Int. J. Adv. Res. Sci. Technol. Volume 4, Issue 6, 2015, pp.427-434.

IJARST

International Journal of Advanced Research in Science and Technology

journal homepage: www.ijarst.com

ISSN 2319 – 1783 (Print)

ISSN 2320 – 1126 (Online)

Habitat Suitability analysis for Chital (Axis axis) using Geo-spatial Technology of Panna National Park (M.P.) India.

Rajesh Kumar Prajapati[1]*, Shashikant Triptathi[1] and Rahasya Mani Mishra[2]

[1]Department of Energy and Environment, Mahatma Gandhi Chitrakoot Gamodaya University, Chitrakoot- 485334, India.

[2]School of Environmental Biology, A.P.S. University Rewa-486003, M.P., India.

****Corresponding Author's E-mail: prajapati.rajesh8@gmail.com, Phone +91-9755039331.***

A R T I C L E I N F O

Article history:

Received 19 Sep. 2015

Accepted 05 Oct. 2015

Available online 07 Oct. 2015

Keywords:

Remote Sensing,
GIS,
Habitat Suitability,
LISS and IRS P6.

A B S T R A C T

The habitat fragmentation issue is of particular relevance to developing countries where most of the biodiversity rich tropical ecosystems are located. The purpose of this study was to produce habitat suitability model for the Chital in Panna National Park India (North latitude 24°27′ and 24°46′ and East longitude 79°45′ & 80°9′). Habitats were evaluated using Multi criteria analysis and habitat suitability index with remote sensing and GIS. Satellite imageries of LISS-III (IRS-P6, LISS-III) of study area were digitally processed. To generate collateral data, topographic maps were analyzed in a GIS framework. Layers of different variables such as: Land use/Land cover, forest density, proximity to disturbances and water resources and a digital terrain model were created from satellite and toposgraphic sheets. In the study area landscape, there are an only Ken River is the perennial water sources, the surrounding of the river is more suitable habitat for chital. Human settlements areas are usually avoided by wild animals. Species like the chital, which prefer edge habitats, generally avoid core areas of park.

PAPER-QR CODE

IJARST

Volume-4, Issue-6

Citation: *Rajesh Kumar Prajapati. et al. Habitat Suitability analysis for Chital (Axis axis) using Geo-spatial Technology of Panna National Park (M.P.) India. Int. J. Adv. Res. Sci. Technol. Volume 4, Issue 6, 2015, pp.427-434.*

Introduction:

Each species has some requirements based on its behavioral, biological, genetics and evolutionary history to choose a habitat for survival and each habitat must provide these species requirements. By identifying species requirements within habitats we can define suitable areas for species survival. This issue is critical, especially in tropical areas with high species richness that the habitat is losing the suitability due to human pressure. The main purpose of habitat Suitability (HS) models was to define the relationship between biotic and abiotic factors and the species spatial distribution [Guisan et al., 2000]. The most important thing to build the habitat suitability model was to identify habitat preferences of the species from an eco-geographical point of view. HS models can then help with describing species-environment relationships and can help to derive a map of habitat quality. The important key for any habitat suitability model was the nature of the species data i.e., presence data, presence and absence data and abundance data [Eastman, 2006].

Habitat is a sum total of environmental condition of a specific place occupied by wildlife species or a population of such species. All species have specific habitat requirements, which can be described by habitat factors. These factors were connected to the critical characteristics of the habitat, such as vegetation, soil, spatial structure of landscape elements and climatic condition of the area. Urbanization, industrialization, infrastructure development projects, agriculture, grazing, deforestation, wildlife trade and poaching continue to create tremendous stress on pristine natural habitat and wildlife. Remote sensing and GIS (RS and GIS) can be used as tool for getting information about the habitat preference of the wildlife species. RS and GIS also help in monitoring areas of land for their suitability to endangered species, through integration of various habitat variables of both spatial and non-spatial nature [Davis and Goetz, 1990].

Natural ecosystems in many developing nations are currently facing an unprecedented threat from diverse competing pressures arising from a burgeoning human population and unregulated economic growth. India is one of the twelve mega-biodiversity nations of the world [Alfred, 1998]. Of these, around 175 animal species are in the IUCN [IUCN, 2010] red list threat category. Information of habitat features used by an animal, and the ones that a preferred or avoided are needed to understand many ecological aspects of animals and further to plan for conservation. Habitat suitability modeling can be used as a tool to help explain or predict important ecological parameters for different species, including species distribution and habitat quality. Identification of high habitat quality areas for tiger is urgently needed for future conservation of that species in the study area.

