

# **Rhinoceros (*Rhinoceros unicornis*) Habitat Evaluation in Royal Bardia National Park Using Remote Sensing and GIS**

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## **ABSTRACT**

*Application of the remote sensing technology for wildlife habitat evaluation and management is relatively new but, studies using remotely sensed data on physical attributes of the habitat as well as analysis of spatial data through geospatial modeling have been found the technology to be accurate, cost and time-effective. The GIS help to integrate and analyze spatial data, in order to utilize such information in resource management. We evaluated satellite derived landscape parameters to predict suitable habitat for globally endangered Greater one-horned rhinoceros (*Rhinoceros unicornis*) using GIS modeling of known wildlife habitat relationship. Our result suggests that several variables such as land cover types, water availability, topography, altitude, prevailing major human activities and their impact on species and habitat are significant in predicting suitable habitat for rhinoceros.*

Key-words: Rhinoceros, Habitat evaluation, Suitability prediction, Satellite imagery, GIS.

## **INTRODUCTION**

The Greater one-horned rhinoceros (*Rhinoceros unicornis*), once ranged throughout Terai plains, is a globally endangered species survived as fragmented populations in some protected areas (PAs) of Nepal and India. Indiscriminate poaching and massive scale forest conversion into agricultural purpose are two important reasons for population decline. In Nepal the rhino population declined to about 100 animals and survived only in Chitwan in sixties (Caughley, 1969; Pelinck and Uprety, 1972). However, effective conservation measures adopted through the establishment of National Park in 1973 the rhino population of the Chitwan increased to about 466 in 1994 (Yonzon, 1994) and 544 in 2000 (Rhino count, 2000). Because of high population density, rhinos in Chitwan caused human casualties and heavy damage to crops since mid eighties (Jnawali, 1989; Sharma, 1991; Nepal and Weber, 1993). It has been believed that the rhino population in Chitwan is close to the carrying capacity of the park.

Since, mid eighties a number of rhinos translocated from the Royal Chitwan National Park (RCNP) to Royal Bardia National Park (Anstey, 1987; Bauer, 1988; Wegge et al., 1990; Jnawali and Wegge, 1991) to establish a new viable breeding population and to minimize the conflicts with the neighbouring people in Chitwan (Jnawali and Wegge, 1993). Till date a total of 83 rhinoceros have been successfully translocated from the RCNP to the Royal Bardia National Park (RBNP) with the hope that the Bardia could serve as a potential home to second viable population in Nepal. Rhino count 2000 estimated 67 animals in Bardia including 52 translocated individuals till that time. Now Bardia is expected to harbour above 100 rhinos including 29 individuals translocated since 2000.

However, studies indicate that rhinos in Bardia performing very well (Jnawali 1995), but the habitat of the park for the species is yet to be assessed. This study attempted to use remote sensing satellite and GIS data for analysis of habitat conditions to predict suitable habitat for rhinoceros in the Royal Bardia National Park. Habitat models have become well-accepted tools to understand the habitat characters of different organisms evaluating habitat qualities and developing wildlife management strategies (Verner et al., 1986).

## STUDY AREA

The Royal Bardia National Park (RBNP) in western Terai of Nepal (approx. 280 15' to 280 44' N, 810 10' to 810 45' E) encompasses a wide diversity of habitat and most undisturbed wilderness areas in the tropical and sub-tropical region of the country. Altitude of the park ranges from 152 to 1441masl. The park covers an area of 968 sq. km. and is surrounded by buffer zone. Karnali and Babai rivers and their tributaries drain the park. About 70% of the park is covered with dominantly Sal (*Shorea*) forest with a balance mixture of grassland, savanna and riverine forest. The park provides excellent habitat for endangered animals like Rhinoceros, wild Elephant, Tiger, Swamp deer, Black buck, Gangetic Dolphin, Gharial crocodile, Marsh mugger crocodile, Bengal floricon, lesser floricon, Saurus crane, etc.

## MATERIALS AND METHODS

### *Data*

The primary data used in this study were Landsat ETM 2002. However other spatial (Table 01) and field data were also used.

