Population Status, demography and conservation of Golden Langur *Trachypithecus geei* in an isolated habitat of Kakoijana Reserve forest, Assam, India

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ABSTRACT

Extensive survey of golden langur, *Trachypithecus geei,* was carried out in Kakoijana reserve forest of Assam, during March, 2017 to find out the comprehensive population size, troop size, distribution and demographic structure. Total count method was used for population surveys with direct encounter method. Troops were identified based on their actual site locations and number of individuals in each troop and demographic structure in various sighting locations. Vegetation data of trees, shrubs and climbers at the point of contact with golden langur troops were collected at 10×10 meter quadrate. Study revealed altogether 45 distinct troops with a total population size of 489 individuals from dense, open, edge matrix zones and human habitation areas in the study area. Mean troop size of golden langur was 10.87± 3.42SD. Of the total population, 25% was immature, 29% was sub-adult and 46% was adult individuals. Average adult male-female ratio was 1:3.15 and that of adult female to immature ratio was 1: 0.72. Study emphasized the conservation and management of the isolated population of globally endangered primate species of Indian boundary of Assam.

Key words: age-sex ratio, conservation management, habitat zones, means troop size, Population size, forest population, village population.

INTRODUCTION

The golden langur *Trachypithecus geei* Khajuria(1956) is one of the world's most endangered primate species of Asia and endemic to Assam plains and eastern Himalayan region (Schwitzer *et al.*, 2017). Its Indian distribution ranges restricted to present Bongaigoan, Dhubri and Kokrajhar District of Assam with an estimated forested areas of 900 km², bounded by the rivers Sankosh in the west and Manas in the east and Brahmaputra on the south (Gee, 1961; Roonwal & Mohnot, 1977; Mukherjee, 1978,1980; Saikia *et al.,* 1987; Srivastava *et al.*, 2001a; Srivastava *et al.*, 2001b; Biswas, 2004: Choudhury, 2002; Medhi *et al.,* 2004; Srivastava, 2006; Biswas *et al.*, 2006; Nigam *et al.,* 2014; PRCNE Report news, 2016). Bhutan population is restricted from 199 - 2600m above msl. in the foot hills of black mountains within forested areas of 1400 km² (Saha, 1980; Subba & Santiapillai, 1989; Subba, 1989; Choudhury, 2002; Wangchuk, 1995; Lhendup *et al.*, 2018). Nearly 30% of golden langur's habitat was lost during 1988-1998 owing to severe habitat fragmentation (Srivastava *et al.,* 2001b). The estimated existing population sizes of golden langur in their range areas are > 1,500 individuals in India and roughly 4,000 individuals in Bhutan with comprising < 2,555 mature individuals of globally threatened langur species (Srivastava, 2006; Das *et al.*, 2008). Deforestation and fragmentation of habitats

Were considered as the threat to Golden Langur population (Choudhury, 2002; Biswas *et al.*, 2006; Srivastava, 2006; Schwitzer *et al.*, 2011; Horwich *et al.*, 2013).

Kakoijana reserve forest is an isolated habitat of golden langur and sustains a comfortable numbers of golden langur but no such serious study has been carried out to uncover the demographical status, troop size and existing habitat condition as haw they adapted in such an isolated habitat with potential conservation threats. This population is also a major stronghold of golden langur conservation for future survival through conservation and management initiation. Thus, the present study has emphasized on the research hypothesis that the population status, demographical structure and distribution of the troops in the small isolated habitat has no differences with the primary habitat in India as well as in Bhutan population. To proof the hypothesis, two objectives were considered in the study area in Kakoijana reserve forest of Assam. Study was mainly emphasized the characterization of the forest into different zones and to study the population status, troop size, distribution and demography of golden langur in different study zones.

Study area

The Kakoijana reserve forest (Coordinates: 26.22°N-26.21°N & 90.33°E- 90.34°E) covering an area of 17.19 km² located in Bongaigoan district of Assam, India. The
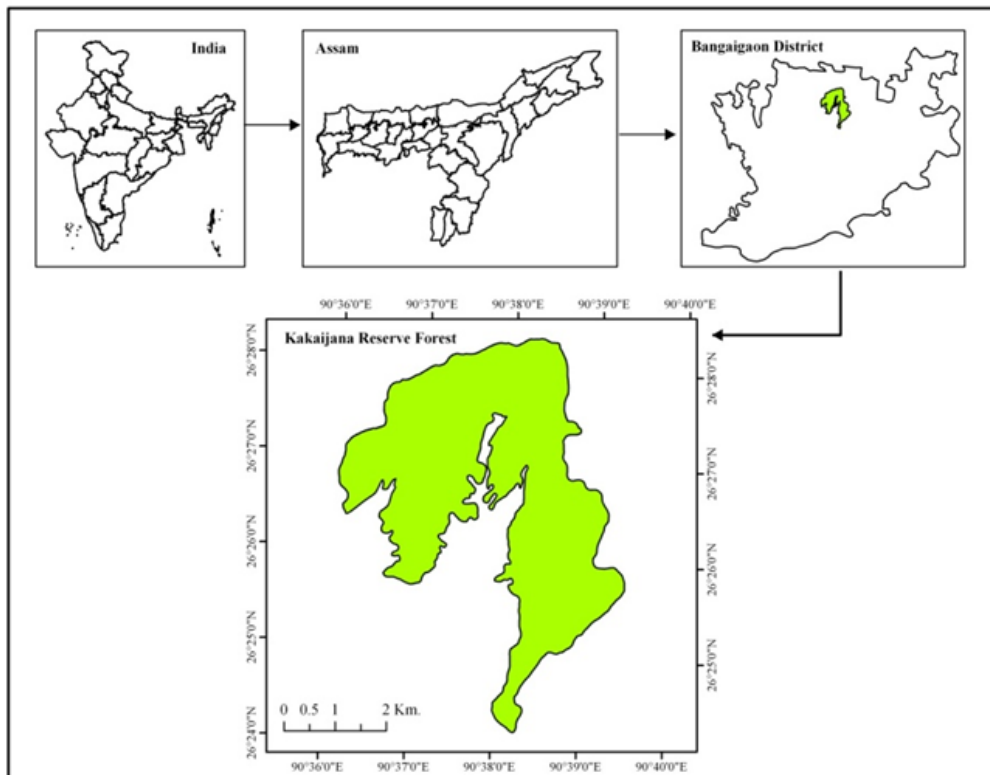

Figure 1. Map of Kakoijana Reserve Forest.

forest is a hilly terrain, surrounded by human habitation that makes it isolated from the nearby forest areas of Manas Biosphere Reserve (Figure 1). The forest vegetations are dominated by secondary growth of moist mixed open deciduous forest with bamboo growth that regenerated since last 20-35 years with a few remnant patches of dense primary deciduous forests. The altitude of the study area ranges from 41 to 321m above msl. However, major parts of the forest remain as a scrubland and degraded forest including some plantation patches. The water source of the forest is supported by large numbers of small natural streams and reservoirs. The annual rainfall in the study area ranges from 2631 mm to 3136 mm with an average monthly rainfall of 134.12mm. Temperature ranges from 9 °C to 10 °C in winter and 33 °C to 38 °C in summer. The soil of the study area is composed of red coarse loams and productive one and that harbouring large numbers of plant and animal species.