In this study Chital densities were estimated using photographic capture-recapture sampling in the dry forests of Panna National Park in Central India. The chital population in India has undergone a sharp decline during the last few years. Of the number of factors attributed to this decline, habitat fragmentation has been the most worrisome. The habitat fragmentation issue is of particular relevance to developing countries where most of the biodiversity rich tropical ecosystems are located.

Geospatial technology including: remote sensing, geographic information system (GIS) and global positioning system (GPS) along with a habitat suitability index (H.S.I.) model provide an efficient and low-cost method for determining habitat quality [Schamberger et al., 1982]. Use of satellite imagery, geographical information systems (GIS) and statistics may assist in quantifying available habitat for animal species [Johnson, 1990]. The outputs of such models are usually simple, easily understandable and can be used for the assessment of environmental impacts or prioritization of conservation efforts in a timely and cost-effective manner [Kushwaha et al., 2004 and Zarri et al., 2008]. The main objectives of Habitat modeling are predicting distribution of wildlife species in geographical area with high species diversity [Butterfield, 1994, locating of species of concern [Sperduto, 1996] predicting area of suitable habitat that may not be currently used by species [Lawton, 1991] and aid to species re-introduction or prediction of the spread of an introduced species [Nazeri et al., 2010].

A suitability index provides the likelihood of how much area is suitable for a particular species. The higher the values the better are the chances that a particular location is suitable for the occurrence of that species. In this model, regression is used on several environmental parameters to calculate an index of species occurrence [Clark and Evans, 1954]. Forest and habitat modeling can be used to evaluate the potential impacts of alternative biodiversity conservation strategies. The effective planning for preservation of biodiversity in managed forest landscapes requires the application of decision support systems (DSS) to evaluate the potential impact of alternative stand and landscape management activities on indicators of habitat suitability.

Habitat suitability index (HSI) models have been used to evaluate wildlife habitat and the effects of management activities and development since the early 1980s [U.S. Fish and Wildlife Service 1980, 1981]. These models are based on functional relationships between wildlife and habitat variables. Values of habitat variables (e.g., herbaceous canopy cover, tree canopy cover, tree height) are related to habitat quality on suitability Index (SI). Habitat suitability index scores are usually calculated using a mathematical formula representing hypothesized relationships among the individual SIs. Wildlife–habitat relationships may be supported by empirical data, expert opinion, or both [U.S. Fish and Wildlife Service 1980, 1981].

Study Area:

The Panna National Park Consists of areas from the former Gangau Wildlife Sanctuary Created in 1975, Panna National Park was created in 1981 and was declared a Project Tiger Reserve by Govt. of India in 1994. Panna is the twenty-two tiger Reserve of India and fifth in Madhya Pradesh. It is situated in longitude 79^0 45'E to 80^0 09'E, Latitude 24^0 27' N to 24^0 46' N and altitude 211.2 meters (near ken river, Compt. 228, Mandla range) to 540 meters (a hillock near Talgaon, Compt. 1340, Panna range) in the Vindhya range and spreads over Panna and Chattarpur districts in the north of the state Madhya Pradesh and area contain about 542.67 sq. KM (Panna 373.5473 sq KM and Chhatarpur 169.1153 sq KM) (Figure 1.). The Ken river which is recognised as perennial water sources for the wild life of the national park. Within the park Ken makes boundry between the two districts of Panna and Chhatarpur and traverses a distance of about 55km. There are at present 13 Villages comprising 15 habitations inside the park. These are all revenue villages. The region, famous for its diamond industry, is also home to some of the best wildlife species in India and is one of the most famous Tiger Reserves in the country. The park is known worldwide for its wild cats, including tigers as well as deer and antelope. Due to its closeness to one of the best known Indian tourist attraction in India, Khajuraho, the park is recognized as an exciting stop-over destination. The climate of the region is tropical. The terrain of the reserve is characterized by extensive plataeus and gorges. Climate is hot and dry for about 7 months. Rains from southwest Monsoon, from about June – end till mid – September, bring much pleasure in the sense that weather then becomes milder with average relative humidity rarely crossing 95%. Average annual rainfall for Panna district is 1,200 mm. and about 1,100 mm. in Chhatarpur. Panna National Parks consisting of 6 types of forests as

Southern Tropical Dry Deciduous Dry Teak Forest, Northern Tropical Dry Deciduous Mixed Forest, Dry Deciduous Scrub Forest, Boswellia forest, Dry Bamboo Brakes and Anogessius pendula Forest [Champion and Seth, 1968].

