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Application of GIS in Welfare and Management of Captive Elephants in Karnataka

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Elephants in Captivity: CUPA/ANCF -Technical Report 3d

Compassion Unlimited Plus Action

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Preface

In the last few years, a wide variety of people working with wild and captive elephants in India, have recognised the need for change in policies regarding these majestic creatures. Over the years it became clear that if there were changes to be made in the situation of captive elephants, the first thing needed was a comprehensive overview of the existing situation, or understanding of the population status or spatial distribution of them and the location where captive elephants are kept. The knowledge of these aspects may enable policy-makers to come up with viable proposals for the improvement in current management regimes and Ownership Laws that could safeguard the conservation and welfare potential of these magnificent giants.

The ecological and biological needs of elephants are intricately connected with land. Their need for movement across varied habitat, dependence on features of landscape for better thermoregulation, generalist feeding habits may/may not occur in captive conditions. Even if the movement of captive elephants is restricted due to long hours of chaining or confinement, the occurrence of landscape features around the animals may influence their welfare. It is this aspect that this investigation aims to focus on: the presence/ absence of suitable landscape features for captive elephants around and their consequent effect on welfare of the animal/s.

Karnataka has about 160 elephants distributed across 40 locations and 36 locations were visited and geo-coordinates of these locations exported to Google Earth. For each of the points the nearest flowing river and natural forest cover was identified, along with the relationship between the distances of natural forests and free flowing water sources for the locations and across the management regimes. In addition an area of 1000 m^2 surrounding each location was demarcated to determine the landscape features prevalent in that location. A maximum area under suitable landscape elements was observed in forest camps. Elephants from temples, circus and private ownership are exposed to unsuitable landscape elements.

This document provides details of the landscape elements around each elephant and also traces the fact of suitable and unsuitable landscape elements around each elephant. The influence of different landscape elements around the elephants can be clearly seen from this investigation.

Acknowledgements

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Abstract

Information on landscape features provided by GIS can be used as an indicator of welfare of a non-domestic species such as the elephant. Keeping elephants in urban areas with little or no vegetation, devoid of space to move around, travelling or standing for long durations on hard unsuitable substrates may affect the elephant's physical and psychological health in the long-term. Through this investigation, we assume that the information provided by GIS on different locations with captive elephants may give an indication of the current/existing welfare status vis-à-vis the surrounding physical environment. Thirty six locations of captive elephants were visited. Handheld GPS, Survey of India toposheets, and Wikimapia were used to obtain the geo-coordinates of the locations and the geo-coordinates were exported and plotted in Google Earth (KML). This data was used to assess the mean distances of forests and rivers for all the elephant locations. In addition, an area of 1000 m^2 surrounding each location was demarcated (with the centre being 500 m from the perimeter) to determine the landscape features prevalent in that location. Supervised classification was carried out using Maximum Likelihood Classifier (MLC), and based on the classification; the area of each of the landscape element was calculated. The results of MLC was also compared with the extent of area covered by each landscape element that was determined by 200 × 200 m sized grids (referred to as Grid Based Analysis) over images to estimate the accuracy of the results.

The results show that on an average the captive elephants in Karnataka were located 27 km away from forests and 7 km away from a river. About 13% of the locations were found at a distance of 50 km away from forests and about 8% of the locations were 100 km away from any water body. Forest camp elephants, on an average, were located 0.13 km away from a forest, although 66% of the elephant locations were in and along the periphery of the forests. Mean distance of a river from the forest elephant camp location was 2.13 km and about 11% of all locations were located at an amenable (very close) distance to a river whereas a significant 66% were within 2 km. On an average private elephant locations were found 3.4 km away from forests. A river was 4 km away for elephants of private owners; temple elephants were found 41 km away from a forest. No elephants were found within the forest and the distance varied from 52 to 100 km away from forests. The river for temple elephants was at a distance of 9 km. The zoo elephants were located 1 km from forests and the river was 5 km from the elephant locations. The location of the one circus investigated was 25km and 17 km from forest and river respectively.

The results of percentage occurrence of different landscape elements in different regimes show an occurrence of forests in 18 locations, a river in 16 locations, and man-made water bodies in 8 locations. Barren land and roads dominated - found in 34 locations, followed by individual trees (31 locations), built-up areas (28 locations). These elements were also categorized as suitable and unsuitable for elephants. Locations with private-owners and temples showed relatively high percentage of unsuitable landscape elements. The extent of occurrence of suitable landscape elements was the highest among forest camps followed by a location with a private owner. Zoos showed relatively high extent of unsuitable landscape elements as there was a deficiency of 38%. The results also present details of possible implications of unsuitable surroundings in given elephant locations.

Introduction

Information on landscape features provided by GIS can be used as an indicator of welfare of a non-domestic species such as the elephant. The ecological and biological needs of elephants is intricately connected with the surrounding land because of their need for movement across varied habitats (Sukumar, 1989, Williams, 2009), their dependence on features of landscape for better thermoregulation (Kinahan, et al., 2007), and their generalist feeding habits (Sukumar, 1991). Each of these factors may or may not occur in captive conditions. Even if the movement of captive elephants is restricted due to long hours of chaining or confinement, the occurrence of landscape features around the animals may influence their welfare.

Keeping elephants in urban areas with little or no vegetation, devoid of space to move around, and travelling or standing for long durations on hard unsuitable substrates may affect the elephant's physical and psychological health in the long-term. This may be irreversible as with the occurrence of foot related problems (Mikota, et al., 1994) arthritis, excessive weight, skin abrasions or forms of stereotypic expression. Availability of vegetation such as trees, bushes and grass may also act as a source of food: elephants are known to feed on a wide variety of plants; young ones learn to feed from different sources from herd members (Kurt and Garai, 2007). Foraging can also act as a source of psychological stimulation (Roocroft, 1998) and exercise as elephants use different parts of their body to manipulate and eat: bark/ large branches/ branches with thorns and spines, grass with mud attached, fruits that require to be opened up, etc.

Given their poor surface area-mass ratio (Weissenbock, 2006), heat exchange between the elephant's body and its surrounding can be affected in the absence of shade or sunlight as the situation demands, leading to poor thermoregulation and consequent ill-health or psychological stress. This is circumvented to a certain extent by behavioural means such as actively seeking suitable locations to allow for lowering or raising body temperature (Kinahan et al., 2007), sprinkling of water or immersion in water-sources/ sprinkling of dust or wallowing, flapping of their ears (Weissenbock, 2006). Exposure to solar radiation is less in wooded areas and therefore it is highly valuable for elephants. In addition, patches of exposed areas in the wooded vegetation can be accessed for sunlight if needed. When such wooded areas have rivers as water-sources, elephants can access shade, sunlight and water, hence providing the right physical environment to maintain their body temperature.

