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Study the changes in Habitat Quality of Indian Elephants in Uttarakhand region using InVEST Model

PRAGATI JHAMB*, G.AREENDRAN, P.K JOSHI, KRISHNA RAJ, ANKITA SHARMA

1. *IGCMC, WWF-India, 172-B Lodi Estate, New Delhi 110003, India*
2. *TERI University 10, Institutional Area, Vasant Kunj, New Delhi 110070, India*

Abstract: This study is an application of Remote sensing and GIS where InVEST Model has been used to see the changes in habitat quality of Indian Elephants in Uttarakhand region as this region is frequently visited by elephants from the neighboring areas. The state is facing a large number of Human Elephant conflicts because of human interference in the habitat region of elephants. The Landsat images of year 1998 and 2014 have been used to prepare landuse land cover maps and threat layers including urban area, agriculture and fallow land have been extracted from them. Also road layer has been used as threat which is downloaded from DIVA-GIS. The inputs including landuse landcover maps, threat layers, access layer, sensitivity table and threat table area fed to the model and outputs were generated. The outputs provided by the model include Habitat Quality and Degradation maps which clearly show the decline in the habitat quality of elephants in this region. Finally the overlay analysis has been performed to extract suitable area for elephants to survive.

Key Words: Biodiversity, ecosystem, endangered, habitat degradation, habitat suitability, Human elephant conflict (HEC).

Introduction

Objectives

The main objective behind this study is to see the changes in landuse landcover pattern and to generate maps using InVEST model which will clearly show how the habitat condition has deteriorated between the two years with increase in human activities. Also we will be able to compare spatial patterns of biodiversity and ecosystem services, and to identify areas where conservation can benefit both natural systems and human economies.

Background

A large number of elephants are losing their homes because of change in habitat quality from last many years. They have been categorized as “endangered” species as per IUCN red list. Conversion of forested land with human activities into settlements, agriculture and other infrastructure such as dams has led to fragmentation, shrinkage and degradation of elephant habitat and they lose their traditional path for movement. When this happens, elephants in search of food, water and habitat enter into human habitations and create human conflicts such as destroying crops, livestock, property and may also kill human beings (Areedran et al. 2011). So it is very important to do habitat analysis in order to properly plan and manage protected areas. Habitat quality depends on a habitat’s proximity to human land uses and the intensity of these land uses. Generally, habitat quality is degraded as the intensity of nearby land-use increases.

India has the largest remaining populations of Indian elephant (estimated at around 57% of the total). There are four populations and ten sub populations of the mainland Indian elephant, distributed in the South, Central, Northwest and Northeast regions in India**.** In the north Indian state of Uttarakhand, the distribution of the Indian elephant population spreads in the Sivalik-Terai biotic zone from its north western limit in the Timli range of Kalsi Forest Division in Dehradun district through the Rajaji-Corbett corridors, up to the eastern limit of Khatima-Kilpura-Surai Sivalik elephant corridor bordering with Nepal. This stretch of elephant range is distributed between two major rivers, Yamuna in the west and Sharda in the east. Also a larger section of Uttarakhand's population is concentrated in its sub-Himalayan Terai region outside the protected areas of Rajaji-Corbett Elephant Corridor and adjoining reserved forests with an average population density being 400km^2. This is apparently an indication of the fact that the higher population density in the Terai belt increases the chances of more human pressure on its forest covered landscapes and can adversely affect the natural habitats of the elephants creating an environment of threat to the elephants through increasing incidences of Human-elephant conflict (HEC) and loss of natural habitats. The Rajaji-Corbett elephant corridor in the western side and the Khatima-Kilpura-Surai forest range bordering Nepal under the Terai East forest division are the two key segments of Uttarakhand's elephant range from where elephants often migrate from one segment to another in search of seasonally available food resources. During the migration, the elephants tend to select potential areas along the migratory routs for potential food and water resources. In this process of migration, elephants on many occasions enter into the fringe agricultural lands and raid the crops.

Study area

Uttarakhand is a state in the northern part of India has a total area of 53,483km^2 and is geographical located between 79°23 and 79°42E, and 29°20 and 29°30N. Most of the northern part of the state is covered by high Himalayan peaks and glaciers. It is often referred to as the Devbhumi (Land of Gods) due to the many Hindu temples and pilgrimage centers found within the state. It is known for its natural beauty of the Himalayas, the Bhabhar and the Terai. Uttarakhand has a great diversity of flora and fauna. It has total forest area of 34,651km^2, which constitutes 65% of the total area of the state. Highly endangered species like the Snow Leopard, Musk Deer, Tiger, Asian Elephant, Bharal, Himalayan Monal, Cheer Pheasant, King Cobra etc. find suitable habitat in the forests of Uttarakhand. Four major forest types are found in the Uttarakhand, which includes alpine meadows in the extreme north, temperate forests are in the Great Himalayas, tropical deciduous forests are present in the Lesser Himalayas, and thorn forests in the Sivalik Range and in parts of the Terai. The forests provide not only timber and fuel wood but also huge grazing land for livestock. Only a little portion of the state's total land area has permanent pastures.

