International Scholarly Research Network
ISRN Ecology
Volume 2011, Article ID 498258, 9 pages
doi:10.5402/2011/498258

Research Article

Evaluation of Habitat Suitability for Rhino (*Rhinoceros unicornis*) in Orang National Park Using Geo-Spatial Tools

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Received 15 January 2011; Accepted 21 February 2011

Academic Editor: S. Sabater

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Orang National Park (Orang NP) is one of the important conservation areas in the Brahmaputra valley within North East India biogeographic zone covering an area of 78.8 km^2. It is one of the prime habitats of one horned rhino (*Rhinoceros unicornis*) in its distribution range in south Asia. Satellite imagery of November 2008 was used to evaluate the rhino habitat pattern in the park. A habitat suitability model for one horned rhino was prepared using primary and secondary sources. Result indicates that out of total geographical area of the park 25.85% is covered by woodland. About 26.06% is covered by wet alluvial grassland and 17.97% is covered by dry savannah grassland. Similarly degraded grassland is covering 15.23% and eastern seasonal swamp forest is covering 1.72% of the park. About 8.22% of the park is covered by water body and 6.83% is covered by sandy area. The habitat suitability model for rhino shows that 25.13% of the park is most suitable habitat for rhino, 13.62% is moderately suitable and 61.23% is less suitable habitat for rhino in the park. This information will help the park managers to conserve rhino and its habitat in Orang NP.

1. Introduction

Wilderness areas for Indian rhinos (*Rhinoceros unicornis*) continue to shrink and fragment due to multiplicity of natural phenomena as well as ever increasing anthropogenic pressures. Rhinos are in critical demographic crisis; primarily by overexploitation through poaching for rhino horn and other products and secondarily by loss of habitat due to expanding and developing human populations [1]. Revised IUCN categories and criteria, approved by the 40th meeting of the IUCN council has rated one-honed rhino as vulnerable based upon the parameters, namely, population reduction, population estimate, and probability of extinction. With the decreasing size of rhino habitat and increasing fragmentation, it has become essential to develop species-specific habitat suitability maps. Habitat is a place occupied by a specific population within a community population [2]. Habitat selection is important part of organism's life history pattern. Roy et al. [3] states that preservation of wildlife requires a complete knowledge of their spatial requirements commonly referred to as habitat. Habitat evaluation is the assessment of the suitability of land or water as habitat for specific wildlife species. A wildlife habitat suitability map is defined as a map displaying the suitability of land or water as a habitat for a specific wildlife species [4]. To achieve this one we need a model to predict the suitability of land in a given particular set of land conditions. Such model is called a habitat (environmental) suitability model [5]. The species habitat information is required to be known by the wildlife managers in order to prepare proper habitat suitability analysis of a species in an integrated scientific manner [6]. Conservation biologists and managers need a range of both classical analyses and specific modern tools to face the increasing threats to biodiversity [7]. Among these tools, habitat-suitability modeling using geo-spatial tools has recently emerged as a relevant technique to assess global impacts, for example, those due to climate change, [8] to define wide conservation priorities [9] and to evaluate the completeness of regional nets of protected areas [10].

During the last four decades, development of remote sensing and GIS techniques has made significant contribution in the management of natural resources [11, 12] and environmental monitoring [13, 14]. Remote sensing and GIS have been widely used in wildlife habitat studies [15–19]. Remote sensing and GIS technologies together provide vital geoinformation support for relevant, reliable, and timely information needed for conservation planning [20]. GIS has assumed a central role over the years in numerous species-specific applications, but there is more scope for GIS in modeling species assemblages, scale-dependent habitat preferences and geographical fragmentation of population, habitat heterogeneity, and ecological integrity [21]. However these techniques have not been widely used for wildlife habitat studies in Assam. Here in this research geo-spatial tool with a modeling approach was adopted to address the questions of habitat suitability for rhino in Orang National Park (Orang NP). The population of rhino in Orang NP is fluctuating from 35 rhinos in the year 1972 to 1997 rhinos in the year 1991 and which is again reduced to 64 rhinos in the year 2009. This unpredictable population fluctuation in the floodplain ecosystem of Orang NP demands habitat suitability evaluation for identifying the key habitat factors and total suitable area for determining fate of rhinos in the park.

2. Materials and Methods

2.1. Study Area. Orang NP covering an area of 78.8 km^2 is a prime habitat for rhino, located in the north bank of river Brahmaputra and within the administrative boundary of Darrang and Sonitpur districts of Assam, India. This park enjoys a flood plain ecosystem and is a prime habitat for other important species of conservation importance like Royal Bengal Tiger, Asiatic Elephant, and different Deer species. The park has been often regarded as the man made forest, and it lies within the geographical limits of 26° 29′ N to 26° 40′ N latitude to 92° 16′ E to 92° 27′ E longitude. Figure 1 shows the geographical location of RG Orang NP.

2.2. Methods. The methodologies for assessment of habitat suitability condition for rhino in Orang NP was consisted of extensive survey and direct monitoring of rhino, habitat assessment of the park through IRS P6 LISS III satellite imagery of 2008, relationship between rhino presence and habitat parameters, and preparation of suitability model using GIS tool based upon habitat parameters.

