# LAND AREA CHANGE AND RHINO HABITAT SUITABILITY ANALYSIS IN KAZIRANGA NATIONAL PARK, ASSAM

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## Introduction

Each species requires a particular habitat, food, shelter and other survival needs to the extent that species are said to be a product of their habitat (Smith, 1974). Evaluation of any habitat for its suitability for a particular species requires information on a host of parameters pertaining to biotic and abiotic components of the habitat, in particular the food, water and shelter. With the passage of time, human influences on habitats have had an alarming impact. The cases of encroachment of habitats and activities like poaching and grazing are threatening a majority of the wildlife habitats around the world (Panwar, 1991).

The original wide range of the one-horned rhinoceros (*Rhinoceros unicornis*) on the Indian subcontinent has contracted eastwards and presently this species is reported mainly from Assam (Kaziranga and five other locations) and West Bengal (Jaldapara) in India, Royal Chitwan National Park in Nepal, and Lal Suhanra in Pakistan, with a population totaling 1,893. Kaziranga alone holds about 63% of the world's one-horned rhino population today. In the survey carried out in 1959 by the great biologist E.P. Gee (Gee, 1959), the rhino population was estimated to be about 260 individuals, which has risen to about 1,200, i.e. a five-fold increase between 1959 and 1985. Since 1985, it has been noticed that the rhino population has not increased significantly.

## Remote Sensing and GIS in Habitat Suitability Analysis

Ground-based methods have been traditionally used to evaluate the habitats (Lamprey, 1963; Giles, 1978). It is felt that ground-based methods have specific limitations because of the fact that the whole area cannot be traversed in one instance. Remote sensing coupled with ground-based methods provides timely and accurate information on all three of the basic parameters used for habitat evaluation (Kamat, 1986). Vegetation cover mapping and water bodies assessment (Shedha *et al.*, 1986; Kushwaha, 1990) which are of primary importance in wildlife habitat analysis, are already in practice in India using remote sensing. The Geographic Information System (GIS) is another technology which is being increasingly used in habitat analysis and modeling (Porwal *et al.*, 1996; Kushwaha *et al.*, 1998). A few studies have already been done in Kaziranga using remote sensing. Kushwaha and Madhavan Unni (1986) studied the Kaziranga National Park to detect the land cover changes in the park using remote sensing. Boruah and Goswami (1997) studied the vegetation cover and wetlands of Kaziranga National Park.

## Current Status of Land Area in Kaziranga

Although the Kaziranga National Park is said to officially have an area of 428.7 $km^2$, the park area keeps changing due to erosion/accretion caused by the mighty river Brahmaputra (Lahan and Sonowal, 1973). The Brahmaputra River marks the northern boundary of the park and as the river changes its course year after year, the park area is affected. Hence, an effort was made to study the status of the park area (land area) at three points in time, i.e. in 1967-68, 1990 and 1997, using Survey of India maps and satellite imagery of the same season. There is a general feeling among the park managers that the park area is shrinking over time, due to the erosion caused by the river. The actual extent of the park area is unknown. The park extends east-

west along the southern boundary of the Brahmaputra River and is sandwiched between the river in the north and the Karbi Anglong Hills in the south.

## Problems of the Park

Soil erosion is a serious problem in Kaziranga National Park during the summer floods. Every year chunks of land from the northern boundary of the park are washed away by the frequently changing course of the Brahmaputra River. New islands are also formed along the northern boundary of the park by silt deposition, but owing to the legal complications such islands are not considered to be within the area of the park. New areas take time to stabilize and support vegetation.

Floods occur every year, sometimes several times in a year. As the Brahmaputra River is the immediate boundary of the park, during the floods the excess water submerges the area and covers 80-90% of the total land area. The flood waters remain for 10-20 days or more, affecting the wildlife considerably.

The killing of rhinos by hunters and poachers for the alleged aphrodisiac value of rhino horn is the major problem relating to the survival of this animal in Kaziranga National Park.

