Elephant distribution and habitat preferences in the Western Ghats of Karnataka from the available direct and indirect evidences

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Abstract

The spatial and statistical data analysis was carried out to understand the response of the elephants to different landscape features and anthropogenic factors from the available information hosted on the Western Ghat Spatial Data Infrastructure web portal. A series of vector analysis was carried out on the elephant location layer and a random point layer to simulate the random elephant occurrence over the study area to extract the information for further statistical analysis. The results show that elephants are not randomly distributed and they respond to their surrounding environmental and anthropogenic factors. However, it is not wise to comment on the effect of the set parameters on elephant distribution pattern with this small data set.

Introduction

Asian elephant (*Elephas maximus*) is the largest terrestrial mammal of India and distributed over wide vegetation types across the country. As per the official website of the Ministry of Environment, Forest and Climate Change (MoEF&CC), there are around 30000 elephants left in wild (Anonymus 2012). The Asian species is listed as endangered by IUCN and under Part-1 of schedule -1 of the Wildlife Protect Act 1972) conferring it the highest level of protection. To conserve and protect the species, India has formally notified 28 Elephant Reserves (ERs) extending over about 61830.08 km^2. Recently, the ministry has accorded consent for establishment 2 more ERs - Khasi Elephant Reserve in Meghalaya and Dandeli Elephant Reserve in Karnataka.

Asian elephants were believed to be widely distributed - from Tigris - Euphrates in West Asia eastward through Persia into the Indian sub-continent, South and Southeast Asia including Sri Lanka, Java, Sumatra, Borneo and up to North China. However currently they are confined to Indian Subcontinent, South East Asia and some Asian Islands - Sri Lanka, Indonesia and Malaysia. About 60% of the Asian elephant population is in India. This former range covered over 9,000,000 km^2 which has now shrunk to 486,800 km^2 (Sukumar 2003). The present-day distribution of elephants in India is around 110000 km2 (about 3.5%) of its former range that extended from south of Himalayas to cover the entire subcontinent (Baskaran et al. 2011). The current range of the elephant population across India can be categorized based on their distribution over four forested landscapes i.e. (i) the foothills of Himalayas in the north (ii)

the north-eastern states (iii) the forests of east-central India, and (iv) the forested hilly tracts of Western and Eastern Ghats in southern India.

Among all four elephant populations in India, the elephant population of south India has been well studied and characterised better than those in other parts of the country (Nair et al. 1970, Krishnan. 1972, Nair and Gadgil, 1978, Nair, et.al, 1980, Sukumar, 1985,). As per recent census report, around 14,000 elephants are found in southern India (Baskaran et al. 2007), with over one-fourth of the habitat being Protected Areas (Baskaran et al. 2007). It is also evident from the research study by Baskaran et al. (2007) that most of these Western Ghats sub population is growing and dispersing into neighbouring forests and therefore this population has great conservation significance for the species in the wild.

The present study aimed to assess and understand the pattern of elephant distribution and response to some of the landscape features and anthropogenic structures over a small area in Uttar Kannada district. The location data of direct and indirect evidences of elephants as well as land use land cover map, terrain, fire locations over three consecutive years, distribution of water-bodies were accessed from the Western Ghats Spatial Data Infrastructure portal.

Research questions

1) Whether elephants are randomly distributed in the area or follow some land use land cover pattern?
2) Which of the vegetation or land cover type is intensively used by elephants?
3) Do ecological or anthropogenic factors such as human settlements, roads, water-bodies and fire affect the elephant distribution pattern? If yes then which parameter has overriding effect on elephant distribution?