2.3. Direct Monitoring of Rhino. A year-long field survey was conducted in Orang NP from September 2008 to September 2009 to understand the habitat utilization pattern of rhino in different seasons. GPS locations of the direct evidences like sighting and indirect evidences like dung piles, foot print, and wallowing sign of rhino was taken and plotted over the boundary layer of the park, which was digitized from the map available with the State Forest Department of Assam using Arc GIS 9.3 software. Throughout the different seasons of the year, rhino was sighted in 183 times in the park.

2.4. Habitat Assessment Using Satellite Imagery. Satellite imagery of IRS P6 LISS III of 8th November 2008 having path and row nos. 110 and 52 was used to assess the land cover or habitat types in Orang NP. The satellite image-ry of 2008 was procured from National Remote Sensing Centre (NRSC), Hyderabad. The imagery was then projec-ted to UTM-WGS 84 projection system using Landsat ETM imagery as reference which was downloaded freely from National Aeronautics and Space Administration's (NASA) Global Land Cover Facilitator's (GLCF) website (http://www.glcf.umiacs.umd.edu/). Subpixel image to image registration accuracy was achieved through repeated attempts. A radiometric correction of the image was done using dark pixel subtraction technique [22]. Subset operation of satellite imagery was carried out by creating an area of interest (AOI) layer of the vector layer of forest boundary of Orang NP, which was digitized from the published maps of department of forest and environment, Government. of Assam at 1 : 50,000 scale. After subsetting, the image of the study area was processed through spectral enhancement technique using ERDAS Imagine 9.2 software. Principal component analysis (PCA) was carried out to the image. The imagery was then converted into three principal components. PCA is often used as a method of data compression. It allows redundant data to be compacted into fewer bands, that is, the dimensionality of the data is reduced. The bands of PCA data are noncorrelated and independent and are often more interpretable than the source data [23]. After generating the hybrid PCA image for the year, a supervised classification technique was used using maximum likelihood algorithm to assess the habitat pattern of Orang NP for the year 2008. Since supervised classification is a process where the image analyst supervised the pixel categorization process by specifying to the computer algorithm, numerical descriptors of the various land cover types present in a scene [22]. Many researchers have been using supervised classification technique to extract the features from the remotely sensed imagery, as it demonstrates the classification that can incorporate both the spectral and spatial features of the pixels in the image resulting in better defined categories in terms of its homogeneity [24, 25] Ground truth verification was made during the period from September 2008 to September 2009 and based on the ground verification data, classes were assigned in the PCA-based images. Nine land cover types were identified from the field observation and training sets of the land cover classes were gathered using handheld GPS receiver. The nine classes are as follows:

