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Full Length Research Paper

Brahmaputra River islands as potential corridors for dispersing tigers: A case study from Assam, India

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We present the first scientific study on Brahmaputra River Islands as potential corridors for the tigers and other animals to move across the region in Assam, India. The study was carried out from February to April 2009, with a goal to ensure connectivity and long term conservation of meta-population of tigers in the Brahmaputra Valley in central Assam landscape of India. We did sign surveys and line transects to determine the carnivore and herbivore presence in the area. A total of 52 islands were sampled, out of which 11 islands showed tiger presence while almost all the islands showed ungulate presence. Positive relationship was seen between livestock presence and tiger sign. The study through its activities has been able to identify the islands and river banks that are being used by tigers to move within and from one island to another or to nearby protected area in the landscape, particularly the four closely place parks, viz. Kaziranga, Orang, Laokhowa and Burhachapori and the meta-populations within them. We suggest measures to save the landscape from encroachment and denudation. The entire landscape needs improvised conservation and management strategies for long term survival of the threatened species like tigers.

Key words: Anthropogenic pressures, Burhachapori, Kaziranga, Laokhowa, line transect, meta-population, occupancy survey, Orang, *Panthera Tigris Tigris*, Riverine landscape, royal Bengal tiger, sign survey.

INTRODUCTION

Corridors are meant to ease movement between connected patches of habitats, consequently increasing gene flow, promoting re-establishment of locally extinct populations, increasing species diversity within otherwise isolated areas and effectively increase population sizes of a number of species (Tilman et al., 1997; Gonzalez et al., 1998; Tewksbury et al., 2002; Haddad et al., 2003). Until very recent, most of the wildlife species lived in well connected landscapes (Noss and Cooperrider, 1994; Hunter, 1996; Meffe and Carroll, 1997) and conservation biologists in general concur that the landscape connectivity enhances population viability for various species (Noss, 1987; Primack, 1993). Many conservationists also believe in retention of the habitat corridors, since urbanizations and other anthropogenic pressures often sever natural connections among landscapes. Corridors are believed to facilitate the movement of fauna that are otherwise isolated within disjunct habitat patches (Bennett, 1990). The resultant faunal interchanges increase the conservation value of the otherwise disjunct habitats. The importance of corridors to meta-populations in heterogeneous landscapes is well documented (Taylor et al., 1993; Anderson and Danielson, 1997). Recent studies suggest that, corridors increase movement rates between patches for a broad range of animal species (Hass, 1995; Coffman et al., 2001). But no such information is available on the priority large carnivore like tigers dispersal pattern within a meta-population in important landscape areas particularly in the North East India.

The Royal Bengal Tiger (*Panthera tigris tigris*) is considered as a flagship species that indicates health of the forests and ecosystems. The tiger is a globally endangered (IUCN, 2006) and a conservation dependent species listed under Schedule-I of Wildlife (Protection) Act, 1972 in India and Appendix-I of the CITES. The habitats of wild tigers have reduced dramatically over the

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last century (Sanderson et al., 2006) and the tiger is under severe anthropogenic threats that are ever increasing.

The habitat having probability of long term survivability of tigers need to be identified and conserved on basis of sound principles of conservation biology and landscape biology (Wickramanayake et al., 1999). The Assam state in the foothills of the Himalayas is recognized as one of the significant and potential natural tiger habitats for its long term conservation.

Assam represents about 15% of India's wild tiger population with 265 wild tigers estimated in eleven (11) protected areas (PA) covering around 2453 km^2. Notably, 85 tigers inhabit in 4178 km^2 of Reserve Forests (non PAs) in the state (Talukdar and Barua, 2003). However, the last national estimation of tigers put the number of tiger in the state at 80 at about 1164 km sq. of tiger occupied forest areas (Jhala et al., 2008). The Brahmaputra Valley in Assam is considered to be an important stronghold of the tigers in India (Jhala et al., 2008). The region is a very important landscape for tigers in its best of the habitats that include the Kaziranga National Park (KNP) on the east and Orang National Park (ONP) in the west with Laokhowa and Burhachapori Wildlife Sanctuary (WLS) in between these two protected area. The area is known to hold highest density of tigers in the world with 32 tigers/100 km^2 in the Kaziranga National Park (Ahmed et al., 2010).