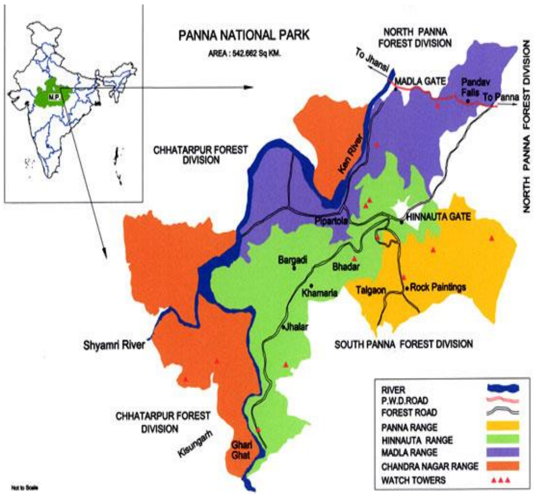

Fig. 1: Location map of Panna National Park

Methodology:

Field Method and Data Collection:

The data collection effort was comprised of two components: Prey species population distribution by the line transect Method [Burnham et al., 1980] and pellet group count Technique [Bennett et al., 1940, Ebernhardt et al., 1956 and Neff, 1968] and habitat evaluation consider to our understanding of the needs and requirements of the animal.

Topographic maps of (1:50,000 scale) were collected from Geographical Survey of India (GSI), Dehradun. All topographic sheets were scanned separately and were geo-referenced to Geographic Lat-Long Projection to sub-pixel accuracy. The common uniformly distributed ground control Point‘s (GCP) were marked with root mean square error of one third of a pixel and images were re-sampled by nearest neighbor method with the help of software ERDAS IMAGINE 9.1 in image format (.img) and then mosaicking of them. After Geo-referencing and Mosaicking of all toposheets area of interest (AOI) was extracted. The Land-use land cover map was prepared through digital analysis of satellite data using supervised maximum likelihood classification technique. The layout of data collection and different strategies which were applied for the study described in figure 2.

Satellite data:

Indian remote-sensing satellite data of IRS P6, linear imagine self-scanning LISS-III (IRS-P6, LISS-III) data of dated 25th February 2009, swath width 140 km with a ground resolution of 23.5m has been acquired from National Remote Sensing Centre (NRSC), Hyderabad, India and Landsat TM satellite data has been downloaded from the website www.glovis.usgs.gov, which have swath width 185*185 sq. km. with a ground resolution of 30 m. The satellite data of study area has been imported into *ERDAS IMAGINE 9.1* in img. format for geometric correction. Images have been co-registered with already rectified Landsat TM satellite data of April 2010 to accuracy below root mean square error (RMSE) 0.2 precision. Then rectified scenes (LISS-III) have been mosaiced. From the mosaiced data, a subset of area of interest (AOI) has been made for further analysis. Image has been displayed in false color composite (FCC) using three bands 3, 2, 1 and color print has been taken out for field work (ground truthing).

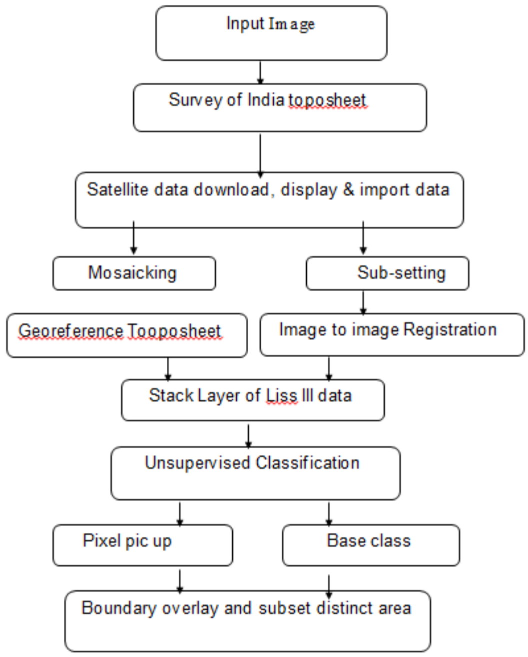

Fig. 2: Flow Chart of data collection and classification strategies

The digital elevation model (DEM) data of ASTER has been downloaded from the website (http://Gdem and imported to *ERDAS IMAGINE 9.1* for producing the layer maps of aspect, slope, elevation, and altitude (figure 3).