(i) Eastern Himalayan Moist Mixed Deciduous Forest (Dense),

(ii) Eastern Himalayan Moist Mixed Deciduous Forest (Open),

(iii) Dry Savannah Grassland,

(iv) Wet Alluvial Grassland,

(v) Seasonal Swamp Forest,

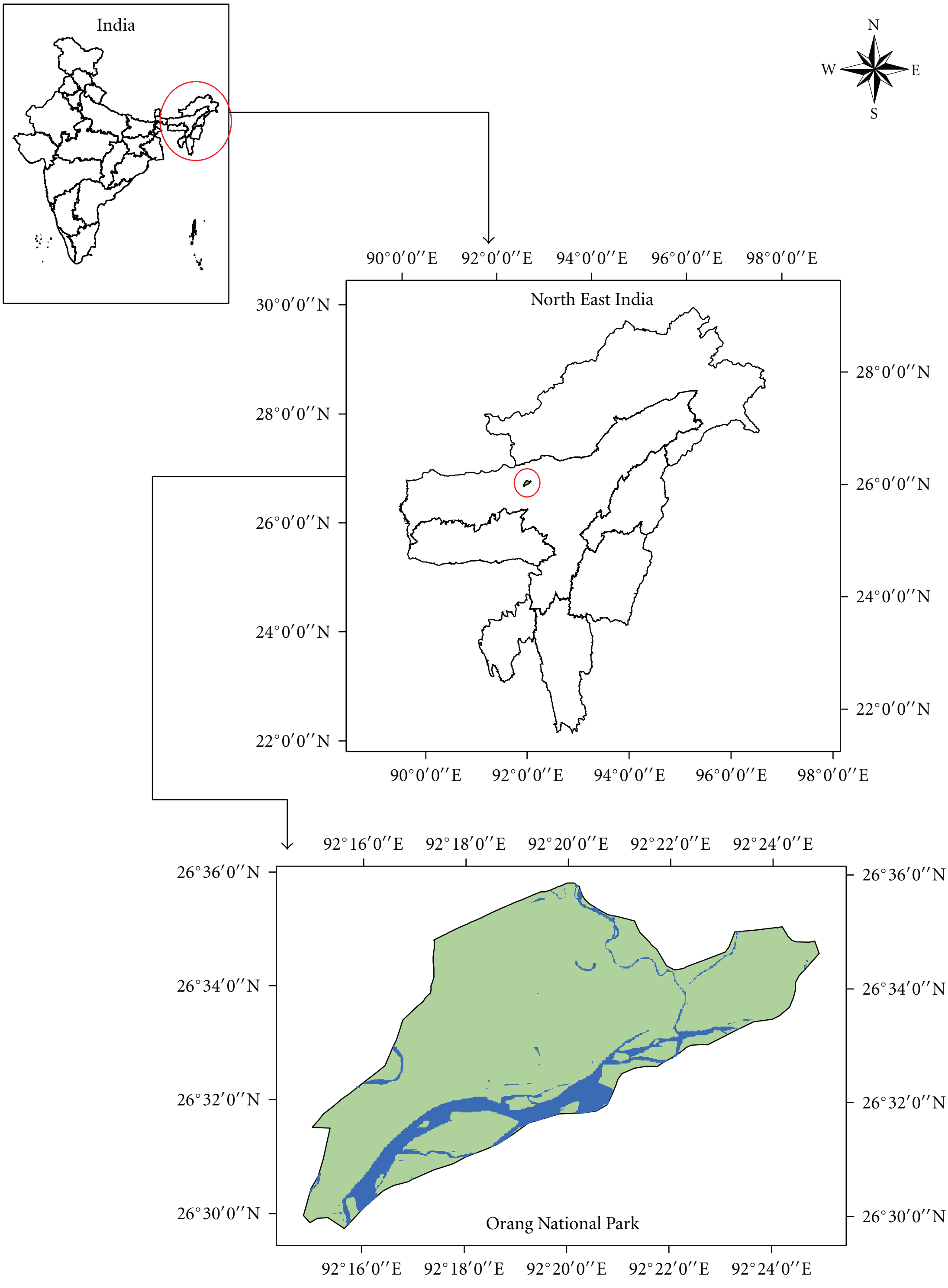

FIGURE 1: Location of study area.

(vi) Degraded Grassland,

(vii) Water Body/River,

(viii) Moist Sandy Area,

(ix) Dry Sandy Area.

2.5. Relationship between Rhino Presence and Habitat Parameters. Wildlife habitat suitability analysis is considered as most important criteria for the conservation and management of wildlife and its habitat [26]. Such suitability analysis includes a wide variety of factors like habitat pattern, habitat quality, distance from road, availability of water, topography, and land cover characteristics including human interferences. It is very essential to understand the relationship between these controlling factors and the species distribution, to make an assessment of the species habitat suitability in a landscape. A variety of analytical techniques have been used to investigate species-environment relationships. These include logistic regression [27–30] discriminant analysis [31] classification and regression trees [30, 32], correlation analysis [33], and artificial neuron network [34]. Here in this research a correlation analysis method was used to understand the relationship between rhino and their habitat. Based upon the direct monitoring of rhino and its relations with habitat types, some habitat parameters were identified. These are habitat types, availability of water, location of human settlement, elevation, distance from roads, and their impacts on distribution of rhinoceros in Orang NP.

2.6. Habitat Suitability Modeling. Based upon the coefficient of correlation analysis habitat suitability for rhino in the park was categorized in to three categories namely most suitable, moderately suitable, and less suitable. Table 1 shows the habitat suitability classes and their respective parameters.

Based upon the parameters mention in Table 1 a habitat suitability model for rhino was generated in Arc GIS 9.3 environment. A new tool box in arc tool box was generated under which a model for rhino habitat suitability was designed. The habitat parameters for rhino were placed in the model and spatial analysis tools, namely, select, buffer, erase, union, and intersect were used to get the final habitat suitability map of Orang NP showing the most suitable, moderately suitable, and less suitable habitats for rhino in the park. Figure 2 shows the habitat suitability model designed in Arc GIS 9.3 environment.

3. Results

3.1. Habitat Patterns of Orang NP. The entire habitat types of Orang NP were categorized into nine classes based upon field knowledge and collection of training sets of vegetation types. The overall accuracy of the habitat classification was 94 percent and the overall kappa ($\kappa^\wedge$) statistics was 0.9099. The nine classes are as follows:

(i) Eastern Himalayan Moist Mixed Deciduous Forest (Dense),

(ii) Eastern Himalayan Moist Mixed Deciduous Forest (Open),

(iii) Dry Savannah Grassland,

(iv) Wet Alluvial Grassland,

(v) Seasonal Swamp Forest,

(vi) Degraded Grassland,

(vii) Water Body/River,

(viii) Moist Sandy Area,

(ix) Dry Sandy Area.

(i) and (ii) Eastern Himalayan Moist Mixed Deciduous Forest (Dense and Open). This comprises of trees mostly belonging to moist deciduous type represented by *Bombax ceiba, Lagerstroemia flosreginae, Careya arborea, Terminalia bellerica, and Gmelina arborea,* and their distribution is mainly concentrated in the high altitude areas of the park. This land cover type covers an area of 20.38 km^2 of Orang NP out of 78.8 km^2.

(iii) Dry Savannah Grassland. This type of grassland is dominated by grasses such as *Narenga porphyrocoma, Imperata cylindrica, Phragmites karka, Arundo donax, Saccharum spontaneum, and Themeda arundinacea.* This land cover type is mainly concentrated in the transitional zones of high and low lying areas of the park. This land cover type covers an area of 14.17 km^2 of the Orang NP.