Encroachment into the park area is an emerging problem in Kaziranga. With the human population in the vicinity growing steadily, the demand for land for cultivation, grazing or settlement has increased manifold. Grazing of domestic animals is a serious problem, especially in Agoratoli Range. Grazing animals are a potential threat to the wild animal population as they not only compete for fodder, but also spread diseases like anthrax among park animals, including rhinos (Choudhary, 1964; Pathak, 1978).

The tendency towards urbanization in the area of rhino habitat, particularly along the side of National Highway No. 37, is noteworthy. Settlements are located right up to the boundary of the park. Although these settlements themselves do not pose much threat to the park at present, they could certainly be associated with several other harmful activities like expansion of agriculture, increase in domestic cattle and consequent demand for fodder and firewood, construction of roads, etc.

Kaziranga National Park has not yet been studied from the erosion and rhino habitat suitability aspect. Hence, this study aims at investigations regarding the erosion and dynamics of the land area over a period of time (1967 to 1997) and a habitat suitability assessment for rhino in collaboration with the Directorate of Kaziranga National Park, Bokakhat, Assam and Assam Remote Sensing Application Centre, Guwahati. The results of the present study are expected to reveal the changes in the land area between 1967-68, 1990 and 1997 and show the suitability of the park for the one-horned rhino.

## Study Area

Kaziranga National Park occupies an area of about 430 km$^2$ along the Brahmaputra River in central Assam. Although the park is most famous for its great Indian one-horned rhinos, other animals such as elephants, tigers, leopards, wild buffaloes, deer, etc. are also found in the park. Kaziranga was declared a reserve forest in January 1908, with an initial area of 226.2 km$^2$. Subsequently more areas were added and it was declared a game sanctuary in November 1916. It acquired the status of wildlife sanctuary in 1926 and was declared a national park in February 1974. Since then, the area has been under intensive wildlife management. Unesco has declared Kaziranga National Park as a World Heritage Site, thus according it a special status among other Indian national parks.

Kaziranga N.P. has a generally flat terrain with a gentle almost imperceptible slope from east to west. The park being the flood plain of the Brahmaputra River, the soil is rich in alluvial deposits due to recurrent floods, which are an annual phenomenon. The area is swampy and waterlogged for a major part of the year, having small and large shallow water bodies spread all over. These water bodies are locally called beels. The park is also criss-crossed by river

channels, of which the prominent ones are Mora Diphlu, which demarcates most of the southern boundary of the park, and the Jiya Diphlu, which runs east-west in the middle of the park. In the extreme south of the park are the Karbi Anglong Hills. There are a few artificially made highlands in addition to the natural ones in the park which provide shelter to the wild animals during floods.

The climate of Kaziranga is the typical subtropical monsoon type. There are three distinct seasons. A dry and windy summer runs from mid-February to May with an average maximum temperature of 35°C and minimum of 10°C. The rainy season extends from May to September with average rainfall ranging between 15-25 cm. This is a hot and humid period. The mild winter with an average maximum temperature of 25°C and average minimum temperature of 10°C extends from November to mid-February. This period is practically rainless except for a few winter showers.

The vegetation of Kaziranga consists of extensive alluvial flood plains having tall and short grasses and interspersed by tropical moist deciduous to semi-evergreen forests (woodlands). These grasslands have been classified as Eastern Wet Alluvial Grasslands (4D/2S2) by Champion and Seth (1968). Tall grasses include *Erianthus ravennae, Phragmites karka, Arundo donax, Saccharum procerum, Themeda arudinacea, Vetiveria zizanoides, Imperata cylindrica, Arundinella bengalensis*, and *Alpinia* sp. They attain up to 5m height. Tall grasses are extensively distributed throughout the park. Short grasses, which are distributed only around beels are of high forage value as the majority of them are soft and palatable to rhinos. They include *Hemarthria compressa, Cynodon dactylon, Cenchrus ciliaris, Crysopogon aciculata* and *Andropogon* sp. Short grasses start growing from November when the water recedes. An adult rhino requires, on an average, 150 kg. of fodder per day, and spends most of its time feeding on short grasses (Dutta, 1991)