Habitat suitability:

Habitat is a sum total of environmental condition of a specific place occupied by wildlife species or a population of such species. All species have specific habitat requirements, which can be described by habitat factors. These factors were connected to the critical characteristics of the habitat, such as vegetation, soil, spatial structure of landscape elements and climatic condition of the area. The evaluation procedure consists of the following steps [Store and Kangas, 2001]:

(i) The assessment of a suitability structure:

Choosing the habitat factors and determining their importance and effect on the habitat priority. Here, judgments made by experts on ecology had been applied.

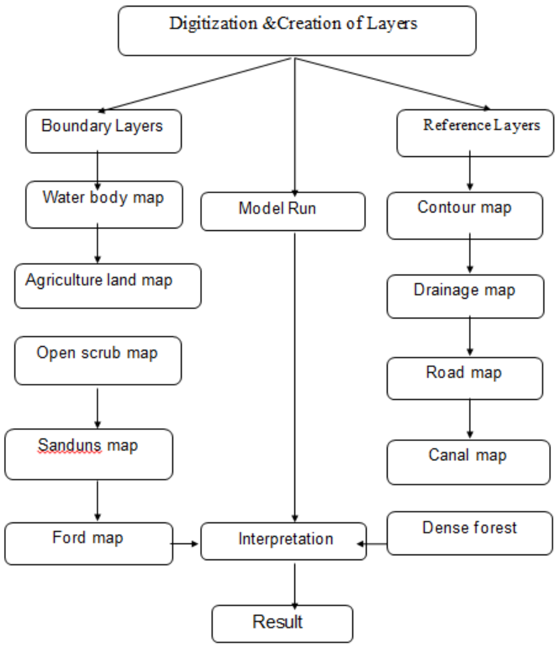

Fig. 3: Flow Chart of digitization & layer creation

(ii) Producing map layers:

GIS application was used for managing, producing, analyzing and combining Spatial/Non spatial data. The data describing the habitat factors were rasterized and every factor have been stored in its own map layer.

(iii) Remote sensing & GIS Integration:

After pre-processing, combining data of the different type and from different sources (SOI, GSI and DEM), was the pinnacle of data integration and analysis. In a digital environment, where all the data sources were geometrically registered to a common geographic base, the potential for information extraction was extremely wide. The integration with GIS allows a synergistic processing of multi-source spatial data. The integration of the two technologies creates a synergy in which the GIS improves the ability to extract information from remotely sensed data, and remote sensing in turn keeps the GIS up-to date with actual environment information. As a result, large amount of spatial data can now be integrated and analyses. This was allowing for better understanding of environmental process and better insight into the effect of human activities. Defining the feasible area and combining the habitat factors. Habitat suitability can be measured by a habitat suitability index, which was a unit less (0 to 9) variable, describing the priority of the habitat with respect to the need of the species (or group of species) under consideration. [Anselin et al. 1989] have pursued the idea of multi-criteria techniques with an analytic hierarchy process (AHP). Now a day's tiger is threatened species and holds top position in food chain of forest ecosystem, so the procurement of Tiger was in top priority. For Habitat suitability modeling of Tiger, the most important factor was availability of Prey in the area.

Multi-Criteria Analysis (MCA) is a decision-making tool developed for complex problems. The research studies the conceptual framework of habitat development and introduces the theoretical basis of MCA, and methods such as ranking, rating and pair wise comparisons in the Analytic Hierarchy Process (AHP).

Suitability maps have been developed by integrating expert opinion with Geographic Information System (GIS) database. The 0-9 points scale multi-criteria evaluation methodology has been implemented to solicit the importance of ground characteristics (criteria) for Tiger. The layers of interest have been Forest Density, Vegetation Type, Land-use, Lithology, Slope, topography and some other Human Disturbance Factors. In this study has used ranking/weighted based analysis. The evaluations of the respondents have been in agreement. Suitability scores and preference weights have been determined from questionnaire responses and input into the ARC GIS program. Habitat suitability have been calculated as weighted averages of suitability scores of individual ground characteristics.