The tiger population of the Kaziranga National Park is considered as single largest source population in the region (Sanderson et al., 2006; Jhala et al., 2008). Similarly, though small in total area, Orang National Park also has a sizable number of breeding tigers which are capable of dispersing into the nearby islands of the Brahmaputra. The Buhrachapori WLS is a riverine Island of Brahmaputra close to Laokhowa WLS and only 20 to 25 km away from the Orang National Park and 15 to 20 km away from Kaziranga National Park. The rhinos are known to move within these areas but there is no study yet carried out on movement of tigers within these areas. No ground effort was made previously to study the meta-population of tigers and their connectivity to different tiger inhabiting areas in the Brahmaputra valley or in the entire northeast India.

The Brahmaputra flood plains have high prey biomass and support one of the highest densities of tigers. The tiger population of the KNP is considered as the only source population in the entire region (Jhala et al., 2008). Further, ONP is known to hold a strong breeding population of tiger with estimated number going up to fourteen in 2009 (Ahmed et al., 2009). The present study was carried out with an objective to assess the potentiality of the Brahmaputra River islands to support dispersing tigers. We provide measures to ensure connectivity and long term conservation of meta-population of tigers in the Brahmaputra Valley of central Assam landscape through this study.

MATERIALS AND METHODS

Study area

The study was carried out in the islands of Brahmaputra River between the eastern border of Kaziranga National Park and the western border of Orang National Park (Figure 1). We designate and refer the area as Kaziranga Orang Riverine Landscape (KORL) in subsequent mention within the paper. This landscape also include two more Protected Areas (PA's) viz. Laokhowa and Buhrachapori Wildlife Sanctuary in between and Reserve Forests (RF's) viz. Panpur RF, Kochmara RF and Singri RF. We, however, concentrated mainly on the river islands and the banks of the river and channels.

Methods

The methodology for the assessment of tigers and other carnivores, prey and their habitat consisted of extensive survey of the islands in the Brahmaputra River during the period from February to April 2009 for carnivore signs, wild ungulate presence-absence index and habitat parameters (Jhala et al., 2005).

Grid based approach

A 5 km × 5 km grid was overlaid on the map of the entire area to be surveyed, so that all the islands within the study area were covered uniformly. We then selected random grids from each of these islands to carry out the sampling, ensuring that there were no major gaps in sampling procedure. A handheld GPS unit was used to record the coordinates of each prospective area where sampling was carried out.

Field data collection

Extensive field survey was carried out for collection of information related to ecological parameters while considering presence and absence of prey and predator species. The pugmarks and pellets/droppings were used as direct evidence of animal presence. For the prey species, line transect method was used. The line transects and sign survey walk were done in the sites identified on the suggestion of local people and at time according to feasibility while carrying out the field survey. The plots for vegetation sampling were circular with a diameter of 20 m. For each sampling site altitude, canopy cover, total number of trees and where possible species names, saplings, shrub cover, grass cover, number of dung/pellets and other anthropogenic pressure related data were recorded. The detail procedure of the data collection is as follows:

Carnivore sign survey

Survey was carried out for detecting the presence of tiger's and other carnivores' signs in the river islands of the River Brahmaputra. Various signs such as pugmarks, scrapes, scats and scratches were taken into account and recorded. To obtain data on the presence, absence and intensity of use by tigers, we quantified the relative abundance of tiger signs in the sampled area. The following procedure was followed for data collection:

(i) Areas within the island that had the maximum potential for tiger occupancy and use were intensively searched. Since tigers have a tendency of using trails, foot paths, river beds and ravines, such features within the islands, where available, was searched