Table 01: Primary data used for the study

S. N.	Data type	Path/row	Acquisition date
1.	Landsat ETM	144/040	2002/0202
2.	Topographic maps	-	1996
3.	Land use maps		1978
4.	Aerial photos		1996/11

## **METHODS**

1. Field Survey- Field surveys were conducted in June 2002 to identify distribution and habitat use of the rhinoceros in Bardia. Animal sightings and observed signs such as wallows, tracks (i.e. lines of footprints), dung and feeding sign were marked on the topo sheets. Habitat features and vegetation types were recorded along with the locational data.

2. Remote Sensing: Spatial dimension of land use/land cover types was determined by digital analysis of satellite data using well-documented and widely used supervised classification techniques and maximum likelihood classification algorithms available in ERDAS IMAGINE 8.6 software.

3. Habitat Suitability Modelling (HSM): HSM of rhinoceros was prepared using a GIS modelling of known wildlife habitat relationship. We determined life requisite data by literature review (Laurie, 1978; Jnawali, 1995; Jnawali and Wegge, 1993; Adhikari, 2003) and field survey. We evaluated rhinoceros habitat by modelling potential and realized habitat effectiveness using resource selection functions. Habitat suitability model was based on linking of animal to cover types, water availability, altitude, and sensitivity to major human activities and their impacts on rhinoceros using Arc/view 8.3.

## **RESULTS**

### ***Rhinoceros Location***

All the identified spatial locations of rhinoceros are distributed in a narrow stretches of karnali floodplain and Babai valley, close to water bodies and far from roads, generally below the altitude of 320 masl.

### ***Land Cover Types***

Based on the spectral characteristics, land cover of RBNP and surrounding areas were classified into 13 cover classes (Figure 01).