Multi-criteria Analysis:

A model to evaluate tiger suitability has been developed using multi criteria suitability index approach by integrating different inputs parameters. Each parameter has in the form of output map derived from source layers and have been categorized in 0-9 scale which was further grouped into highly suitable 8-9, High Suitable 6-8, moderately suitable 4-6, less suitable 2-4 and unsuitable 1. Further weighted have been assigned to each parameter so as to accommodate their significance. Weightage for each parameter have been assigned by taking into account the significance of each parameter in deciding tiger habitat as well as its ecological value derived from literature survey and expert knowledge.

For Chital Habitat Suitability analysis Vegetation type has assigned the weightage of 20, Forest density (15), Slope (15), Distance to water (15), Topography (10), Drainage Density (10), Distance to Habitation (10) and Distance to Road& Railway have been assigned the weightage of (5).

Finally, all the parameters (P1…P9) have been integrated to derive the chital habitat suitability map. Figure shows the over view of the model structure. As this approach was common in a management decision or policy making context, the critical concern was whether the map was so sensitive to variation in inputs that a different decision would be reached with a different realization of the inputs. A simple correlation between range-wise estimated suitable area and their respective chital population distribution has used to qualitatively assess the model prediction.

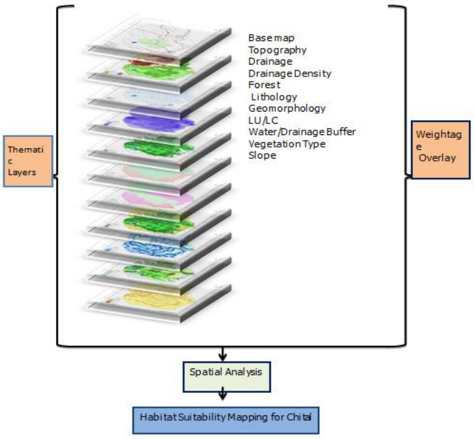

Fig. 4: GEOSPATIAL MODELING – Habitat Suitability Mapping for Chital

(i) All the data sets have been then converted into raster grid in the model in order to perform different GIS analysis between data layers such as overlay analysis.

(ii) All the data sets have been reclassified based on their importance to Habitat potentiality (availability).

(iii). Prior to integration of the data sets, individual class weights and map scores have been assessed based on Multi criteria weighted overlay (Table 1).

(iv). After given the weight of the each class and influence (%) of the each layer depend on the Habitat Suitability prepare the Habitat Suitability Map.

A Number of factors that tells how important a variable are for a particular calculation. The larger the weight assigned, the more that variable will influence the outcome of the operation, called the weighted based function. All steps were done on Arc GIS 9.3.

Table: 1. Influences and weightage of different thematic layers for contributing habitat for Chital in Panna National Park.

Raster Layer	Influence % (Theme Weight)	Feature Classes or Buffer Distance	Feature Class Weight
Vegetation	**20**	**Vegetation Type**	
		Misc forest with grassland	9
		Mixed Forest	7
		Teak & bamboo plantation.	6
		Teak Forest	5
		Pure Sal	6
		Salai Forest	2
		Non Forest	1
Forest Cover	**15**	**Forest density**	
		Dense	6
		Moderate Dense	9
		No Forest	1
River & WB	**15**	**River & WB Buffer**	
		0-500m	9
		500-1000 m	7
		1000-2000m	5
		2000-3000	3
		Above 3000 m	1
Slope	**15**	**Slope Gradient in Degree**	
		0-2 %	2
		2-5 %	9
		5-10 %	7
		10-15 %	5
		15-20 %	4
		20-30 %	3
		Above 30 %	1
Topography	**10**	**Elevation in M**	
		0-400m	9
		400-500 m	6

		500-600 m	5
		600-700 m	4
		700-800 m	3
		800-900 m	2
		Above 900m	1
Drainage density	**10**	**Drainage Density**	
		Very high	9
		High	7
		Moderate	5
		Low	2
Road & Rail	10	Distance to Road & Rail	
		0-100 m	4
		100-500 m	3
		500-1000 m	5
		1000-2000 m	7
		Above 2000m	9
Human Settlement	**5**	**Distance to Settlement**	
		0-100 m	2
		100-500 m	4
		500-1000 m	6
		1000-2000 m	9
		Above 2000 m	9

