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A Geo-Spatial Assessment of Habitat Loss of Asian Elephants in Golaghat District of Assam

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Introduction

The state of Assam is regarded as one of the strongholds of Asian elephant conservation (Stracey 1963; Santiapillai & Jackson 1990; Choudhury 1999; Bist 2002), with about 5,200 elephants as assessed in 2005 by the Assam Forest Department. In comparison, the total Indian elephant population numbers about 26,400. The forest areas of Golaghat and Karbi Anglong districts are one of the richest forest covers with outstanding biodiversity values. The forest areas of Golaghat and adjoining areas of the Karbi Anglong districts are represented by the Nambor-Doigrung Wildlife Sanctuary (120 km^2), Garampani Wildlife Sanctuary (6 km^2) and Nambor Wildlife Sanctuary (37 km^2). These sanctuaries are also part of the Kaziranga-Karbi Anglong Elephant Reserve, declared on 17 April 2003, with an estimated area of 3,270 km^2.

The forest areas of Golaghat district play a major role in the conservation of elephants in the Kaziranga-Karbi Anglong Landscape. Massive shrinkage and fragmentation of natural habitat due to illegal human settlement, and opening up for tea industry are major anthropogenic disturbances that have contributed enormously towards the total destruction of elephant habitats in Golaghat district. Moreover, the killing of wild elephants for ivory and meat has led to a decline in elephant populations in these areas since 1980 (Lahiri Choudhury 1980). Growing animosity between humans and elephants has increased tremendously resulting in massive human-elephant conflict that has shattered the age-old co-existence of humans and elephants (Talukdar *et al.* 2006).

In view of the increased human-elephant conflict, we undertook a study on the loss of forest cover since 1974, in the Golaghat district in Assam, excluding the Kaziranga National Park (430 km^2). The study was based on satellite images of the areas in 1974, 1991 and 2004, and intense ground assessment of the current forest cover, to find out the relationship between habitat loss of elephants and subsequent increases in human-elephant conflict in Golaghat district. We used remote sensing and GIS technologies for analyzing and estimating loss of Asian elephant habitat due to deforestation and encroachment in the moist deciduous and semi-evergreen forests.

Methods

Study area

We selected eight Reserve Forests of Golaghat district of Assam (Fig. 1, Table 1). The study area is about 942 km^2 of the 3,588 km^2 total area of Golaghat district. We excluded the area of Kaziranga National Park (380 km^2) and the Panbari RF (12 km^2) area because these areas are properly protected and there is no massive forest degradation noticed in these areas in the recent past. The latitudinal and longitudinal extension of our study area is from 25°45' to 26°30'N latitude and 93°45' to 94°05'E longitude. The average annual rainfall is between 2,000-2,300 mm, and average temperature in the winter season is 8°C which rises to 37°C in summer. Relative humidity varies from 60% in March to 95% in July. These

Table 1. Reserve forests (RF) of the study area.

#	Name	Area [km^2]
1	Doyang RF	252.93
2	Nambor South RF	236.86
3	Diphu RF	165.25
4	Rengma	150.90
5	Nambor North RF	93.15
6	Disma RF	20.15
7	Lower Doiugurung RF	13.54
8	Upper Doigurung RF	9.30