Through this investigation, we assume that the information provided by GIS on different locations with captive elephants may give an indication of the current/existing welfare status vis-à-vis the surrounding physical environment. The findings of this study of the physical features around the animal may give some scope for the improvement of elephants' welfare given proper husbandry conditions (in the event of the animal being severely restricted in its movement). The use of landscape features to assess welfare status may not take into account future changes that are likely to take place in the landscape as it is restricted to the conditions existing at the time of reference of the available GIS information. Future changes may be positive (shift from barren land to tree cover) or negative (shift from forest areas to built-up area/ agricultural lands). All such changes need consistent reviewing and processing of GIS information of the selected locations for comparisons to be made with previous landscape features. Thus, this investigation can form a baseline for understanding the temporal status of changes in the location.

Method

Karnataka has about 160 captive elephants distributed across many locations. The locations were classified based on ownership (henceforth referred to as regimes) into five types, namely, forest camps (FC- Figure 1a), zoos (Figure 1b and c), temples (Figure 1d), private owners (Figure 1e, f and g) and circuses (Figure 1h). Among private owners, the locations were further sub-divided into Private-II type and Private-I. Private-I comprised of all three private owners, while Private-II comprised of only one of the three owners. The reason for segregation of this owner into a separate sub-category was the difference in occurrence of landscape features between this and the remaining two owners. Landscape features have been estimated for both Private-I (to provide an overall estimate for all private owners) and Private-II. The landscape features observed for the circus in this report does not imply its occurrence for all circuses due to the transient nature of their locations.

Figure 1a: An example of a location of forest camp

Figure 1b: An example of a location of a zoo

Figure 1c: An example of a location of a zoo

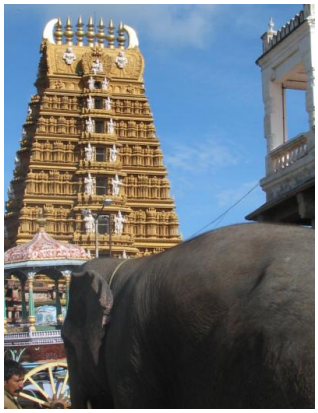


Figure 1d: an Example of a location of a temple

Figure 1e: An example of a location of one private ownership

Figure 1f: An example of a location of private owner

Figure 1g: An example of a location of private owner

Figure 1h: An example of a location of a circus

These 36 locations (Figure 2a and b) where the elephants were visited included 7 from forest camps, 2 zoos, 23 temples, 3 private owners and 1 circus. Wherever possible GPS points were taken and for some of the locations, official names were searched using Survey of India toposheets, Wikimapia and other relevant sources. From these names the geo coordinate was

extracted for each location. Once coordinates were entered in the database, the data was converted into shape file using Arc View 3.2. The shape file was imported in GPS TrackMaker and using this, the points were exported to and plotted in Google Earth (Figure 3).


Figure 2a and b: Examples of locations surrounded by river (a) roads, and buildings (b)

Figure 3: locations of captive elephants presented through Google Earth for Karnataka State, southern India

Green dots denote Forest Camps; Blue denotes Zoos and Red denotes Temples, Mutts and Private Ownership

*For abbreviations used
PK: Pilikula Nesargadama
SHAKBT: Sri 108 Acharya Keshu Bhusan Trust
SJPSM: Sri Jagatguru Pakkireshwara Samsthana Mutt
SMSSDJ: Sri Madacharya Shanti Sagar Digambar Jain
DT: Durgaambike temple
KKS: Kukke Subramanya
MMDK: Mukti Mandir Dharma Kshetra
SLB: Shri Laxmisen Bhattarak

The coordinate system used for mapping was geographic coordinates (latitude/longitude) on the WGS84. Images used in Google Earth are of different resolutions ranging from 15 m (each pixel is a square of 15 meter by 15 meter) to a fine resolution of 2.5 m and 1 m, and due to this images appear as patches (www.roumazeilles.net). Once the locations of

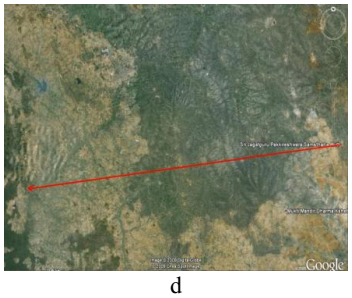
elephants were established, the nearest flowing river and natural forest cover to each of these points was identified (Figures 4a b, c and d for examples). This data was initially used to know the mean distances of forests and rivers from each elephant location. In addition, range and proportions of the distance classes from forest or river were located for all the locations and also calculated across the management regimes.

a

b

Figure 4a and b: Examples of the nearest (a) and the farthest (b) forest cover from the elephant location

c

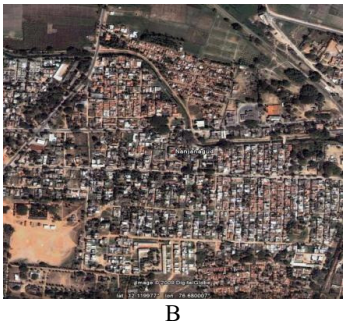


d

Figure 4c and d: Examples of the nearest (c) andfarthest (d) water sources from the elephant location

In addition to the distance data of natural forest and river, an area of 1000 m^2 surrounding each location (Figure 5a and b) was demarcated (with the centre being 500 m from the perimeter) to determine the landscape features prevalent in that location.

A



B

Figure 5a and b: Examples of 1000 m^2 area for elephant location from a forest camp (a) and a temple (b)

Reasons for choosing 1000 m^2 as the area are:

- If we assume that captive elephants in forest camps are allowed to range-free over a mean area with 2 km radius (without making the elephant walk on unnatural surfaces and with just the elephant's interests in mind), the same area cannot be used by other institutions as the elephants in the other institutions may not be allowed to range-free or there may be no space to free-range.
- If we consider very small units (less than 10 m or the length of the chain in which elephants are normally confined) the landscape surrounding such a minimum area may be limited to a few elements such as a tree or concrete built-up area. However, a relatively larger area may provide a better picture of the surrounding micro-environment: presence or absence of forests/ trees/ rivers/ the land-use pattern and consequent ambient conditions.

For this investigation 1000 m^2 was selected as an experimental unit. Bigger/ smaller areas may be considered depending on the need and other associated information available.

Data processing

Snap shot images (1000 m^2) of Google Earth were processed using ERDAS IMAGINE 8.4 software. The image processing involved was of two different kinds: 1. Supervised classification and 2. Grid Based Analysis (GBA)

Landscape elements classified are

1. Agricultural land
2. Barren land
3. Built-up area
4. Forested land
5. Road
6. Individual tree
7. Water body

Each 1000 m^2 was then analysed to identify and list the presence or absence of different landscape elements. Example of landscape elements (encircled) is given in the Figure 6.

Supervised classification was carried out using Maximum likelihood classifier (MLC), and based on the classification, the area of each of the landscape elements was calculated (Figure 7).