Null Hypothesis

H_0 = Elephants are randomly distributed across the different land use/cover types

H_0 = Human settlements, roads, fire and water-bodies have no effect on elephant distribution

Methods

Study area

The present study covers the part of the Northern distribution range of the Indian elephant in the Western Ghats. The study area was located between 150 02' N 740 25' E and 150 12' N 740 43' E (Map-1). The area spread across the forested landscape of 28 villages in Uttar Kannada district of the state of Karnataka and within 10 km from the newly declared Anshi

Dandeli Tiger Reserve. The area has gently undulating to steep hilly terrain covered with diverse land cover types such as Primary moist deciduous forest, Wet evergreen primary forest, secondary wet evergreen forest, forest plantation, Secondary moist deciduous forest, Open Savannah or grassland Agriculture land, habitation/built-up areas and water bodies. The study area encompasses part of Bommanhalli reservoir and is close to Supa Dam and Tatttihallia Dam. The area is alos rich in minerals such as manganese and iron ore as there are several operational mines in and around area. There have been reports of extensive human-elephant conflict in the area. To support the elephant conservation efforts in the lanscape, the Ashoka Trust for the Research in Ecology and Environment has initiated a conflict mitigation program funded by Asian Elephant Conservation Fund.

Data acquisition and compilation

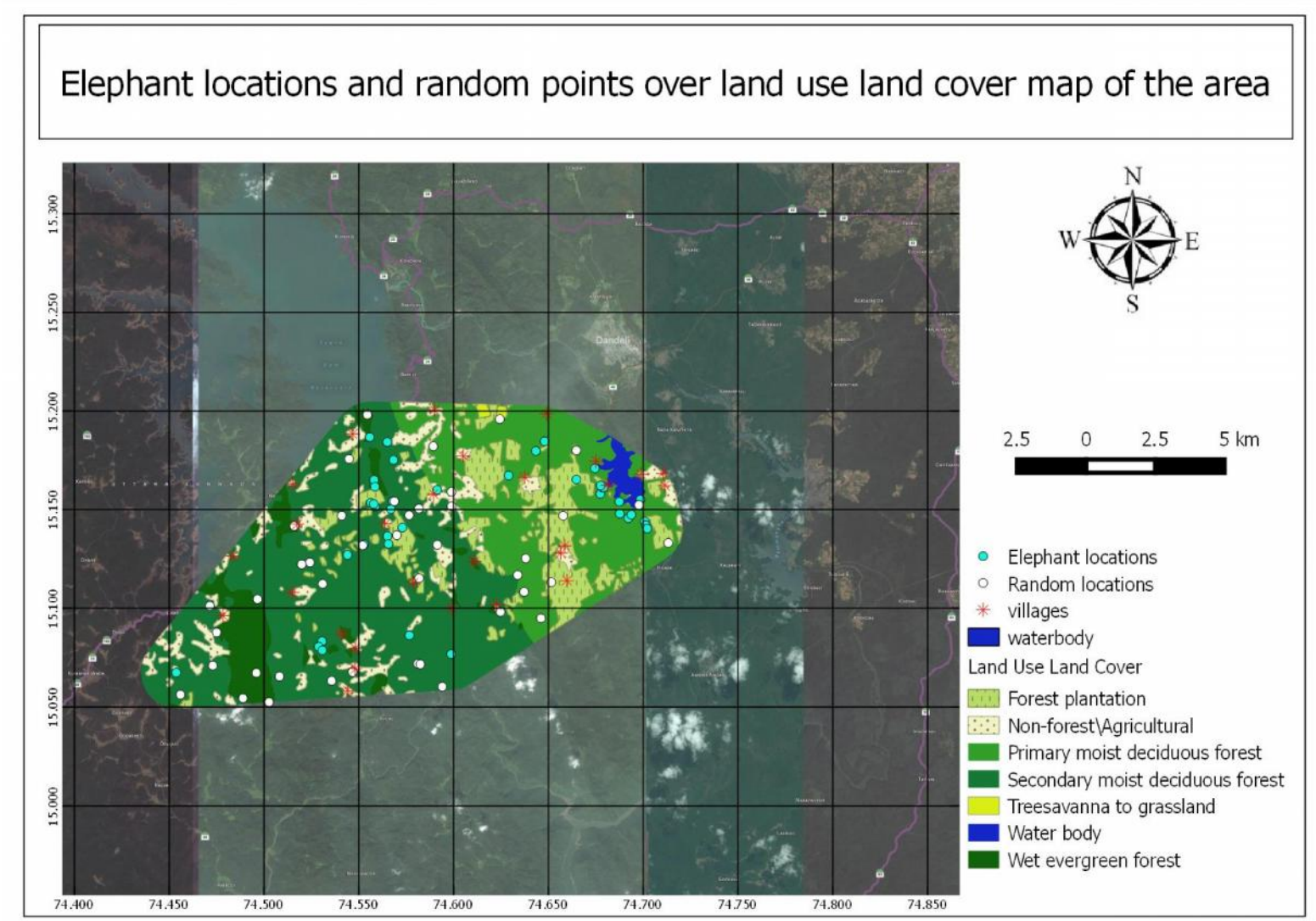
For the present study we used available spatial vector data from Western Ghat Spatial Data Infrastructure (WGSDI) portal such as direct and indirect evidence locations of elephants, fire locations from 2008 to 2010, land use land cover map of the area (1:25000), terrain data as SRTM imageries and boundary maps of the water bodies. The locations of all the human settlements and roads were digitized from the Open Street Map using open layer plugins in Quantum GIS ver. 2.12.1. Since the original data were in WGS84 coordinate reference system (CSR), they were transformed in to UTM 43N CRS for precise distance and area calculations.

