# The Rufford Foundation
# Final Report

Congratulations on the completion of your project that was supported by The Rufford Foundation.

We ask all grant recipients to complete a Final Report Form that helps us to gauge the success of our grant giving. The Final Report must be sent in **word format** and not PDF format or any other format. We understand that projects often do not follow the predicted course but knowledge of your experiences is valuable to us and others who may be undertaking similar work. Please be as honest as you can in answering the questions – remember that negative experiences are just as valuable as positive ones if they help others to learn from them.

Please complete the form in English and be as clear and concise as you can. Please note that the information may be edited for clarity. We will ask for further information if required. If you have any other materials produced by the project, particularly a few relevant photographs, please send these to us separately.

Please submit your final report to [jane@rufford.org](mailto:jane@rufford.org).

Thank you for your help.

**Josh Cole, Grants Director**

| Grant Recipient Details | |
|---|---|
| **Your name** | Roshan Kumar Thakur |
| **Project title** | Geospatial Modeling of Walk Trails of Asian Elephant *Elephas maximus* as tool for mitigating Human Elephant Conflicts in Central Nepal |
| **RSG reference** | 17279-1 |
| **Reporting period** | 30th March |
| **Amount of grant** | 4962 £ |
| **Your email address** | hroshanthakur@gmail.com |
| **Date of this report** | 31th May |

**1. Please indicate the level of achievement of the project's original objectives and include any relevant comments on factors affecting this.**

| Objective | Not achieved | Partially achieved | Fully achieved | Comments |
|---|---|---|---|---|
| Elephant Walk trail investigated out | | | Fully Achieved | |
| Habitat Suitability Analysis | | | Fully Achieved | |
| Exact human Elephant conflict Status documented | | | Fully Achieved | |
| Public Presentation program | | | Fully achieved | Workshop was conducted and presentation was given to the local stakeholders. The forest officials blames Park staffs for negligence i.e. deforestation while the park staffs says the forest officials has killed the forest for monetary value. They were made aware about the geographical areas which elephant liked, or with suitable habitat. |
| Farmer's awareness program | | | Fully Achieved | During project implementation time, luckily Parsa wildlife reserve's area extended. CFUGs were made aware about the area elephant are likely to be found. They are amazed about the result and accepted not to disturb the habitat of elephant. |
| Distribution of Elephant Ecology Pamphlet | | | | 250 copies of posters and 500 pamphlets were distributed in the local community for mitigating Human Elephant Conflict. |

**2. Please explain any unforeseen difficulties that arose during the project and how these were tackled (if relevant).**

Earthquake on 12th Baisakh i.e. 25th April 2015 and major aftershock on 12 May, 2015 and Indian blockade to Nepal affected my project to some severe extent. My project's mate's grandmother died in the earthquake due to which the project went

a month delay as per the proposed. Also Indian blockade to Nepal made crisis in Nepal for almost everything from food supplies to day to day living. Due to that blockade, prices hike was four fold of the normal price. The cost of project as projected was not coping with the situation, which made my project very difficult to operate. Due to these two unexpected unforeseen difficulties, every activity went 2-3 months delay.

I waited for my mate because he was an important member of the project which made project a month delay as projected.

Finally, the dates of activities were delaying due to unstoppable Indian blockade so to cope with timeline, logistics were bought at hiked price and the project activities were conducted.

## 3. Briefly describe the three most important outcomes of your project.

Three most important outcomes of my project are as follows-

a. Land Use Land Cover detection for habitat Suitability Assessment.
b. Habitat suitability Analysis was done using Maxent Modelling.
c. Walk trails were identified in the study area.
d. Conservation Program i.e. School Presentation and Public Presentation programs was conducted.
e. The exact status of Human Elephant Conflicts was documented.

Line Transect Survey Layout
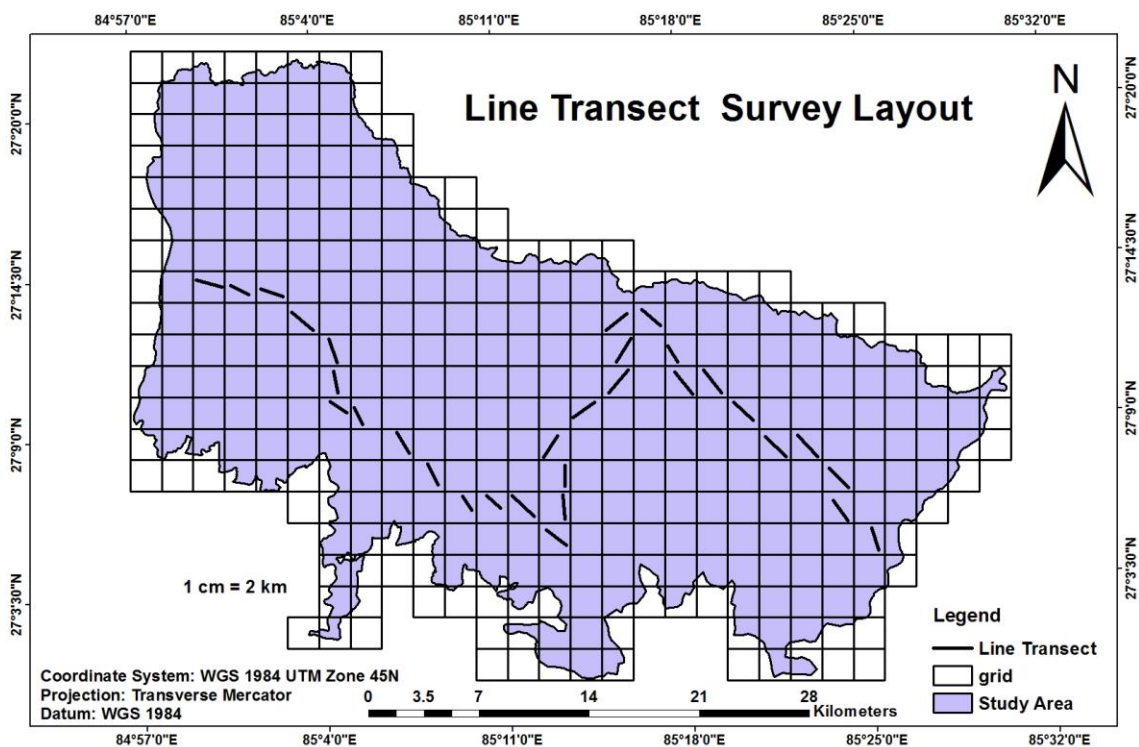
## Images used in Land use Land Cover Classisfication
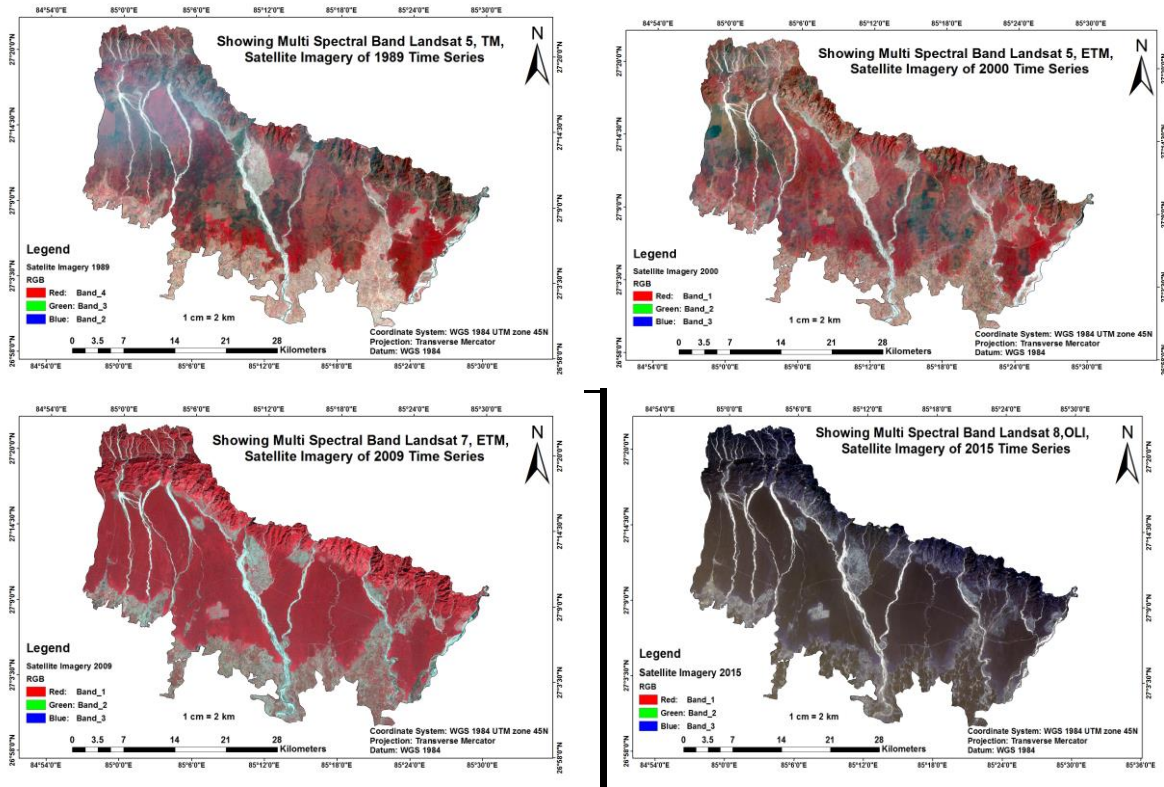


### 3. a Land Use Land Cover Detection for habitat Suitability Analysis.

Land use land cover (LULC) map was prepared to identify forest condition in the study area. Five LULC classes were derived from satellite data(Resource Sat) interpretation for study area using Supervised Maximum Likelihood Image Classification viz. Dense forest, Land area, Sand, Sparse forest, and water bodies with accuracy 86 %. The details of supervised classification are given here below of different four time series.