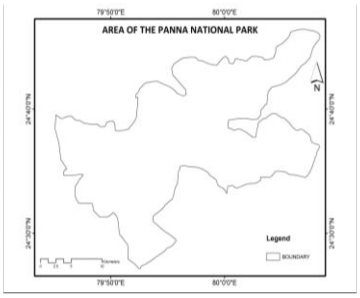

Fig. 5: Area of Interest (AOI) map of the Study area

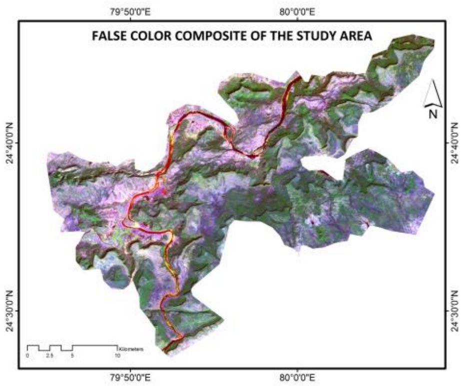

Fig. 6: False color composite (FCC) of the Study area

Results and Discussion:

The habitat evaluation for the wild animals depends on the various environmental and ecological factors like vegetation type, height and slope, drainage patterns, water proximity, human settlement, road and railways construction, forest types and prey availability. In the Present study we analysis the habitat suitability and preparation of the habitat suitability maps for the chital on the basis of weighted rank given by opinion of expert, topographic maps, and remotely sensed data through ERADS 9.1 and Arc GIS 9.3 software and field survey method were applied. for the present study area weightage maps (Figure 7 to figure 12) of the parameters Vegetation type, Forest density, Slope, Distance to water, Topography, Drainage Density, Distance to Habitation and Distance to Road& Railways have been assigned respective theme weight and their class weights.

The individual theme weight has been multiplied by its respective class weight and then all the raster thematic layers have been aggregated in a linear combination equation in Arc Map GIS Raster Calculator module as given

For Chital:

HSM = (FDwt * 0.15) + (VTwt * 0.20) + (DWwt * 0.15) + (Slopewt* 0.15) + (Elvwt * 0.10) + (DDwt * 0.05) + (DHwt * 0.05) + (DR&Rwt * 0.10)

Here,

HSM = Habitat Suitability Map, FD = Forest Density, VT= Vegetation Type, DW= Distance to Water, ELV= Elevation, DD = Drainage Density, DH = Distance to Habitation, DR& DR = Distance to Road & Railway, wt = Feature class weight.