Spatial data analysis

A distance matrix was calculated for the elephant locations. To decide the extent of the study area the average minimum distance calculated from the distance matrix was used to create a buffer over the minimum convex polygon. All the vector data layers i.e. Land Use Land Cover, water-bodies, fire locations, were extracted for the study area extent using intersection tool under vector analysis operations.

To assess the randomness of the distribution of elephant locations, we generated equal number of random points in the AOI. The frequency of actual elephant evidences and random locations in each land use/cover type was calculated using ‘point in polygon’ function. The area under each of the land cover type was calculated using ‘export/add geometry columns’ function. The field calculator in attribute table was used to calculate the density of the occurrences of actual elephant locations and randomly generated points. The attribute data were exported to spreadsheet for further statistical analysis.

Map-1: Geographic extent of the study area and locations of elephant evidences, village settlements, fire locations and roads



A digital elevation model was built using Shuttle Radar Topography Mission (SRTM) satellite data to generate the terrain ruggedness index (TRI) using raster analysis tool in QGIS. The raster data were clipped for the study area extent for further overlay operations. The point locations of elephant evidences as well as random points were overlaid on the DEM grid and terrain ruggedness index for each of the actual and random elephant occurrences was extracted. The TRI was categorized in to four classes as per the natural breaks in attribute using field calculator. The frequency of occurrence of actual and random elephants in each of the TRI classes was calculated and exported it as a spreadsheet for statistical analysis.

The minimum distance from each of the actual elephant locations and random points were calculated to nearest fire locations, water-bodies, human settlements and roads using 'distance to nearest hub' in vector analysis tools. The attribute data of each of these vector layers were exported to spreadsheet for further statistical analysis.

Statistical analysis

The frequency of occurrence of both i.e. actual elephant locations and random points in different land use were tabulated for *chi square* test for assessing the null hypothesis i.e. 'elephants are randomly distributed across the different land use/cover types'. We also tested for the randomness of the elephant occurrence with respect to terrain ruggedness using *chi square* test. To test the second null hypothesis i.e. 'Human settlements, roads, fire and water-bodies have no effect on elephant distribution', independent sample *t*-test was performed assuming unequal variances of the sample data sets.

Results and discussions

We could compile 42 point locations of direct and indirect elephant evidences from the WGSDI web portal. Based on the minimum average distances between elephant locations a buffer of 2 km was generated over minimum convex polygon calculated from the elephant point locations (Map-2).

The area of the AOI was calculated to be 349.17 km^2 covering 28 village settlements and part of Bommanhalli reservoir. Within the extent of the study area, a set of same number of random points (n=42) were generated to simulate the random distribution of elephants over the study area.

Available land use land cover map from the database was clipped for the study area extent and area calculation for each of the cover class was carried out. Subsequently, elephant locations and randomly generated points were overlaid on LuLc Map (Map-3). Points in polygon function in QGIS 2.12 was used to count the frequency of occurrences of both i.e. actual and random locations for latter statistical comparison (Table -1).