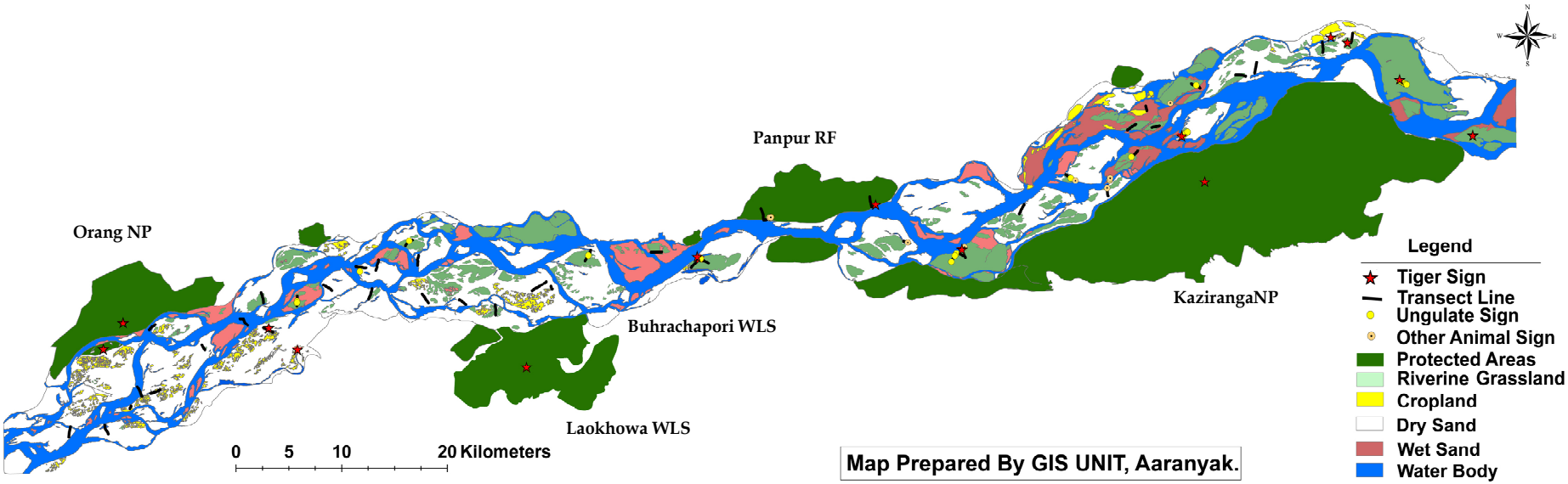

Figure 1. Map of the study area and Kaziranga Orang Riverine Landscape (KORL) (Map of the Kaziranga-Orang Riverine landscape (KORL) showing vegetation cover, protected areas, transect lines, presence of tigers, prey and other animals (Based on IRS P6 LISS III, 2008).

intensively.
(ii) The total distances covered while searching for tiger sign was from 1 to 3 km per island in areas having the best potential for tiger presence. A brief description of the topology and habitat type was recorded for each sign detected.
(iii) Tiger signs if encountered outside of the sampling route were recorded with GPS coordinates with appropriate comments.
(iv) Special emphasis was given in searching signs of tigress with cubs, and any authentic evidence of tiger cubs (sightings of cubs, lactating tigress or tracks).

Line transect

The distance sampling method (Buckland et al., 2001) was used for sampling ungulates in the river islands. Using the describedprinciple, we demarcated transects in the islands and walked along the lines within the sampling area. Data on sighting angle were recorded using a see-through compass having 0.5 degree calibrations and the radial distance of animals, wherever sighted, was measured using a laser range finder having an accuracy of 1 m in 1 km estimation. Starting and end points of transects were recorded using a GPS. We standardized the transect length into a distance of 1 km taking into account the size of the island. More than one transect walk was carried out where the size of the island was larger than 5 km^2.

Vegetation sampling

The same transect line was sampled every 200 me, while returning, for determining the type of vegetation present in the islands. GPS points were taken on each of the sampling point. Data was collected on the major habitat type, microhabitat and terrain type of the islands sampled. These locations were plotted on satellite generated and digitized imagery of the area on a 1:50,000 Scale. Habitat types were classified to generate a habitat type map for the area of the islands sampled.

Others

Data on several factors like prey encounters rates, wildlife dung index, canopy cover, anthropogenic disturbances indices, signs of lopping, wood cutting, grass cutting, livestock trails, people seen on transects and livestock dung were taken to determine if they differ significantly between river islands occupied or unoccupied by tigers. Principle component analysis was used to extract parsimonious, independent information from the data. Tiger signs (as dependent variable) were modeled using Multiple Linear Regression (Fisher, 1954) with the principle components as the independent variables.

GIS based land-use mapping

Remote sensing and GIS was extensively used to map the land use pattern by tigers in the study area. Recent dated satellite imagery (IRS P6 LISS III, 2008) was used for mapping the entire area including the protected areas. The

images were geometrically corrected taking the reference point from the Survey of India topographical sheet at 1:50,000 scales. The process of geometric correction of the image was done in ERDAS Imagine 9.0 software. Mosaic operation of all the images were done as the entire area was not covered by single scene. An onscreen visual interpretation classification method was adopted using Arc GIS 9.2 software.