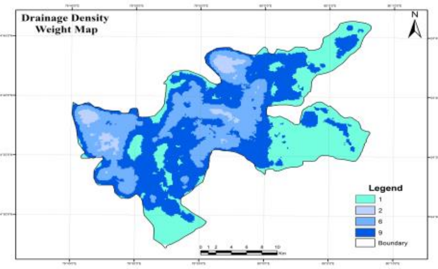

Fig. 7: Drainage Density Weight Map

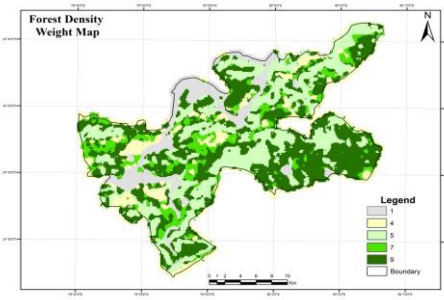

Fig. 8: Forest Density Weight Map

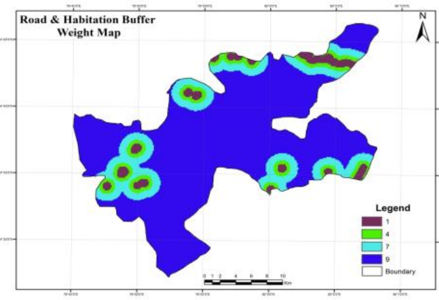

Fig. 9: Road and Habitation Buffer Weight Map

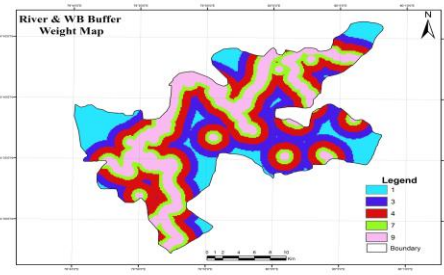

Fig. 10: River and Water Body Buffer Weight Map

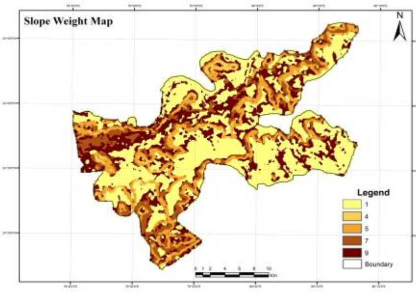

Fig. 11: Slop Aspects Weight Map

The Arc GIS 9.3 was used for suitability modeling (to locate suitable areas); higher values generally indicate that a location is more suitable. The tool has been used to generate a Habitat Suitable area for chital. The final cumulative map generated by applying the above equation. Run the Weighted Overlay tool; the cell values of each input raster are multiplied by the raster's weight (or percent influence). The resulting cell values are added to produce the output raster.

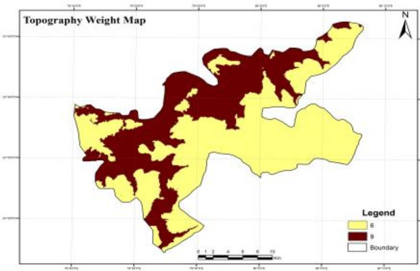

Fig.12: Topography Weight Map

The delineation of Habitat Suitability Zone by reclassifying into different potential zones; Very Good, Good, Moderate, Low and Unsuitable (figure13) was made by utilizing the Criteria for GIS analysis have been defined on the basis of Field survey, Field Data and experts knowledge, appropriate weightage has been assigned to each layer according to relative contribution towards the desired output. The map produced has shown that the Habitat Suitability Zone of the project area is related mainly to Forest density, Forest type Availability of water, Slope and Topography of the area.

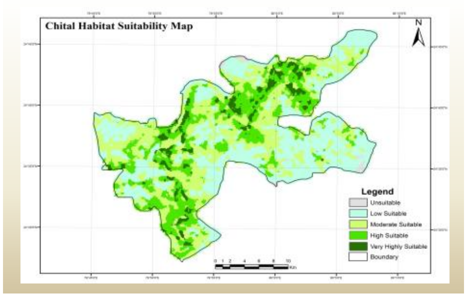

Fig. 13: Habitat Suitability Map for Chital

Water availability is a critical requirement for survival of wild animals in the study area. In the study area landscape, there are an only Ken River is the perennial water sources; water becomes particularly scarce during the summer months. At such times, prey populations also converge at water sources providing predators with hunting opportunities. Movement into areas proximate to perennial water sources would therefore be favored.

Human settlements areas are usually avoided by wild animals. The denser and more populous an area, the more formidable it is as a movement barrier. Within the forest habitat show preferences for different habitat conditions imposed by the structure and composition of forest. An area having a high density of road would be avoided by wild animals as compared to an area with few or no roads because there is a high traffic and constant noise. This edge effect includes a distinctive species composition or abundance in the outer part of the landscape patch (Forman, 1995). Species like the chital, which prefer edge habitats, generally avoid core areas of areas.

Conclusion:

Habitat suitability modeling is the best tools to analysis the suitable site of the particular habitat for the occupancy of wild animals; it depends on the environmental conditions, ecological parameters and availability of food for their survival in the habitats. This study was undertaken to prepare the habitat suitable model for the chital in the Panna National Park with the help of remote sensing and GIS tools. The study represents the more suitable sites for the habitat occupancy of chital surrounding of the proximate to water body other than the human settlement. The denser and more populous an area, the more formidable it is as a movement barrier. Within the forest habitat show preferences for different habitat conditions imposed by the structure and composition of forest. An area having a high density of road would be avoided by wild animals as compared to an area with few or no roads because there is a high traffic and constant noise.