Map-2: Creating buffer over MCP to generate the area of interest for the present study

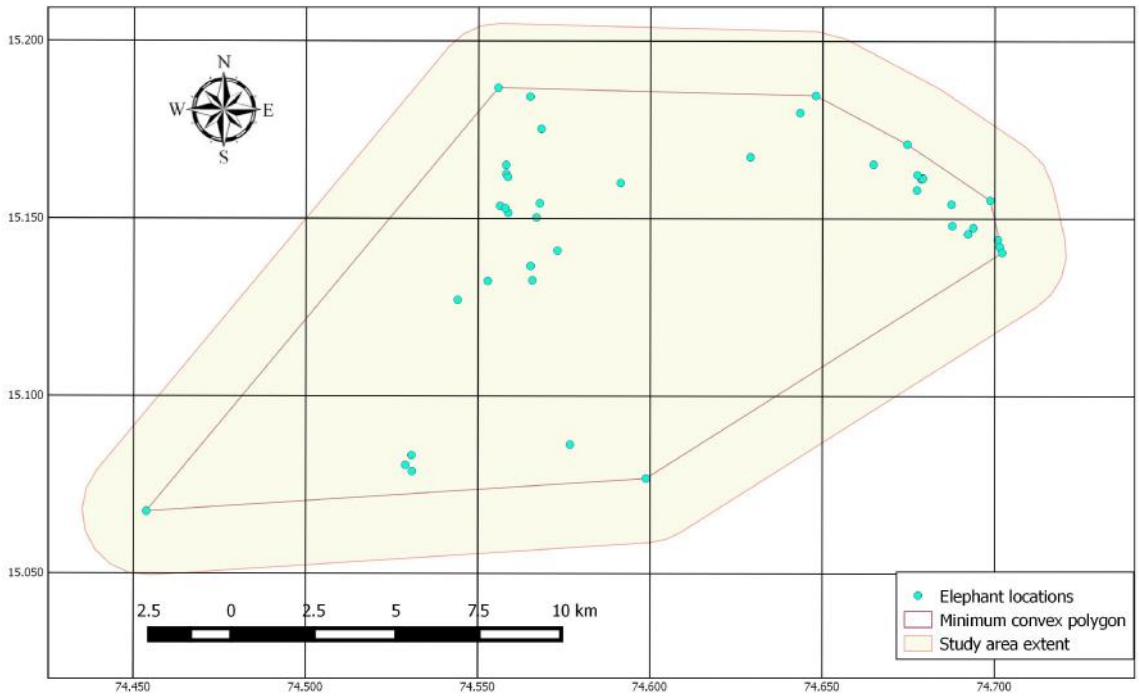
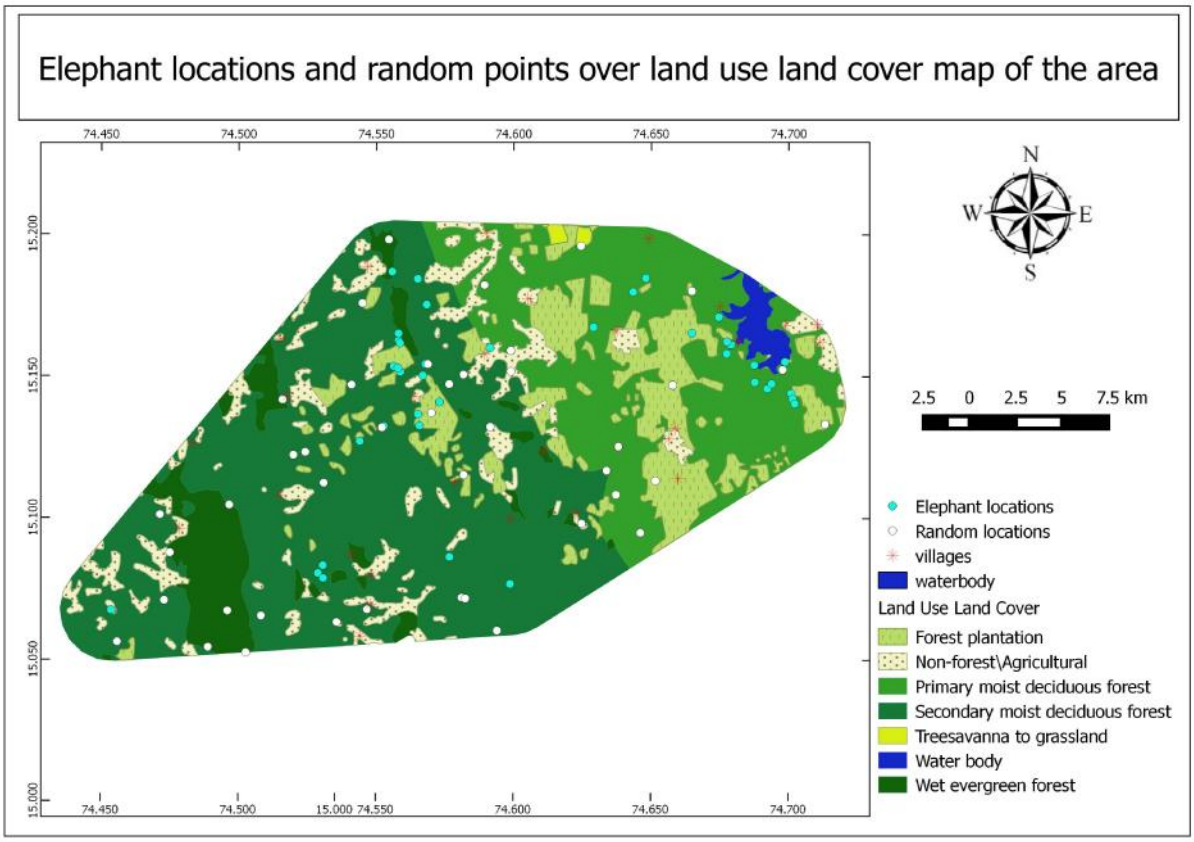