## Landcover Types in RBNP and Surrounding Areas

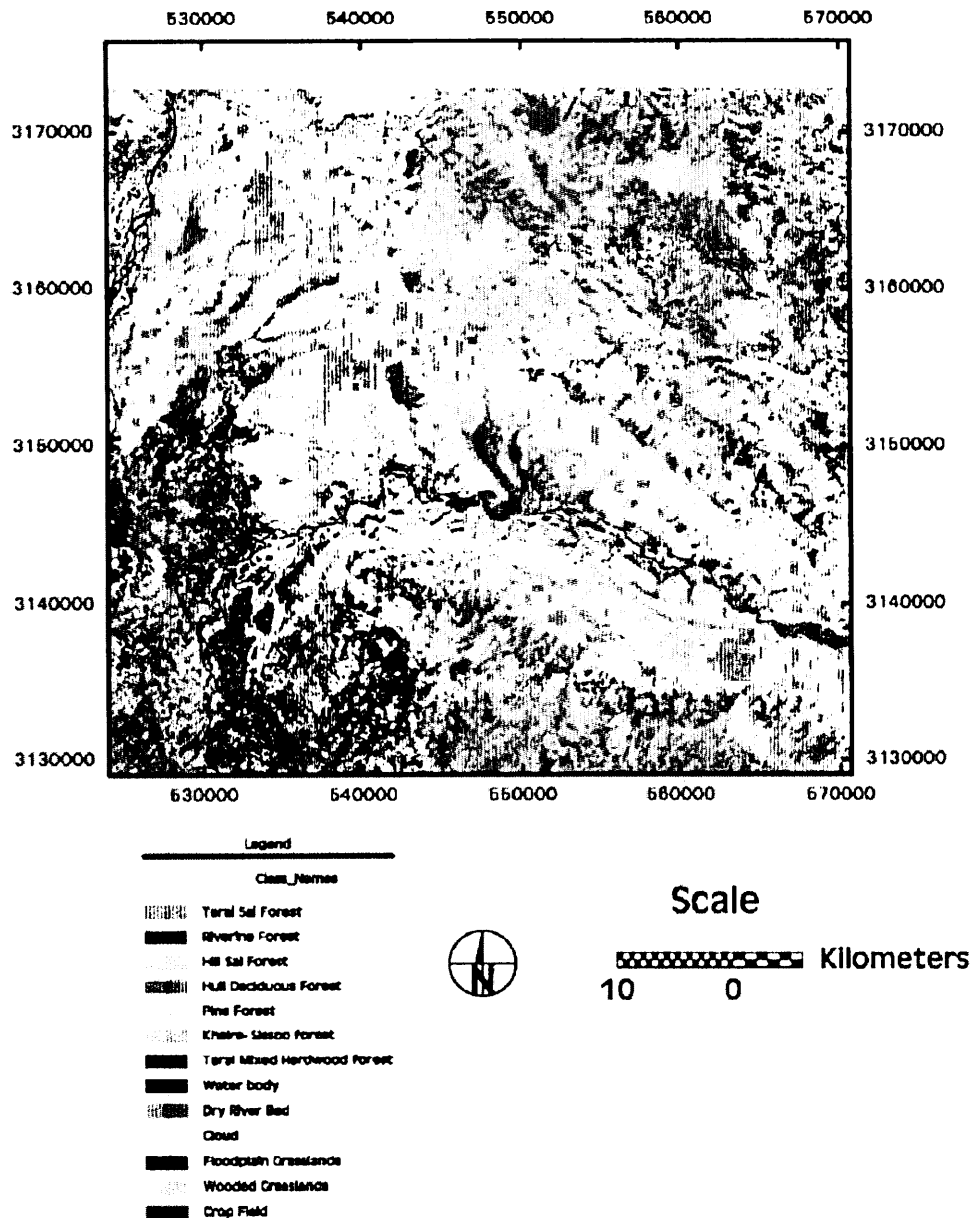


Figure 01: Land covers Types of RBNP and Surrounding Areas

### *Habitat Suitability*

Based on frequency of the identified locations of rhinoceros and linking of species with vegetation cover, water resources, altitude and sensitivity to human disturbances specifically roads and human settlements, the Royal Bardia National Park has been divided into four habitat suitability categories (Table 02 and Figure 02).

Table 02: The criteria used in Rhinoceros habitat modelling

No.	Habitat suitability classes	Altitude	Vegetation Type	Proximity to water source	Proximity to settlements	Proximity to highway
1.	Most suitable	Up to 260 m Masl	Mosaics consisting of Khair-sissoo forests; Floodplain grasslands; Riverine forests	Within 1.0 km	More than 1.0 km	More than 500 m
2.	Suitable	260-300 m Masl	Wooded grasslands, Wetlands, River beds, Terai mixed hardwood forests	Within 1.5 km	More than 0.5 km	300 - 500 m
3.	Less suitable	300-320 m Masl	Terai Sal Forest;	Within 2.0 km	More than 0.3 km	200- 300 m
4.	Unsuitable	Above 320 m Masl	Hill Sal forest, dry river bed, Hill deciduous forest	More than 2 km	Less than 0.3 km	Less than 100 m

We digitised the locational data of the rhinoceros on the land cover map. About 72 % of identified locations of rhinoceros were observed in habitat mosaics consisting of Khair–Sissoo forest, floodplain grasslands and riverine forest in the Karnali floodplain and Babai valley. Another 23 % of rhino locations were found in the wooded grasslands, wetlands, Terai mixed hardwood forests and River beds; and 5 of the locations on Terai Sal forest.