The study area was classified into major categories of habitat types, which was further categorized in other sub classes depending upon the species wise variation of different habitat. The major classes classified were as follows, a) cultivation or cropland, b) riverine grassland, c) water body, d) dry sandy area and e) wet sandy area. With these major habitats class, intensive ground verification was carried out. After completion of necessary verification and collection of preliminary data from the field, necessary rectification of the prior classified habitat categories was done and final map of the different habitat and land use pattern of the study area was produced. For the distribution of tiger and its prey animals, spatial data was collected from sign survey and other methods. All these primary data was fed into GIS domain using the Arc GIS 9.2 software, which provide the distribution map of tigers and its prey animals.

Consultation

Small group consultation or individual interviews were conducted to know more about the islands, its human and livestock population and use as well as about presence of tigers, other animals and what the inhabiting people felt about the animals living in these islands.

RESULTS

A length of 185 km was covered in the stretch of the River Brahmaputra from eastern end of KNP to western end of ONP. Out of total 78 small and large islands (area ranging from 3 to 37 km^2) in the stretch, 52 islands were sampled for tiger and prey presence, habitat suitability as well as presence of humans and livestock. Direct evidences of tiger presence were detected in six of the river islands, while indirect evidences were found in five other river islands. Presence of wild ungulate prey species were detected in nine river islands. Most of the islands showed presence for human or livestock except for some islands near KNP.

Tiger occupancy

The total effort in carnivore sign survey was of 78.09 km on the river islands. The calculated mean encounter rate and standard error (SE) for tiger pugmark was 0.15 ± 1.46 and for scat was 0.058 ± 0.98 (Table 1). Fresh tiger signs were encountered in 6 islands, namely, at Libe Tapu, Lahoroni Chapori 1 and 2, Kartikay, Kotwal and Maj Chapori islands, comprising a total tiger presence area of 84.26 km^2. Secondary data collected from interviews in human settlements or in river islands used by cattle grazers revealed tiger presence in five other river islands, namely Kartika Balu Tapu, Kere Chapori, Baghe Chapori, Lower Laharia Chapori and Gakhir Chapori.

Relationship between presence of tigers and prey animals

A weak relationship was seen with two variables viz. vegetation (R^2 = 0.002) and human disturbance (R^2 = 0.116) that may have occurred due to scarce dependent variable (tiger sign) across the sampling area. When the variables were analyzed separately, only ungulate pellet showed slight positive relation (R^2 = 0.27), while the livestock encounter rate showed more positive relation (R^2 = 0.42) to tiger sign indicating relationship between presence of tigers to that of its prey, particularly livestock.

Ungulate presence

Out of 52 river islands surveyed, 47.15 km of transect walks were carried out to determine ungulate presence. Direct sightings of ungulates including livestock were detected in nine river islands, while indirect signs were detected in the other 39 river islands. Wild ungulates sighted directly included hog deer *Axis porcinus* and elephant *Elephas maximus*, while livestock included cows and buffaloes while indirect evidences showed presence of wild pig *Sus scrofa*.

Landuse / landcover pattern

The total riverine area of 1100.9 km^2 of study area was classified into major categories of habitat types, which was further categorized in other sub classes depending upon the species wise variation of different habitats. The major classes were as follows:

a) Cultivation or cropland: Some of the islands had human settlement and were being extensively used for agriculture. The total area under agriculture was found to be 30.27 km^2.
b) Riverine grassland: It covered most of the river island area where it agriculture was absent. The total area covered by such vegetation was 166.85 km^2. Though there were two sub class of such vegetation, it was difficult to show them separately using remote sensing as the area was too small. The subclasses were dry short grassland and wet tall grassland.
c) Water body: This included the riverine water and the wetlands. The total area covered by water body was 350 km^2.
d) Dry sandy area: The sandy areas that were devoid of vegetation were classified as dry sandy area and were mostly new sand bars and were result of erosion by the river. Most of the land mass in the study area was dry

Table 1. Encounter rates of tiger signs at the different sites of the Brahmaputra River islands recorded during 2009.

Site	Search effort (km)	Pugmark track sets (SE)	Scat (SE)	Other signs (SE)	Total signs
River Islands	78.09	0.15 ± 1.46	0.058 ± 0.98	0	0.20 ± 2.44

sandy area and covered an area of 461.47 km^2.
e) Wet sandy area: The wet sandy areas were mostly close to the river water or bed of drying wetlands. This covered an area of 92.31 km^2.