Table-1: Frequency of occurrences of elephant evidences in different land cover types in comparison with randomly generated point locations.

Sr. no.	Landuse type	Observed	Random
1	Non-forest\Agricultural	1	3
2	Wet evergreen secondary or disturbed forest	2	5
3	Forest plantation	9	4
4	Secondary moist deciduous forest	13	21
5	Primary moist deciduous forest and degradation	16	8
6	Wet evergreen primary forest	0	0
7	Tree-savanna to grassland in dry zone	0	0
8	Water body	0	0

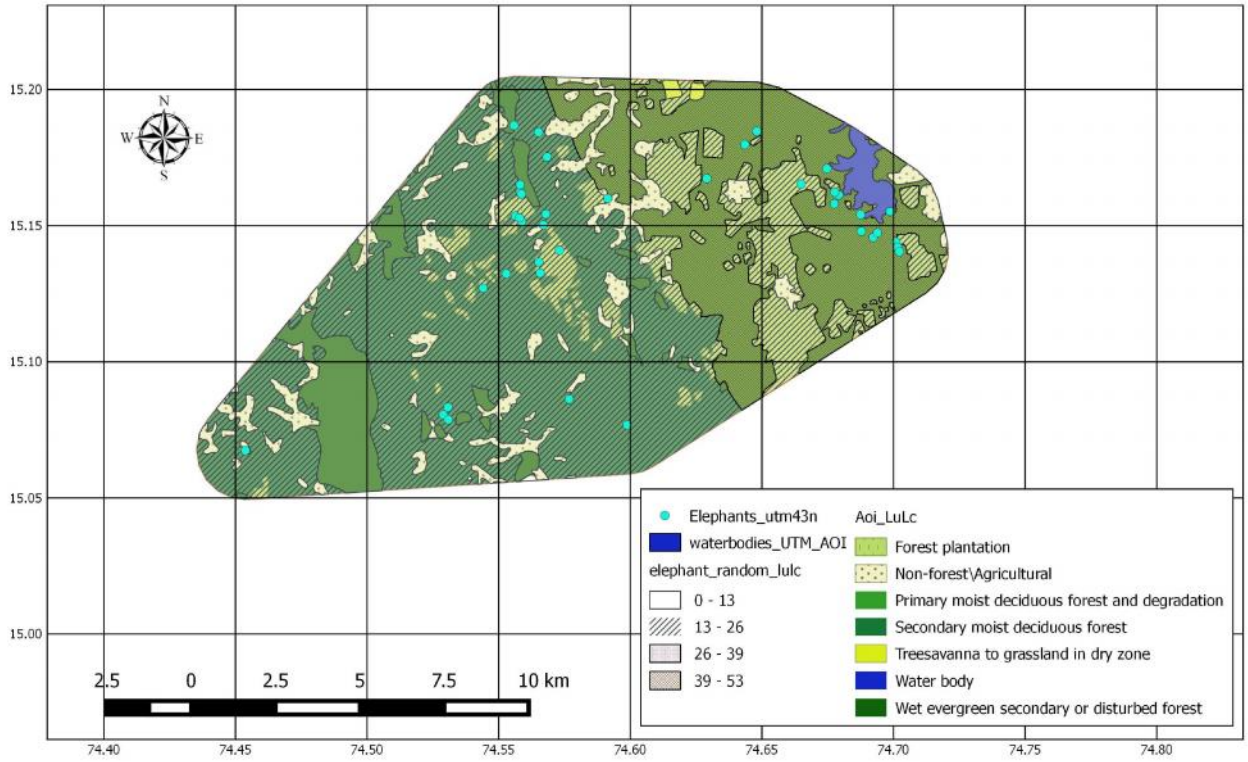
Map-3: Elephant distribution and randomly generated point locations over different land use types in the study area.