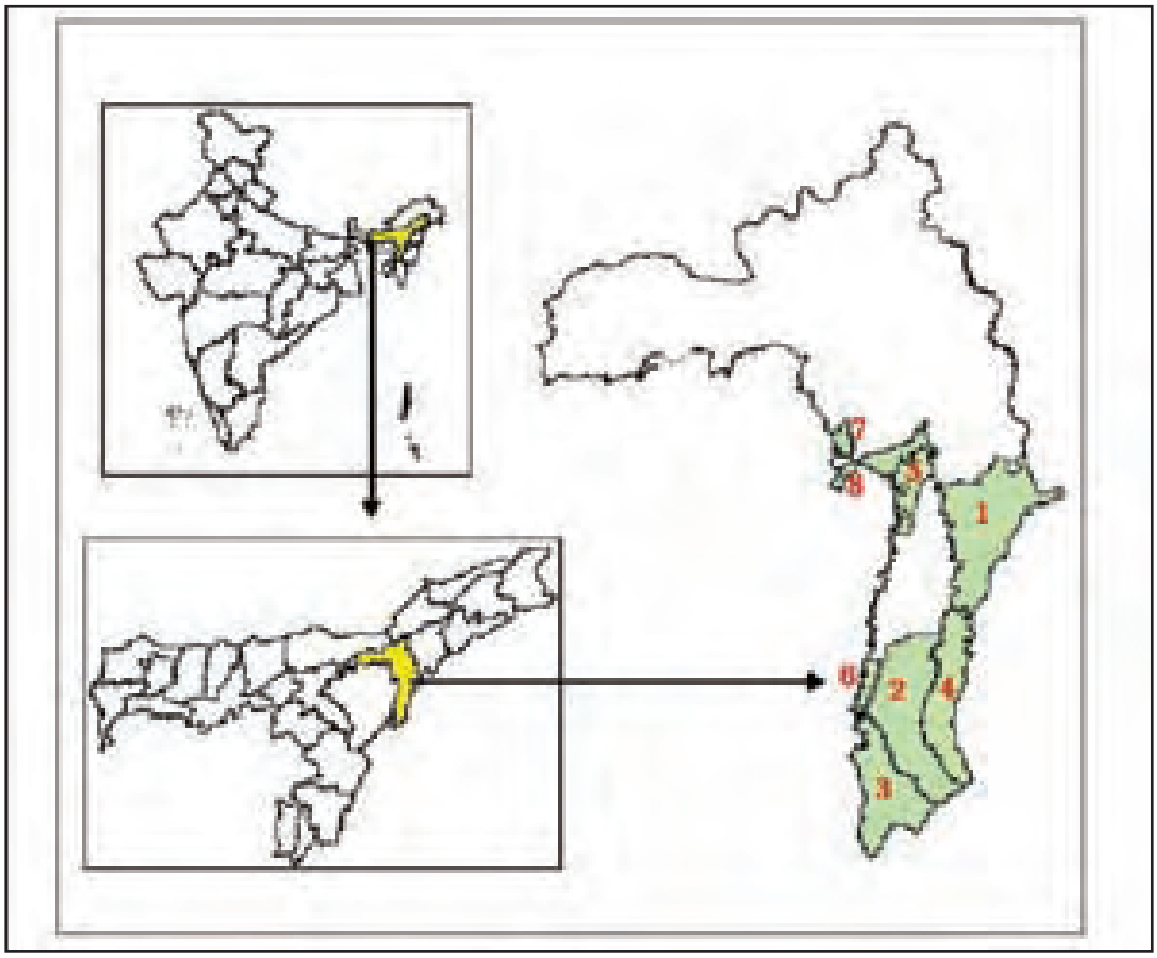

Figure 1. Location map of the study area in Gree.

reserve forests were once ideal habitat for Asian elephants (Choudhury 1999).

Data set used

For this study the primary data used were serial satellite images, Survey of India (SOI) topography maps, ground control points (GCPs) and other spatial data that includes forest boundary maps available with state forest department and also sketch maps of forest areas available with the State Revenue Department. The satellite images used in this study are Landsat MSS imagery of 1974, Landsat TM imagery of 1991 and IRS 1D LISS III imagery of 2004 (Table 2). The Survey of India topography maps no. 83F/6, 83F/10, 83F/13, 83F/14, 83F/15, 83F/16, 83G/13, 83J/2, 83J/3 and 83J/4 (1:50,000) and 83F, 83J, and 83F (1:250,000) were used for geo-referencing of satellite images. In addition, a base map and the vector layers i.e. district boundary, forest boundary and drainage available within the study area were prepared.