DISCUSSION

Recent studies have indicated that large animals can significantly alter the structure and function of river corridors and that management of population demography may have long-term ecosystem-level consequences (Naiman, 1988; Butler, 1995; Johnston, 1995). The information gathered during the study revealed that the tigers were actually using the river islands for dispersing from one to another protected areas and may even be using it for establishing territories. Further, this landscape is also a safe home to Gangetic Dolphin *Platanista gangetica*, the national aquatic animal of India, as well as corridor for movement of rhinos *Rhinoceros unicornis* and elephants within the protected areas. This emphasizes the importance of KORL as far as long term conservation of mega charismatic faunas like tigers, elephants, rhinos and dolphins was concerned. The island survey revealed tiger presence in 84.26 km^2 area, ungulate presence in 95.06 km^2 area and human presence in 257.24 km^2 area. For endangered species like tigers that have large dispersal range and different kinds of habitat through which they can disperse, factors such as species-specific dispersal behaviors are of primary importance (Fahrig and Merriam, 1994).

The study confirms the presence of tigers in the river islands along with prey animals. Whenever presence of tigers were confirmed, it was found that there was a positive correlation between presence of tiger and presence of prey animals, particularly livestock. It was also observed that the grasslands on the river islands were degraded due to overgrazing by livestock and is most likely the reason that is affecting the natural prey populations of tigers. However, this study did not look at this aspect intensively. It has been seen that in river corridors, the numbers of animals and the abundance (and quality) of food vary constantly, and the variations are irregular, both spatiotemporally and in amplitude (Naiman and Rogers, 1997). Variations in the abundance of one species have direct and indirect effects on the abundance of others, which themselves also vary somewhat independently in abundance (Elton, 1930). Interestingly, the livestock were acting as a major source of prey for the tigers on the river islands. Though, this would require further in-depth study before concluding, we would like to draw an inference that the planned livestock removal from the proposed addition areas, which encompasses the river islands, of the KNP needs to be carried out cautiously and gradually (see recommendations).

The human settlement on the river islands in the section west to the KNP is a major hindrance for animal movements. The islands, further west, toward the ONP are more thickly populated by human that results in continuous disturbances to animal movement due to agricultural activities and livestock grazing. However, we observed that some new river islands are not yet occupied by human and can be brought under administrative control of the forest department for protection and management purposes. This again would require strategic planning, intervention and will on the part of the departments concerned. The remote sensing data has also revealed that most of the island areas are covered with riverine grassland and only about one fifth is used for agricultural purposes. This indicates that the river islands can be and are being used by tigers, prey and other animals as preferred habitat and stepping stone while moving across the landscape. Change in land use pattern to give space to tigers and prey animals may lead to increased use of the river islands in the near future.

The Brahmaputra River islands in the KNP stretch forms an important and vital habitat link for the tigers to disperse within the river islands and to the North Bank Landscape. The tiger populations of Orang and Kaziranga are presently separated from each other with little opportunity to exchange genes. This is primarily due to human use of the river banks and islands and degradation of Laokhowa and Buhrachapori Wildlife Sanctuary over the last few decades. It is vital that as conservation effort of tigers in its best of the habitats, the Brahmaputra floodplain ecosystem, all these areas from Kaziranga to Orang through Laokhowa and Buhrachapori and the river islands are protected and connected. This will ensure necessary movement of tigers within the populations ensuring their long term survival in the wild.

Recommendation

Based on the data collected, we recommend bringing the entire KORL under direct control of the Department of Environment and Forest, Government of Assam, to aid in better and effective management practices. The islands should be managed properly using robust scientific approach so that they are conserved for movement of the

tigers and other wildlife within different protected areas. Even though the presence of livestock is harming the habitat for natural prey species like hog deer, removing the “Khutis” (local cattle farms) in one go would be detrimental to the tiger’s survival. The removal should be carried out gradually and systematically, as tigers often depend on the livestock in islands for survival. Complete removal of the livestock would put gratuitous pressure on the limited population of wild ungulates and may affect the tiger movement too. The recent cases of tigers presence outside the protected areas in villages near KNP confirms that the tigers are dispersing out, some using the islands and some mainland. Thus, the importance of these islands as corridors cannot be ignored and efforts should be targeted to save the KORL from further encroachment and denudation.