Results indicate that elephants occurred largely in primary moist deciduous forest and used this habitat proportionately more than other available habitats. Most often this vegetation type occurs over gently undulating terrain to flat areas in vicinity to water bodies. This vegetation type also offers diverse and abundant foraging material to this large herbivore mammals. The *chi square* test was used to assess whether elephants have any habitat selection pattern or they randomly occupy different habitat types. The test reveals that elephants are not randomly occurring over different vegetation types ($P \leq 0.05$).

The density of elephant locations was calculated for each of the land cover types to visulalize how elephants are using various land cover types (Map-4). It shows that elephants are more frequent in moist deciduous habitat than other land cover types.

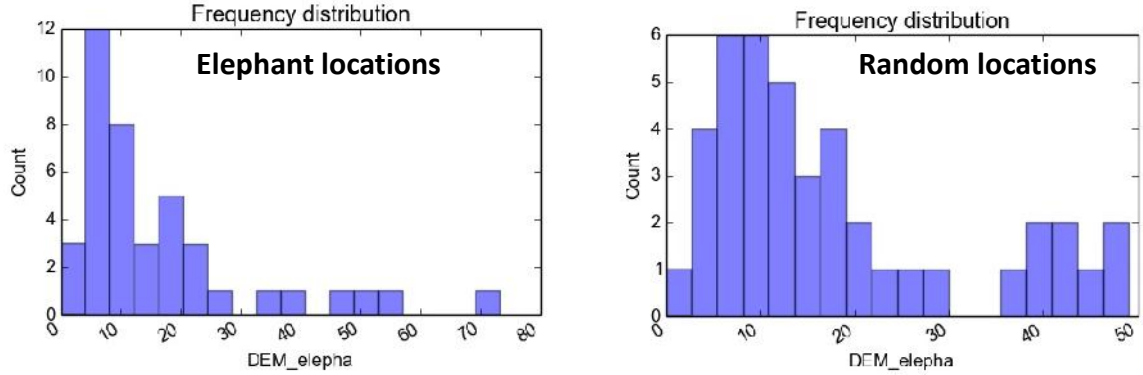
Map-4: Elephant occurrence density gradient over land use land cover map of the study area.