### Accuracy Assessment:

| class Name | 1989 Landsat 5 Satellite Imagery | | | 2000 Landsat 5 TM Satellite Imagery | | | 2009 Landsat 7 ETM Satellite Imagery | | | 2015 Landsat 8 OLI Satellite Imagery | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Producers Acccuracy (%) | User's Accuracy (%) | Kappa Statistics | Producers Acccuracy (%) | User's Accuracy(%) | Kappa Statistics | Producers Acccuracy (%) | User's Accuracy9%) | Kappa Statistics | Producers Acccuracy (%) | User's Accuracy9%) | Kappa Statistics |
| Dense Forest | 0.9633 | 0.8821 | 0.8679 | 0.8212 | 0.8143 | 0.8098 | 0.8788 | 0.8672 | 0.8475 | 0.8744 | 0.8799 | 0.869 |
| Sparse Forest | 0.9234 | 0.8572 | 0.8451 | 0.8042 | 0.7891 | 0.8176 | 0.8676 | 0.8622 | 0.8532 | 0.8633 | 0.8231 | 0.8332 |
| Sand | 0.8921 | 0.8851 | 0.8541 | 0.8376 | 0.8164 | 0.8129 | 0.8539 | 0.8539 | 0.8544 | 0.8724 | 0.8576 | 0.8593 |
| Land Area | 0.8572 | 0.8321 | 0.8541 | 0.8365 | 0.8345 | 0.8213 | 0.8483 | 0.8483 | 0.8343 | 0.8873 | 0.8783 | 0.8883 |
| Water Bodies | 0.8999 | 0.8862 | 0.8356 | 0.8213 | 0.8177 | 0.8193 | 0.8691 | 0.8691 | 0.8591 | 0.8397 | 0.8362 | 0.8062 |
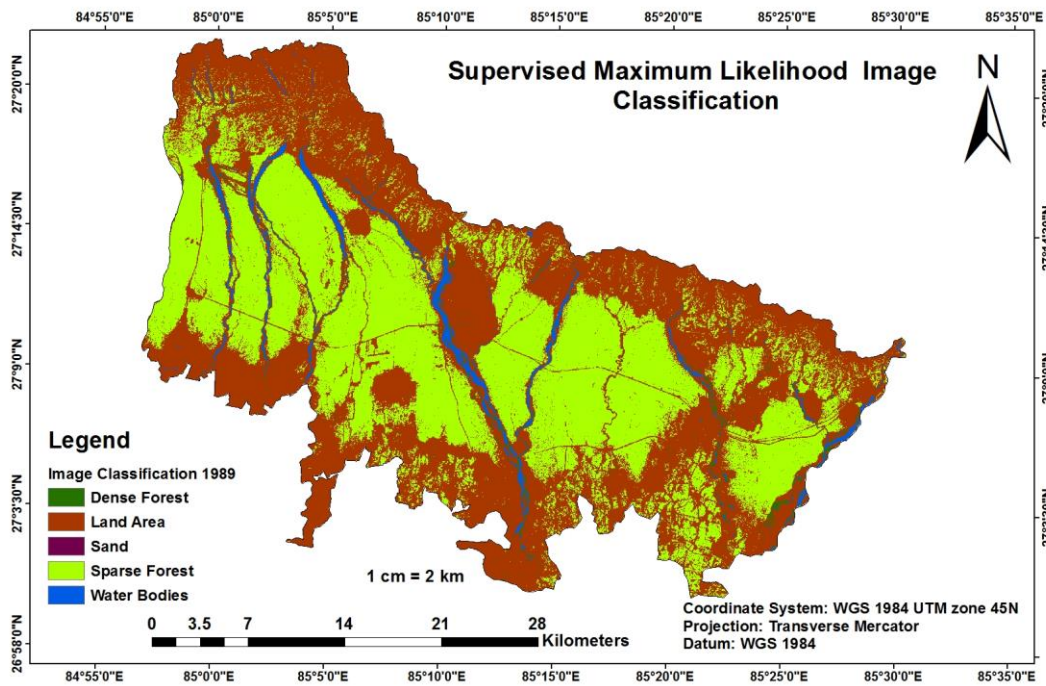
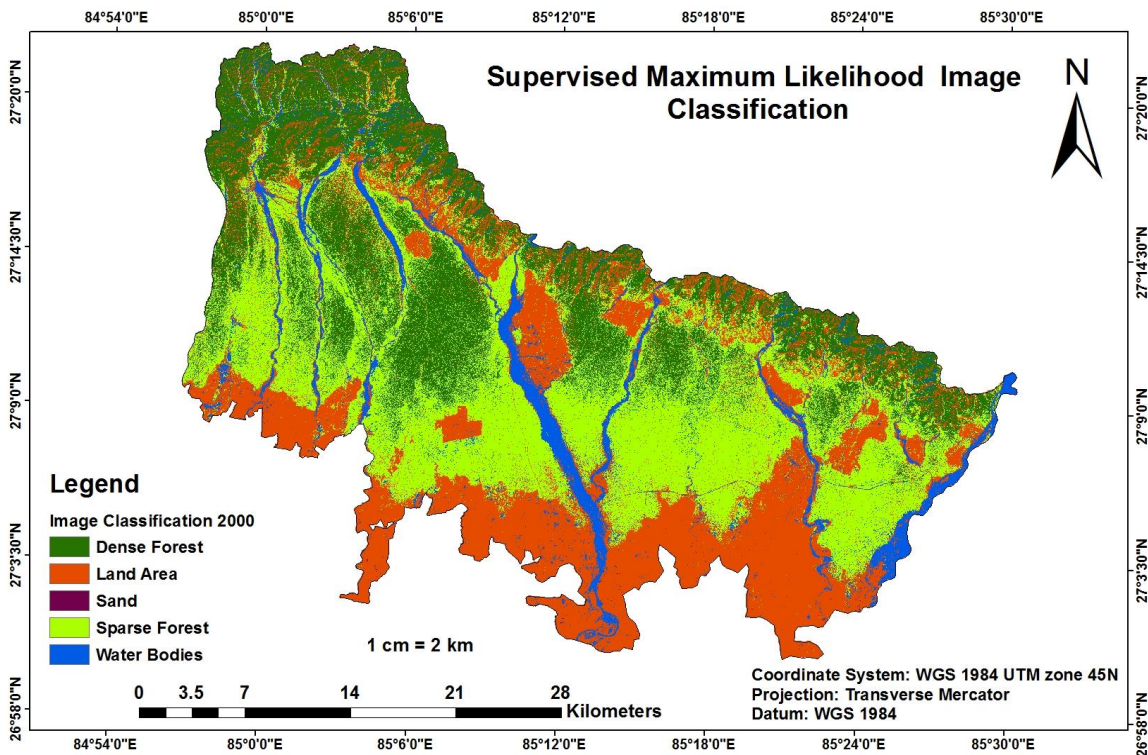Figure 1 Supervised Maximum Likelihood Image Classification Of 1989



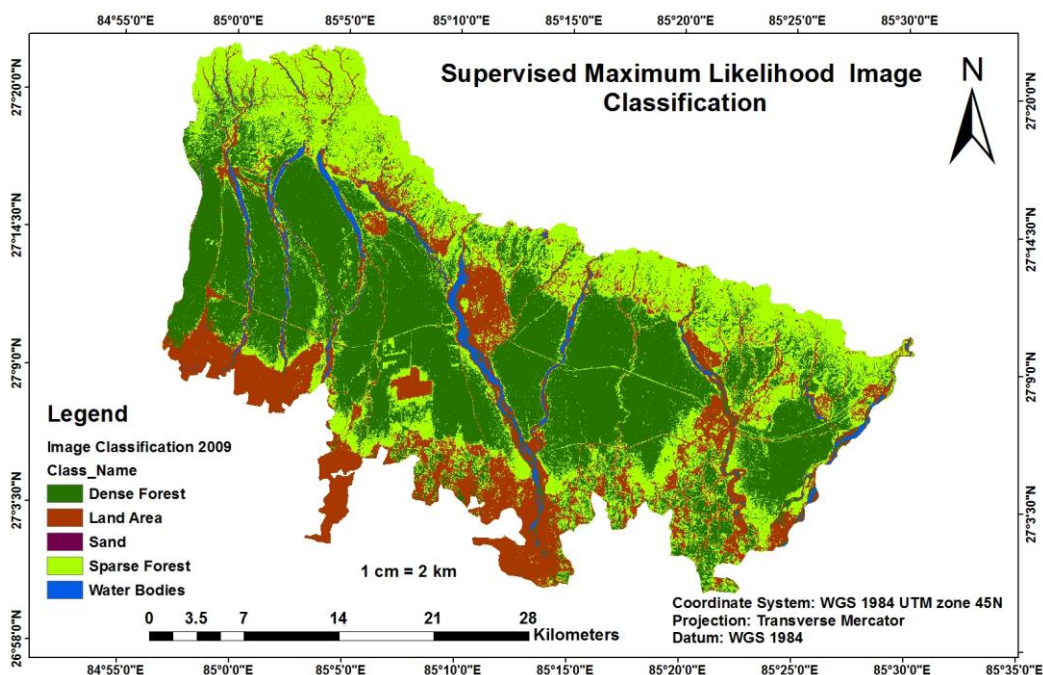Figure 2 Supervised Maximum Likelihood Image Classification of 2000