### Habitat Suitability for Rhinoceros in Bardia

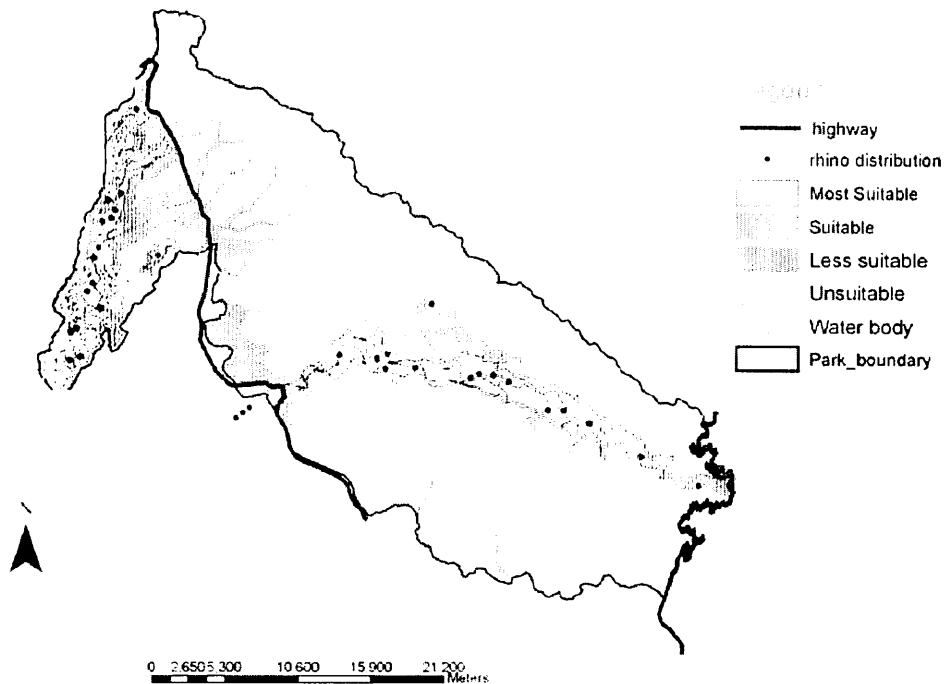


Figure 02: Habitat Suitability for Rhinoceros in Bardia

## DISCUSSION AND CONCLUSIONS

This study predicted the suitable habitat for rhinoceros into four different suitability classes based on the resource selection functions of the species and sensitivity to the physical attributes and human activities on the species. Altitude found to be a most significant predictor for habitat evaluation of rhinoceros. The slope is another important predictor for habitat suitability of terrestrial species, but we ignore it, because the rhinoceros locations were observed only in very gentle slopes and suitable vegetation cover found only in the gentle slope. Vegetation cover has three important functions to animals (a) food, (b) protective cover, and (c) shelter.

The habitat mosaics consisting of Riverine forest, Khair- Sissoo forest and flood plain grasslands are most important determinant in rhinoceros habitat selection. In Bardia, the flood plain grass lands, Khair- Sissoo forest and Riverine forest are contiguous to each other and are all located very close to perennial water body, thus, the mosaic provide food, protective cover and wallows throughout the year. Jnawali (1995) also reported that the rhinoceros is adapted to flood plains and Riverine vegetation where water and some green growth remains available all year round. Grass species, such as *Saccharum spontameum*, *S. bengalensis* and *Erianthus revennae* make up about 70 % of the rhino diet (Jnawali 1995), are dominant vegetation found in the floodplain grasslands (Shrestha and Jha 1997), and ground vegetation in the Khair- Sissoo forest and Riverine forest. Preferred

browse plant species such as *Mallotus philippinensis*, *Murraya koenigii*, *Pogostemon* and *Callicarpa macrophylla* are common species of the Riverine and Khair- Sissoo forest.

Wetlands, Terai mixed hardwood forest and wooded grasslands are on the second in habitat suitability category for rhinoceros because the wooded grasslands consists of important food plants such as *Saccharum spontaneum*, *S. bengalensis* and *Cirsum wallichii*. The wetlands are important places for wallowing and some food grasses like *Saccharum spontaneum* grown in the vicinity of wetland are favourable diet of rhinoceros. The pure stands of the Terai Sal forest with no under story vegetation have little significance in habitat value for rhinoceros.

Human activities pose strong negative effect on the movement and resource selection of wild animals. Wild animals close to human settlement face two types of problems; disturbances and competition for resources with livestock. There is growing evidence that roads impact on large mammals (Mech 1989; Mladenoff et al. 1995; Mace et al. 1996) and this is equally important in rhinoceros habitat.

In conclusion variables such as land cover types, water availability, topography, altitude, prevailing major human activities and their impacts on species and habitat are significant in predicting suitable habitat for terrestrial wildlife species. Royal Bardia National Park provides excellent habitat for a viable breeding population of rhinoceros, but the future conservation efforts should be directed to habitat management and reduction of human intervention in the park. In addition this study demonstrated that the remote sensing and GIS in combination with ecological fieldwork can provide an efficient, cost and time effective alternative methodology for evaluation and prediction of suitable habitat for wildlife.