Summers in the plain region of Uttarakhand have similar climate as other surrounding plain regions of different states, the maximum temperature can cross the 40°C mark and there can be considerable humidity. The winters in the middle Himalayan valleys are very cold and in the higher areas the temperature falls below the freezing point. The Himalayan peaks remain snow covered throughout the year and many places receive regular snowfall. Throughout the state the temperature is from sub-zero to 15°C and the season lasts from November to February. The monsoon is the most pleasant season when temperature differs from 15 to 25°C at most places which reigns from July to September. The state receives 90% of its annual rainfall in this season.

The state has various varieties of soil, all of which are susceptible to soil erosion. In the north, the soil is from gravel (debris from glaciers) to stiff clay. Brown forest soil is often shallow, gravelly, and rich in organic content and is found farther to the south. Uttarakhand is drained by various rivers of the Ganges system. The westernmost watershed is formed by the Yamuna River and its major tributary, the land to the east of this basin is drained by the Bhagirathi and the Alaknanda. The state has 12 National Parks and Wildlife Sanctuaries, they are located at different altitudes varying from 800m to the high altitude Protected Areas at 5400m. Apart from these there are two Conservation Reserves, The Asan Barrage and Jhilmil Tal conservation Reserves.

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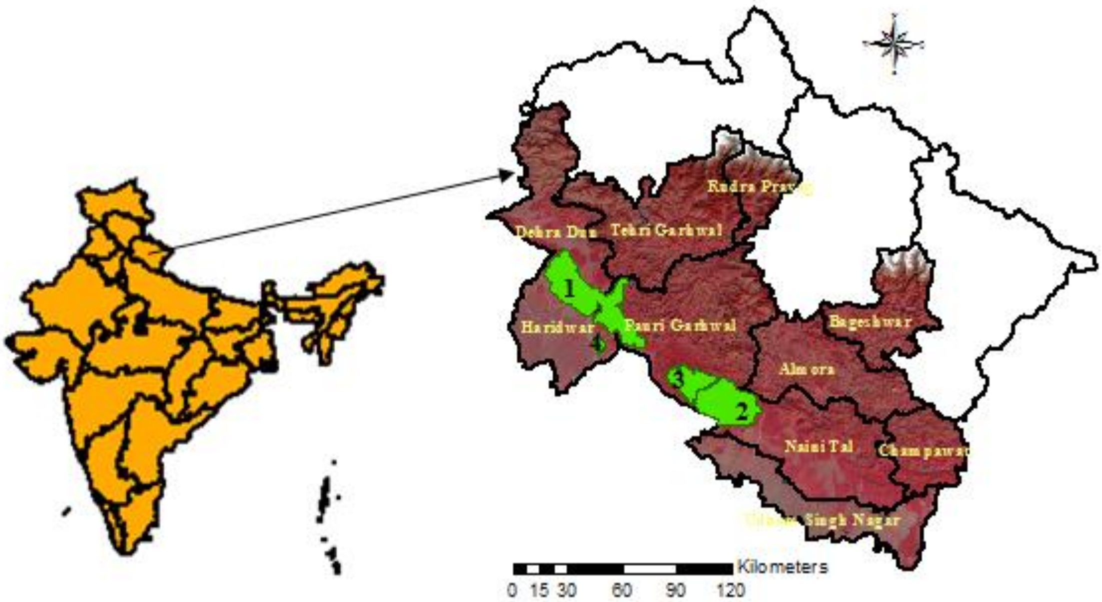

Figure1: Map of study area

There are 13 districts in Uttarakhand which are grouped into two divisions, Kumaon and Garhwal. The districts which have been included in our study are Dehradun, Haridwar, Tehri Garhwal, Pauri Garhwal, Rudraprayag, Bageshwar, Almora, Champawat, Nanital and Udham Singh Nagar **(Figure1).** The protected areas present in this region are 1.Rajaji National Park, 2.Corbett National Park 3.Sonandi Wildlife Sanctuary and 4. Jhimijheel Conservation Reserve.