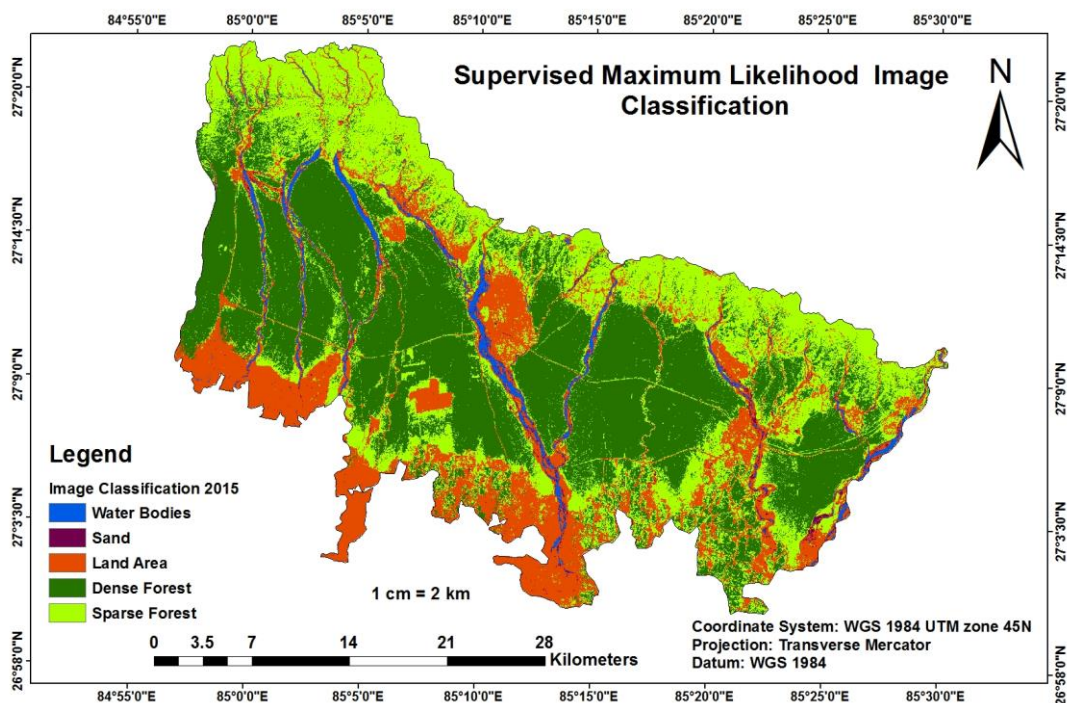Figure 3 Supervised Maximum Likelihood Image Classification of 2009



Figure 4 Supervised Maximum Likelihood Image Classification Of 2015

3.b Habitat Suitability Analysis by Maxent Modelling-

Maximum entropy modeling of species geographic distributions (MaxEnt) was used for predicting probability of occurrence of Elephant. Continuous predictor variables as proximity to agriculture, proximity to water, and proximity to settlement, proximity to dense forest and proximity to sand, proximity to sparse forest, altitude and precipitation were used as independents to evaluate the habitat variable that effectively defines elephant presence.

Fifteen split-sample models for elephant were created using Maxent (software) version 3.3.3k.  624 presence records used for training, 6 for testing & 10632 points used to determine the Maxent distribution (background points and presence points). AUC value ranging from 0 and 1. The Regularized training gain is 0.715, training AUC is 0.824, unregularized training gain is 0.800. Unregularized test gain is 0.914. Test AUC is 0.789, standard deviation is 0.101 (calculated as in DeLong, DeLong & Clarke-Pearson 1988, and equation 2). Algorithm terminated after 500 iterations (13 seconds). Maxent software was run by using environmental layers agriculture, altitude, dense forest, precipitation, sand, settlement, sparse forest, and water. The Regularization values: linear /quadratic / product: 0.050, categorical: 0.250, threshold: 1.000, hinge: 0.500.  Continuous predictor variables are proximity to agriculture, proximity to water, proximity to dense forest, proximity to settlement. LULC map were used as independent to evaluate the habitat variables that effectively define the elephant presence.  Agriculture showed the highest (51.4%) heuristic estimate of relative contribution to the Maxent model. The variables altitude, sparse forest and precipitation had least contribution 1%, 0.4%, 0% respectively.

This is a representation of the Maxent model for Elephant. Warmer colors show areas with better predicted conditions. White dots show the presence locations used for training, while violet dots show test locations
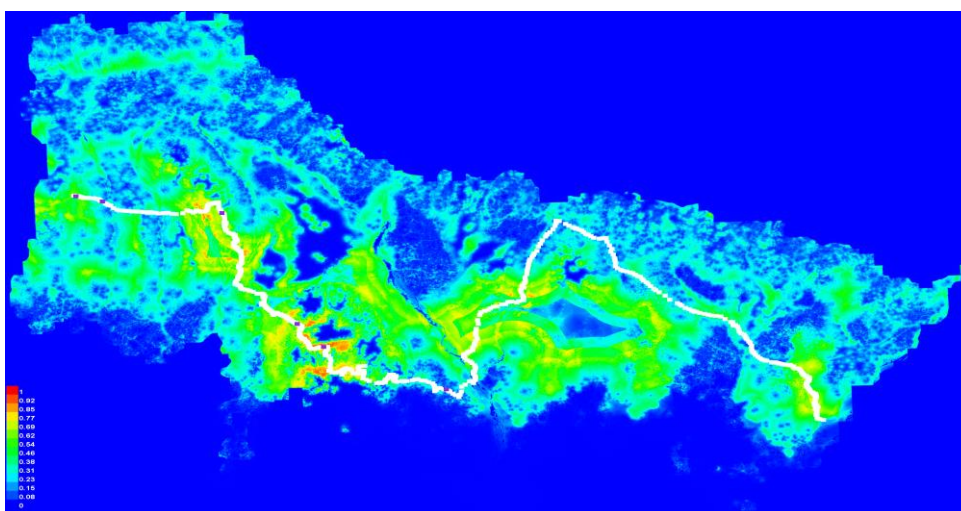


Figure 5 Maxent Model Map
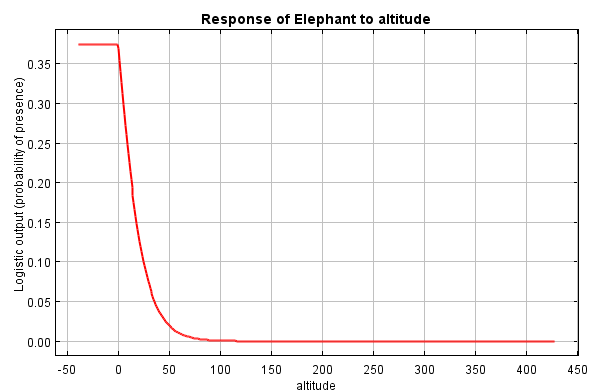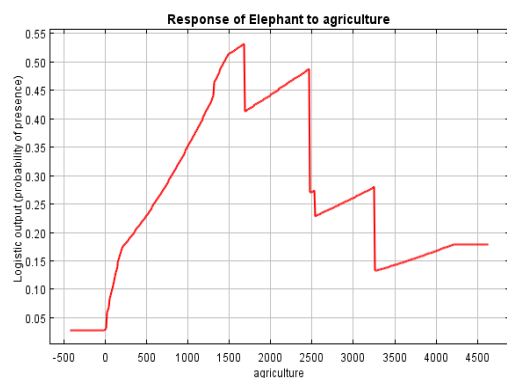
3.c <u>Analysis of variable contributions:</u>

The following table gives estimates of relative contributions of the environmental variables to the Maxent model. To determine the first estimate, in each iteration of the training algorithm, the increase in regularized gain is added to the contribution of the corresponding variable, or subtracted from it if the change to the absolute value of lambda is negative. For the second estimate, for each environmental variable in turn, the values of that variable on training presence and background data are randomly permuted. The model is reevaluated on the permuted data, and the resulting drop in training AUC is shown in the table, normalized to percentages. As with the variable jackknife, variable contributions should be interpreted with caution when the predictor variables are correlated. Values shown are averages over replicate runs.