The woodlands of Kaziranga have been classified as Tropical Seasonal Swamp Forest (4D/SS5) by Champion and Seth (1968). Areas which are somewhat elevated allow growth of woodlands. *Bombax ceiba* is normally the earliest colonizer, followed by *Albizia procera, Ziziphus nummularia, Duabanga grandiflora, Lagerstroemia speciosa, Dillenia indica, Emblica officinalis, Careya arborea, Sterculia urens*, etc. The cane (*Calamus* sp.) makes a considerable understorey, especially in moist places. Kaziranga supports a great variety of wild animals viz. rhino, elephant, wild buffalo, tiger, leopard, swamp deer, sambar, barking deer, hog deer, bear, bison, wild boar, hog badger, capped langur, gibbon and otter.

### Data

Survey of India (SOI) topomaps (of the 1967-68 period), Landsat Thematic Mapper (Landsat-TM) standard false color image (of January 1990) and an Indian Remote Sensing Satellite (IRS-1B) standard false color image (of January 1997) on a 1:50,000 scale were used. The wild animal census data and a road network sketch were provided by the Directorate of the park.

## Methods

*Habitat map generation*

A 10-day field visit was made between 15 February and 1 March 1998 to correlate the image tone, texture, shape, size, etc. with land cover types. An interpretation key was prepared and all features on the image were interpreted. Survey of India topomaps were used for preparation of the base map. In the base map, the park boundary was taken from topomaps pertaining to the 1967-68 period and a map showing the overall park boundaries and a few inside details was prepared. A similar procedure was adopted for the 1990 and 1997 images and three maps of the study periods were prepared.

*Database creation*

As stated earlier, any habitat suitability analysis requires generation of an accurate database on various life support systems as well as on potential disturbance regimes in the habitat.

**Table 1: Prioritization of various habitat parameters for modeling purposes**

| Parameter | Priority/Suitability |
|---|---|
| **Land cover:** | |
| (a) Short grass, beels | Highly suitable |
| (b) Tall grass | Suitable |
| (c) Woodlands | Moderately suitable |
| **Waterbody:** | |
| (a) Within 250m (buffer-I) | Highly suitable |
| (b) Within 500m (buffer-II) | Suitable |
| (c) Within 1 km (buffer-III) | Moderately suitable |
| (d) Within 2 km (buffer-IV) | Less suitable |
| (e) Beyond 2 km | Unsuitable |
| **Road:** | |
| (a) Within 500m (buffer-I) | Unsuitable |
| (b) Within 1 km (buffer-II) | Less suitable |
| (c) Beyond 1 km | Suitable |
| **Settlement:** | |
| (a) Within 1 km (buffer-I) | Unsuitable |
| (b) Within 2 km (buffer-II) | Less suitable |
| (c) Beyond 2 km | Suitable |

**Table 2: Area under different land cover types in Kaziranga based on visual interpretation of satellite imagery**

| Land Cover Type | Area ($km^2$) | Area (%) |
|---|---|---|
| Woodland | 114.01 | 27.95 |
| Short grass | 12.30 | 3.01 |
| Tall grass | 248.85 | 61.01 |
| Beels | 24.32 | 5.96 |
| Jiya Diphlu | 3.96 | 0.97 |
| Mora Diphlu | 2.84 | 0.70 |
| Sand | 1.62 | 0.40 |
| **Total** | 407.90 | 100.00 |

**Table 3: Habitat suitability for rhino in Kaziranga**

| Suitability Class | Area ($km^2$) | Area (%) |
|---|---|---|
| Highly suitable | 21.83 | 5.35 |
| Suitable | 84.75 | 20.78 |
| Moderately suitable | 110.65 | 27.13 |
| Less suitable | 80.07 | 19.63 |
| Unsuitable | 110.60 | 27.11 |
| **Total** | 407.90 | 100.00 |

Remote sensing is being applied in habitat related studies. Satellite images from an IRS-1B Linear Imaging Self-Scanning System (LISS-II) sensor with ground resolution of 36.25m x 36.25m were used. The image scale as well as topomap scale was uniformly 1:50,000. Satellite images facilitated in generating the information on three important habitat parameters viz. food, shelter and water, through visual interpretation. While proximity to food/fodder, water and suitable shelter were taken as positive factors, proximity to tourist roads and human settlements were considered as negative factors. A road map, water body map and settlement map were prepared for proximity analysis.