Software used in the study

Erdas imagine 9.1 and Arcgis10.1.InVEST model is a free of cost software product licensed under the BSD open source license. The development of InVEST is an ongoing effort of the Natural Capital Project. It has 2 types of Models:

1.Suporting ecosystem services

2.Final ecosystem services

In this study we have used Habitat Quality Model which is Supporting Ecosystem Services model to study the changes in the habitat quality of Indian Elephants. The InVEST habitat quality model combines information on LULC and threats to biodiversity to produce habitat quality maps. Habitat quality is a function of four factors: each threat's relative impact, the relative sensitivity of each habitat type to each threat, the distance between habitats and sources of threats, and the degree to which the land is legally protected. The inputs required include a LULC map, the sensitivity of LULC types to each threat, spatial data on the distribution and intensity of each threat and the location of protected areas.

Methodology

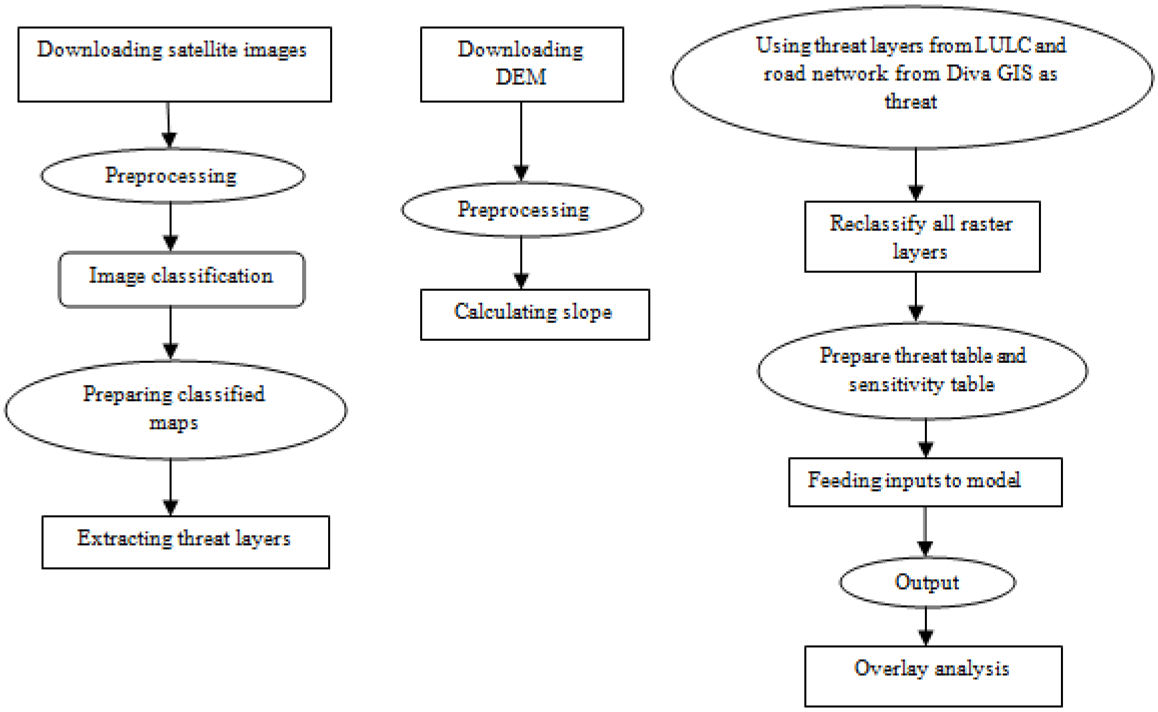

Figure2: Flow diagram of methodology

Creating spatial database

Landsat images of two years including 1998 and 2014 were downloaded from earthexplorerusgs.gov. Since the area of was not covered in single tile, 3 tiles for both the years were taken, each tile was georeferenced and further mosaiced to create a single image. After mosaicing the study area was clipped using shapefile of the same area.

Preparing Land use Land cover maps using Image classification

Unsupervised method of image classification has been used here to group the study area into different classes. In this method the identities of land cover to be classified as classes within the scene are not generally known. The computer is required to group pixels with similar spectral characteristics into unique clusters according to statistically determined criteria. The analyst then relabels and combines the spectral cluster into information classes. Unsupervised classification can be done using different types of algorithm, here ISODATA clustering has been used. It is a self organizing method because it requires very less human input. Here the image was classified into 8 classes including Dense forest, Open forest, Scrubs, Agriculture, Fallow land, Water, Snow and Urban area.

Dem downloading and processing

SRTM DEM OF 90m resolution was downloaded from srtm.csi.cgiar.org website. The total area was covered in 4 tiles, after that each tile was georeferenced, mosaiced and finally clipped to study area **(Figure3).** Slope i.e the incline, or steepness, of a surface of area was calculated using Surface tool present in Spatial analyst tool of ARCGIS toolbox.