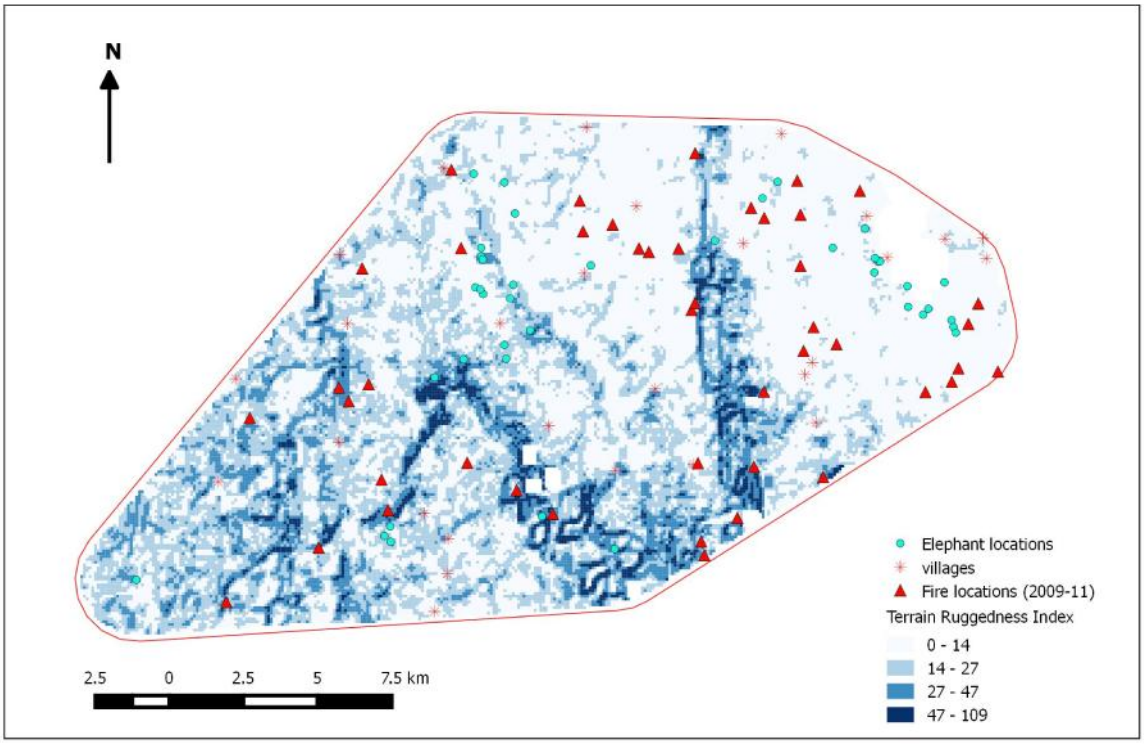
We computed the Terrain Ruggedness Index using the SRTM data available on WGSDI for the study area extent. When elephant locations were plotted over the TRI grid, it showed a preference for gentle to moderate undulation (Map-5).

The data on elephant occurrences and random point locations over various terrain ruggedness class types were used for *Chi square* analysis. The results indicate that elephants are not randomly occurring over the study area and prefer gentle to moderate undulation (Figure-1a & 1b)

Figure-1: Comparative account of frequency of occurrences of elephant evidences and random point locations over terrain ruggedness index.



Map-5: Elephant locations in different terrain ruggedness classes in the study area