MATERIALS AND METHODS

Systematic combing survey was done extensively using eight pre-trained field helpers of local youths. Total count method was followed to count the number of troops and its respective age sex classification in the study area during March, 2017 (NRC 1981; Kumar & Solanki, 2008; Plumptre *et al*, 2013). Age-sex categorization was done as per Biswas *et al.* (2004) and photographs taken from the field (Plate 1). Along with population and distribution information, the vegetation of the study area was also studied. Entire study area has been divided in to seven different zones based on habitat stratifications such as deciduous, moist mixed dense, moist mixed open, scrub forest, degraded forest,

plantation/ mono-culture area, secondary forest and croplands. Remote sensing and GIS technique was applied for land cover estimation (Lahkar *et al.*, 2007; Plate 3). Vegetation data of trees, shrubs and climber were collected in 10×10 m quadrate. A total of 50 quadrates were selected in different zones of the study area using stratified random sampling method (Clark, 1986) in all study parameters. All the woody plants> 20cm in GBH was considered and the tree was measured using standard tape. Identification of plant species was done using available literature (Kanjilal, 2005; Bora, 2003; Barooah and Ahmed, 2014; www.efloraindi.com (accessed on 2015-16). Herbariums were prepared for unidentified specimens and brought to the Botanical Survey of India, Shillong for taxonomic identification. The habitat has been divided into five zones depending on landscape elements determined by land use/ land cover pattern analysis within the forest as well as surrounding villages that provides shelters of focal species (Plate 2).

Zone 1: Moist mixed deciduous dense forest

The estimated area of zone-1 was 1.65 km^2 and canopy cover estimated was 51- 70% (Rank 4; Mueller-Dombois & Ellenberg, 1974). 42% of trees height was ranges between 10-16-meter with a GBH of 1.51 to 1.75 m. The trees species were- *Castanopsis indica* (Roxb.) DC.*, Aesculus assamica* Griff., *Trewia nudiflora* L.*, Elaeocarpus species, Castanopsis tribuloides* (Sm.) A. DC.*, Daubanga grandiflora* (Roxb.ex DC) Walp., *Tetrameles nudiflora* R. Br., *Shorea robusta* Roth., *Terminalia bellirica* (Gaertn) Roxb. etc.. 46% trees height was ranges between 5- 10 meter and GBH was 1.01– 1.50 m. Important tree species were *Ficus auriculata* Lour. *Mallotus philippensis* (Lamk.) Mull.Arg., *Ficus lamponga*
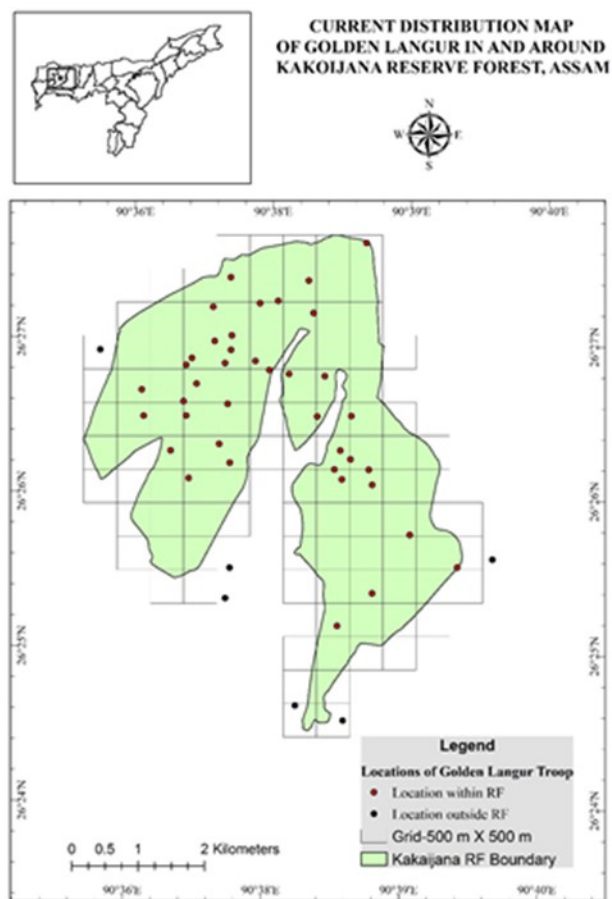
Figure 2. Present distribution map of *Trachypithecus geei* Khajuria (1956) in the study area.

Miq.,*Uvaria bracteata* Roxb., *Dillenia pentagyna* Roxb., *Oreocnide integrifolia* (Gaudich)Miq., *Saurauia napaulensis* DC., *Balakata baccata* (Roxb.) Esser, *Schima wallichii* (DC.) Korth. etc. Lower strata (11.76%) formed by trees with a height of 1.5-5.00m and GBH was 0.20-1.00m. Trees species includes *were Salix tetrasperma* Roxb, *Pithecellobium heterophyllum (*Roxb.) J. F. Macbr. *Dysoxylum binectariferum* Hiern., *Holarrhena antidysenterica* Wall, *Alstonia scholaris* (L.) R.Br., *Mangifera sp., Bauhinia acuminata* L., *etc.* Shrub species includes were *Dalbergia stipulacea* Roxb., *Sarcochlamys pulcherrima* Goud., *Holmskioldia sanguinea* Retz., *Mimosa rubicaulis* Lam., *Cyathea gigantea (*Wall.Ex Hook), *etc.* The existing Climbers and lianas includes were *Aristolochia saccata* Wall., *Smilax perfoliata* Lour, *Desmos chinensis* Lour., *Hodgsonia macrocarpa* (Bl) Cogn., *Ampelocissus barbata* (Wall.) Planch, *Mikania micrantha* Kunth., *Millettia pachycarpa* Benth., *etc.* with a few patches of wild bamboo (*Dendrocalamus hamiltonii* Nees.).