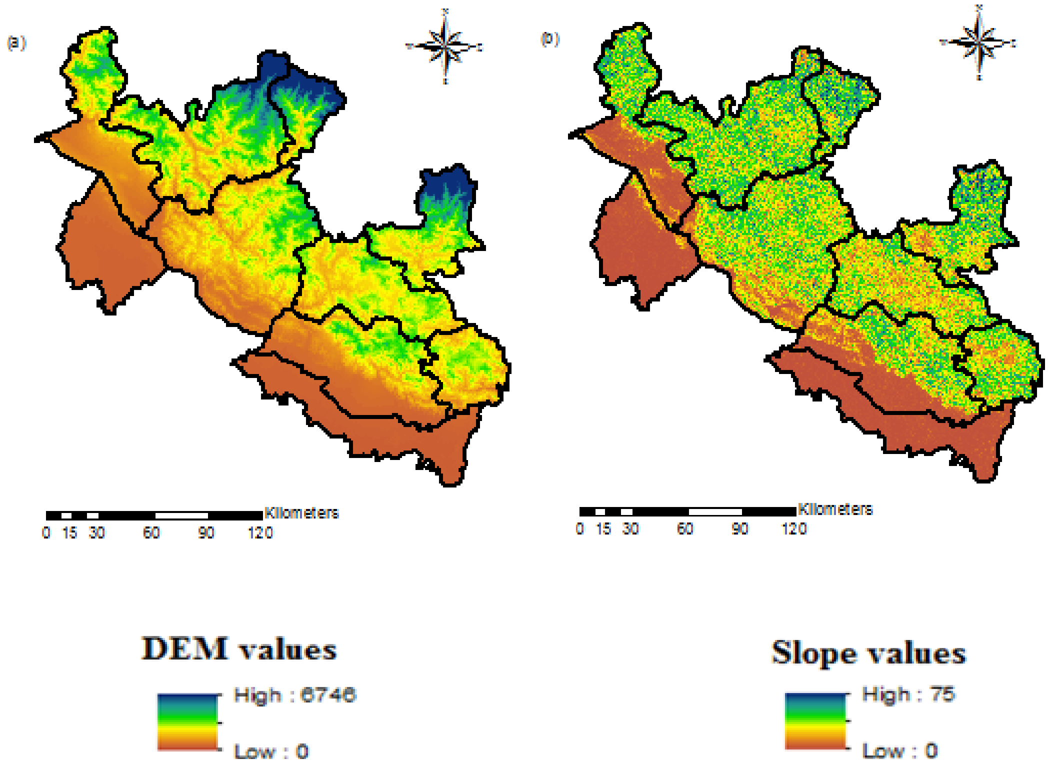

Figure3:(a) DEM of study area (b) Slope of study area

Preparing inputs to run the model

1. *Current and baseline land use land cover maps:* A GIS raster dataset, with a numeric LULC code for each cell. The LULC raster should include the area of interest, as well as a buffer of the width of the greatest maximum threat distance. They are taken from the outputs derived at 1st step of methodology.
2. *Threat images of both current and base year:* There should be as many of these maps as you have threats. These threat maps should cover the area of interest, as well as a buffer of the width of the greatest maximum threat distance. Each cell in the raster contains a value that indicates the density or presence of a threat within it, and all threats should have same metric unit. When LULC images of both the year are obtained, threats including agriculture, fallow and urban are derived from them by removing the other classes. The shapefile of road network of study area

which also acts as a threat was downloaded from DIVA GIS and then some modifications were done using the current satellite image to create the new roads shapefile which was used as a threat image for current year.

3. *Sensitivity table:* A table of LULC types, whether or not they are considered habitat, and, for LULC types that are habitat, their specific sensitivity to each threat. It contain columns and rows. Each row is a LULC type & columns contain data on land use types and their sensitivities to threats. Columns must be named according to the naming conventions below as shown in **Table1**.The values taken in the table are on the basis of expert guidance. The weightage given to each habitat type lies between 0 and 1 with 0 being the least preferred habitat type and 1 being the highest for elephant survival. For example: Open forest are more suitable than dense forest so they have been given higher weightage. The 4 threats including agriculture, fallow land, urban area and roads have also given weightage on the basis of their sensitivity to each habitat type.