Methodology

Landsat MSS, Landsat Thematic Mapper and IRS 1D LISS-III digital data pertaining to 1974, 1991 and 2004 were used to assess the forest cover changes within the eight Reserve Forests of Golaghat district of Assam. Survey of India (SOI) topographical maps at 1:50,000 and 1:250,000 scale and Forest Survey of India (FSI) reports for Assam were also consulted and used as collateral data. Ground truthing was done from October 2005 to September 2006. Landsat MSS, Landsat-TM scene and IRS 1D LISS-III were radiometrically corrected using the dark pixel subtraction technique (Kushwaha & Hazarika 2004). They were then geo-referenced with Survey of India topographical maps using the Polyconic projection system. The Polyconic

Table 2. Satellite data used for the study.

Data type	Path/row	Date
Landsat MSS	144,145-42	26.1.1974
Landsat TM	134,135-43	28.1.1991
IRS 1D LISS III	112,113-53	22.12.2004

projection system was used because the Survey of India topographical maps were based on that projection. As the Golaghat district does not come under a single scene of the satellite images, we constructed a mosaic using the relevant satellite scenes. We took well-identified ground control points (GCP) with the help of a Garmin 72 GPS receiver to rectify the satellite images. Sub-pixel image to map registration accuracy was achieved through repeated attempts. The district image was extracted by superimposing the vector layer of the district boundary of Golaghat district. Similarly the forest area of Golaghat district since 1974 was extracted by superimposing the forest boundary vectorised from Survey of India (SOI) topographical sheets. The three period images were then visually interpreted on-screen using supervised classification, using green, red and near infrared band combination. Training sites were made by demarcating a polygon for the known cover types that were later applied to the entire image. A classification scheme was developed using maximum likelihood algorithm and the overall number of classes in each case was kept constant. The visually interpreted images were superimposed to detect changes from one period to the other. All operations were carried out using ERDAS IMAGINE 9.0 version software.

Results and discussion

Assessment of habitat loss

The Golaghat district of Assam was once famous for its thick forest cover and also as a prime habitat of the endangered Asian elephant (Choudhury 1999). The oldest reserve forest of Assam exists in the Golaghat district. In 1872, the Nambor Reserve Forest was declared with an area of 875.5 km^2. In 1965, for better management, a part of Nambor Reserve Forest was declared as Nambor South Reserve Forest with an area of 199.57 km^2. In 2003, the Upper and Lower Doigrung Reserve Forests along with an additional area of 120 km^2 were included to form the Nambor-Doigrung Wildlife Sanctuary. A large portion of forest cover of Golaghat district has been encroached and deforested. The forest cover change in Golaghat district is summarized in Table 3.

The Nambor-Doigurung Wildlife Sanctuary faces large-scale encroachments, which have occurred from 1980 onwards. As a result, the total forest cover area of Nambor-Doigurung Wildlife Sanctuary has been reduced from 120 km^2 to 54.08 km^2 (55%). The balance 66 km^2 area has been encroached by human populations. Figure 2 shows the encroachment of forest cover in Nambor-Doigurung Wildlife Sanctuary. The same scenario is seen in Diphu RF, Rengma RF, Doyang RF, and Nambor South RF of Golaghat district. These areas were once some of the best elephant habitats in South Asia (Choudhury 1999). Reserve forests like Doyang, Rengma, Diphu, and Nambor South, have been totally encroached during 1974-2004 and currently only 3.38% of forest cover exists in Doyang RF, 4.86% in Rengma RF, 1.97% in Diphu RF and 0.07% in Nambor South RF. One can see these areas are now full of villages, small tea gardens, agricultural practices, shops, etc.

Out of 1,037.94 km^2 of Reserve Forest in Golaghat forest division, only 167.94 km^2 (16.18%) now remains undisturbed. Figure 3 shows the current status of forest cover in the Golaghat District.

Table 3. Forest cover change in the study area.