Zone 2: Moist mixed deciduous open forest

Estimated are of the zone was 6.41 km². The canopy cover in open forest area was estimated to be 20% to 50% (Rank 2 & 3). So, in certain areas of the open forest zone, absence of canopy cover compelled the golden langur to come down from trees to ground for runing on the the ground to cross the neighbouring areas. 28.41% trees were with a height of 10–15m and GBH was

0.55-1.30m. Trees like *Albizia* spp., *Kydia calycina* Roxb., *Actinodaphne obovata* (Nees) Blume, *Schima wallichii* (D.C.) Kuntz. Var. was major trees of this category. *Saurauria napaulensis* DC., *Ficus auriculata* Lour, *Ficus racemosa* L., *Stereospermum chelonoides* DC., *Bursera serrata* Coleb. 55.74% of trees were recorded with a height of 5- 10 meters and GBH was 0.31 - 1.25m. Some of the trees were *Mallotus philippinensis* (Lamk.) Mull.Arg., *Terminalia bellirica* (Gaertn) Roxb., *Sterculia villosa* Roxb., *Litsea monopetala* (Roxb.) Pers., *Bischofia javanica* Blume, *etc*. 15.85% trees recorded with height 3 -5 meters and GBH 0.21 - 0.91 meters some of which were *Hollarhena antydisenterica* Wall., *Lannea grandis* A. Rish, *Garuga pinnata* Roxb., *Toona ciliata* M. Roem., *Syzygium cumini* (L.) Skeels., *Bauhinia acuminata* L., *Derris scandens* (Roxb.) Benth. Etc. Shrubs species includes *Sapindus attenuatus* Wall., *Tabernaemontana divaricata* (L.) R. Br., *Acacia intsia* (L.) Willd., *Grewia glabra* Blume., *Holmskioldia sanguinea* Retz. etc. with patches of *Dendrocalamus hamiltonii* Nees. Climber includes were *Ampelocissus barbata* (Wall.) Planch. *Merrimia vitifolia* (Burm.f.) Hallier.f., *Ipomoea kingii* Prain, *Pegia nitida* Colebr. *Mikania micrantha* Kunth, *Thunbergia grandiflora* (Rotlb.) Roxb., *Millettia pachycarpa* Benth. etc. In open forest, vegetation was clumped in patches with thick growth of understory shrubs like *Chromolaena odorata* (L.) Voigt. *Ageratum conyzoides* L. and different types of grasses.

Zone 3: Secondary, monoculture/ plantation (Edge matrix zone)

The secondary forest was regenerated basically natural processes after largescale removal of the primary forest by anthropogenic or natural causes in a same period of time or extended period of time and showed major differences in forest structure or canopy species plants composition in regards to original primary forest (www.fao.org>docrep). The estimated area under zone-3 was 1.21 km². The monoculture plantation of *Shorea robusta* and *Tectona grandis* were also practiced in zone-3. *Hevea brasilliensis* Muell-Arg. was also planted inside the forest as a private farming. Due to monoculture plantation, the areas lost both lower strata and under stories vegetation of the forest, but the adjacent part of the monoculture areas attained the shape of forest along with secondary growth with a numbers of cultivated plants of forest villages (Height-4.57- 11.58m and GBH 0.50-1.04m). The canopy cover was formed by the cultivated plant and naturally growing trees (15 − 50%). 31.31% tree height was 3–5m. Dominant trees species in zone-3 were *Tectona grandis*, *Shorea robusta* and *Hevea brasilliesis*.

Zone 4: Pastoral/ countryside area

In countryside, the main habitat of golden langur were private gardens with planted vegetations, number of natural wild vegetations and Bamboo growths (area, 8.80 km²). The habitat showed clumped vegetation, especially in private farms. The private farms maintained 10 to 40% canopy covers and supports large numbers of trees to facilitate movement from one private garden to another within the same village but certain villages were exists without canopy coverage, thus golden langur

compelled to came to ground for run over about 1- 2 minutes to reach the next villages. The area was sufficiently large for roaming in and around by the troop. Trees include different types of fruit and edible plants like, *Mangifera indica* L., *Spondius pinnata (*L.f.) Kurz., *Ziziphus jujuba* Mill., *Tamarindus indica* L., *Averrhoa carambola* L., *Moringa oleifera* Lamk., *Artocarpus lacucha* Buch- Ham., *Aegle marmelos* Correa., *Oroxylum indicum* (L.) Vent., cash crop like *Gmelina arborea* Roxb., naturally growing plants like *Neolamarckia cadamba* Miq., *Streblus asper* Lour., *Ficus hispida* L.f., *Mallotus paniculatus* L., *Erythrina stricta* Roxb., *Lannea grandis* A. Rish., *Bauhinia accuminata* L., *Heteropanax fragrans* (Roxb.) Seem., *Artocarpus heterophyllus* Lamk., *Phylanthus emblica* L., *Cassia fistula* L. *etc.* Shrubs includes *Tabernaemontana divaricata* (L.) R.Br., *Manihot esculenta* Crantz., *Acasia intsia (l.) Willd.,* *Codiaeum variegatum* L. Bl.., *Morinda angustifolia* Roxb., *Bambusa tulda* Roxb., *Bambusa balcooa Roxb.,* *Musa sapientum L.,* and large numbers of climber species. The climber species recorded were *Dioscorea bulbifera* L., *Dioscorea alata* L., *Dioscorea pentaphylla* L., *Cissus repanda* Vahl., *Dolichos lablab* L., *Mikania micrantha* Kunth. *etc.*

Zone 5: Scrub forest area

Estimated scrub forest in zone -5 was 5.83 km². Canopy cover recorded was less than 1% of trees with a height of > 1.5m. Understory habitat with shrubs and saplings with 0.12m GBH was recorded with a height ranges from 0.18m - 0.60m and 0.90m respectively.

Zone 6: Degraded Forest area

Estimated degraded forest area was 1.56 km² where no such woody vegetation was found in zone-6. Degraded forest zone was extended in the patches of open forest, secondary forest, bare rocks and soils etc. inside the forest with a conopy cover of 0% and < 1% understory that formed by herbs and grasses (Plate 4).