Table1: Sensitivity table

LULC	NAME	HABITAT	L_agri	L_fal	L_urb	L_road
1.	Dense forest	0.8	0.8	0.6	0.5	0.5
2.	Open forest	1	0.9	0.6	0.6	0.5
3.	Scrubs	1	0.9	0.8	0.6	0.4
4.	Agriculture	0.4	0	0.9	0.7	0.7
5.	Fallow	0.3	0.8	0	0.7	0.8
6.	Urban	0.1	0.7	0.8	0	1
7.	Snow	0	0	0	0	0
8.	Water	1	0.8	0.7	1	0.7

4. *Threat table:* A table of all threats you want the model to consider. The table contains information on the each threat's relative importance or weight and its impact across space. The threat table consists of following factors:

4.1 The first factor is the relative impact of each threat: Some threats may be more damaging to habitat, all else equal, and a relative impact score accounts for this (**Table 2**). For instance, urban areas may be considered to be twice as degrading to any nearby habitats as agricultural areas. A degradation source weight, indicates the relative destructiveness of a degradation source to all habitats. The weight can take on any value from 0 to 1.

4.2 The second mitigating factor is the distance between habitat and the threat source and the impact of the threat across space: In general, the impact of a threat on habitat decreases as distance from the degradation source increases, so that grid cells that are more proximate to threats will experience higher impacts. The user can choose either a linear or exponential distance-decay function to describe how a threat decays over space. If the threat decays at a constant rate then choose exponential decay and if it decays with a fixed value choose linear decay. In the table below the distance has been taken in kilometers.

MAX_DIST	WEIGHT	THREAT	DECAY
1.5	0.5	agri	exponential
1.5	0.5	fal	exponential
3	1	urb	exponential
0.5	0.6	road	linear

Table2: Threat table

5. *Half degradation constant:* By default it is set to 0.5 but can be set equal to any positive number. In general, you want it is set to half of the highest grid cell degradation value on the landscape. To perform this model calibration you will have to the run the model once to find the highest degradation value and set for your landscape. Here the degradation was ranging from 0 to 1 so it has been kept as 0.5.

6. *Accessibility to sources of degradation (optional):* A GIS polygon shapefile containing data on the relative protection that legal / institutional / social / physical barriers provide against threats. Polygons with minimum accessibility (e.g., strict nature reserves, well protected private lands) are assigned some number less than 1, while polygons with maximum accessibility are assigned a value 1. Here the shapefile of protected areas shown in **Figure1** has been used as access layer by giving each area a particular score.

Note: After preparing each of the input as above there is a need to reclassify each of the raster layer including the land use land cover maps and the threat layers. Reclassification helps to remove extra classes present and also the NO DATA present is merged with some other class so that the inputs are accepted by the software without any failure. It is done using the Reclassify tool present in Spatial analyst tool of Arctoolbox.

Performing overlay analysis

After obtaining quality maps from InVEST Model as the output the four layers including DEM, Slope, Protected area boundary and quality maps have been overlayed by giving suitable weightage to each of these layers on the basis of suitable condition for elephant habitat for example slope values are ranging from 0 to 75 degree , so 0-20 has been given highest score then 21 to 35 less value and above 35 zero value was given in similar manner each layer was reclassified and then given a weightage, finally all these weighted layers

were overlayed using weighted sum tool present in Arctoolbox to obtain habitat suitability maps.

Results

Landuse Landcover changes

The image has been classified into 8 categories including dense forest, open forest, scrub land, agriculture, fallow land, urban area, snow and water **(Figure4)** to prepare landuse landcover maps of both the years. Major changes which came up between both the years include that dense and open forests have reduced whereas the scrub land increased also a large part has been converted to agricultural land which is a source of livelihood for common people. Besides these major changes, urban areas have also increased from 0.55% to 1.15% **(Table3),** snow and water bodies have slightly decreases.

Table3: Percent change in area of each class

CLASS NAME	AREA IN 1998	AREA IN 2014
Dense forest	36.69	28.19
Open forest	35.30	24.64
Scrubs	6.58	22.11
Agriculture	4.9	11.74
Fallow land	12.16	10.33
Urban	0.55	1.15
Snow	2.74	1.14
Water	0.98	0.66