All four vector maps (i.e. habitat, road, water body and settlement) were digitized to create a digital map database required for modeling. Digitization was carried out on SPANS (Spatial Analysis System) using TYDIG digitization software. Data was then exported to SPANS software and converted from vector to raster form. The next step was to create the zone of influence of roads and settlements needed for proximity analysis. This was done by creating a buffer zone around these features. Two road buffers of up to 500 m and 1 km distance on either side of the roads were created. Two buffers of 1 km and 2 km radii were created for settlements. Similarly, buffers of 250 m 500 m, 1 km, and 2 km were created around water bodies.

*Spatial Analysis*

Spatial analysis involved integration of digital spatial data, based on the preferences of rhino to various conditions. SPANS facilitated in spatial data handling. Area-based modeling procedures were followed. The complete analysis was done in three stages. Two maps (habitat and water body) were taken at first and overlaid/merged to create the first composite layer. The resultant layer produced was then overlaid on the road buffer map, generating the next layer. This layer in turn was overlaid on the settlement buffer map creating the final layer. Each step involved prioritization of input as well as output classes commensurate with their importance to rhino. The suitability map was derived from the final composite layer by reclassification of the resultant classes. The overall habitat suitability was depicted in six categories ranging from unsuitable to highly suitable.

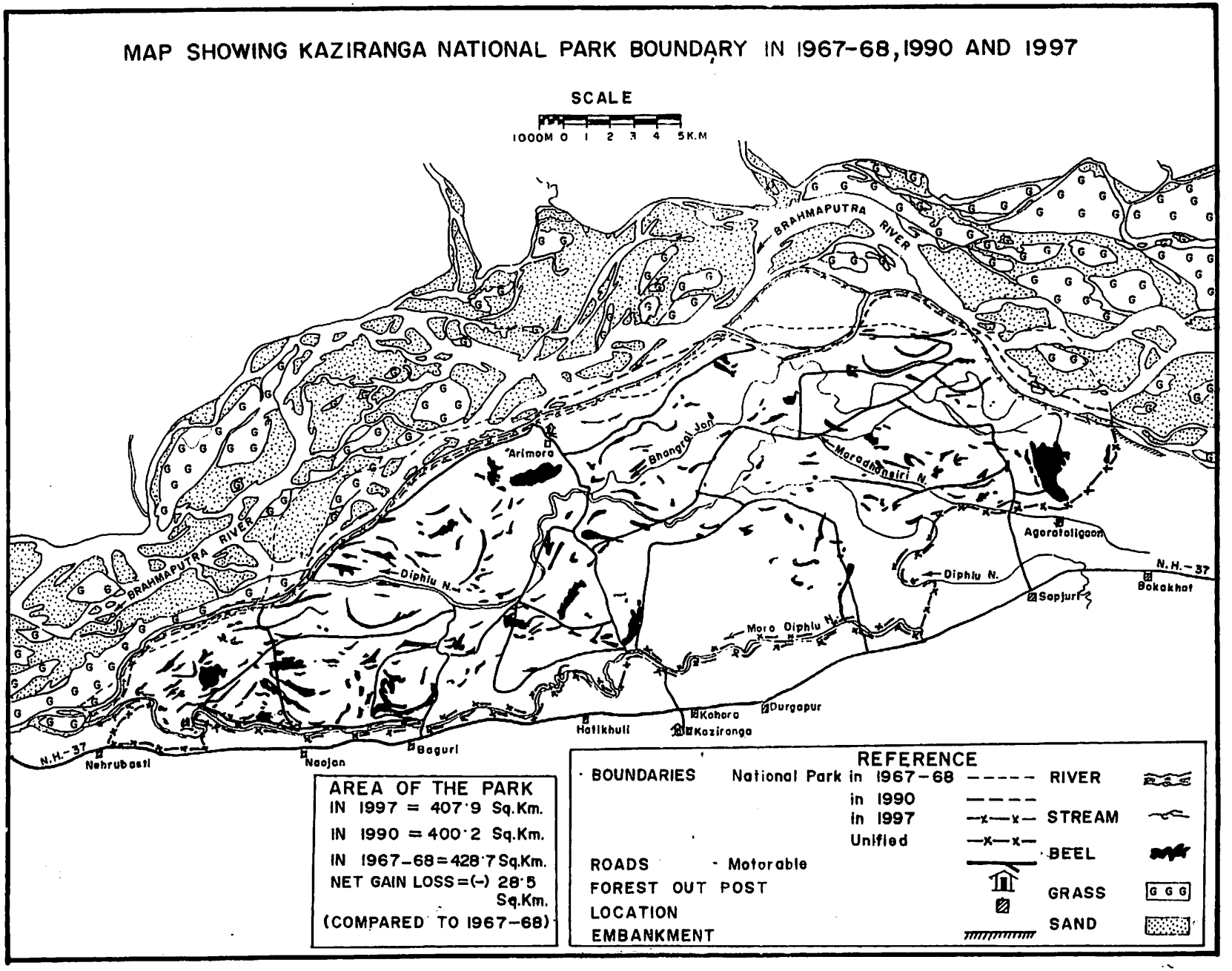
## Results

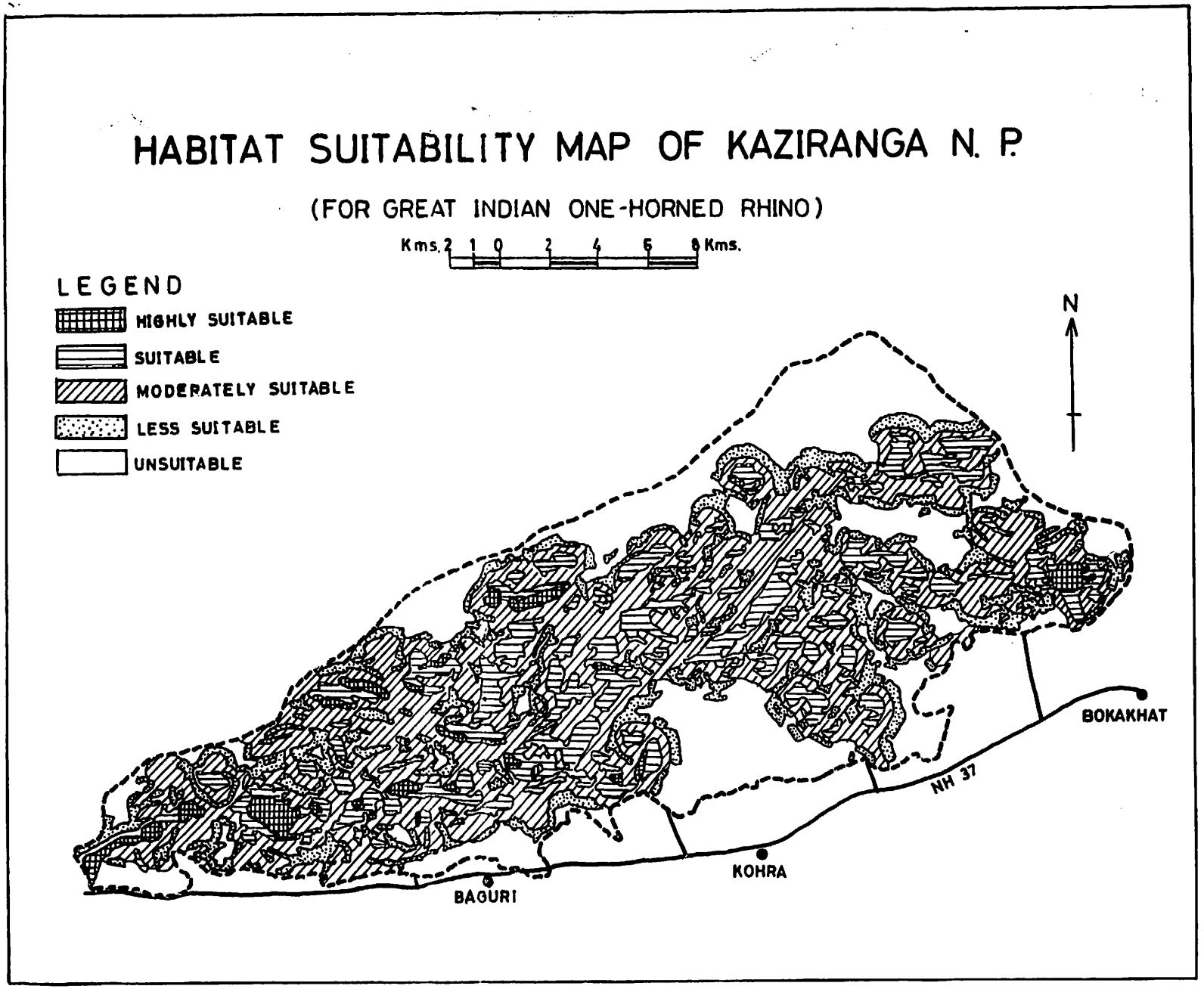
*Land cover in Kaziranga National Park*

The land cover in Kaziranga National Park is 407.9 km$^2$, as estimated in this study from the satellite imagery of January 1997. The majority of the park area (61%) is occupied by tall grasses. Woodlands make up nearly 28% (114.01 km$^2$) of the area and are the second largest land cover category. Beels occupy a significant area (about 6%) of the park and short grasses cover approximately 3% (12.3 km$^2$) of the area, which happens to be nearly half of the area under beels. The area under short grasses and beels is to some extent interchangeable for when the water level in the beels recedes, the short grass area increases. An opposite trend is noted when the water level increases during floods. While two rivers, Jiya Diphlu and Mora Diphlu, together occupy 6.8 km$^2$, the sand makes up an area of 1.6 km$^2$ in the park.

*Dynamics of the land area and wetlands in Kaziranga*