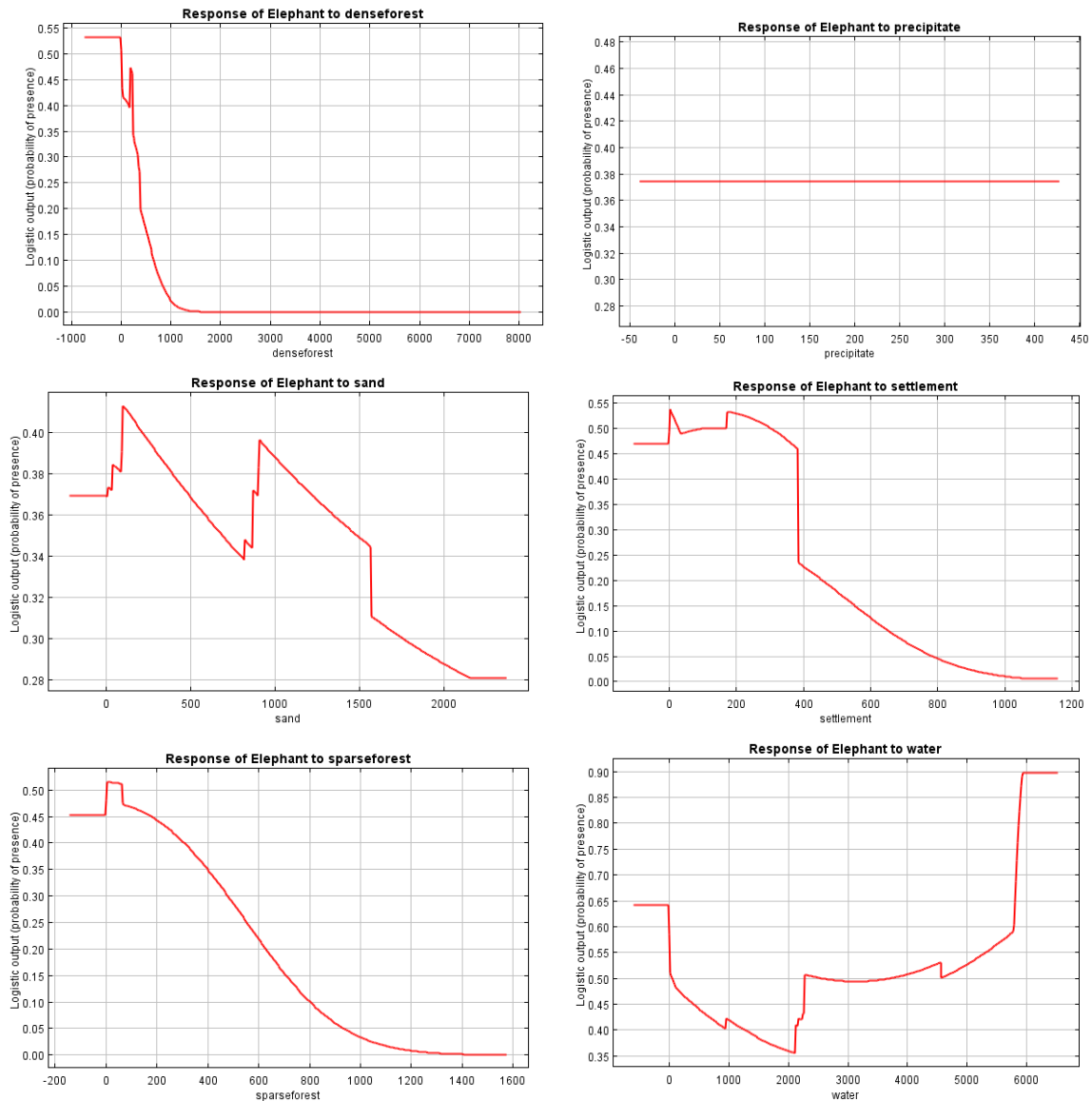| Variable | Percent contribution | Permutation importance |
|---|---|---|
| agriculture | 51.4 | 43.6 |
| water | 25.9 | 18.2 |
| settlement | 11.1 | 10.4 |
| Dense forest | 7.6 | 19.8 |
| sand | 2.8 | 3.4 |
| altitude | 1 | 3.8 |
| Sparse forest | 0.4 | 0.8 |
| precipitate | 0 | 0 |
| | | |

Table 1 Percentage Contribution of AUC and Permutation

Habitat suitability map also prepared by using AUC contribution to show the best suitable habitat for elephants. This map showed that agriculture, water, settlement, dense forests were most suitable habitat in the study area.

3.d <u>Response Curves:</u>

Response of Elephant to denseforest

Response of Elephant to precipitate

Response of Elephant to sand

Response of Elephant to settlement

Response of Elephant to sparseforest

Response of Elephant to water

These curves show how each environmental variable affects the Maxent prediction. The curves show how the logistic prediction changes as each environmental variable is varied, keeping all other environmental variables at their average sample value. The curves can be hard to interpret if you have strongly correlated variables, as the model may depend on the correlations in ways that are not evident in the curves. In other words, the curves show the marginal effect of changing exactly one variable, whereas the model may take advantage of sets of variables changing together. The response curves shown above shows the elephant is likely to be present in within 1.5-2.5 KMs from agriculture and water bodies.

3.e <u>Jackknife Tests</u>:

The following picture shows the results of the jackknife test of variable importance. The environmental variable with highest gain when used in isolation is agriculture, which therefore appears to have the most useful information by itself. The

environmental variable that decreases the gain the most when it is omitted is agriculture, which therefore appears to have the most information that isn't present in the other variables.
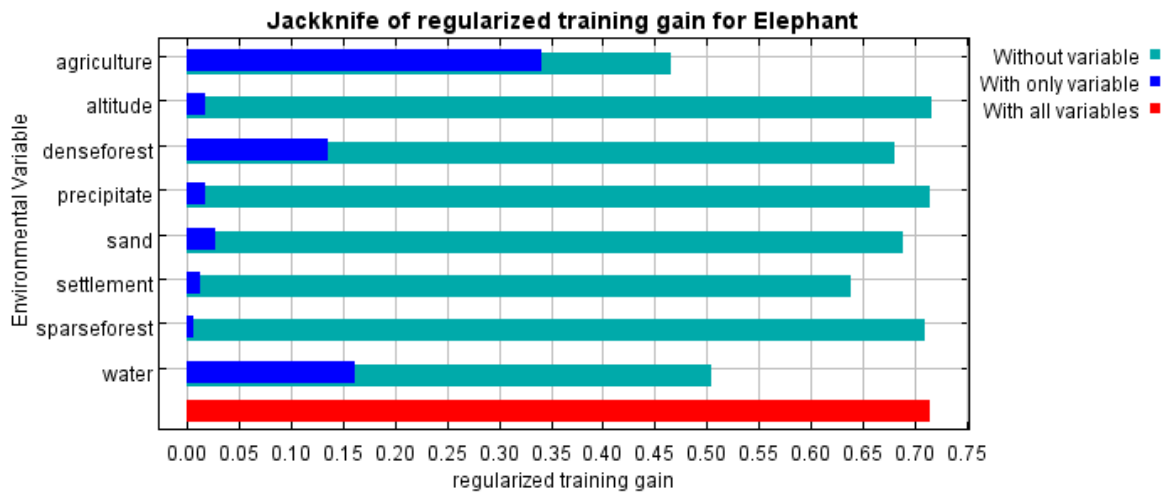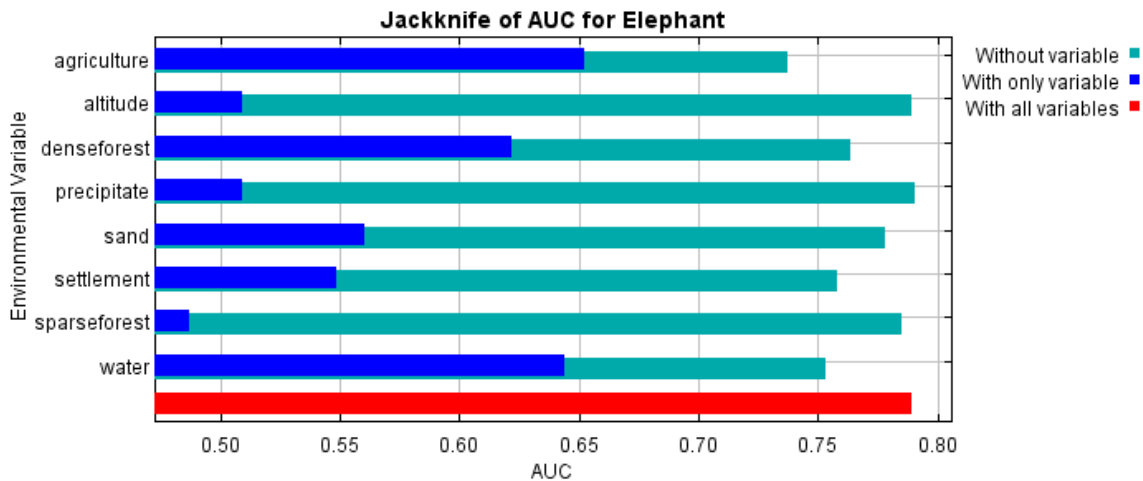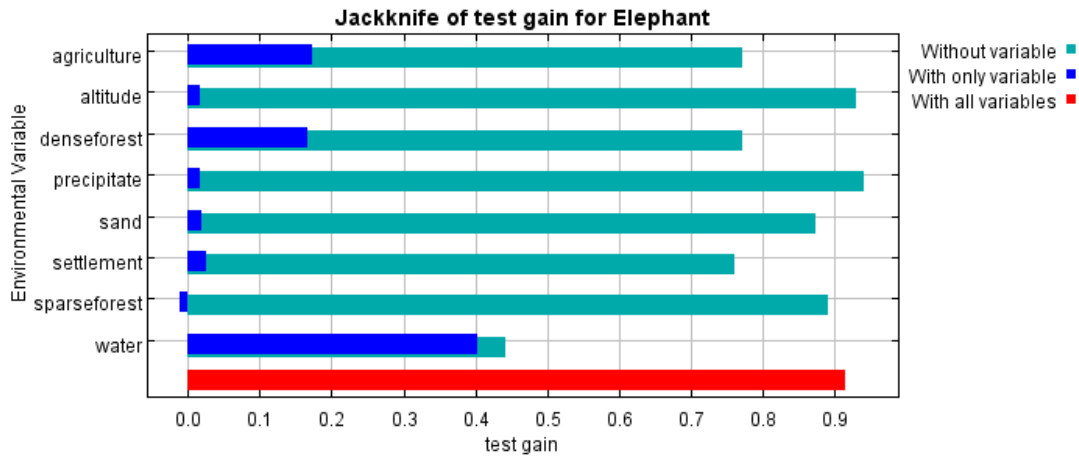