(iv) Wet Alluvial Grassland. The area under this category of habitat type is 20.54 km^2. This habitat type is scattered all over the park area. Pure patches of grassland and presence of water characterize it during the rainy season. This wet alluvial grassland plays a critical role in rhinoceros habitat utilization pattern, as rhinoceros prefer to use this habitat throughout the year. This grassland type is mainly composed of *Alpinia allughas, Mikania scandens*, *Saccharum procerum*, *Pharagmites karka*, and so forth.

(v) Eastern Seasonal Swamp Forest. This land cover type occupies an area of 1.36 km^2 in Orang NP. This type is mainly found along the river Brahmaputra, Dhansiri and Panchnoi and also in and around the wetlands of the park. This is mainly composed of *Barringtonia* type of vegetation.

(vi) Degraded Grassland. This type of grassland covers an area of 12 km^2 of Orang NP. These areas are mainly found near the easternmost and westernmost boundary of the park. The leading factor behind the formation of degraded grassland in Orang NP is the over grazing by the domestic cattle that comes from the fringe villages of the park. The impact of invasive species like *Mimosa invesa* is also a major factor in the formation of degraded grassland in Orang NP.

(vii) Water Body. The area under water bodies in Orang NP is 6.48 km^2. The mighty river Brahmaputra flows along the southern boundary of Orang NP which covers an area of 5.78 km^2 in the park. Besides this, there are several wetlands in the park, which are also recognized as good habitat for rhinoceros in the park.

(viii) and (ix) Sandy Area (Dry and Moist). The area covered by sand in Orang NP is 3.87 km^2. River sand banks devoid of any vegetation are mainly concentrated around the dried river bed of Brahmaputra. The change in course of river Brahmaputra along with excessive siltation during the rainy season has resulted in the expansion of such areas. Table 2 shows the area covered by each habitat types and their percentage of area cover. Figure 3 and Table 2 show the

Table 1: The parameters used for rhino habitat suitability model.

No	Habitat suitability classes	Elevation	Vegetation types	Proximity to water source	Proximity to roads	Proximity to forest camps
1	Most Suitable	<50 mts	Wet Alluvial Grassland	Within 500 mts	More than 200 mts	More than 100 mts
2	Moderately Suitable	>50 mts <60 mts	Dry Savannah Grassland, Eastern Seasonal Swamp Forest	More than 500 m but less than 1 km	Less than 200 mts but more than 100 mts	50 mts to 100 mts
3	Less Suitable	>60 mts	Woodland, Degraded Grassland, Sandy Area, Running Water	More than 1 km	Within 100 mts	Within 50 mts