Forest	Forest cover [km^2]			Change [%]	
	1974	1991	2004	1974-1991	1991-2004
Doyang RF	93.35	4.21	3.16	-95.45	-24.94
Rengma RF	123.63	17.52	6.02	-85.31	-65.64
Nambor South RF	199.57	0.15	0.15	-99.92	0
Diphu RF	118.12	7.74	2.33	-93.45	-70.02
Disma RF	0.02	0.47	0.22	+2250.00	-53.19
Nambor North RF	67	50.51	30.19	-24.61	-40.23
Upper Doigurung RF	8.62	7.71	6.67	-10.55	-13.49
Lower Doigurung RF	13.07	11.49	10.93	-12.09	-4.87

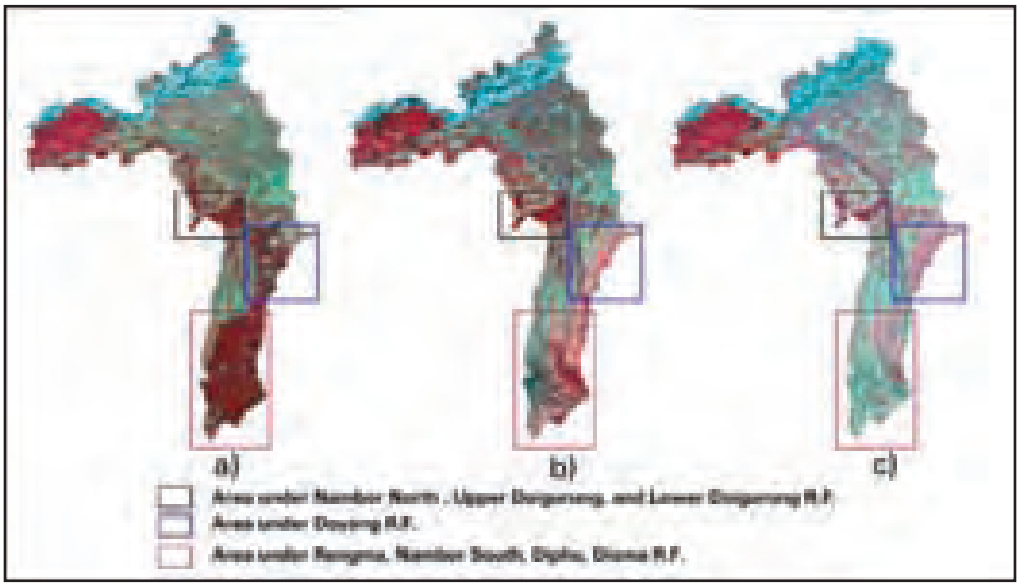

Figure 2. False colour images of Golaghat district pertaining to periods a) 1974, b) 1991 and c) 2004. Red colour indicates the forest cover.

The change in land use in Golaghat district is evident between 1974 to 1991 and 1991 to 2004 (Fig. 4 and Table 4). The forest cover in the southern part of Golaghat district is completely gone, leading to intense human-elephant conflict in the district.

Causes of forest loss

The main causes of elephant habitat loss in Golaghat district are:

- Land use change from forest to agricultural land and tea gardens.
- Encroachment by human populations from nearby villages.
- Use of wood as a source of heat and energy.
- Illegal cutting and felling of trees for business purposes.

Human-elephant conflict

The Asian elephant is considered one of the most significant cultural symbols of the people of Asia, and also stands for the need to safeguard sufficient natural forest areas. However the species is endangered due to a number of conservation issues. Growing human populations, demand for cultivable lands and alteration of forest habitat to human habitation and cropland result in serious human-elephant conflict in Assam (Srivastava *et al*. 2002; Talukdar & Barman 2003). The forest cover in northeastern India is disappearing at an alarming rate. More than 500 km^2 of forests are being destroyed annually (Choudhury 1999). This has resulted in increase of human-elephant conflict to alarming proportions in Assam in general, and in the Golaghat district of Assam in particular, in recent times (Talukdar & Barman 2004). During harvesting season, wild elephants