Altogether eight days were devoted for systematically conduct the population survey and vegetation data collection for both forest and pastoral population of golden langur using on foot at the speed of 6.35 km/hour (Table 1). During data collection, the 'species' occurrences were noted down in different habitat zones of the study area. Direct observation data was used to prepare a distribution map of golden langur in Kakoijana reserve forest of Assam.

Analysis of population density, mean troop size, age- sex ratio of different age-sex categories were done using Microsoft Excel spread sheet 2016. Troop distribution map was prepared by plotting GPS points of troop location site in the study area map.

RESULTS

Population Distribution and Status

During survey, we recorded altogether 45 troops of golden langur with a total population size of 489 individuals in Kakoijana reserve forest and pastoral areas of the study area. The troop locations were plotted in the map of the study area and prepared the distribution map (Figure 2). Study revealed that, various langur troops were distributed in different habitat zones such as dense forest, open forest, secondary growth vegetation and monoculture plantation/cultivation areas in the study area. Among all the troops recorded in the study area, 11 troops were recorded in Zone 1 (dense forest area), 19 troops in Zone 2 (open forest area) and nine troops in Zone 3 plantation area and monoculture area with secondary growth/edge area. No troop was recorded from scrubland and degraded forest area. Six troops were recorded in fringe village areas of the Zone 4. Moreover, six troops were recorded with a pregnant female in six different troops of different habitat zones (Appendix 1).

Troop size and composition

Troop size of golden langur was ranges between 3-20 individuals/troop with a mean troop size of 10.87± 3.42 individuals ($F_{3,41}$= 1.188; p > 0.05; N= 489). Among the forest population, mean highest troop size was recorded in Zone 1 (11.64 ± 2.58; N= 128), followed by Zone-2 (10.68 ± 3.40; N= 203) and Zone-3 (9.33 ± 3.84; N= 84). However, overall highest mean troop size was recorded in Zone-4 (i.e. in village population; 12.33 ± 4.03; N= 74; Figure 3; Table 2). Altogether 32 troops (82.05%) from forest and five troops (83.33%) from pastoral area, showed single male/multi female troop composition. Six troops were recorded with bi-male/ multi female composition from forested area and one troop was recorded in village area. One troop was recorded with multi-male and multi-female composition in forested area.

Age Sex Composition

Among the population, 24.70% was recorded as immature (sex not determined), followed by 29.44% was subadult and 45.80% was adult population. Adult female
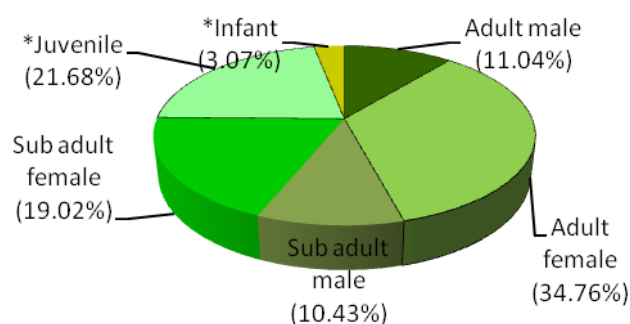
Table1. Survey design and time sampling for the study (Population survey and habitat data were collected during March, 2017).

Sites	Activity	No. of days	Field hours
Zone 1	Troop monitoring (for collection of data on troop size and age-sex composition). Vegetation data collection.	4	40
Zone 2	Troop monitoring & Vegetation data collection.	5	52
Zone 3	Troop monitoring & Vegetation data collection.	3	35
Zone 4	Troop monitoring & Vegetation data collection.	3	35
Zone 5	Troop search & Vegetation data collection	1	12
Zone 6	Troop search & Vegetation data collection	1	8
	Total numbers of survey days and field hours	17	182

Table 2. Troop size and troop composition in different forest area (AM: Adult male; AF: Adult Female; SAM: Sub-adult Male; SAF: Sub-adult female; SND= Sex not determined; JUV: Juvenile; INF: Infant).

S l No	Habi-tatZones	Area (km²)	Total popula-tion	Density/ sq. km.	Mean Troop Size (±SD)	AM	AF	SAM	SAF	SND	
										JUV	INF
1	Zone-1	1.65	128	77.57	11.64± 2.58	15	44	14	23	26	06
2	Zone-2	6.41	203	31.66	10.68±3.40	22	73	21	38	44	05
3	Zone-3	1.25	84	67.20	9.33± 3.84	10	28	09	18	19	00
4	Zone-4	8.80	74	08.41	12.33± 4.03	07	25	07	14	17	04

was found to be highest (34.76%) in overall population size of golden langur in Kakoijana reserve forest and its surrounding areas whereas, second highest population was recorded in case of juveniles langurs (21.68%), followed by sub adult female population (19.02%). Adult male (11.04%) was higher in population than sub-adult male (10.43%). Again, very small numbers of infant (3.07%) was found within total population size of golden langur (Figure 4). In different study zones, highest percentage of adult male population was recorded in zone 3 (11. 90%), followed by zone 1(11.72%), Zone 2 (10.84%), whereas, zone 4 has least numbers (9.36%). Highest percentage of adult female population was recorded in zone 2 (35.96%), followed by Zone 1 (34.38%), Zone 4 (33.78%) and Zone 3 (33.33). Moreover, zone 1 was recorded highest percentage of sub-adult male (10.94%), followed by zone 3 (10.71%), zone 2 (10.34) and zone 4 (9.46%). However, highest percentage of sub-adult female was found in Zone 3 (21.43%) and lowest in Zone 1(17.97%). Similarly, zone 4 and zone 2 had 18.92% and 18.72% sub-adult population respectively. In case of juveniles, highest percentage of population was recorded in Zone 4 (22.97%), followed by zone 3 (22.62%) whereas, zone 2 has 21.67% juvenile population and Zone 1 has 20.31% juvaline. Population of infant was recorded to be low with a maximum of 5.41% in Zone 4 followed by Zone 1 (4.69 %) (Figure 5; Appendix 2).