The three-period maps pertaining to 1967-68, 1990 and 1997 helped in the assessment of the land area of Kaziranga National Park during these periods. The area for the period 1967-68 was 428.7 km$^2$. By 1990, a reduction of 23.6 km$^2$ (5.5%) in the area was noted. In 1997, the area of the park was 407.9 km$^2$. The analysis showed that there was an overall reduction in the park area until 1990, after which there has been a slight gain in the area (7.7 km$^2$). While the erosion of the land area has been all along the north-eastern boundary of the park, it has been relatively greater in the Agoratoli and Baguri Ranges. The accretion, however, has been mostly along the northern boundary of Agoratoli Range. The landscape and especially the topography seem to have changed considerably over time. Compared to the SOI map of 1967-68, the satellite image of 1990 shows that a large area in the south of Kaziranga


MAP SHOWING KAZIRANGA NATIONAL PARK BOUNDARY IN 1967-68, 1990 AND 1997
SCALE
1000M 0 1 2 3 4 5K.M
BRAHMAPUTRA RIVER
BRAHMAPUTRA RIVER
Arimora
Bhangrai Jan
Moradhansiri N.
Agoratoligaon
Diphlu N.
Diphlu N.
N.H.-37
Bokakhat
Sopjuri
Moro Diphlu N.
Durgapur
Kohora
Kaziranga
Hatikhuli
Nehrubasti
N.H.-37
Naojan
Bagori
AREA OF THE PARK
IN 1997 = 407·9 Sq.Km.
IN 1990 = 400·2 Sq.Km.
IN 1967-68 = 428·7 Sq.Km.
NET GAIN LOSS = (-) 28·5 Sq.Km.
(COMPARED TO 1967-68)
REFERENCE
BOUNDARIES National Park in 1967-68
in 1990
in 1997
Unified
ROADS - Motorable
FOREST OUT POST
LOCATION
EMBANKMENT
RIVER
STREAM
BEEL
GRASS
SAND