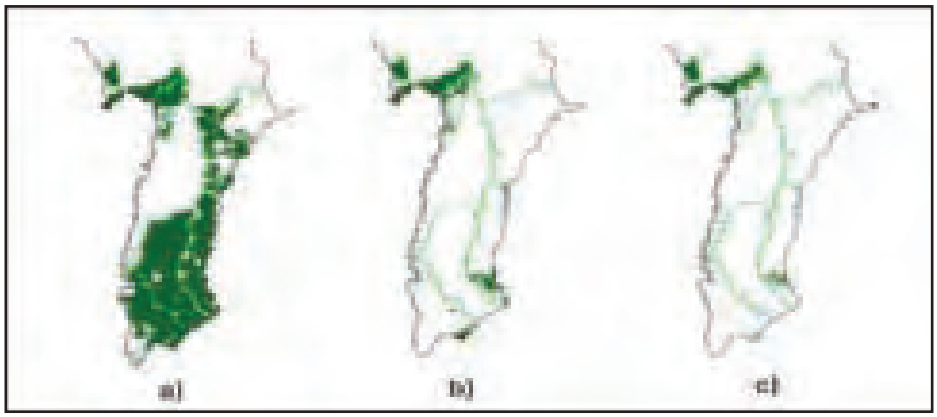

Figure 3. Forest cover change in the study area. Forest cover in 1974 (a), 1991 (b) and 2004 (c).

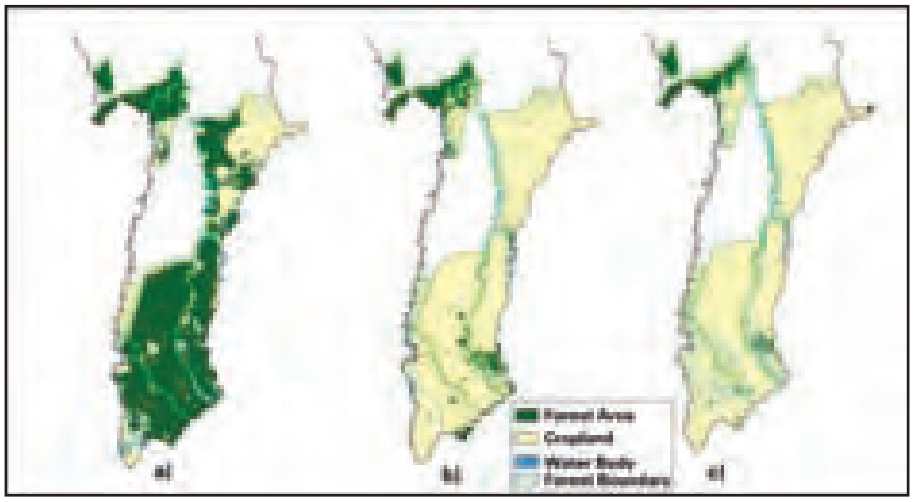

Figure 4. Land use in the study area in 1974 (a), 1991 (b) and 2004 (c).

come out of the existing forest area to nearby villages in search of food and increase the levels of depredation in crop fields giving rise to serious human-elephant conflict situations. The economy of the district as a whole is mainly agro-based, wherein the people basically cultivate paddy as their main livelihood. On the other hand paddy attracts elephants, which ultimately creates loss of farmers' annual food and income. This leads to human-elephant conflict, which results in the loss of human and elephant lives. The large-scale loss of crops and an increase in the numbers of human casualties by wild elephants has disturbed the age-old peaceful bond of co-habitation between humans and elephants, resulting in humans killing elephants in vengeance. The number of human casualties by wild elephants, and the number of elephant deaths as a result of human-elephant conflict in Golaghat district is shown in the following graph (Fig. 5).

Conclusion

In recent years, development activities such as establishment of the Numalighar Refinery in the Telgaram area, widening of the national highway, and increasing tea estates and encroachments has led to fragmentation of elephant habitats. Further, extraction of stones from forests of Behora, Mikirchang, Bogidola and Lakowa area has minimized the free ranging movement of elephants in Golaghat district, leading to a chaotic situation. The present status of elephants in Golaghat is in complete contrast to the past.