Figure 6 Jackknife of Regularized training gain for Elephant

The next picture shows the same jackknife test, using test gain instead of training gain. Note that conclusions about which variables are most important can change, now that we're looking at test data.

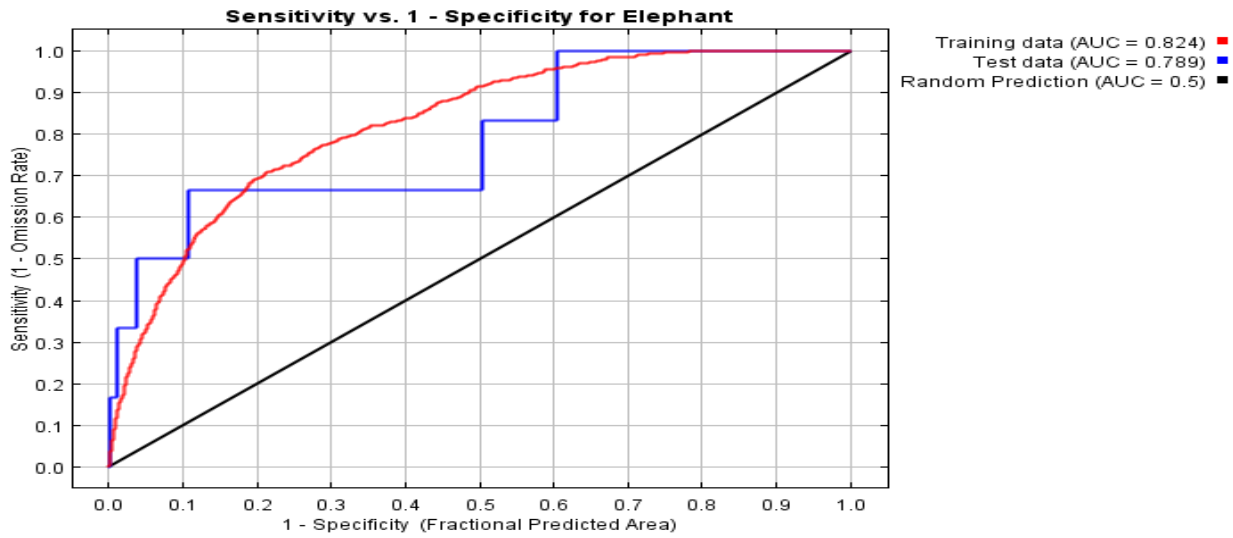Lastly, we have the same jackknife test, using AUC on test data.



**Jackknife of test gain for Elephant**

Analysis of Omission /Commission

The following picture shows the omission rate and predicted area as a function of the cumulative threshold. The omission rate is calculated both on the training presence records, and (if test data are used) on the test records. The omission rate should be close to the predicted omission, because of the definition of the cumulative threshold.



**Omission and Predicted Area for Elephant**
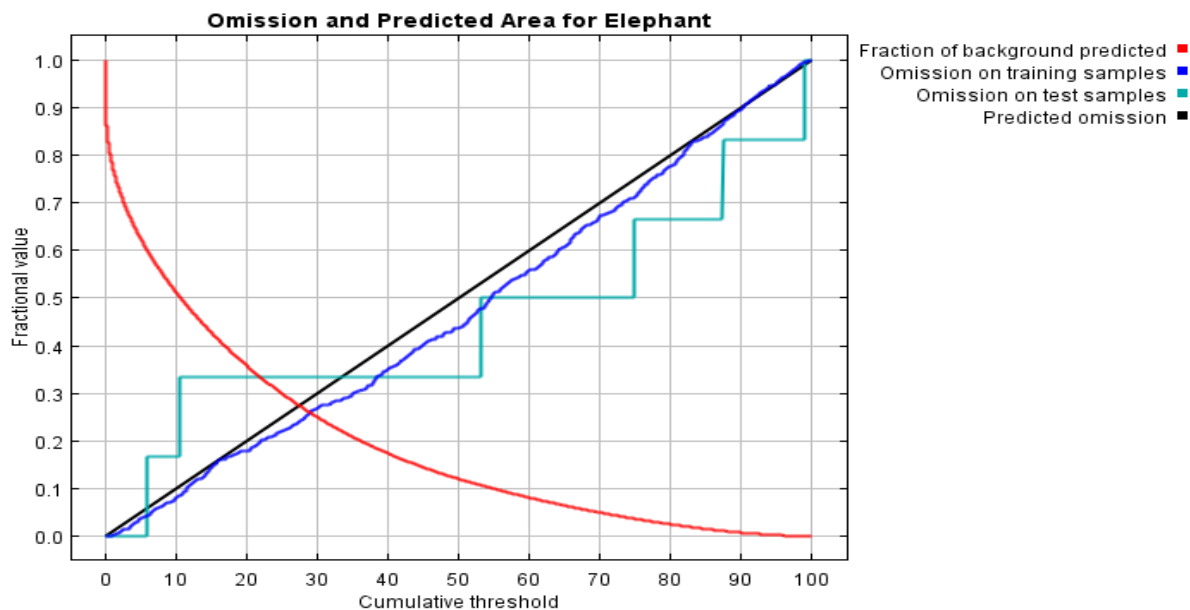
The next picture is the receiver operating characteristic (ROC) curve for the same data. The specificity is defined using predicted area, rather than true commission (see the paper by Phillips, Anderson and Schapire cited on the help page for discussion of what this means). This implies that the maximum achievable AUC is less than 1. If test data is drawn from the Maxent distribution itself, then the maximum possible test AUC would be 0.804 rather than 1; in practice the test AUC may exceed this bound.

Sensitivity vs. 1 - Specificity for Elephant

Training data (AUC = 0.824)
Test data (AUC = 0.789)
Random Prediction (AUC = 0.5)