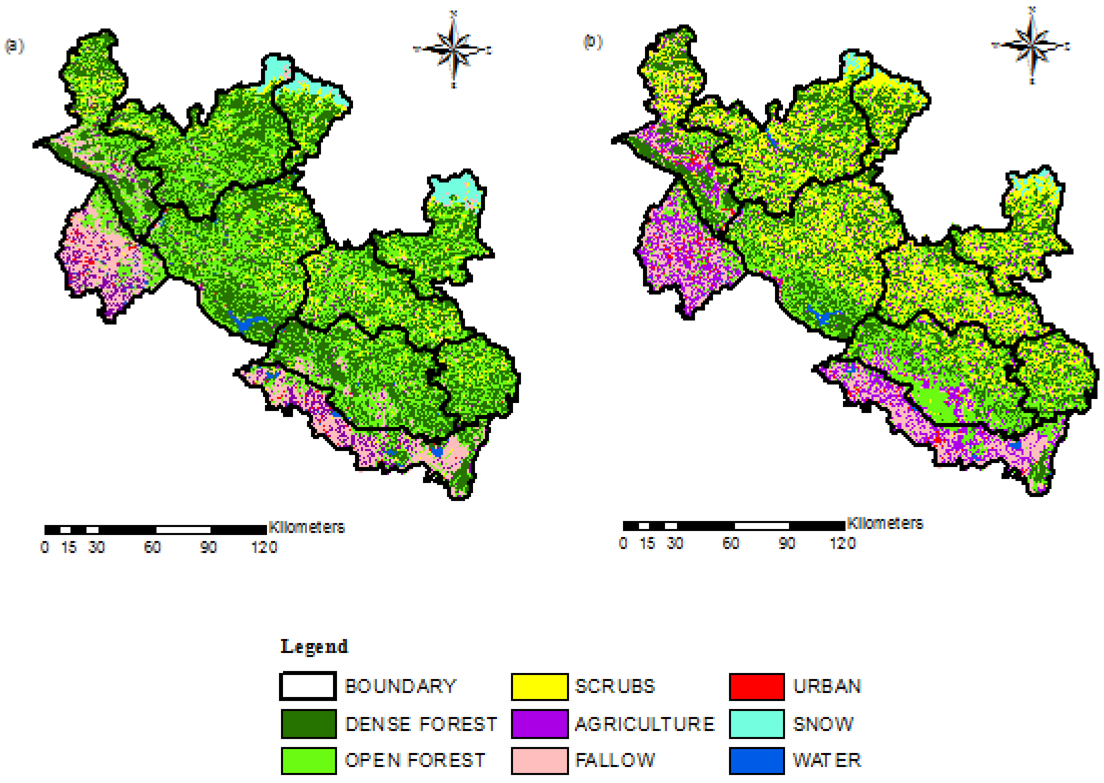

Figure4: (a) LULC map of 1998 (b) LULC map of 2014

Outputs from Invest Model and Overlay Analysis

InVEST Model gives two types of output including degradation and habitat quality maps. Degradation maps show relative level of habitat degradation on the current and baseline landscape. A high score in a grid cell means habitat degradation in the cell is high relative to other cells **(Figure5).** Grid cells with non habitat land cover get a degradation score of 0.