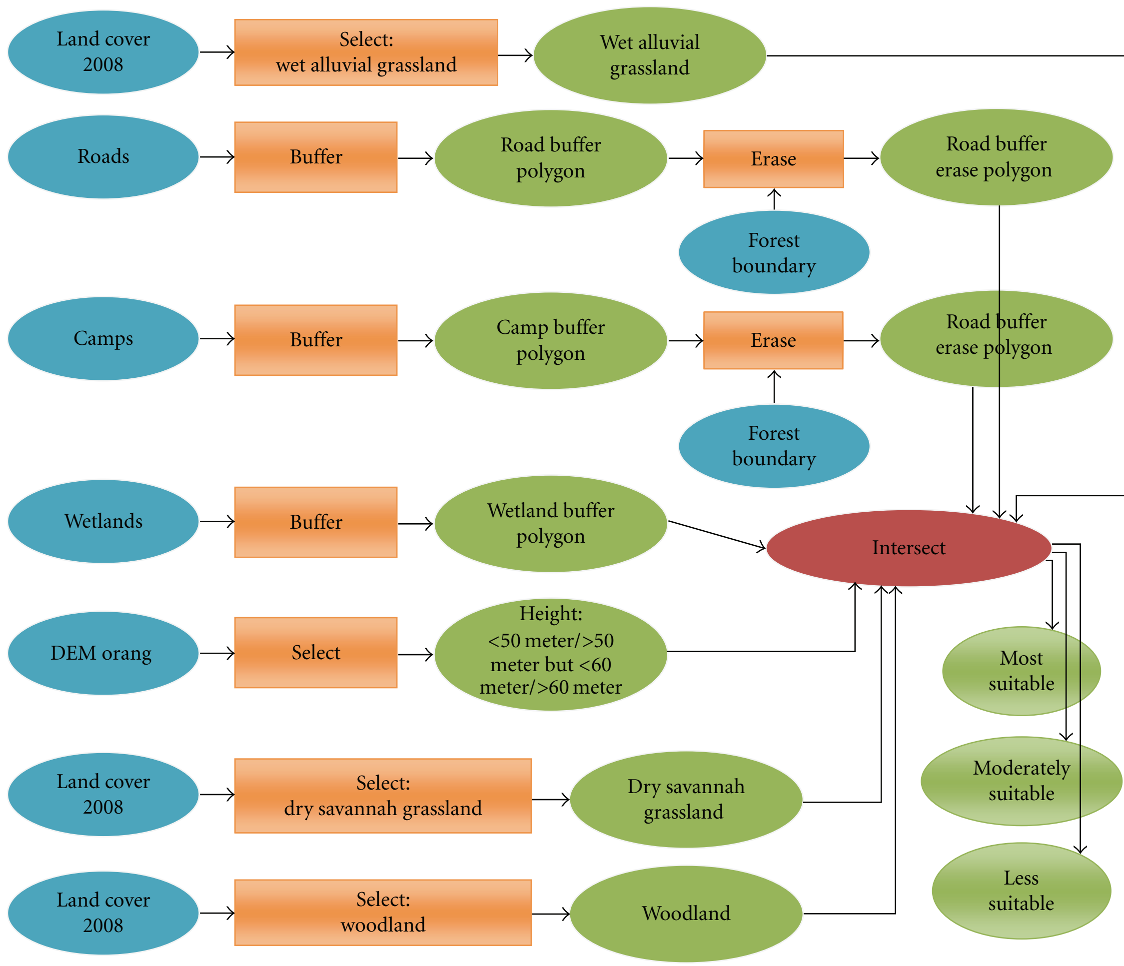

Figure 2: Rhino habitat suitability model.

distribution of different habitat types and their respective area coverage in Orang NP.

3.2. Relationship between Habitat Parameters and Rhino Distribution

3.2.1. Rhino-Habitat Relationship. Out of total 183 rhinos sighted in all the seasons of the park, 109 (59.56%) rhinos were found in wet alluvial grassland habitat, 45 (24.59%) rhinos were found in dry savannah grassland habitat and rest 29 (15.84%) rhinos were found in woodlands and wetland habitats. The coefficient of correlation shows a positive correlation between rhino sighting and wet alluvial grassland ($r = 0.582$). This indicates that rhino prefers wet alluvial grassland more than dry savannah grassland, woodland, and wetland habitats in the park. Thus in selection of habitat suitability parameters, areas with wet alluvial grassland were considered as most suitable for rhino. Figure 4 shows the relationship.

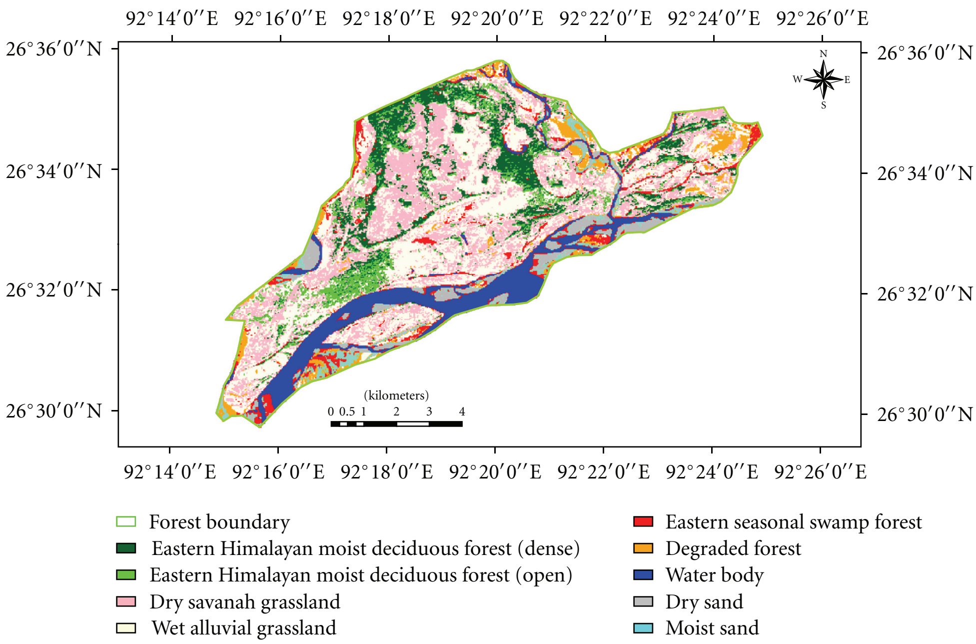

Figure 3: Distribution of habitat types in Orang NP.

Table 2: Habitat patterns of Orang NP in 2008.

Land cover types	Area in km^2	% area covered
Eastern Himalayan Mixed Moist Deciduous Forest (Dense)	9.84	12.48
Eastern Himalayan Mixed Moist Deciduous Forest (Open)	10.54	13.37
Dry Savannah Grassland	14.17	17.98
Wet Alluvial Grassland	20.54	26.06
Degraded Grassland	12	15.23
Eastern Seasonal Swamp Forest	1.36	1.72
Water Body	6.48	8.22
Moist Sand Area	1.02	1.29
Dry Sand Area	2.85	3.61

Source: IRS P6 LISS III Satellite Image of 8th Nov. 2008.

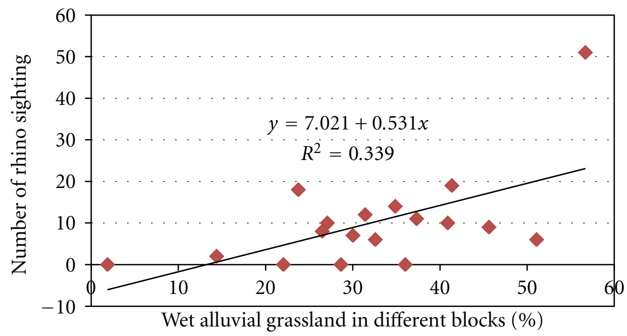

Figure 4: Correlation between wet alluvial grassland and rhino sighting.