Maxent model has finally generated a habitat suitability map (Fig 7). The map was reclassified based on the habitat variable and specific probability thresholds to classify suitability map into different three suitability classes as highly suitable, moderate suitable and non-suitable.
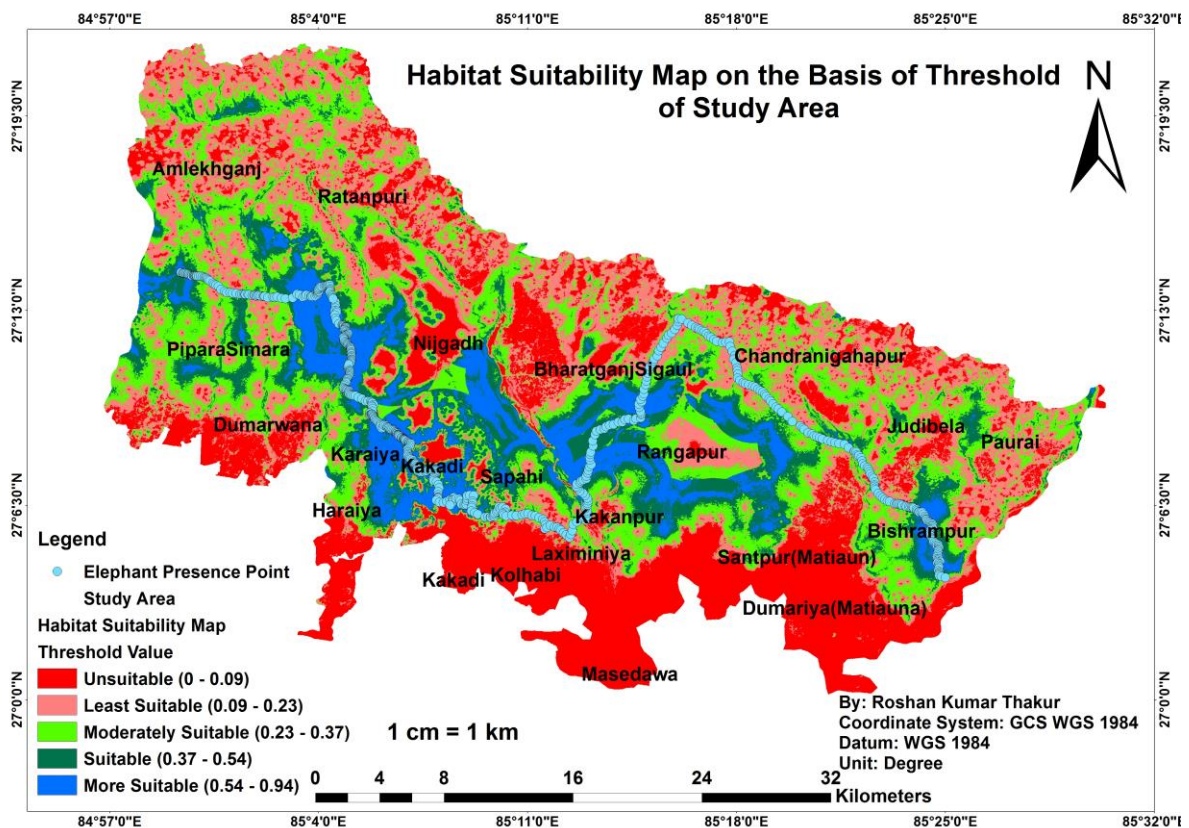


Figure 7 Habitat Suitability Map on the basis of Threshold of Study Area

3. f Habitat status study:

Forest inventory was done during transect survey. 4OO plots (8 Block X 5 transects X 10 plots) were used for detail inventory of plants to access the habitat status. All together 110 species of trees, 12 shrubs, 5 herbs, 6 species of grass and 2 species of climbers were recorded along the study route. From 135 species, elephant as bulk feeder was found impacting and browsing 20 trees,2 herbs,6 grasses and 2 climbers. The palatable within high canopy cover was found to be highly impacted. More than 28 different forage species grazed, browsed and knocked by elephants were listed during the study. The tree species were *Ficus lacor, Acacia hispide, Musa sapientum, Ficus benjamina, Garuga pinnata, Dandrocalamus* spp.*, Artocarpus lakoocha, Acacia catechu, Bombax cieba,Dalbergia sissoo, Dillenia pentagyna, Ficus benghalensis, Ficus racemosa, Ficus religiosa, Litsea monopetala, Mallotus philippinensis,Shorea robusta, Terminalia belerica, Calamus tenuis, Circium wallichi*. Grass species were *Desmostachya bipinnata, Imperata cylindrica, Phragmites kharka, Saccharum bengalensis,Saccharum spontaneum, Typha elephentina, Vetiveria zizanoides* and the very few *Spatholobus parviflorus* and *Bauhinia vellai*. Shannon Weiner(S-W) compares the diversity between two or more ecosystems which goes beyond the most basic species per-unit-area. Shannon-Weiner index diversity (H') varied from protected area (PWR /Bara-Rauthat, H' =1.82) to forest outside PWR (H'=2.18). Finally we predicted that plant species diversity is higher outside the protected area rather the in wildlife reserve.

Similarly we had also calculated Simpson's Index of Diversity. Simpson index shows 0.83 and 0.81 respectively in PWR and Outside the PWR respectively. In both cases Simpson's value is near 1, therefore species diversity in both area seems higher and better. Also Sorenson's index result shows that 75 % of plant species are similar among two habitat types. Therefore habitat status study shows elephant has used 75% similar Habitat in both areas.

Elephants impact study using Index of Species Reduction-

This study showed that Elephants' impact on vegetation depended upon habitat type. Riverine and flood plain Habitat was impacted that hardwood and mixed hardwood forest. *Mallotus philipensis, Acacia catechu, Bombax cieba,* Banana, Bamboo, and Climbers were highly impacted by Elephant in the study area.

3. g Conservation Awareness Program-

Conservation Education Materials, Posters, Pamphlets were distributed were distributed in the study area. Although not proposed in the proposal, for immediate action, the results were shown to high school student so that they will share the information to their family members as immediate action. Public presentation programs and farmers' awareness programs were conducted.

Figure 8 Farmers Awareness Program    Figure 9 School Presentation Program

In this conservation education program, 80 students, 34 farmers and 10 public were benefited directly and more than 500 indirectly.

3. Assessment of Walk Trails:

Walk trails was identified on the basis of transect survey, social survey, stakeholder consultation, elephant presence and absence study and frequency of conflict in the study area. The Elephants of Parsa Wildlife Reserve (PWR) was recorded to walk up to the Bagmati River and return back to their home western region of PWR. They frequency of movement was concentrated highly during ripening of rice/paddy. Also sometimes the movement (very Less) was noticed during maize season. In this study we found that elephant used these areas as walk trails during crop raiding and foraging. NDVI maps were prepared for four time series and presence of healthy vegetation was identified. We overlaid GPS points of elephant presence and signs only points on NDVI Map and joining these elephant presence points, we achieved current walk trail route of elephant.
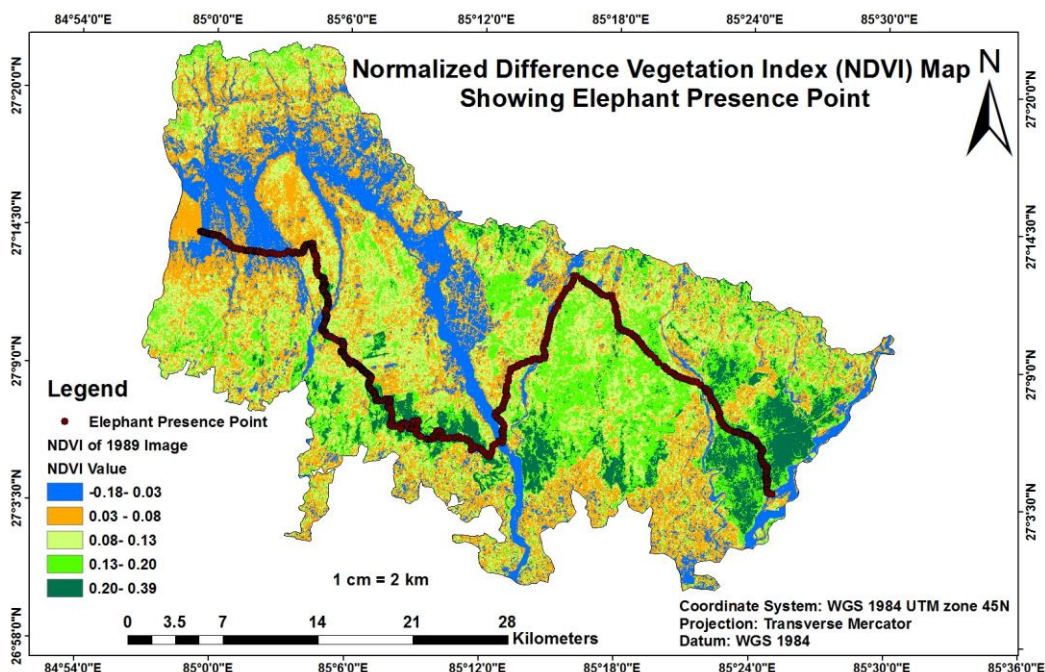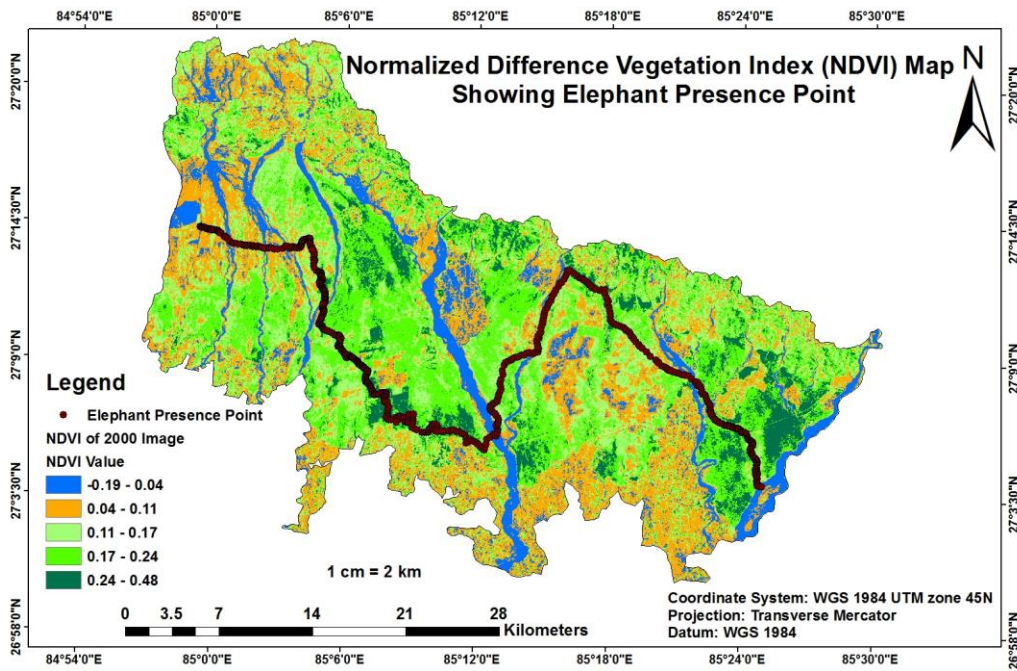