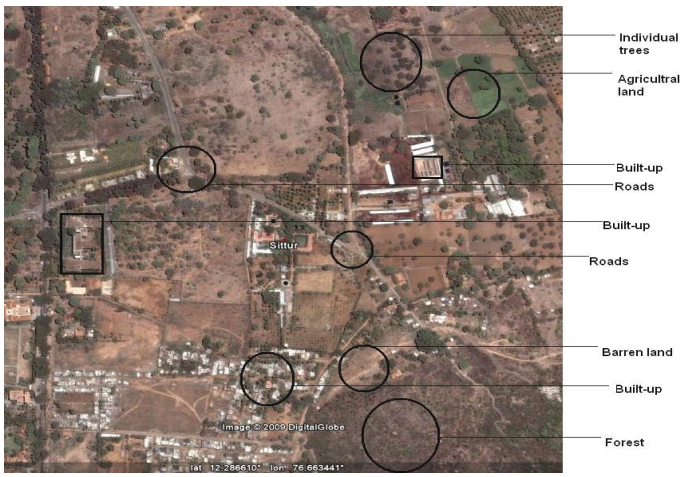


Figure 6: Example of landscape elements identified for the investigations

The ground knowledge of the analyst revealed that supervised classification based on MLC may overestimate or underestimate the total areas of some of the important landscape elements. The Figure 7 provides examples of built-up area (as rectangle and square) that could have been wrongly classified by MLC as barren or agricultural land. Figure 7 also provides an example of errors encountered by supervised classification.

Classification of Digital Globe imageries (Google Earth snap shots) may incur error as the spectral information for those images are limited and are high in spatial resolution. Expert classification technique may give more specialised control and better results than just supervised classification. The images with high spectral and spatial resolution may not be available for every location and thus the investigation depended on the snap shots.

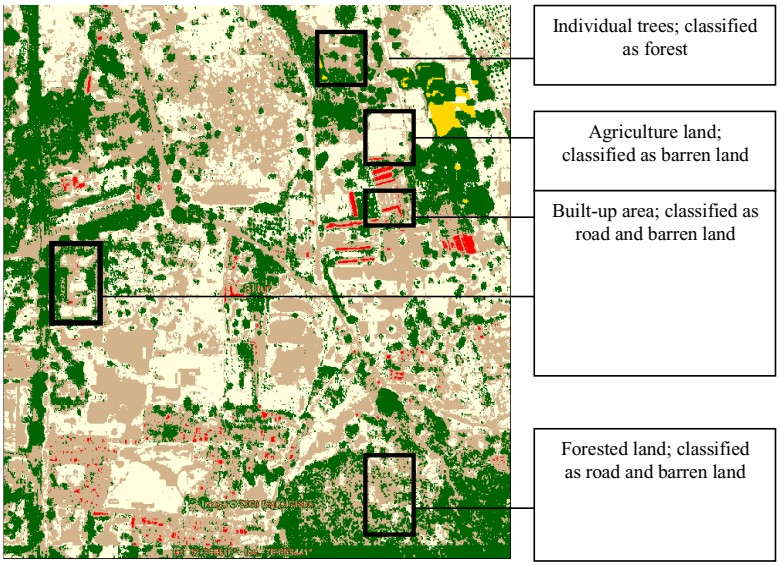


Figure 7: Example of classified image using maximum likelihood classifier (MLC) for one of the locations covering 1000 m^2, note that the errors encountered from MLC are also presented

To overcome the problem associated with the MLC for the classifications of Google Earth Images, the extent of area covered by each landscape element was determined by creating 200 × 200 m^2 sized grids over images (Figure 8) for each location (Heretofore, this approach will be mentioned as Grid Based Analysis -GBA).

Thus, a total of 25 grids were analysed visually (manually) by the analyst for each location and the extent of area covered was calculated as a percentage of the total area.

Figure 8: Example for data processing using 25 equal size girds and smaller girds within individual grid/s

The results of both MLC and GBA were compared and many interesting insights were noticed. For comparison, the area around 1000 m^2 elephant locations from 6 temples, 2 forest camps and 1 zoo, 1private ownership and 1 circus (Table 1) were selected. The selection of the number of locations for regimes was random and the sample size was in proportion to the total number of locations investigated for each regime. Regime wise mean and overall mean (all regimes together) were considered for the comparison.

Table 1a: Comparison of percentage areas of landscape elements of Trees, River and Forest calculated by GBA (1) and MLC (2) for sample areas (1000 m^2) around captive elephant locations selected randomly

Regime	**A**		**B**		**C**	
	1	2	1	2	1	2
Temple	1.4	1.7	6.4	6.7	1.7	
Temple	12	0	3.9	4.2	31	24.1
Temple	31.3	46.9	0.1	0	0	0
Temple	1.2	9.1	0	0	0	0
Temple	6.7	0	0.3	3.4	61.7	70.6
Temple	8.3	0	0	0	10.2	29.2
Temple	2.5	6.3	0	0	0	0
Mean (temple)	9.1	9.1	1.5	2	15	20.6
SE	4.3	7	1.1	1.1	9.6	11.3
Forest camp	1.3	0	29.7	25.4	29.7	32
Forest camp	0	0	6.6	4.9	92.9	63.9
Mean (forest camp)	0.7	0	18	15	61	47.9
SE	0.9	0	16	15	45	22.6
Zoo	29.6	27.7	0	0	0	0
Private	3.8	17.5	0	0	0	0
Circus	20.4	30.8	0	0.8	0	0
Mean (all regimes)	9.9	17.5	3.9	4.1	20	18.9
SE	3.4	5	2.6	2.2	9.1	8.1

A: Trees, B: River, C: Forests

Table 1b: Comparison of percentage areas of landscape elements of Built-up, Agricultural, Barren lands and Roads calculated by GBA (1) MLC (2) for sample areas (1000 m^2) around captive elephant locations selected randomly

Regime	**D**		**E**		**F**		**G**	
	1	2	1	2	1	2	1	2
Temple	21.5	6.6	57.9	68.8	10.1	15	0.8	1.2
Temple	3.9	7.3	8.7	3.8	40.2	60.5	0.3	0.2
Temple	55.9	21.1	9.7	0.5	1.6	21.1	1.5	10
Temple	37.1	6.5	46.1	8.9	13.8	54.5	1.8	21
Temple	0	0	29.7	26	1.1	0	0.5	0
Temple	12.8	0.9	37.9	0.5	29.7	30.4	1	39
Temple	53.7	44.7	0.1	0	40	40.3	3.7	8.8
Mean (temple)	26	12	27	16	20	31.7	1.4	12
SE	9.3	6.4	8.8	10	6.9	8.9	0.5	5.8
Forest camp	0	0	19.4	6.7	19.4	0	0.5	27
Forest camp	0	0	0	0	0	29.2	0.4	2
Mean (forest camp)	0	0	9.7	3.3	9.7	14.6	0.4	14
SE	0	0	14	4.7	14	20.6	0.1	18
Zoo	14.4	12.4	0	0	54.8	40.3	1.3	0
Private	46.7	58.4	0	0	46.7	17.7	2.8	6.5
Circus	24	26.2	0	0	54.4	36	1.2	6.1
Mean (all regimes)	22.5	15.3	17.5	9.6	26	28.7	1.3	10
SE	6.4	5.8	6.2	6.1	6.3	5.8	0.3	3.8

D: Built-up E: Agricultural land F: Barren land G: Roads

It was found that MLC underestimates the areas of both built-up and agriculture landscape elements. The area for barren land and roads are overestimates. In GBA methods the individual trees were distinguishable whereas the MLC was not able to recognise individual trees. This may be due to built-up and agricultural landscape elements having spectral signatures resembling open barren land. Likewise, individual trees have the signatures resembling forest areas.