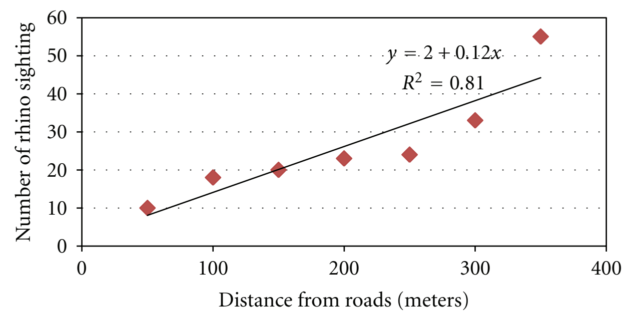

Figure 5: Correlation between distance from road and rhino sighting.

3.2.2. Rhino-Road Network Relationship. The correlation coefficient between rhino distribution and road network shows a positive relationship between distance from road and rhino sighting ($r = 0.9$). It indicates that with the increase of distance from the road the number of rhino sighting has also increased. Figure 5 shows the trend of relationship.

3.2.3. Rhino-Wetlands Relationship. The correlation coefficient between rhino sighting and wetlands in the park shows a negative correlation between distance from wetlands and number of rhino sighted ($r = -0.881$). It indicates that the number of rhino sighting has decreased with the increase of distance from the wetlands. Figure 6 shows the relationship between rhino sighting and distance from wetlands.

3.2.4. Rhino-Elevation Relationship. During the field survey period it was observed that out of total rhino sighted, 129 (70.49%) rhinos were present within 50 meter elevation in Orang NP. Total 41 (22.40%) rhinos were found in more

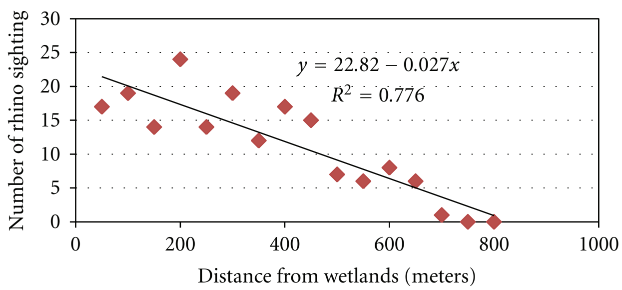

Figure 6: Correlation between distance from wetlands and number of rhino sighting.

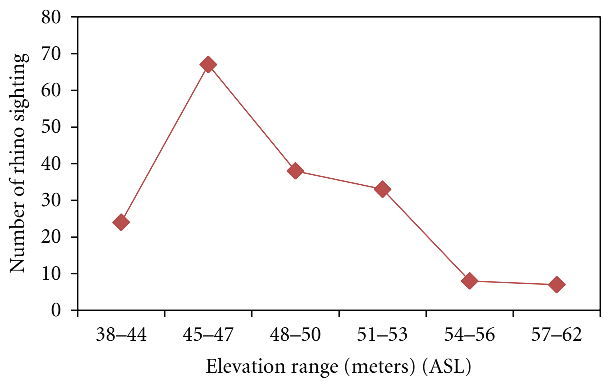

Figure 7: Distribution of rhino in Orang NP in different elevation zones.

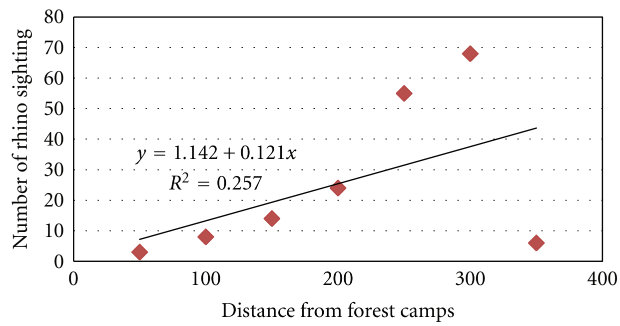

Figure 8: Correlation between distance from forest camps and number of rhino sighting.

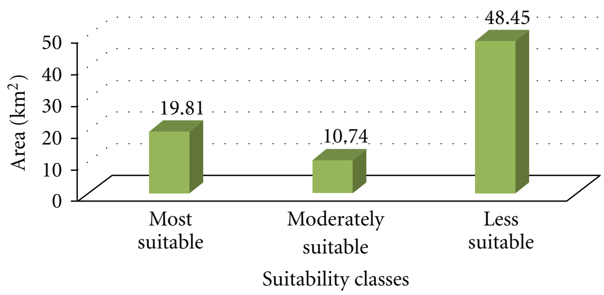

Figure 9: Rhino habitat suitability status of RG Orang NP.

than 50 meter height but less than 60 meter height and rest 7 (3.82%) rhinos were found in more than 60 meter elevation zone. Figure 7 shows the graphical representation of height range and rhino sighting. In the selection of habitat parameters in suitability modeling for rhino, areas less than 50 meter elevation were considered as most suitable for rhino.