Figure 4. Percentage age-sex composition in Golden Langur troops in the study area

Age Sex Ratio

In total population size of golden langur age- sex ratio, the estimated female against each male was 3:15. Again, the adult male and sub adult male ratio was 1: 0.94 and that of sub adult male and sub adult female ratio was 1:1.82. The adult female and sub-adult female ratio was 1: 0.55, again, adult female and juvenile ratio was estimated to be 1: 0.62. Adult female and infant ratio was estimated to be 1: 0.09. Age-sex ratio of adult male and adult female was estimated to be highest in zone 4 (1: 3.57), followed by Zone 2 (1:3.32), Zone 1 (1: 2.93) and Zone 3 (1:2.80). In case of adult male and sub adult male, the age- sex ratio was highest in Zone 4 (1:1), followed by Zone 2 (1: 0.95), Zone 1 (1: 0.93) and Zone 3 (1: 0.90). Among sub-adult male and sub-adult female, the sex ratio was highest in Zone 3 and Zone 4 (1: 2), followed by Zone 2 (1: 1.81) and zone 1(1: 1.64). Adult female and sub adult female ratio was highest in Zone 3 (1: 0.64), followed by Zone 4 (1: 0.56), however, Zone 1 and Zone 2 had same sex ratio of 1: 0.52. The age-sex ratio between adult female and juvenile (1: 0.68) was found to be highest in Zone 3 and Zone 4, followed by Zone 2 (1: 0.60) and Zone 1 (1: 0.59). Adult female and infant ratio was highest in Zone 4 (1: 0.16), followed by Zone 1(1:0.14) and Zone 2 (1: 0.07). In Zone 3, no infant was recorded (Table 3).

Population density

Density of the forest population (N=415) was estimated to be 24.14/ km². Amongst all the habitat studied, the highest density was estimated in Zone- 1 (77.58/km²) and the second highest was 67.20 individuals/ km² in zone 3, followed by 31.66 individuals/ km² in zone-2. Pastoral
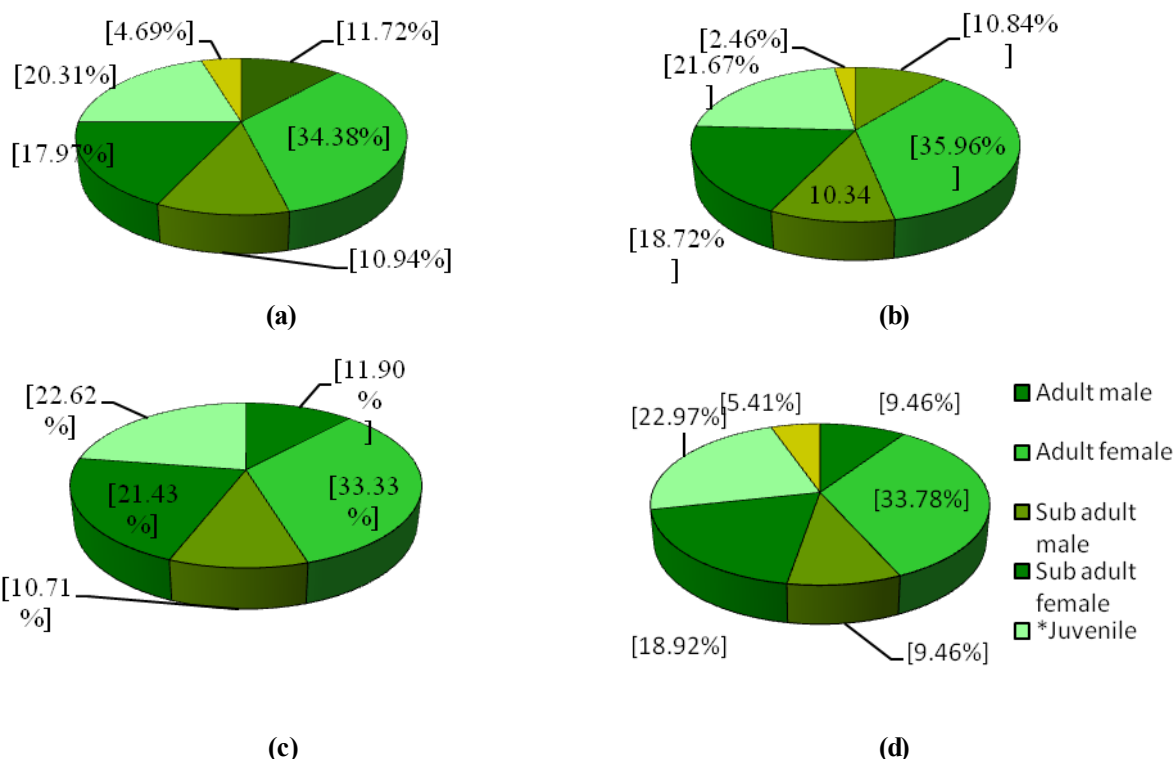

Figure 3. Mean troop size in different habitat zones (Zone-1= Dense area, Zone-2= Open area, Zone-3= Monoculture, plantation area/ edge matrix, Zone-4= pastoral/ village area).

Figure 5. Percentage of age sex composition in golden langur troops in each study zone in the study area (a = Zone-1, b = Zone-2, c= Zone 3 and d=Zone4)

Table 3. Age-sex ratio of different age-sex categories in different habitat zones (AM= Adult male, AF= Adult female, SAM= Sub adult male, SAF= Sub adult female, JUV= Juvenile and INF= Infant).

Area	AM:AF	AM:SAM	SAM:SAF	AF:SAF	AF:JUV	AF:INF
Overall	1:3.15	1:0.94	1:1.82	1:0.55	1:0.62	1:0.09
Zone-1	1:2.93	1:0.93	1:1.64	1:0.52	1:0.59	1:0.14
Zone-2	1:3.32	1:0.95	1:1.81	1:0.52	1:0.60	1:0.07
Zone-3	1:2.80	1:0.90	1:2	1:0.64	1:0.68	1:0.00
Zone-4	1:3.57	1:1	1:2	1:0.56	1:0.68	1:0.16

population had the least density of 8.41 individuals/ km (Figure 6). Population density as estimated in forest as well as in pastoral village areas, with highest density of adult female (8.44), followed by Juvenile (5.18), Sub adult female 4.60); adult male (2.73), and Sub adult male (2.56) and least density was recorded of infants of 0.64. (Table 6). There was a vast difference in population density of different age- sex classes in forest and village population (Figure 7a). Maximum density of different age- sex category was found in Zone-1. viz. adult male was recorded in zone 1 (9.09), adult female (26.67), SAM= 8.48, SAF (13.94), Juvenile (15.76) and infants (3.64), whereas Zone 4 has least (2.84). Adult female was found with maximum density in Zone 1 (26.67) and least in Zone 4 (2.84). Zone 3 was the second highest density (22.40) followed by Zone 2 (11.39). Sub adult male population density was maximum in Zone 1 (8.48), that of least in Zone 4(0.80). However, Sub adult female was found maximum in Zone 3 (14.40), followed by Zone 1 (13.94). Zone 2 density was recorded as 5.93 and Zone 4 was with least density (1.59). Juvenile recorded highest density in Zone 1 (15.76), second highest density

in Zone 3 (15.20), followed by zone 2 (6.86), Zone 4 (1.93). Highest infant density was recorded in Zone 1 (3.64), followed by zone 2 (0.78), Zone 4 (0.45) (Appendix 3, Figure 7b).