The only solution to minimize elephant habitat loss and human elephant conflict is the restoration of key forest cover and elephant corridors. All encroachers should be evicted from the areas with immediate effect as per the existing Forest Conservation Act of 1980, and a rehabilitation plan needs to be prepared for the encroachers. Stringent measures should be adopted to check any further deforestation in the existing forest cover of the Golaghat district. The entire area should be regularly monitored using remote sensing to detect the loss of elephant habitat due to human activities or any natural disaster. The need of the hour is to initiate a concerted approach by involving all the relevant stakeholders and work collectively to ensure that tangible results could be achieved in the field of elephant conservation through community participation and better forest-public relationship. Restoration of forest cover seems to be the only permanent solution for the burgeoning problem. However, in the short run, as immediate measures, crop guarding, chasing wild elephants by using domesticated

Table 4. Land use change in the study area.

Class Name	Area [km^2]			Net change [km^2]		Change [%]	
	1974	1991	2004	1974-1991	1991-2004	1974-1991	1991-2004
Forest	623.38	99.8	59.67	-523.58	-40.13	-83.99	-40.21
Cropland	282.18	805.76	839.8	523.58	34.04	185.55	4.22
Water body	36.52	36.52	42.62	0	6.1	0	16.70

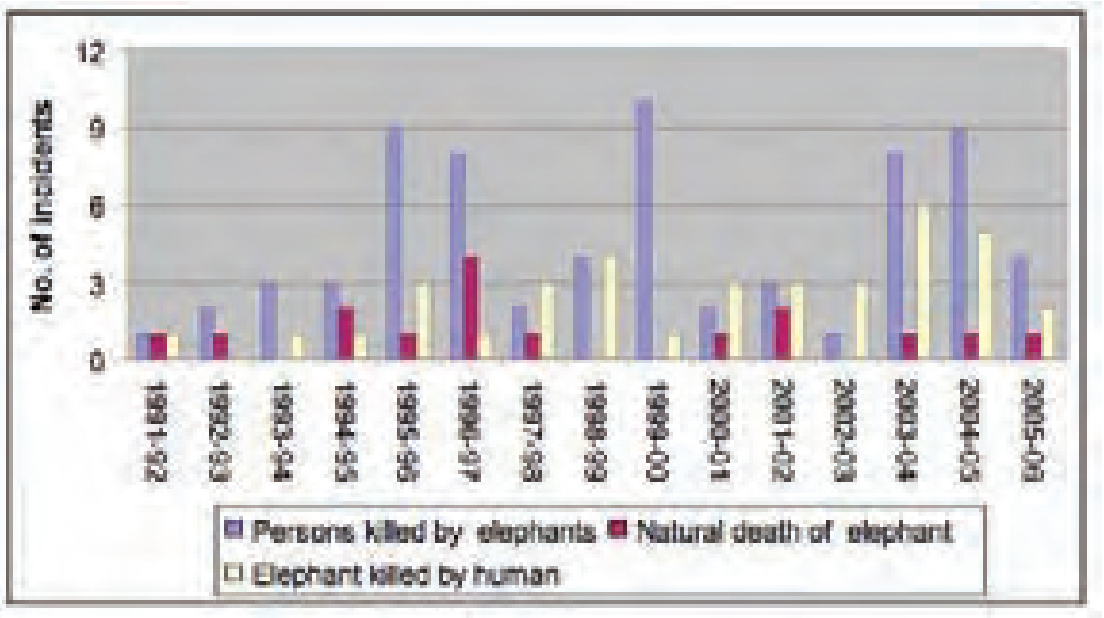

Figure 5. Intensity of human-elephant conflict in Golaghat district.

elephants and the use of fire torches would be helpful. The primary stakeholders need to be provided with alternative livelihood generating options so that they could tolerate the possible damage caused by wild herds, at least in the short term. The general public needs to extend their full support to such collective initiatives and play an active part to minimize human-elephant conflict in the area through restoration of forests as far as feasible.

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