HABITAT SUITABILITY MAP OF KAZIRANGA N. P.
(FOR GREAT INDIAN ONE-HORNED RHINO)
Kms. 2 1 0 2 4 6 8 Kms.
LEGEND
HIGHLY SUITABLE
SUITABLE
MODERATELY SUITABLE
LESS SUITABLE
UNSUITABLE
N
BOKAKHAT
NH 37
KOHRA
BAGURI

Range has been filled up by the river silt and elevated. This has resulted in considerable loss of area under beels and short grasses with a corresponding increase in the tall grass area in this Range.

The extent of wetlands over a period of 30 years was also found to have changed. In 1967-68, wetlands occupied 36.6 $km^2$ (8.5%) of the area, which decreased to 27.4 $km^2$ (6.7%) by 1997, thus showing an overall decrease in the area under wetlands between 1967-68 and 1997. The study, in general, showed considerable siltation and fragmentation of beels, decreasing the suitability of the habitat with the passage of time. The above findings also reflect the highly dynamic nature of the Kaziranga landscape.

*Habitat suitability for rhino*

Only about 5% of the area was found to be highly suitable for rhino in Kaziranga. Approximately 21% of the park area was found to be suitable, and about 27% moderately suitable. Another 20% turned out to be less suitable and the remaining 27% unsuitable.

## Discussion and Conclusions

Kaziranga National Park is a unique wildlife reserve not only in India, but perhaps in the whole of Asia. It harbors a variety of wildlife and the wild animal population has increased manifold since it was declared a wildlife reserve, primarily due to the protection provided by the park authorities. The two rivers, (Brahmaputra and Mora Diphlu) make a natural boundary for the park on three sides, providing considerable protection to the park. The results of this study have shown that the park land area is vulnerable to erosion by the Brahmaputra River. The land eroded is land lost. The amount of erosion over the last 30 years has exceeded the accretion. Land erosion or accretion in Kaziranga poses problems of a similar kind. In the former case, the habitat is summarily lost to the river, while in the latter case the newly added area remains practically useless for a considerable length of time.

The scenario with regard to the water bodies is similar to the land area in Kaziranga. Over time, the water bodies have given way to tall grass due to siltation. Consequently, the water spread and short grass areas have decreased with the passage of time. Both water bodies as well as associated short grasses constitute a very important life support system in the park. The above-mentioned changes are more pronounced in the Kaziranga range. As concluded in this study, Kaziranga National Park, by and large, makes a suitable habitat for the rhino. The 27% area found unsuitable, however, should be taken seriously. Such areas have much fewer water bodies and short grasses, thus rendering the place unfit for the rhino.

Floods in Kaziranga are the most severe of all natural calamities that affect the area. The flood waters submerge up to 90% of the area during the rainy season. Such a situation was seen in 1988 and resulted in the migration and death of a large number of animals. Floods compel the larger animals to take refuge in the nearby Karbi Anglong Hills during the flood season. Such a choice, however, is not without problems. The heavy traffic on National Highway No.37 which links upper Assam with lower Assam makes animal migration difficult. Many times animals get killed while crossing the highway. The chances of migrating animals being exposed to hunters and poachers are also high. The root cause of the problem is the absence of corridors linking Kaziranga with Karbi Anglong Hills and the presence of human habitations all along the highway. The park authorities have been demanding the incorporation of surrounding areas into the park to expand the territory and also to get the nearby forested tracts to facilitate animal migration. The population of Karbi Anglong Hills is also growing very fast and the time may not be far off when the animals will be left with no refuge.

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