It was important to define and distinguish between different landscape elements, particularly agricultural and barren land. Agricultural land can be defined as land with regular shapes and distinguishable with or without any occurrence of vegetation, whereas open barren land may not have distinct boundaries and are irregular in shape. There are smaller grassland areas in between forest trees and there are distinct large patches of barren land in some places. Small patches of grasslands located between trees in the forests during dry season may also appear as barren land.

As we use MLC, it calculates both the small and bigger areas as total barren area. This may give an impression that a large proportion of the area is under barren land. With the ground knowledge of the analyst, the definitions and issues associated with errors in classifications were possible in GBA. As signatures for water bodies are distinct and don't merge with any other landscape element, the area calculated is consistently similar for both these approaches (Table 1a and b). Given these points the results from the GBA were used for the final analysis.

Landscape elements were then classified into those suitable for elephants like the occurrence of forests, individual trees, rivers and water-bodies. Forests and rivers form the basis for distribution of wild elephants in terms of providing food, water (river) shelter or cover and shade to the animals.

Landscape elements such as built-up area, agricultural land, barren land and roads around the animal are considered unsuitable as built-up areas and agricultural land cannot be accessed as a resource by the elephants. Built-up area adds to the temperature gradient in an area. Barren land/roads do not provide any form of protection from temperature variation (high temperatures)/rain; also such resources cannot be accessed for food and are not natural shelter and shade.

The following were determined for the regimes:

1. Comparison of the number of landscape elements predominant across regimes
2. Comparison of landscape elements across regimes for the extent of area
3. Proportion of suitable/ unsuitable elements occurring in each regime

Results

On an average, captive elephants in Karnataka were located 27 km (SE=8.9, N=39) away from forests and 7 km (SE=2.4, N=39) away from a river. The distances ranged from 0 to 291 km, for forest and 0 to 17 km for a river. For both forest and river the distance class of 2 km dominated (Figure 9), 33% and 41% of locations fall under this distance for forest and river respectively. About 13% of the locations were found at a distance of 50 km away from forests and about 8% locations were 100 km away from any water body.

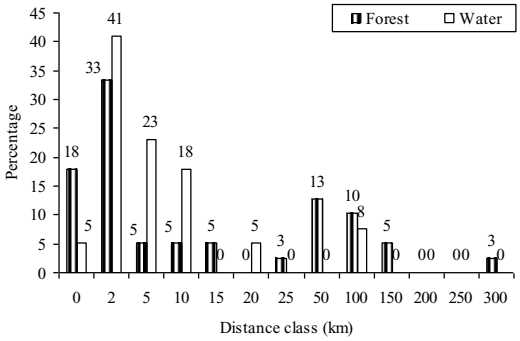


Figure 9: Patterns of occurrence of forest and river from captive elephant locations

Forest camp elephants, on an average, were located 0.13 (SE=0.11, N=9) km from any forest, the distance ranged from 0 to 0.1 km, and 66% of the elephant locations were in very close proximity (~ 0 km) of the forests. Mean distance for a river from the forest camp elephant location was 2.13 km (SE=0.93, N= 9) and the distances ranged from 0 to 5.9 km, about 11% of the locations were located at very close proximity (~ 0 km) to a river and 66% were within 2 km. On an average private elephant locations were found 3.4 km (SE=2.3, N=3) away from forests; the distances ranged from 0 to 7 km and 33% of the locations were found at ~ 0, 4 and 7 km away from a forest. The mean distance to the river for the elephants of private ownership was 4 km (SE= 2.6, N=3) and it ranged from 1 to 7 km and 33% of the locations were found at ~ 1, 5 and 7 km from a river.

Temple elephants were found at a mean distance of 41 km (SE=13.2, N=24) away from a forest, the distances ranged from 0.1 to 107 km. No elephant was found in ~ 0 km distance from the forest and about 12% of the elephants' locations varied from 52 to 100

km away from forests. The river for temple elephants was at a distance of 9.2 km (SE=3.7, N=27), the distance ranged from 0 to 59 km and 12% of the locations were 50 to 100 km from rivers. The zoo elephants were located 1 km (SE=1.76, N=2) from forests, the distance ranged from 0 to 2.5 km and 50% locations were at a distance of 0 to 2.5 km. The river was 5 km (SE=3.3, N=2) from the elephant locations, the distance ranged from 3 to 7 km and both (3 and 7 km) contributed 50%. The location of the one circus investigated was 25 and 17 km from forest and river respectively.

Landscape elements around elephant locations

Percentage occurrence of different landscape elements in different regimes using GBA method is presented here. The results show the occurrence of forests in 18 locations, river in 16 locations and man-made water bodies in 8 locations. Barren land and road dominated in locations where captive elephants were kept and these landscape elements were found in 34 locations, followed by trees (31), and built-up areas (28).

The overall mean percentage area covered by different landscape elements (considering all locations together) is given in Figure 10.

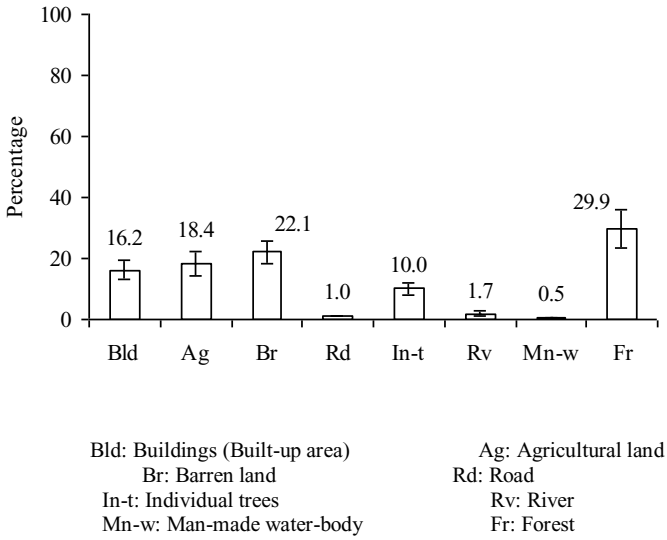


Figure 10: Overall percentage occurrence of landscape elements

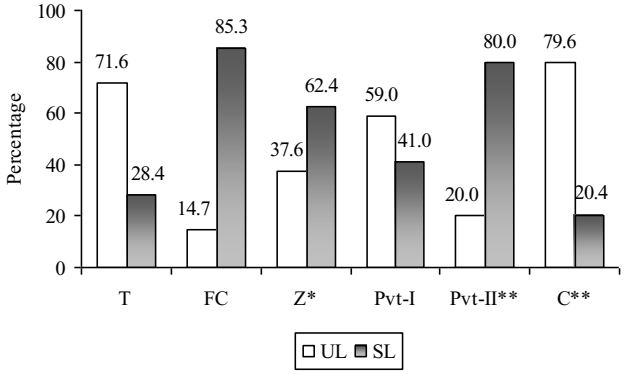
Forest cover in elephant locations ranged from 0% in temples to 98% in forest camps, barren land ranged from 0% in forest camps and 94% in temples, agricultural land ranged from 0% in forest camps to 85% in temples, built-up area ranged from 0% in forest camps and 56% in temples, percentage area under individually scattered trees ranged from 0% in forest camps and 42% in zoos, river ranged from 0% in temple, zoo, private ownership and circus to 29% in forest camp.