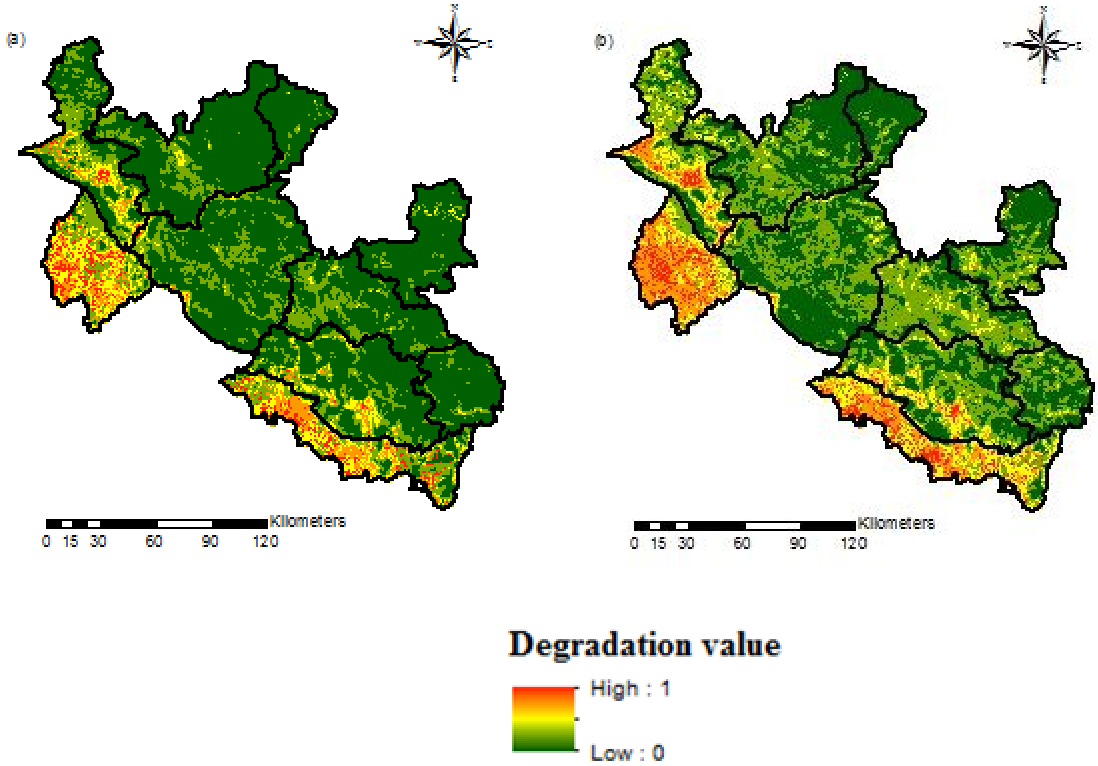

Figure5: (a) Habitat degradation in 1998 (b)Habitat degradation in 2014

Quality maps show habitat quality on the current and baseline landscape. Higher numbers indicate better habitat quality whereas areas on the landscape that are not habitat get a quality score of 0 **(Figure6).** The results obtained by the model clearly show that the quality of area has been degraded but it does not demarcate the area which is finally suitable for elephants to survive so it is necessary to perform overlay analysis, protected area boundary and quality maps. considering all important factors including slope, protected area boundary and quality maps.The results of weighted overlay has divided the area into three categories including least suitable, moderately suitable and highly suitable zones for elephants to live**(Figure7).**