Figure 10 NDVI Map of Landsat 5 TM

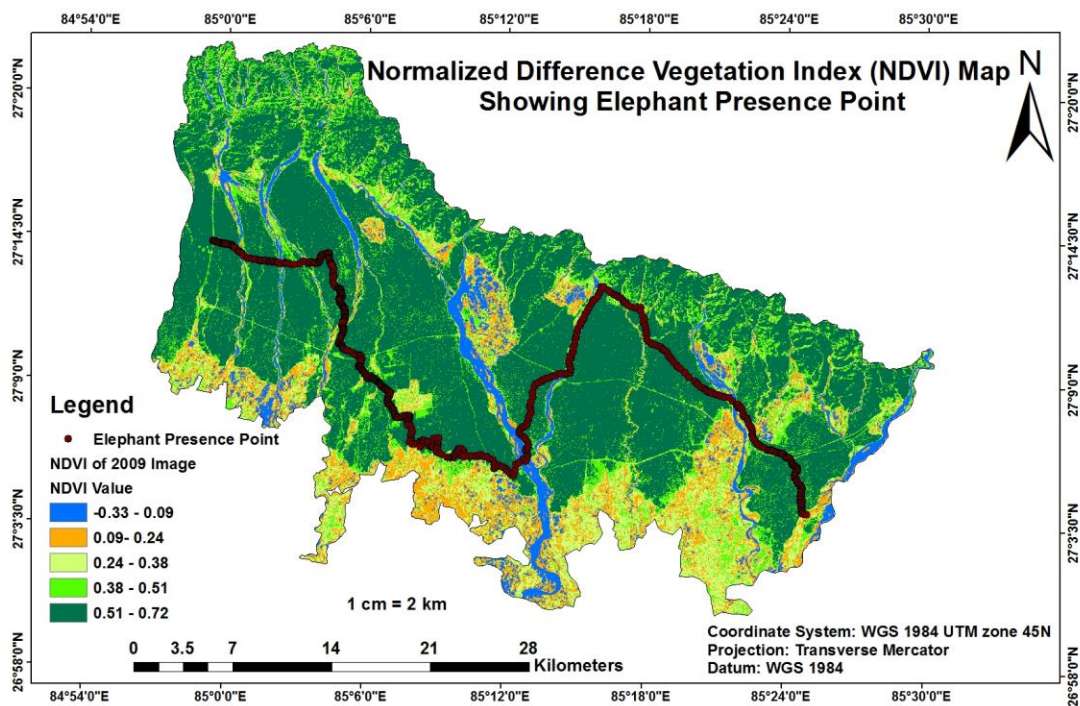Figure 11 NDVI Map of Landsat 5 ETM

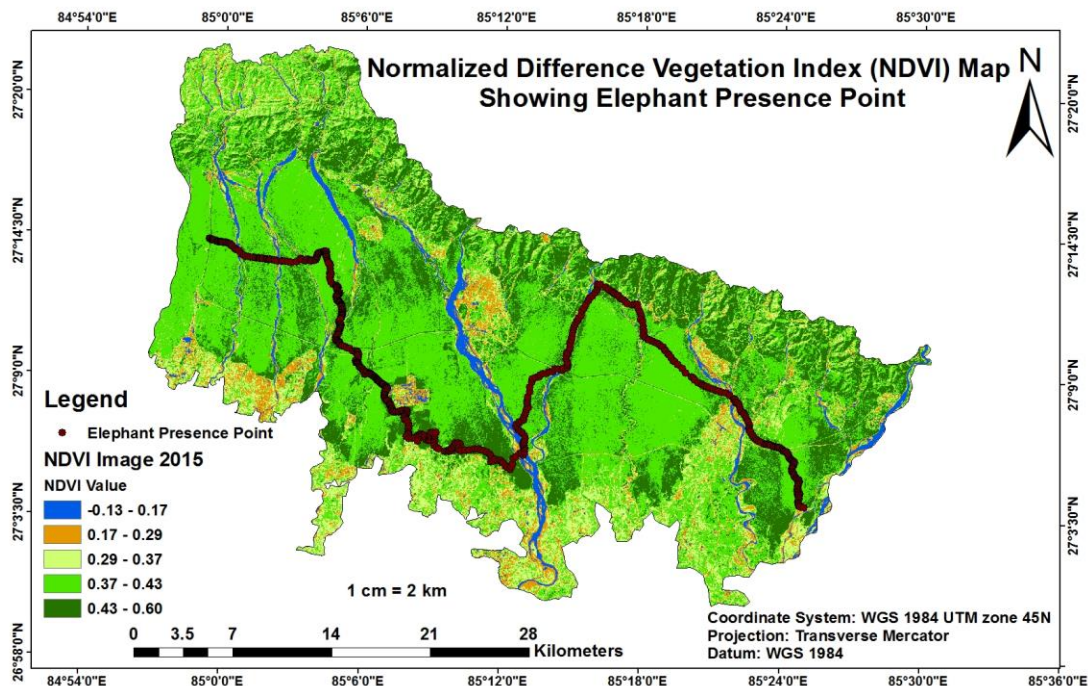

Figure 12 NDVI Map of Landsat 7 ETM

Figure 13 NDVI Map of Landsat 8, OLI

This study identified following walk trails in the study area:

a. 1 km south of PWR headquarters' office (In the highway Amlekhganj Pathalaiya segment) – Halkhoriya Daha- 11/12/13 Kms (Road Mark in Highway Pathlaiya Nijgadh Segement) – Tangiyabasti- Kakadi- Sapahi- Simri-Bharatganj- Gaidatar- Chandranigahpur- Judibela- Bishrampur forest-Bagmati River.

b. 1 km south of PWR headquater's office (In the highway Amlekhganj Pathalaiya segment) – Halkhoriya Daha- 11/12/13 Kms Road Mark in Highway Pathlaiya Nijgadh Segement) – Tangiyabasti –Simri Forest area- Bharatganj-Chandranigahpur- Judibela- Bishrampur forest- Bagmati River.

c. 1 km south of PWR headquater's office (In the highway Amlekhganj Pathalaiya segment) – Halkhoriya Daha- 11/12/13 Kms Road Mark in Highway Pathlaiya Nijgadh Segement) – Tangiyabasti- Kakadi- Sapahi- Kolhbi-Chocha- kakanpur- Rangapur- Chandranigahpur- Judibela(Ban Tole)-Bagmati Canal- Bishrampur forest- Toribari- Bagmati River.

3. I Human Elephant Conflict (HEC) status-
HEC cannot be neglected while implementing project for elephant conservation. Asian elephants are concentrated in range countries faces severe challenges in the form of HEC. Nepal has four isolated populations (Eastern, Central, Mid-western, and Far-Western). Out of which, this study is concentrated to central population outside the protected area.
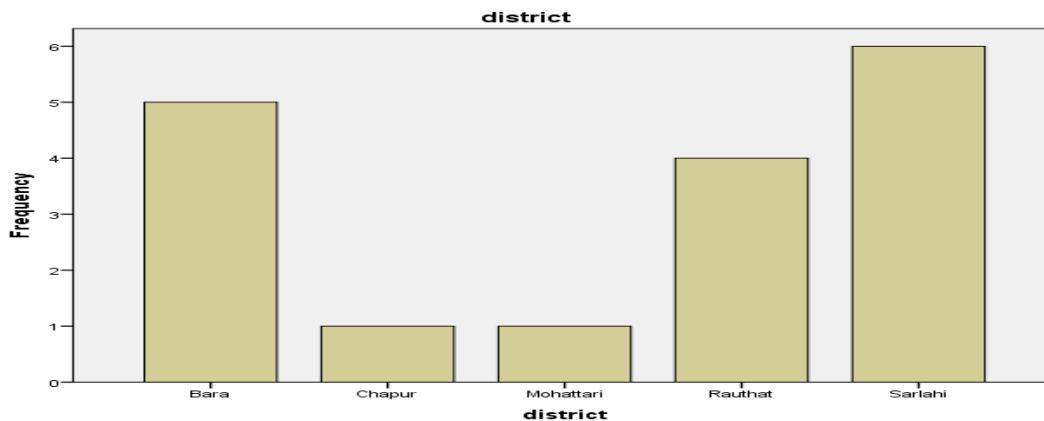
Figure 14 District wise Tolls of Deaths in 2070/71 and 2071/72 BS

## 4. Briefly describe the involvement of local communities and how they have benefitted from the project (if relevant).

The project was framed to conduct a communication between Conservationist, policy makers, and farmers. So the dialogue at local community level was the major impact of our project. At each steps local communities were consulted, advised as well as taken advice from them and then incorporated in to results and finding. Lastly, they were made aware about the results. For detail Representatives from existing Community Forest User Groups (CFUG), Buffer Zone User Groups (BZUG), Local Community Based Organizations (CBOs) and Village Development Committee (VDC) were consulted at each phase. Sector forest officials were incorporated in this research.