Roads ranged from 0% to 4% in temple, and manmade water bodies ranged from 0% in all the regimes to 8% in temples.

Percentage occurrence of landscape elements from different management regimes

Locations with private-owners and temples showed relatively high percentage of unsuitable landscape (UL) elements. In other words, there was absence of suitable features to the extent of 80% for circuses and 72% for temples.

The extent of occurrence of suitable landscape (SL) elements was the highest among forest camps followed by a location with a private owner. Zoos showed a relatively high extent of unsuitable landscape elements as there was a deficiency of 38% (Figure 11).



T: Temples FC: Forest camps Z: Zoo
Pvt-I: Private ownership type I Pvt-II: Private ownership type II C: Circus

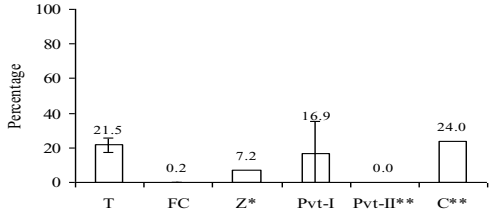
*: Two zoos were considered **: One location was considered

Figure 11: Comparison of suitable/ unsuitable landscape features across institutions

Percent occurrence of different landscape elements across different management regimes

Built-up area

The maximum occurrence of built-up area was seen in locations with circus and temples which accounted for more than 45% of the total area observed. Minimum was seen in forest camps with less than one percent occurrence of built-up areas and none for Private-II (Figure 12).

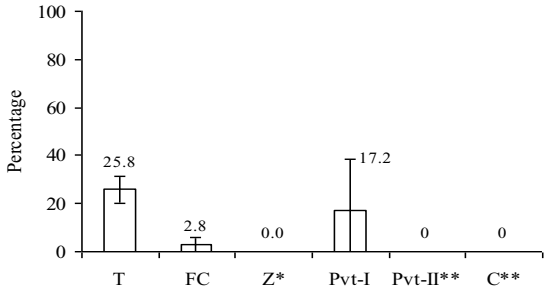


T: Temples FC: Forest camps Z: Zoo
Pvt-I: Private ownership type I Pvt-II: Private ownership type II C: Circus
*: Two zoos were considered **: One location was considered

Figure 12: Comparison of percent occurrence of built-up area across institutions

Agricultural lands

There were no cultivated lands in locations with Private-I / zoos/ circus, 25% of the total area around temples was under cultivation while the same land-use was less than 5% in forest camps (Figure 13). Private-II showed more than 15% occurrence of agricultural lands.



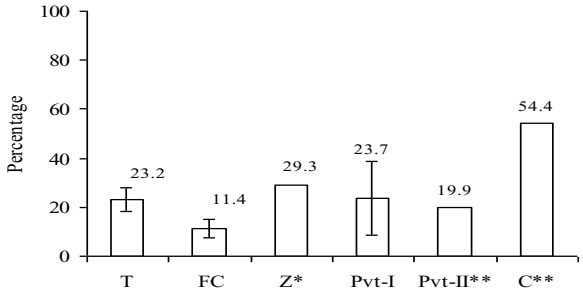
T: Temples FC: Forest camps Z: Zoo
Pvt-I: Private ownership type I Pvt-II: Private ownership type II C: Circus

*: Two zoos were considered **: One location was considered

Figure 13: Comparison of percent occurrence of agricultural lands across institutions

Barren land

Maximum occurrence was seen in the location of the circus with more than half of the total area being described as barren. Zoos showed nearly 30% occurrence of barren land followed by temples and Private-I which showed similar values with less than 25% occurrence. Forest camps showed minimum percentage of occurrence (Figure 14)



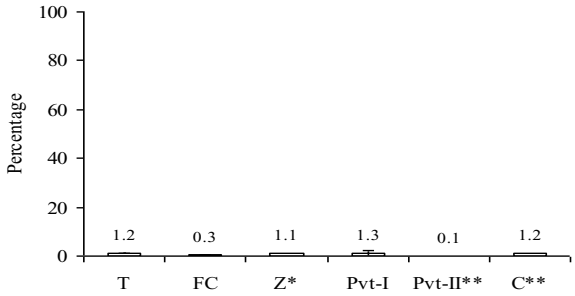
T: Temples FC: Forest camps Z: Zoo
Pvt-I: Private ownership type I Pvt-II: Private ownership type II C: Circus

*: Two zoos were considered **: One location was considered

Figure 14: Comparison of percent occurrence of barren lands across institutions

Roads

All institutions showed less than two percent occurrence of this land use. Comparable occurrence was noticed for Temples, Zoos, Private-I and circus. Less then one percent was seen in Forest camps and Private-II (Figure 15).



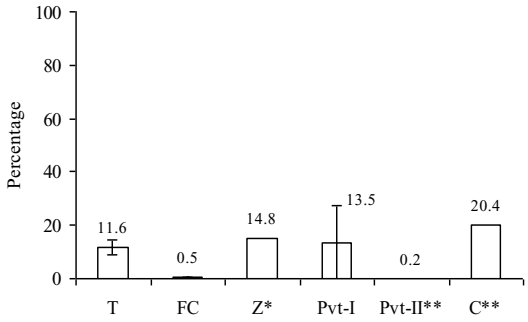
T: Temples FC: Forest camps Z: Zoo
Pvt-I: Private ownership type I Pvt-II: Private ownership type II C: Circus

*: Two zoos were considered **: One location was considered

Figure 15: Comparison of percent occurrence of roads across institutions

Individual trees

Maximum occurrence of individual trees was seen in the circus which was less than 25% of the total area observed. Comparable occurrence was observed for Zoos and Private-II. Minimum was observed for Forest camps and Private-II (Figure 16).



