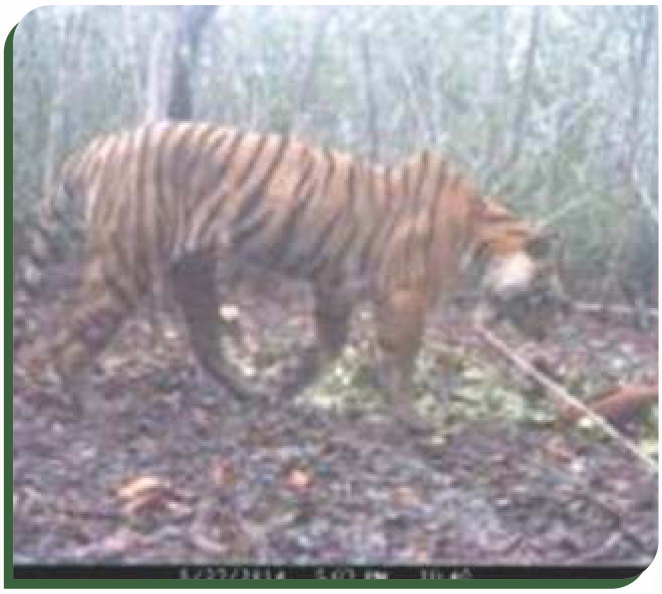

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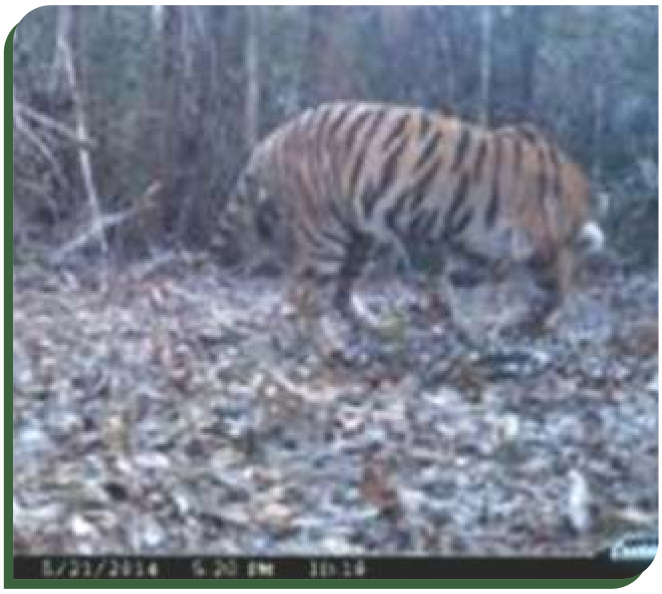

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Tiger photos given in the report include those used for analysis as well as those not used, so as to provide a reference database for the future.

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