Conclusion

As demonstrated by this study, it is possible to collect the basic and vital information on the tiger, prey animal and anthropogenic pressures crucial for monitoring and for planning conservation and management of wildlife at a broad level in the Brahmaputra River islands. The entire KORL would need improvised conservation and management strategies for long term survival of the threatened species mentioned above. This study needs to be continued to understand ecology of carnivores and ungulates on river islands and use of these islands by animals and human over time and space.

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Appendix 1

List of River Islands surveyed showing wildlife and human usage during the time of survey from February to April 2009.

S. no	Name of river islands	Habitat type	Tiger usage	Ungulate and livestock usage	Human usage
1	Hatilong	Grassland	No signs	Moderate	Moderate
2	Lonkey	Riverine	No signs	Optimum	Optimum
3	Laxmi/Lakhi	Grassland	No signs	Moderate	Optimum
4	Unknown1	Riverine	No signs	No signs	Optimum
5	Theng bhanga chapori	Riverine	No signs	Moderate	Optimum
6	Alubari	Riverine	No signs	Optimum	Moderate
7	Telia gaon	Riverine	No signs	Moderate	Moderate
8	Unknown2	Riverine	No signs	Optimum	Moderate
9	Natun chapori	Riverine	No signs	Optimum	Moderate
10	Busura chapori	Riverine	No signs	Optimum	Moderate
11	Biskuti chapori	Riverine	No signs	Moderate	Optimum
12	Dauri	Riverine	No signs	Optimum	Moderate
13	Lohori chapori	Riverine	No signs	Optimum	Optimum
14	Soneswar chapari	Riverine	No signs	Moderate	Optimum
15	Khutir chapori	Riverine	No signs	Moderate	Moderate
16	Chitalmari char	Riverine	No signs	Moderate	Optimum
17	Tengaguri chapori	Riverine	No signs	Moderate	Optimum
18	Unknown3	Riverine	No signs	Moderate	No signs
19	Arimari chapori	Riverine	No signs	Moderate	Moderate
20	Kathkhori chapori	Riverine	No signs	Moderate	Moderate
21	Kisamkuri	Riverine	No signs	Optimum	Moderate
22	Nangli chapori	Riverine	No signs	No signs	Optimum
23	Lower Lohoriya chapori	Riverine	Moderate	Optimum	No signs
24	Libe Tapu	Riverine	Optimum	Moderate	No signs
25	Kere Chappori	Riverine	Moderate	Optimum	Moderate
26	Baghay tapu	Riverine	Moderate	Moderate	Moderate
27	Hatibali	Riverine	No signs	Optimum	Moderate
28	Puspa(Hatibali)	Grassland	No signs	Optimum	Optimum
29	Hoplote	Riverine	No signs	Optimum	Moderate
30	Koltapu	Riverine	No signs	Moderate	Moderate
31	Chikari tapu	Riverine	No signs	Optimum	Optimum
32	Korna	Riverine	No signs	Optimum	Optimum
33	Karne west	Riverine	No signs	Moderate	Moderate
34	Kartik bali	Riverine	Moderate	Optimum	Moderate
35	Arimora Bali	Riverine	No signs	Moderate	No signs
36	Nungchali	Riverine	No signs	Optimum	No signs
37	Hati tapu	Riverine	No signs	Optimum	Moderate
38	Maukhuwa chapari	Riverine	No signs	Moderate	No signs
39	Lahoroni chapari	Riverine	Optimum	Optimum	No signs
40	Khasari tapu	Riverine	No signs	Moderate	No signs
41	Tanki tapu	Riverine	No signs	Moderate	Optimum
42	Tintika chapari	Riverine	No signs	Optimum	Optimum
43	Panpur	Riverine	No signs	Optimum	Moderate
44	Gakhire Khatir chapari	Grassland	Moderate	Moderate	Moderate
45	Gakhir Khati chapari	Grassland	Moderate	Moderate	Optimum
46	Debi sing tapu	Riverine	No signs	No signs	No signs
47	Jahaj ghat tapu	Grassland	No signs	No signs	No signs
48	Kartike Chapori	Grassland	Optimum	Moderate	Optimum
49	Kotwal Chapori	Grassland	Optimum	Optimum	Moderate

List of River Islands surveyed showing wildlife and human usage during the time of survey from February to April 2009 (continues).

50	Baghe Tapu	Grassland	Moderate	Optimum	Moderate
51	Maj Chapori	Grassland	Optimum	Moderate	Moderate
52	Lahoroni Chapori 2	Riverine	Optimum	Optimum	Moderate