T: Temples FC: Forest camps Z: Zoo
Pvt-I: Private ownership type I Pvt-II: Private ownership type II C: Circus

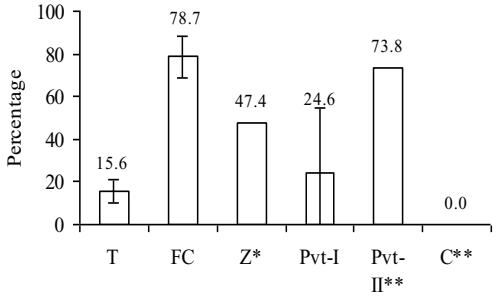
*: Two zoos were considered **: One location was considered

Figure 16: Comparison of percent occurrence of individual trees across institutions

Forests

Forest camps and Private-II showed maximum occurrence of forests, a deficiency of 19% was observed in forest camps. Variation was seen in the occurrence of this feature

implying non-uniform distribution across forest camp locations. A deficiency of 53% in the occurrence of forests was seen in zoos. Temples showed a deviation of 84% while there were no forests for locations under circus. Private-II locations had maximum variation among all the regimes implying heterogeneity in distribution among private locations (Figure 17).



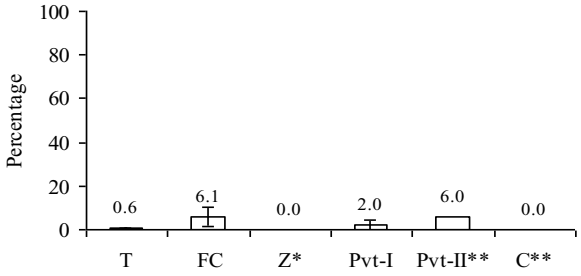
T: Temples FC: Forest camps Z: Zoo
Pvt-I: Private ownership type I Pvt-II: Private ownership type II C: Circus

*: Two zoos were considered **: One location was considered

Figure 17: Comparison of percent occurrence of forests across institutions

Rivers

Only forest camps and Private-II showed occurrence of more than 5% area for rivers, variation in occurrence indicating non-uniformity in its availability across forest camp locations. Less than one percent of area among temples had rivers flowing and none of the zoos/ circus had access to rivers. When all private owners were considered together (Private-II) the area under rivers reduced to 2.0% indicating the absence of this landscape for the other two locations with private owners (Figure 18).



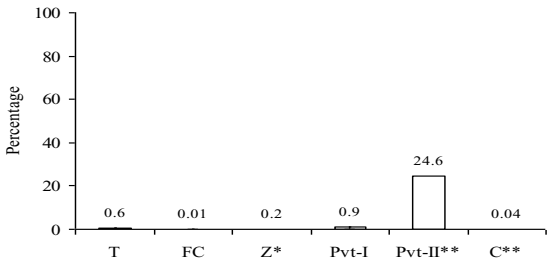
T: Temples FC: Forest camps Z: Zoo
Pvt-I: Private ownership type I Pvt-II: Private ownership type II C: Circus

*: Two zoos were considered **: One location was considered

Figure 18: Comparison of percent occurrence of rivers across institutions

Water-body

Overall occurrence of a water body was less than 1% for all institutions, except for Private-II. Zoos and temples showed occurrence of this feature in less than one percent of the area observed. The circus location had negligible area as water-body. (Figure 19).



T: Temples FC: Forest camps Z: Zoo
Pvt-I: Private ownership type I Pvt-II: Private ownership type II C: Circus

*: Two zoos were considered **: One location was considered

Figure 19: Comparison of percent occurrence of water-bodies across institutions

Proportion of landscape elements

Proportion of occurrence of suitable (forests, rivers, individual trees and water-body) elements showed some pattern, as most locations (N=16) showed a deficiency of 44% in the availability of number of suitable landscape elements, i.e., presence of only two suitable elements (Figure 18). Five locations (14%) had only one of the four possible suitable elements. Of these locations (N=5), three were temples, one was from a private ownership and one from a zoo. Figure 20 shows the occurrence of suitable landscape elements relative to all the landscape features in a given location. For example, only four locations have 60% occurrence of suitable elements in relation to the total elements available in that particular location.

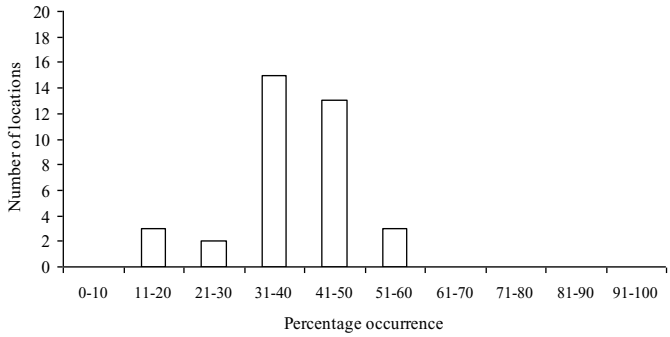


Figure 20: Overall distribution of suitable landscape

Landscape elements contributing to major portion (>10%) of unsuitable features

For temples, unsuitable landscape was distributed in comparable areas with built-up area, agricultural land and barren land contributing a total of 70% area. Barren land occupied 11% area under forest camps. For Private-II, comparable areas were occupied by built-up area, agricultural land and barren lands contributing to 58% of the area. However, only 19% area was under barren lands for Private-I. For zoos, 29% area was under barren land. For circus, built-up area and barren land contributed 78% of the area.

Landscape elements contributing to major portion (>10%) of suitable features

Individual trees and forests occupied comparable areas, contributing 27% of the total area for temples. For forest camps, 79% of the area was under forests. Private-I locations had areas under individual trees and forests to the extent of 38%. Suitable landscape area for Private-II was 74% of forests. Zoos showed 62% of area under individual trees and forests. Individual trees occupied 20% area in circus.

Occurrence of water-sources

Comparable area under sources of water (water-bodies/ rivers) was seen in Forest camps and Private-I (6%). Private-II showed 3% area while temples had 1% area for water-sources. Zoos and circus had less than 1% area for water-source.

Number of locations with >70% forest area and presence of rivers

Five of the seven forest camps had access to a mean of 70% area under forests along with occurrence of rivers. This was true for Private-II also. None of the other regimes had access to both these features to the extent mentioned.

Overall patterns of suitable and unsuitable landscape elements around captive elephants in Karnataka:

- Forest camps (N=7) and Private-II (N=1) locations show the occurrence of suitable landscape features (forest area and river/ water-body) in terms of number and area covered. Only one forest camp lacked access to river/ man-made water-body while one had less than 30% of forest cover (with 1% individual tree cover). Maximum area under suitable landscape (relative to all other elements occurring in that location) was 60% for FC and Private-I.
- Among temples, 18 locations (N=23) showed the occurrence of each of the two types of suitable elements (forest/tree and river/water-body). However, when area under forest or individual trees to the extent of at least 50% along with occurrence of any of the two types of water-sources is considered, only three locations satisfy this criterion implying lack of suitable forest/ tree cover. Even when the area under individual tree/ forest cover to the extent of 10% or more was considered along with occurrence of any of the two types of water-sources, only nine (N=23) temples had occurrence of the specified features. When percentage under suitable landscape (relative to all elements occurring in that location) was considered, maximum area under suitable landscape was only 50%.
- Two private owners, excluding Private-II, lacked at least two suitable landscape elements. In terms of area, only one private owner (excluding Private-II) had access to > 10% area under individual trees and water-body. The extent of tree cover was, however, less than 50%. The maximum area for these two private

owners was 33% for occurrence of suitable landscape relative to all other landscape elements existing in that location.