The project conducted two main conservation program- farmer awareness program and public presentation programs. The main target beneficiaries of these programs were obviously the local community. Along with that questionnaire surveys and focal group discussions were praiseworthy.

This project has been successful in collecting the scattered information on Habitat status, walk trails, human elephant conflict (HEC) status in central Nepal. Local community was now aware about favourable geographical area of elephant, ecology of elephant, walk trails, peak time of travel, elephant behaviours, driving factors of elephant to and away from human territories which will help them to fight and cope with on-going HEC in Central Nepal.

In this way, community people were involved in each activities of this project and had benefitted from this project.

## 5. Are there any plans to continue this work?

Of course, I have plans to continue this work. Actually the people in the study area were found very intolerant about elephant presence in their surroundings. They were complaining that "Why these Parsa Wildlife Reserve officials could not keep

ELEPHANT in their premises"? They didn't realize about their encroachment of Elephant Habitat. Actually, low income, illiteracy were the major issues for this conservation issue. Low income in the sense that they depended on forest for firewood which is their major income source and due to HEC they blamed officials. Illiteracy as they didn't want to understand the issues of conservation. The workshop and presentation program conducted were not enough as it could not cover all the study area. Along with intense conservation workshops, capacity building to local communities so that forest dependency decreases is prime concerns for HEC mitigation in these areas. Therefore I am planning to continue conduct capacity building for community, income generation training for deceased family members due to HEC, particularly woodcutters and formation of Elephant Crop Raiding Deterrence group in these areas to prevent human causalities. For this I will undoubtedly need financial support from the organisations like The Rufford Small Grants Foundation.

**6. How do you plan to share the results of your work with others?**

During Project period, the results were shared with farmers and public (First Relevant Stakeholders). Also the report will be presented in relevant workshops and seminar. As per the coordination with forest offices and part offices, the results will be presented. The finding of this project will be compiled in the form of a brief report and will be distributed to relevant stakeholders in Department of National parks and wildlife conservation, Kathmandu, and also kept in Central Department of Zoology library and Central Library of Nepal, Kirtipur for public use. Also the result and finding will be published in National daily newspaper in local language and published in international journal.

**7. Timescale: Over what period was The Rufford Foundation grant used? How does this compare to the anticipated or actual length of the project?**

| Activities | Proposed Schedule(In Month) | Actual time it took (In Month) | Comments |
|---|---|---|---|
| Preliminary Field Visit | 1st May to 10th May | 5th August to 15th August | Apologies for delay, even I didn't knew earthquake would hit Nepal. |
| First field data Collection | 1st June to 20th June (20 days) | 8th October to 30th October | |
| Data Analysis | 25th June to 30th July | 2nd November to 25th November | |
| Preliminary Report Submission | 10th August to 25th August | Dec 11, 2015 | |
| Second Field Data Collection | 10st September to 30th September (20 days) | 25th December to 20th January | |
| Data Analysis | 20 October to 30th November | 29th January to 10th February | |
| Final Data Analysis and GIS Works | 15th December to 15th January 2016 | 15th February to 20th March | |

| | | | | |
|---|---|---|---|---|
| Farmer's Awareness program | February | 25th March 2015 | |
| Public Presentation programs | February | 29th March , 2015 | |
| Final Report Submission | 1st March to 30th March | 31 May 2016 | Due to 2-3 months delay as above mentioned unseen difficulties. |

**8. Budget: Please provide a breakdown of budgeted versus actual expenditure and the reasons for any differences. All figures should be in £ sterling, indicating the local exchange rate used.**

| Item | Budgeted Amount | Actual Amount | Difference | Comments |
|---|---|---|---|---|
| Travel costs (researcher and one member ) | 180 | 150 | +30 | (Preliminary field visits) |
| Travel during Field | 320 | 450 | -130 | Vehicle was hired. |
| DSA for Team leaders | Not included | 266 | -266 | Researcher has to manage local support at different places with CFUG, Mother's Groups |
| Food Cost (All Members) | 665 | 670 | -5 | |
| Living Cost (All Members) | 1333 | 1200 | +133 | Somewhere we got home stay. |
| Allowances (Field Level Assistant) | 999 | 933 | +66 | |
| Allowance for Guide/Ranger | 250 | 250 | 0 | |
| Allowance for Army Personnel | 250 | 200 | +50 | |
| Equipment/Stationary | 100 | 100 | 0 | |
| Transect Survey Materials/ Equipment | 100 | 100 | 0 | |
| Topographic Materials | 10 | 30 | -20 | |
| GIS Digital Layer From Land use Project office | 105 | 100 | +5 | |
| Awareness Materials | 200 | 150 | +50 | |
| Insurance for team members | 150 | 66 | +84 | |
| Public Presentation Programs | 150 | 100 | +50 | |
| Farmers Awareness program | 150 | 100 | +50 | |
| Resource Sat Image 5m resolution | Not included | 150 | -150 | Landsat was not enough for supervised classification. |

| Communication | Not included | 60 | -60 | |
| --- | --- | --- | --- | --- |
| **Total** | 4962 | **5075** | -113 | |

## 9. Looking ahead, what do you feel are the important next steps?

Human Elephant Conflict is a very serious problem in this study area. Every year, about 10 people are killed by Elephants. Sudden encounter is the main problem here. Woodcutters wander in the forest area. Also elephant are regularly visiting the crops i.e. agricultural land to observe the ripening of crops. So formation of Crop Raiding Deterrence Group (CRDG), Elephant conservation Group (ECG) and extensive conservation workshop per village, HEC relief fund (HERF) must be done to ensure the decrease in HEC.

Supporting or capacity building activities to crop raiding deterrence group would be the timely action for elephant conservation. I plan to disseminate results at local level (farmers) through the villagers in the route. During this project, I have done workshop at only one village. But the need is at large scale.

## 10. Did you use The Rufford Foundation logo in any materials produced in relation to this project? Did the RSGF receive any publicity during the course of your work?
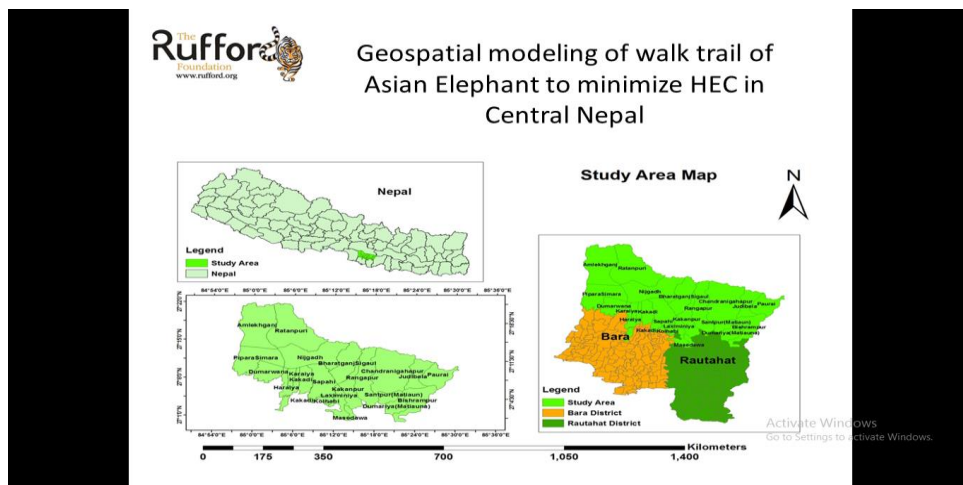


Figure 15 Power point slide shown to School Children and local stakeholders

I had used RSGF logo for preparing conservation awareness material i.e. posters for sharing the elephant information. During my project work, people raised question about logo and after explaining that this project is funded by Rufford organization they were happy to know that. In this way RSGF had received publicity during my project work.

## 11. Any other comments?

Human and Asian elephants is in constant struggle in Nepal and several studies have been undertaken to assess the gravity of such conflicts and recommend way

forwards to mitigate such conflicts. But Nepal still lacks even basic information on elephant migration within the country. The project team, thus, expects support from the organization like the RSGF in its next step to study its corridor thing. Corridor thing is not highlighted in eastern Nepal which must be focussed at landscape level conservation. The people in the HEC zones in the study area were found primarily focused on negative impacts of elephant presence. They didn't think of positive value of elephant presence.  So positive type of activities (Elephant Park, Zoo, Breeding centers) must be planted in the study area for elephant conservation in Nepal.

**Photos**



Left: A favourite and resting place halkhoriya dah. Right: Foggy morning and Machan



Left: Oil yielding crop at HEC mitigation

Left Consulting monks. Right: Consulting forest officials





Left: Human disturbance. Right: Inspecting dung

Left: Fresh dung. Right Baby dung.



Houses torn down by elephants



Left: Damage made by elephants. Right: Wild elephants/