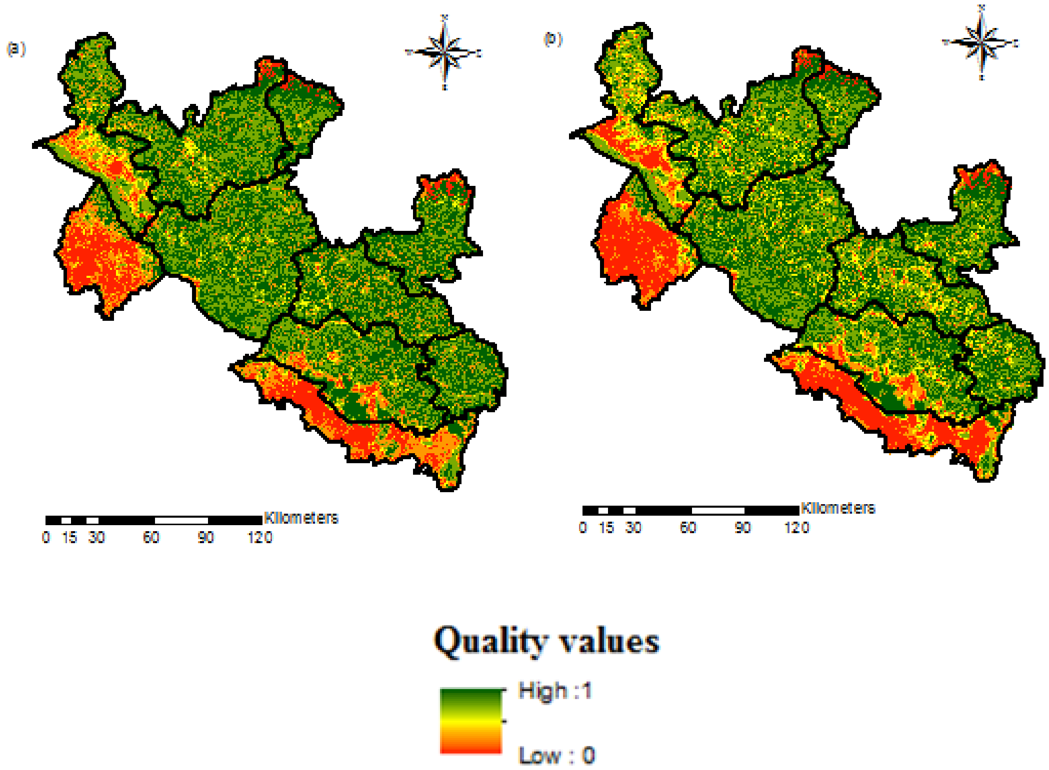

Figure6:(a) Habitat quality in 1998 (b) Habitat quality in 2014

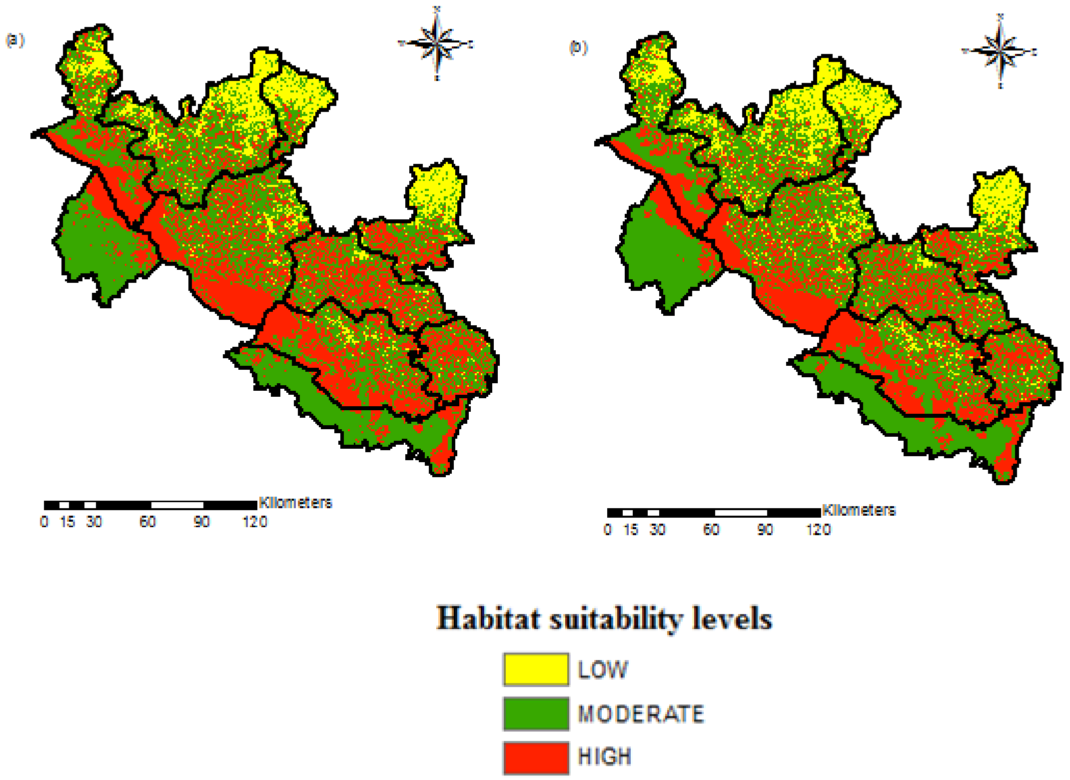

Figure7: (a) Habitat suitability in 1998 (b) Habitat suitability in 2014

Conclusion

This study is an application of geospatial tools to study and model the changes which have occurred in the habitat quality of Indian elephants in Uttarakhand region. The land use land cover changes clearly show that a large area of dense forest has been converted to open forest and open forest have been converted to scrubs. So the habitat quality is degrading day by day due to which elephants are becoming homeless and are entering into human habitations.

The INVEST model which has been used to study the habitat quality and also the results obtained using weighted overlay clearly show that the areas highly suitable for elephants including the protected area boundary have decreased which indicate that the areas where human activities are increasing are losing their quality and have become unsuitable for elephants to live. Till now the development was happening in the unsustainable manner so it was becoming a threat for both animals and human being, but now it has been realized that with use of GIS and Remote sensing the areas which are away from our access can also be managed properly so that the future developments which occur are in a systematic and environment friendly manner so that both animals and human beings live comfortably without interfering into each other habitat.

References

Areendran, G., Krishna Raj, Sraboni Mazumdar, Madhushree Munsi, Himanshu Govil and Sen, P. K.(2011) Geospatial modeling to assess elephant habitat suitability and corridors in northern Chhattisgarh, India. *Tropical Ecology*. 52(3): 275-283.

www.extension.org/pages/40214/whats-the-difference-between-a-supervised-and-unsupervised-image-classification#.VZZNChuqqko(accessed on 10 May 2015)

Human Elephant Conflict (HEC) Issues in Uttarakhand 2015

conservationhimalayas.com/index.php?option=com_content&view=article&id=122:protect-the-elephants&catid=42:wildlife-news(accessed on 5 May 2015)

InVEST_Documentation 2015 www.naturalcapitalproject.org/InVEST.html(accessed on 10 January 2015)

help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#//009z000000s1000000.htm (accessed on 22 April 2015)

www.culturenorthindia.com/uttrakhand/(accessed on 29 April 2015)

www.indianetzone.com/5/flora_uttaranchal.htm(accessed on 25April 2015)

www.uttarakhandtourism.net/climate_of_uttarakhand.htm(accessed on 12April 2015)

www.indianlovesindia.com/uttarakhand/climate-of-uttarakhand.html(accessed on 12April2015)

www.ukgk.in/en/climate.html(accessed on14April2015)

www.bms.co.in/uttarakhand-a-tourist-location/(accessed on 25April2015) ncp-dev.stanford.edu/~dataportal/invest

releases/documentation/current_release/habitat_quality.html(accessed on 11January 2015)

ncp-dev.stanford.edu/~dataportal/invest-releases/documentation/2_4_5/biodiversity.html(accessed on 11January 2015)