References:

1. Alfred, J.R.B. (1998) - *Faunal Diversity in India: An overview - in Faunal Diversity in India*. I-viii, 1–485. Ed. Alfred J R B, et al., 1998. Envis Centre, Zoological Survey of India, Kolkata.
2. Butterfield, B.R.B., Csuti, J.M.S. (1994) - *Modeling vertebrate distribution for Gap analysis.* In: R.I.Miller, E., editor, Mapping the diversity of nature. London: Chapman and Hall.
3. Champion, H. G., Seth, S. K. (1968) - *A Revised Survey of the Forest Types of India*, Government of India, Delhi, India.
4. Clark, P. J., Evans, F. C. (1954) - *Distance to nearest neighbor as a measure of spatial relationships in populations*. Ecology, 35, 445-453.
5. Davis, F. W., Goetz, S. (1990) - *Modeling vegetation pattern using digital terrain data*. Landscape Ecology, 4, 69-80.
6. Forman, R.T.T. (1995) - *Land Mosaics: The Ecology of Landscapes and Regions.* Cambridge University Press, Cambridge, UK.
7. IUCN (2010) - *IUCN Red List of Threatened Species.* Version 2010. Available: http://www.iucnredlist.org. Accessed January 2012.
8. Jhala, Y.V., Qureshi, Q., Gopal, R., and Sinha, R. P. (Eds.) (2011) - *Status of the Tigers, Co-predators, and Prey in India, 2010.* National Tiger Conservation Authority, Govt. of India, New Delhi, and Wildlife Institute of India, Dehradun. TR 2011/003, 302
9. Johnson, L. B., (1990) - *Analyzing spatial and temporal phenomena using geographical information systems*. Landscape Ecology, 4, 31-43.
10. Karanth, K.U. (2003) - Tiger ecology and conservation in the Indian subcontinent. Journal of Bombay Natural History Society, 100 (2&3), 169–189.
11. Kushwaha, S. P. S., Khan, A., Habib, B., Quadri, A. and Singh, A. (2004) - *Evaluation of sambar and muntjac habitats using geostatistical modelling.* Current Science, 86 (10) 390–1400.
12. Lawton, J.H. and Woodroffe, G.L. (1991) - *Habitat and the distribution of water volves: why are there gap in a species range?* Journal of Animal Ecology, 60,79-91.
13. Nazeri, mona, Jusoff, Kamaruzzaman, and Madani, nima (2010) - *Habitat model as a research gap in biodiversity conservation in tropical rain forest of Southeast Asia*.
14. Rathore, C.S., Dubey, Y., Shrivastava, A., Pathak, P. and Patil, V. (2012) - *Opportunities of Habitat Connectivity for Tiger (Panthera tigris) between Kanha and Pench National Parks in Madhya Pradesh, India.* PLoS ONE 7(7): e39996. doi:10.1371/journal.pone.0039996.
15. Reichert, P. and Omlin, M. (1997) - *On the usefulness of overparametrized ecological models.* Journal of Ecological Modeling,95:289-299.
16. Saunders, D.A., Richard, J. H. and Chris R. M. (1991) - *Biological Consequences of Ecosystem Fragmentation: A Review.* Conservation Biology. 5(1),18-32.
17. Schadt, et. al. (2002) - *Assessing the suitability of Central European landscapes for the reintroduction of Eurasian lynx.* Journal of Applied Ecology, 39,189–203.
18. Schamberger, M., Krohn, W. B. (1982) - *Status of the habitat evaluation procedures*. Trans North American Wildlife Natural Resource Conference, 47, 154–164.
19. Sperduto, M.B. (1996) - *Predicting rare orchid (small whorled pogonia) habitat using GIS.* Photogrammetric Engineering and Remote Sensing, 62, 1269-1279.
20. U.S. Fish and Wildlife Service (1981) - *Standards for the development of habitat suitability index models for use in the habitat evaluation procedure.* Div. Ecol. Serv. Man, 103. Washington, DC: U.S. Department of Interior, Fish and Wildlife Service, 170.
21. U.S. Fish and Wildlife Service (1980) - *Habitat evaluation procedures (HEP)* Div. Ecol. Serv. Man. 102. Washington, DC: U.S. Department of Interior, Fish and Wildlife Service, 127.
22. Zarri, A. A., Rahmani, A. R. Singh A. and Kushwaha, S. P. S. (2008) - *Habitat suitability assessment for the endangered Nilgiri Laughingthrush: a multiple logistic regression approach*. Current Science, 94,1487–1494.