## REFERENCES

- Adhikari, P. 2003. Status, dispersal and habitat use of Greater one-horned rhinoceros (*Rhinoceros unicornis*) in Royal Suklaphanta Wildlife Reserve, Far Western lowland, Nepal.
- Bauer, J.J. 1988. A preliminary assessment of the reintroduction success of the Asian one-horned rhinoceros (*Rhinoceros unicornis*) in Bardia Wildlife Reserve, Nepal. Tiger Paper, October-December: 26-32.
- Caughley, G. 1969. Wildlife and recreation in the Trisuli watershed and other areas in Nepal. HMG/FAO/UNDP Trisuli Watershed and Development Project Report No. 6, Kathmandu, 56pp.
- Gurung, K.K. 1989. The Indian rhinoceros Pp- 87-89. In: Indian wildlife (Israel and Sinclair, eds.). APA publications, Singapur, 380pp.
- Jnawali, S.R. 1989. Park people interaction: Assessment of crop damage and human harassment by rhinoceros (*Rhinoceros unicornis*) in Sauraha area adjacent

to the Royal Chitwan National Park Nepal. M.Sc. thesis, Agriculture University of Norway.

Jnawali, S.R. 1995. Population ecology of greater one-horned rhinoceros (*Rhinoceros unicornis*) with particular emphasis on habitat preference, food ecology and ranging behaviours of a reintroduced population in Royal Bardia National Park in lowland Nepal. Doctor scientiarum Thesis, Department of Biology and Nature Conservation, Agricultural University of Norway, Aas, Norway.

Jnawali, S.R. and Wegge, P. 1993. Space and habitat use by a small-reintroduced population of greater one-horned rhinoceros (*Rhinoceros unicornis*) in Royal Bardia National Park in Nepal. A preliminary report. Pp 208-218. In: rhinoceros biology and conservation (O.A. Ryder eds). Proceeding of an international conference zool. society, San Diego, USA.

Khan, M.K. Bin and Foose, J. 1994. Chairman's report: Asian rhino specialist group. *Pachyderm*, 18: 3-8.

Laurie, W.A. 1978. The ecology and behavior of the greater one-horned rhinoceros. Ph.D. dissertation, University of Cambridge, Cambridge.

Mace, R.D., Walker, J.S., Manley, T.L., Lyon and Zuuring, H. 1996. Relationships among grizzly bears, roads and habitat in the Swan Mountains, Montana. *Journal of Applied Ecology*, 33, 1395- 1404.

Mech, L.D. 1989. Wolf population survival in an area of high road density. *American Naturalist*, 121, 387- 389.

Mladenoff, D.J., Sickley, T.A., Haight, R.G. and Wydeven, A.P. 1995. A regional landscape analysis and prediction of favourable gray wolf habitat in the Northern Great Lakes region. *Conservation Biology*, 9, 279- 294.

Nepal, S.K. and Weber, K.E. 1999. Struggle for existence: park people conflict in the Royal Chitwan National Park Nepal. Asian Institute of Tech., Thailand. 199pp.

Pelinck, E. and Upreti, B.N. 1972. A census of rhinoceros in Chitwan National Park and Tamaspur forest, Nepal, HMG/FAO/UNDP. National Park and Wildlife Conservation Project. Internal report, Kathmandu. 10pp.

Sharma, U.R. 1991. Park People Interactions in Royal Chitwan National Park. Nepal. Ph. D. dissertation. University of Arizona. 274pp.



Shrestha, K.K. and Jha, P.K. 1997. Plant diversity analysis and evaluation of conservation measures in the Royal Bardia National Park (RBNP). Unpublished report submitted to WWF Nepal Program, Kathmandu, Nepal.

Verner, J., Morrison, M.L. and Ralph, C.J. 1986. Wildlife 2000. Modeling Habitat Relationships of Terrestrial Vertebrates. University of Wisconsin Press.

Wegge, P., Jnawali, S.R. and Mac, S.R. 1990. Bardia conservation research program: Progress report 1990. Department of Biology and Nature Conservation, Agricultural University of Norway, King Mahendra Trust for Nature Conservation Nepal and DNPWC. Nepal. 37pp.

Yonzon, P. 1994. Count rhino 1994. WWF Nepal program, report series. No. 10 Kathmandu.