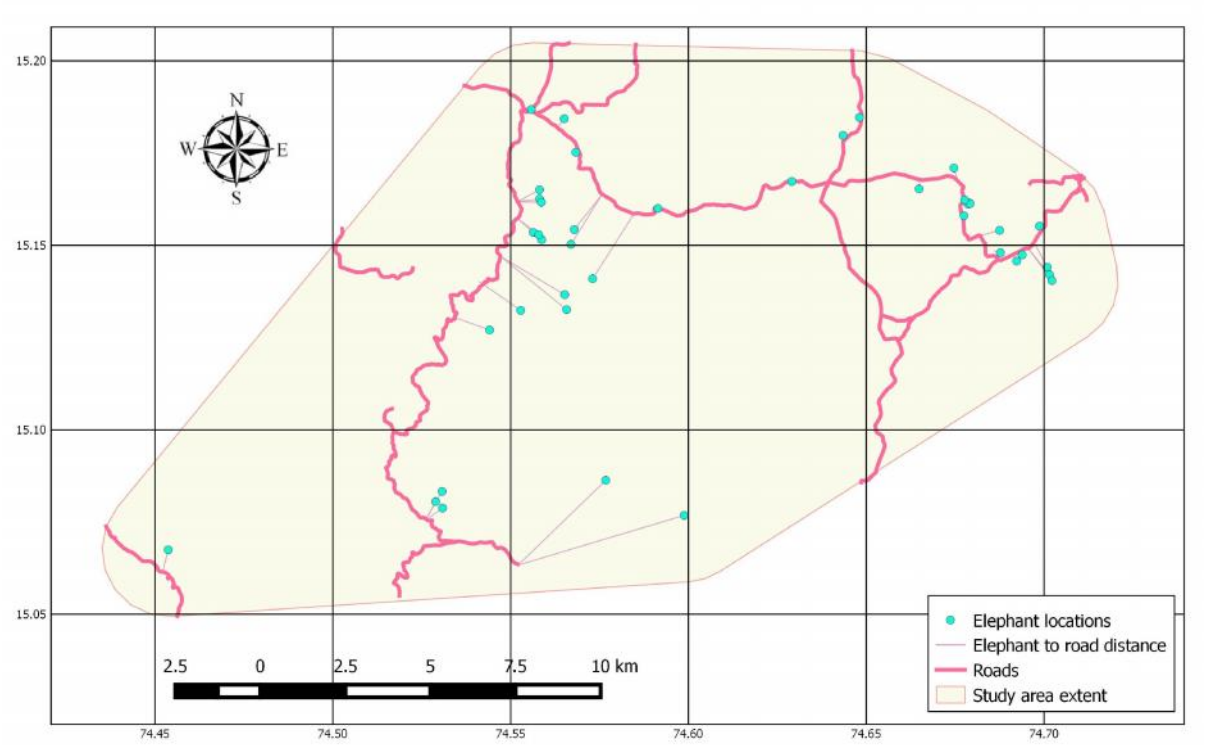


We also attempted to assess the effect of some of the ecological and anthropogenic factors on elephant distribution. To generate the average minimum distances (in km) (± SE) for each of these factors such as roads (0.89 ± 0.16), villages (1559 ± 135.8), waterbodies (7.01 ± 0.72) and fire locations (1.65 ± 0.14) were calculated.

The below map (Map-6) shows the minimum distance depicted as lines from each of the elephant locations to nearest road. Similar measurement data were generated for other vector files as well i.e. to fire, to water-bodies and to villages. Similarly the minimum distances were generated from random points to all these spatial features.

The statistical comparisons were made between minimum distances from elephant locations and random points for each of these factors using *t*-test assuming unequal variances. Results indicate that elephants do not respond to the burn areas (t= -0.14, P = 0.89) but have responded to roads (t = -3.36, P ≤ 0.05), human settlements (t = -2.06, P ≤ 0.05) and water-bodies (t = -2.18, P ≤ 0.05).

Map-6: Map shows minimum distance from each of the elephant locations to nearest road element.



Since the fire locations were point locations and did not carry the information about the size of the burn patch, elephant's response to fire was not discernible from the data as expected from previous study (Baxter & Getz 2005). It is generally observed that such *ad libitum* location data collected are biased as observers record evidences while on roads or foot trails and that could lead to such result. However, the data supports the past research on Asian elephants where it has been observed that elephants frequent human settlement areas for crop raiding (Garcia et al. 2010) and occupy habitats near water-bodies (Gaugris & Van Rooyen 2010, Gray & Phan 2011, Sukumar 1989).

Conclusions and future scope

Scope of the present study was limited to the analysis of the data available at WGSDI. For the large mammalian species such as elephants it is desirable to have relatively bigger datasets for larger areas. Therefore, it is not wise to make any concluding remarks on the effect of various landscape features on such large ranging species from the present data analysis. For any strong statement on the species response to different habitat parameters, more rigorous data sets and analytical approach is required.

Looking at the present data analysis from the existing information it is evident that elephants somewhat respond to the environmental, topological and anthropogenic factors such as human settlements, water-bodies, roads and land cover types. For the conservation of the species is desirable to maintain it's habitat and reduce the human foot print over the landscape. Since, elephants tend to frequent in vicinity of human settlement area, appropriate conflict management measures needs to be planned for lowering community antagonism.

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