DISCUSSION

Present study indicated that, the population size of the golden langur has been declined about 3% than the previous study done by Horwich *et al.*(2013) in Kakoijana RF, that might be due to unprotected situation prevailed in the Kakoijana Reserve forest where accidental death of Golden langurs are occurred caused by high tension electric wire, vehicular collisions with golden langur in the NH-31 and occasional death of golden langur while they have crossed the connecting roads of countryside attached to the study area. However, the population density/km^2 and mean troop size of golden langurs in the study area is higher (18.81individuals/km^2) than that of existing primary forest habitats of Indian boundary (in Assam) and neighboring Bhutan range. In which, the mean troop size of Golden langur in Royal Manas
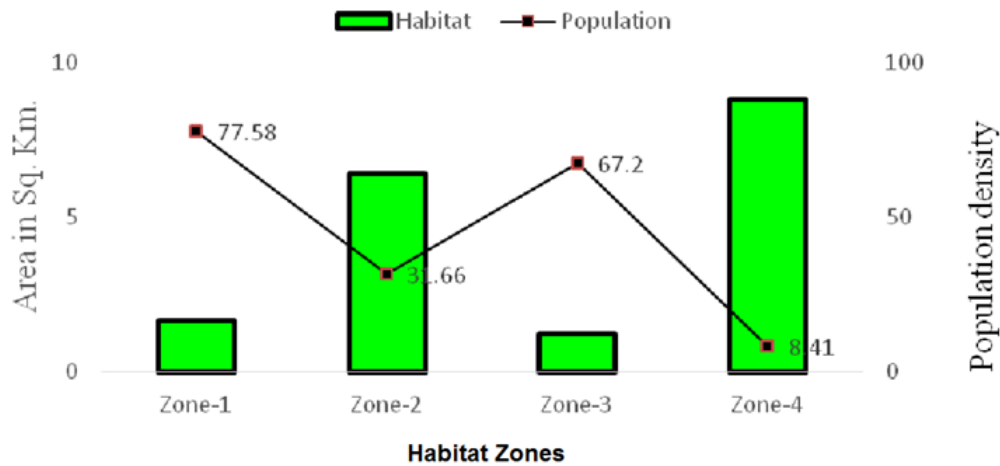
Figure 6. Population density in different habitat zones.
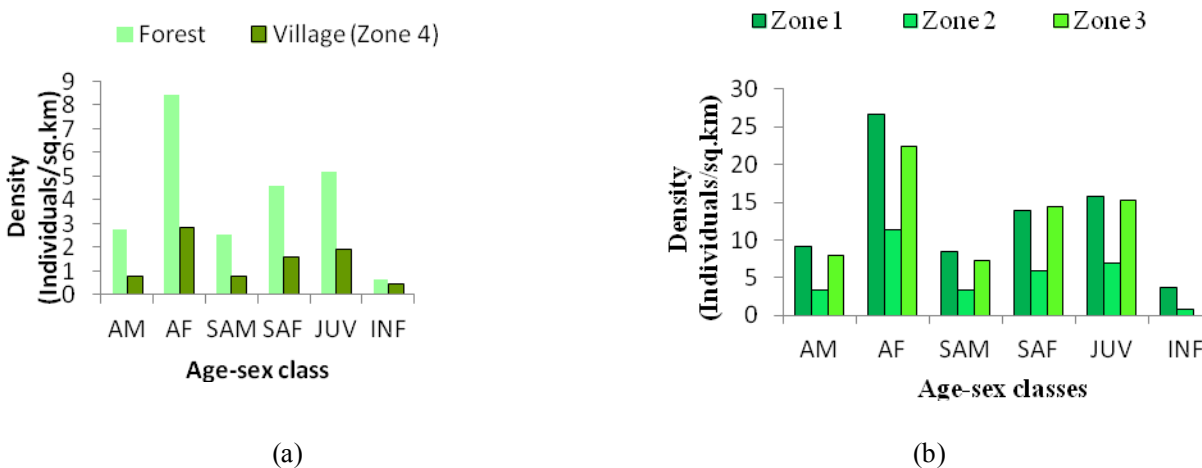

(a)

(b)

Figure 7. Population density of different age- sex classes in (a) Total forest area and village area. (b) in different habitat zones of forest area.

National Park of Bhutan and Chakrasila Wildlife Sanctuary of Kokrajhar have no differences (see Lhendup *et al*., 2018; Chetry *et al*., 2010), whereas, the present findings of the Kakoijana reserve forests (10.87± 3.42 SD) and contiguous Bhutan hills primary forest populations' troop size (11±0.38 SD) have also no significant differences (Thinley *et al*.,2019). Higher density of golden langurs population with higher troop size in Kakoijana isolated Reserve Forest than the contiguous habitats' population of Bhutan hill forests and other ranged localities of Indian boundary have certainly indicated that, the Kokoijana population has still survive within its suitable habitats having diverse and nutritious and as well as quality foods within its indigenous land. Again, the larger troop sizes in the countryside habitat (zone-4) might be due to shared protection by the larger troops from existing predators like stray dogs etc. in and around the village areas' habitats and thereby adapting themselves through developing their collective protection and foraging strategies in and around the human habitational area similar to that of rhesus monkey. In general, golden langur never come down to the ground for feeding or any other activities and as well as crossing one habitat patch