3.2.5. Rhino-Forest Camp Distance Relationship. Human interference or disturbance is always as an important factor for the distribution of wild animals. The correlation coefficient between rhino sighting and distance from forest camps shows a positive correlation ($r = 0.507$). It indicates that the rhino sighting increases with the increase of distance from the forest camps. Figure 8 shows the trend of relationship.

3.2.6. Suitability Condition of Rhino Habitat in Orang NP. The results of the rhino habitat suitability modeling of Orang NP shows that 19.81 km^2 of the park is most suitable for rhino, which covers 25.13% of the total geographical area of the park. The area covered by moderately suitable habitat for rhino in the park is 10.74 km^2, which is 13.62% of the total geographical area of the park. The area covered by less suitable habitat is 48.25 km^2, which is 61.23% of the total geographical area of the park. Out of 48.45 km^2 of less suitable habitat for rhino, 5.78 km^2 is covered by river Brahmaputra, 5.77 km^2 area is covered by degraded grassland, and 5.39 km^2 area is covered by river sands. These are the habitat types which are rarely used by rhino and hence identified through the model as less suitable habitat.

Wildlife suitability maps and their underlying suitability models have been criticized because of their assumed poor accuracy [35].The maps produced by these models have rarely been validated [36, 37], although this was clearly advised in the habitat evaluation procedures [38]. An accuracy assessment of habitat suitability map was done based on rhino presence and absence and relationship with habitat suitability and rhino sighting. The result shows that out of 183 rhino sighted, 100 (54.64%) rhinos were found in most suitable habitat of RG Orang NP, 68 (37.16%) rhinos were found in moderately suitable area, and rest 15 (8.20%) were found in less suitable habitat of the park. It indicates that the model prepared for the assessment of rhino habitat suitability in RG Orang NP has its validation with the reality. Similarly the relationship between habitat suitability and rhino sighting shows that there is a positive correlation between most suitable habitat and number of rhino sighting ($r = 0.682$). This indicates that the number of rhino sighting increases with the increase of most suitable habitat in Orang NP. Similarly correlation coefficient was done between less suitable habitat and number of rhino sighting. The result shows a negative correlation between these two variables ($r = -0.525$). It indicates that the number of rhino sighting decreases with the increase of less suitable habitat in Orang NP. It shows that the output of the model is well correspond to reality, hence it can be assumed that the model is accurate and well validated and this model can be implemented in

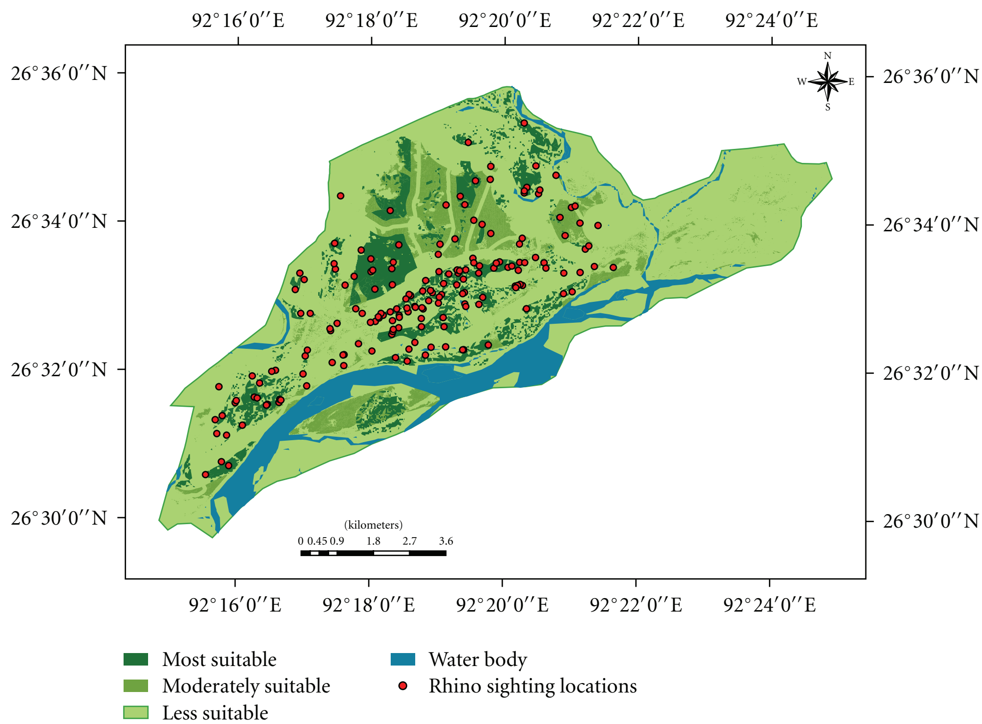

Figure 10: Habitat suitability map for rhino in Orang NP.

other rhino bearing areas of Assam like Pabitora Wildlife Sanctuary and Kaziranga National Park. Figures 9 and 10 show the area covered different suitable habitats in Orang NP.