- Only one zoo lacked three of the four desirable landscape elements. In terms of area, only one zoo had >50% of forest cover with access to man-made water-body. Zoo showed a maximum area of 50% for suitable landscape relative to all other elements in that location.
- Circus lacked two of the four desirable landscape features. When area was considered as a criterion, tree cover was less than 50%; access to man-made water-body was available. The location for circus showed a maximum area of 50% under suitable elements relative to all other features.

Discussion

Elephants have been maintained by humans for thousands of years, yet this species has not been domesticated (Lair, 1997). They cannot be considered to have been changed genetically to suit human preferences and needs. Essentially, they are wild animals undergoing/ having undergone life in conditions provided by people. Given a situation in which elephants are cared for by people, features of their captive condition curtailing their natural, species-specific expression of behaviours are likely to affect their physical/ physiological/ social/ psychological well-being, in other words, their welfare. Welfare could be defined, in this context, as any deviation observed in the living conditions (biological/ ecological/ social) of the elephants when compared to those observed in the wild. With this perspective, physical features of the surrounding landscape for captive elephants assume greater importance when availability/ accessibility to elephants and effect of such features on the ambient temperature are considered.

Keeping elephants in wooded/ forest areas alone does not take care of their biological needs: water has to be provided when the elephant needs it. Lack of water may have negative physiological consequences, a factor compounded by poor nutrition encountered when the animal is provided only stall-feed with limited food types. Captive elephants are usually provided water through various means such as ponds/ tanks/ through buckets/ hose-pipes. Several disadvantages with such sources are:

- Chance of contamination when accessing stagnant water sources (tanks/ ponds/ buckets)
- Unavailability of water when the elephant needs to access it (water-tap/ hose-pipe) either for drinking/ bathing, limited quantity available from such sources
- Absence of opportunity to perform species-typical behaviours such as dust-bathing/ wallowing/ immersing itself in water—behaviours with a thermoregulatory function/ assisting in maintaining skin health—when ponds/ tanks are created without proper substrate around such sources

Maintaining single elephants in isolation, lack of opportunity for elephants to decide on their social partners, absence of individuals of opposite sex, restraining elephants when they are reproductively active, separation of dependent young from kin: are all social factors of importance to a species considered to maintain a complex interaction of relationships across generations (Poole and Moss, 2008; Vidya and Sukumar, 2005). Thus, it is a combination of the physical and social which ensures that the well-being of elephants is not compromised in captivity. Suitable living areas along with presence of conspecifics with unrestrained access to resources/ social partners may provide an extent of near-natural living environment for captive elephants.

Maintaining elephants in areas with little or no vegetation with temperatures reaching more than 40 ˚C during summer can be considered to represent poor welfare, at best. This is regardless of the management practice adopted— allowing the elephant to free-range / chaining it in one place, providing artificial cooling systems, etc. as mentioned earlier. The elephant has limited choice in regulating its body temperature as firstly the location itself is not chosen by the elephant and secondly most accessory features for temperature regulation are controlled by people. In conjunction with presence of appropriate water sources, landscape features decide the suitability of a location for maintaining elephants.

The investigation of assessing the nearest forest and river to captive elephant locations for Karnataka provide very interesting results. Except for forest camp elephants, the actual distances in which these two important parameters found for elephants in Karnataka are very far. The forest could be found as far as 300 km and River could be as far as 17 km away from elephants. In terms of occurrence of unsuitable landscape elements, maximum area was observed with private owners followed by temples. The least area under unsuitable elements was observed for forest camps. Conversely maximum area under suitable landscape elements was observed in forest camps followed by zoos. It can be seen from the results that the most suitable landscape features (occurrence of forests and rivers) were available for forest camps. When tree cover (inclusive of forests) and water-sources (river and water-body) were included, temples and zoos provided these features, though to a lesser extent than forest camps. Minimum suitable landscape features were provided in locations with private owners.

The influence of different landscape elements around the elephants can be clearly seen from this investigation. The occurrence of built-up areas around elephant locations have several implications as unavailability of space for the elephant, such structures may also have an effect on the micro-environment (temperature). There is also an absence of feeding opportunity for the animal as a consequence of absence of vegetation. Two aspects of agricultural lands can be seen as occurrence of vegetation and seasonality of agricultural practice. However, when land is cultivated, it becomes unavailable to the elephant. Secondly, when land is left fallow, it adds to the temperature gradient of a place and cannot provide resources such as feeding opportunity or shade.

Barren land may provide space for the elephants to move, but in conditions of high temperature prevalent during summer, such areas are not of any use. They do not provide any protection during the cooler months of winter or from the rains during monsoon. In addition, absence of vegetation makes it meaningless for the animal to traverse such a space. A feature of most places with human population is the presence of roads. Both tarred and un-tarred roads have been considered together. Movement on tarred roads is undesirable and harmful for elephants, while un-tarred roads can act as strips of barren land. In conjunction with built-up area, such features can add to the negative welfare of elephants in that location.

The presence of tree cover in the form of individual trees around the elephant location may be considered suitable as they may affect or influence ambient temperatures, provide shade, act as rubbing posts, and depending on the species, it may act as a source of food for the elephants. The difference from forests is that individual trees are tended to by people and are not spread over vast areas. Presence of vegetation across vast stretches of land can be considered as forests. Such areas not only provide space to move but also feeding opportunity for elephants. In conjunction with rivers they are integral to the well-

being of elephants as such features allow performance of species-typical activities. Even when captive elephants are restricted in their movement, the presence of vegetation in surrounding areas can act as a cooling factor during periods of high temperature.

Presence of flowing water of a perennial nature is ideal as it ensures supply of relatively less contaminated water throughout the year. In conjunction with suitable management practices such as opportunity to free-range and presence of conspecifics, this feature adds to the value of a location. In the absence of free-ranging opportunity, the presence of rivers ensures availability of water to the captive elephant. In the absence of rivers, water-bodies can act as a source of water. The only disadvantage is their stagnant nature and size (smaller bodies may not provide enough water and maybe more contaminated as they do not flow).

Captive elephants and human interference are interlinked and the very presence of an elephant in a location can be attributed to a human cause. However, this interference or control by people can be such that it could have a positive effect on elephants' welfare through provision of features which prioritise elephants' biological and behavioural needs. One such example is that of privately-owned elephants (Private-II): two unrelated female adult elephants have very suitable landscape features around them; they have been allowed access to the adjoining forest area with access to a river. These elephants are allowed to roam in the forest to forage (with drag chains/ hobbles) and are exposed to resident wild males. Consequently, a calf was born to one of the captive females adding to the number of elephants in the region. An additional feature of their captivity is minimal interference in the form of a work schedule.