to another on foot by running, walking etc. but in Kakaijana RF, most of village troops as well as open habitat troops are travelling from one patch to another patches through walking and running even for a long distance. This walking and running locomotion in ground by golden langur is a new adaptive behavior for their survival in a human modified habitat situation. Gee (1961) has also confirmed that, the golden langur existed in the reserve forest areas near Maure village of Jamduar had never descend to the ground for raiding the crops like Rhesus monkey. The author also stated that, in December, 1959, the village headman of Maure village of Jomduar has confirmed that they never saw the golden langur for get down to the ground zones for any occasions or never visited to the home gardens. Mukherjee and Saha (1974) also observed similar types of large troops of 15 individuals only in Rimona forest range of Kokrajhar, where forest villages were exists nearby, but not such large troops had observed by the authors. But in other distribution localities viz. Royal Manas Park etc., the troop sizes were comparatively smaller than present study area (Lehendup *et al.,* 2018; Srivastava *et al.,* 2001b), because such habitats were dense and supported

by primary forest and no such human inhabitant areas and stray dogs are exists within the vicinity. Langur troops in the village areas are supported by horticultural plantations, planted trees and as well as naturally growing wild vegetations in the privately-owned gardens, in which the villagers are quite accustomed and mutualistic with the existence of the golden langur troops. Apart from that, the village people indirectly safeguarding the golden langur troops by protecting the scattered forest/ open forest and as well as other reserve forest areas (JFM) under their control from the illegal tree fellers approaching from outside the village area.

The open forest areas of Kakoijana reserve forest has supported by highest numbers of troops with largest population sizes in the study areas, where tallest trees are exists and that forests have utilized by the golden langur for the purpose of arboreal activities or other essential movements like playing, jumping etc. Furthermore, Kakoijana reserve forest could successfully be conserved for long-term perspectives to build up sustainable healthy population of the globally endangered primate species through creating artificial corridors with the neighboring distribution localities. From the demographic point of view, the golden langur troops of Kakoijana RF exhibits most stable social system such as one male and multi female social systems/multi male multi female social system as suggested by Biswas (2004) and Chetry *et al.* (2010) for Golden Langurs and Kumar & Solanki (2008) and Naher &Khan (2018) for Capped langur. As the polygamy is the rule of social systems of golden langur as per Mukherjee and Saha (1974), the social troops of golden langurs in Kakoijana reserve forest supported by highest numbers of adult females than that of adult males. Moreover, number of adult male in a primate group probably depends upon the number of adult receptive female (Mitani, *et al.,* 1996) may support Bi-male/ multi-female as well as multi-male/ multi-female troop composition. More than one male in a troop may also help the female during mate selection. However, age- sex composition of different age-sex classes in the present study is less than some other studies in some other areas (Srivastava, *et al.* 2001b); (Lhendup *et al.,* 2018) may be due to comparatively smaller study area with high anthropogenic pressure. Moreover, adult age-sex ratio in the present study is comparatively higher than different previous studies in its primary habitat (Srivastava, 2006); (Chetry *et. al*, 2010); (Lhendup *et al.,* 2018). Over all adult female to immature ratio in the present study (1:1.56) is almost same with the previous studies conducted in different Indian and Bhutan population (1: 1.13- 1: 1.86) (Srivastava *et al.,* 2001b); (Chetry *et al.,* 2010); (Thinley *et al.*, 2019).

The study area also harbored highest diversity of food plant species even after large scale logging of most of the forest area prior to 25 years back and the langur population density is also highest (489, individuals) compare to the other distribution areas in Indian boundary and Bhutan (Royal Mans NP, Bhutan: 239, Lhendup *et al.,*2018); (Chakrashila: 476; Chetry *et al.*, 2010). Balko and Underwood (2005) and Seiler, Holderied & Schwitzer, (2014) have suggested that, abundance of food resources and plant species diversity might be the best indicator of the increasing population density of primates. In Kakoijana RF, the illegal logging of the forest has been made before two decades and as such, during this gap period, secondary growth and forest regeneration from the existing tree stamps/animal seed dispersers etc. provides available feeding and roosting habitat for the golden langur in Kakoijan Reserve forest. The immediate threat recorded in the study area is the forest destruction for fire wood collection, illegal logging and grazing of life stock. However, the village communities residing in the surrounding area plays an important role for the conservation of golden langur and habitat since long times (Horwich *et al.*, 2013). The villagers provide shelter to the troops with a good conservation perception of the globally endangered primate species and shared them with their horticultural and winter crops and bamboo shoots as their foods. Scrub and degraded part of the forest (45% of total area) should be planted with food plants of Golden Langur instead of monoculture practice so that the species can travel easily without by coming down to the ground to cross distances and get sufficient quantity of main food instead of taking a variety of secondary food, which may cause some physiological problems in course of time. For plantation of food as well as tall branched native tree species like different *Ficus* spp., *Syzygium* spp., *Albizia* spp., and bamboo to maintain the proper canopy for Golden Langurs in the study area.

Conflict of interest: 'None'.