4. Conclusion

It is evident from the present study that the distribution of rhino in Orang NP completely depends upon the habitat parameters like availability of food plant, distance from water body, distance from road, distance from human settlement, elevation, and so forth. The habitat parameters have tremendous impact over the habitat utilization and suitability pattern of rhino in Orang NP. From this study it is also clear that most suitable habitat for rhino in Orang NP is only 19.81 km^2 which is 25.13% of the total geographical area of the park. This indicates that most suitable habitat for rhino in the park is not sufficient for the rhino population that is in the park. Immediate attention should be taken to conserve the existing suitable habitat for rhino in the park and measures should also be taken to expand the most suitable habitat of the park from 25% to at least 40% to 45% of the total geographical area of the park. The park managers should also take the initiative to increase the wet alluvial grassland habitat in the park, which rhino prefer most in different seasons throughout the year. Finally from this study it is evident that geo-spatial technology has the capability to evaluate the habitat suitability condition of wild animals. Through spatial modeling in GIS environment it is quite possible to understand the wildlife habitat suitability condition of any wildlife species.

Acknowledgments

The authors express their gratefulness to the PCCF and CCF (Wildlife), Assam Forest Department for their encouragement and thanks to the DFO and Range Officer of the Orang National Park for their continued support in the study. The authors are thankful to team members of the survey particularly, Chatrapati Das, Arup Kumar Das, Bhaskarjyoti Bhuyan Anil Das, Biraj Saikia, and staffs of Orang NP. The authors are thankful to International Foundation for Science (IFS), Sweden for providing necessary financial support to carry out this study in Orang NP.

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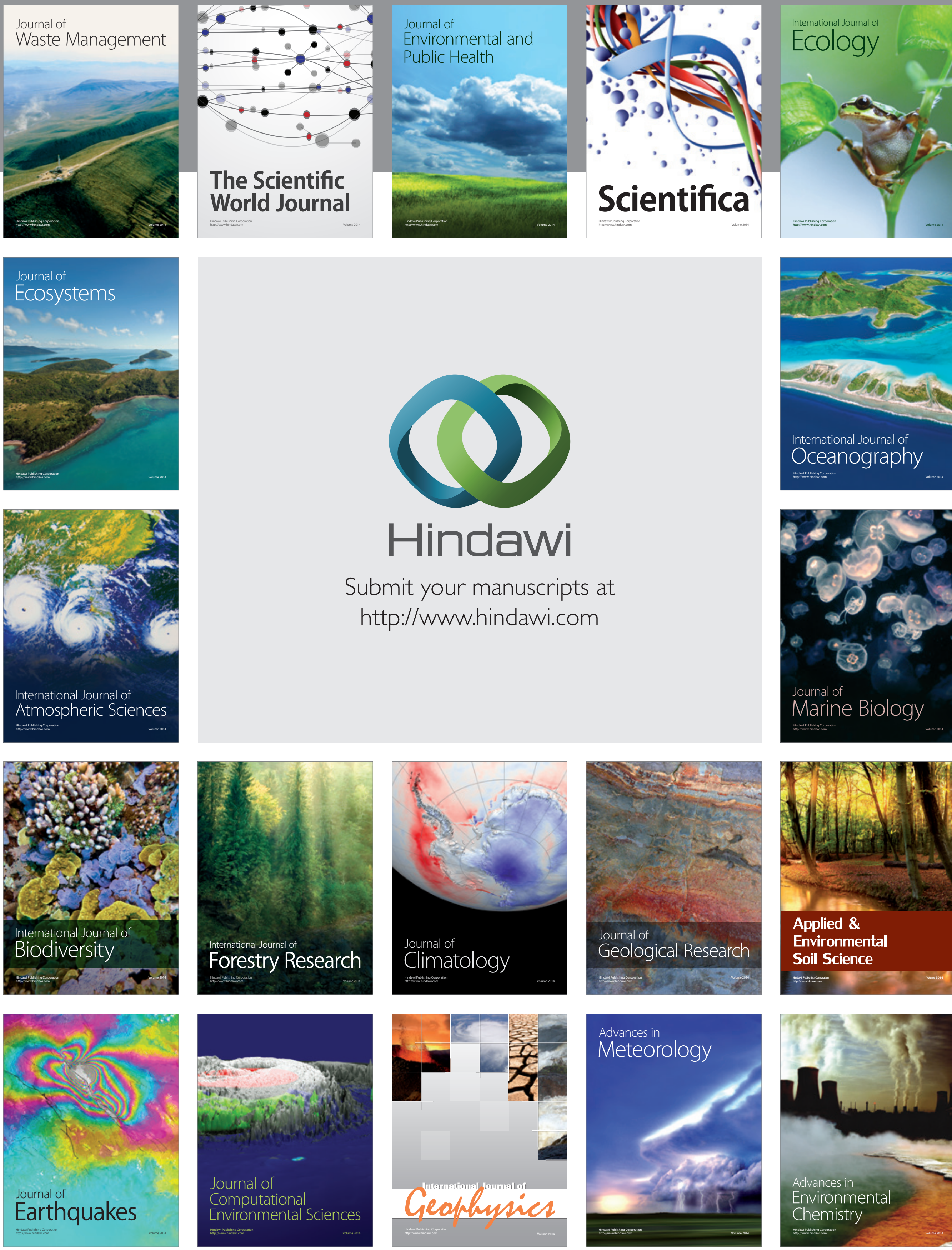
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