Conclusion

Animals such as elephants are wild species. They are not domesticated/ modified to suit human environment. If such animals are brought to a human environment for religious/ cultural/ economical/ recreational purposes, the area provided to them may not be suitable for their living conditions. This study provides the basic knowledge of how suitable/ unsuitable or how similar/ dissimilar the physical environment of captive elephants is.

Once this knowledge is gained through this investigation, land use planning could be made appropriate to the animal's welfare. Animal welfare is not only important to the animal to fulfill human objectives (economical/ cultural/ religious/ recreational), it also affects the owners. For example: when used for entertainment such as in circuses, environment provided if not suitable, may not be conducive for an animal to be active to entertain public. When used to create awareness as in zoos such unsuitable environments provide wrong knowledge about the species' needs.

Land use planning around animal/s in areas with unsuitable landscape elements: for a regime surrounded by built-up areas— since built-up area cannot be accessed by the animal and cannot be demolished─ the animal can be moved to areas where buildings do not occur and to places with varied vegetation and natural substrates. If area is surrounded by barren land, it could be manipulated to create suitable landscape. For forest areas, even with private ownership, it should motivate the owner to maintain the same set of land use and prevent any degradation of land.

It's also assumed that the application has more potential:

1. To verify the suitability of a location to which a confiscated elephant is being moved.
2. To verify the suitability of a location where exchange of elephants between places is being planned.
3. To verify the suitability of a location before a license is issued or renewed.
4. As a scientific documentary evidence for declaring the location of an elephant unsuitable.
5. To estimate the carrying capacity of a location (the maximum number of elephants that can be maintained at a site)
6. To plan the location of elephant care centres and elephant orphanages.
7. To plan sites where captive elephants can interact with their wild counterparts.

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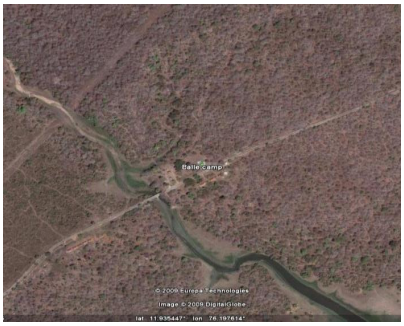
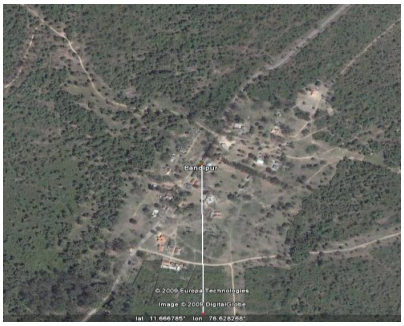
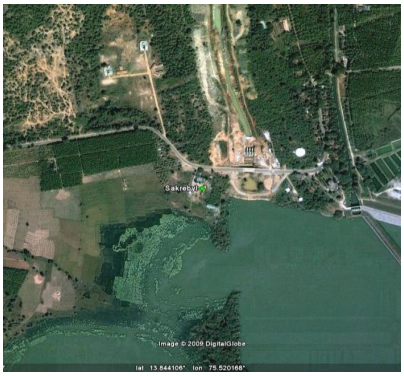
Appendix 1: Landscape elements around elephants from different management regimes

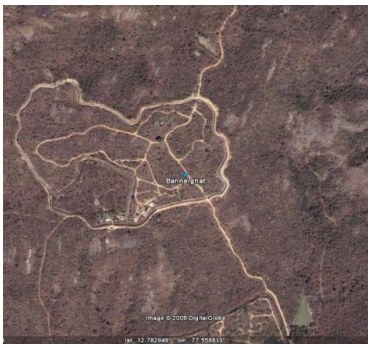
Forest Camps



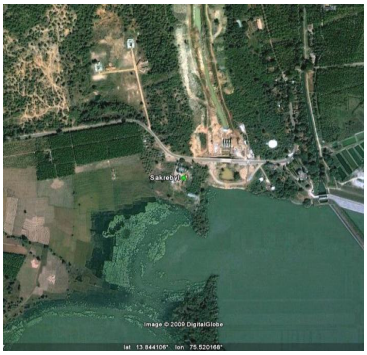




Zoos



Private Ownership



Private Ownership

Temples


Durgaambika temple


Mukti Mandir Dharma kshetra


Kodyadka
Image © 2009 DigitalGlobe


Marldevpur
Image © 2009 DigitalGlobe


Kollur
Image © 2009 DigitalGlobe


Madhoa

Temples


Kukke Subramanya
Image © 2009 GeoEye


Udupi


Nanjangud
Image © 2009 DigitalGlobe


Alrani
Image © 2009 DigitalGlobe


Sirigere
© 2009 Cnes/Spot Image


Sittur
Image © 2009 DigitalGlobe

Temples

Circus

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Compassion Unlimited Plus Action (CUPA) is a non-profit public charitable trust registered in 1991 that works for the welfare of all animals. Since 1994, CUPA has worked in close collaboration with government departments and agencies on various projects. CUPA's mission is to protect animals from abuse and violence and do what may be required to alleviate their suffering at the hands of humans. CUPA does not differentiate among pet, stray or wild animals, since all of them may require assistance and relief from cruelty, neglect and harm. The organisation's objective has been to design services and facilities which are employed fully in the realisation of these goals.

Wildlife Rescue & Rehabilitation Centre (WRRC) is a registered public charitable trust for the welfare of wild animals and birds that often find themselves trapped in an urban environment. The Trust is a sister concern of CUPA and both organisations complement each other in their services. WRRC was established as a separate Trust in 1999.

Asian Nature Conservation Foundation (ANCF) is a non-profit public charitable trust set up to meet the need for an informed decision-making framework to stem the rapidly declining natural landscape and biological diversity of India and other countries of tropical Asia. The Foundation undertakes activities independently and in coordination with governmental agencies, research institutions, conservation NGOs and individuals from India and abroad, in all matters relating to the conservation of natural resources and biodiversity, endangered flora and fauna, wildlife habitats and environment including forests and wetlands. It participates and disseminates the procured information, knowledge and inferences in professional, academic and public foray.

World Society for Protection of Animals (WSPA) With consultative status at the United Nations and the Council of Europe, WSPA is the world's largest alliance of animal welfare societies, forming a network with 910 member organisations in 153 countries. WSPA brings together people and organisations throughout the world to meet the challenge of global animal welfare issues. It has 13 offices and thousands of supporters worldwide.

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This study conducted on Asian Elephants has resulted in obtaining information on the spatial distribution of their locations and their influence on the welfare of the species in captivity. The spatial data helps in understanding the concept of a welfare location, and this can be defined by determining the landscape features prevalent around the captive elephants. The influence of different landscape elements around the captive elephants can be clearly seen from this investigation.

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Compassion Unlimited Plus Action

WRRC
WILDLIFE RESCUE AND REHABILITATION CENTRE

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