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Plate 1. Plate Shows the different age-sex categories used for identification and age sex data collection in the study area during survey period (a: Adult male; b: Adult female; c: Sub-adult male; d: Sub-adult female; e: Juveniles; f: Infant with mother).
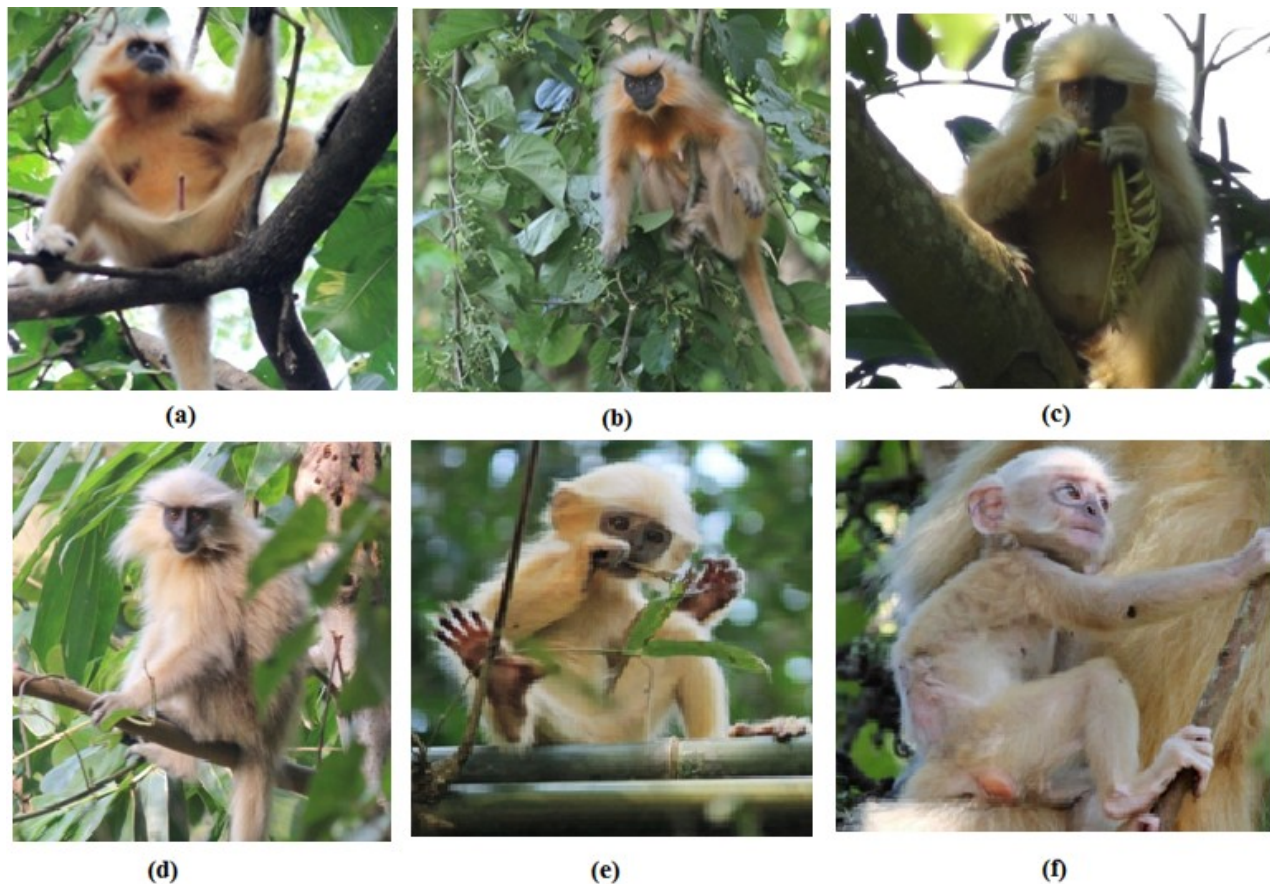
Plate 2. Different types of habitat area of Golden Langur in Kakoijana Reserve Forest and village garden area. (a), (b)- Moist mixed deciduous dense area of the forest, (c), (d)- Moist mixed deciduous open forest area, (e) Mono culture of *Haevia brasilliensis,* (f) Monoculture of *Shorea robusta,* (g) Mono culture of *Tectona grandis.* (h) Secondary area zone, (i) Scrub forest area, (j) Degraded forest area, and (k), (l) village garden area.

(a)

(b)

(c)

(d)

(e)

(f)
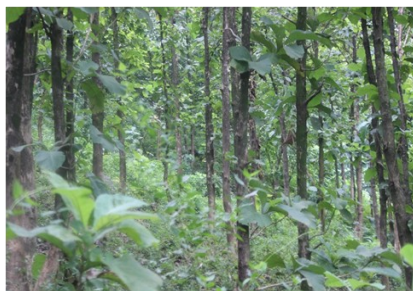
(g)
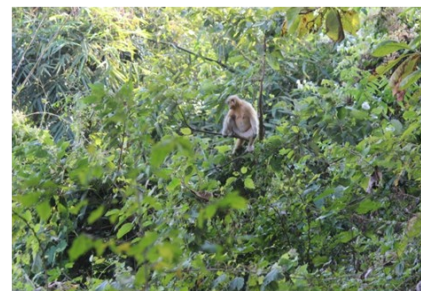
(h)

(i)

(j)

(k)

(l)

Plate 3. Methodology for land cover analysis
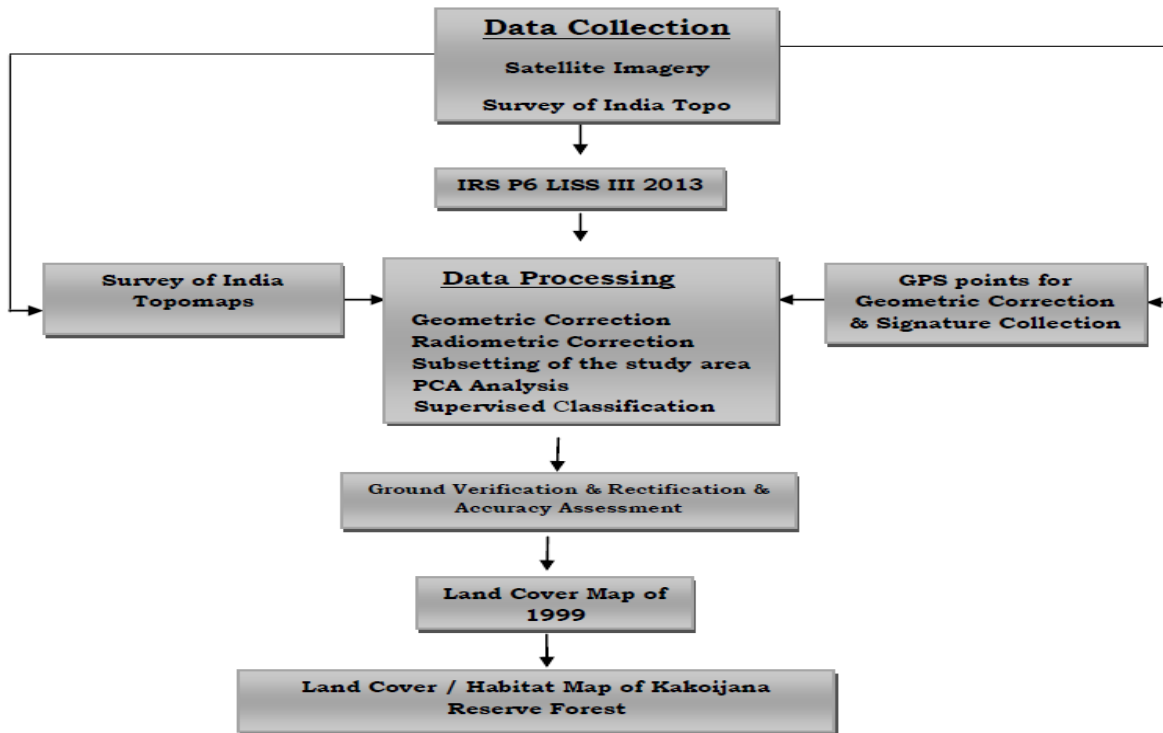
Plate 4 . (a)Land use/ land cover maps of Kakoijana Reserve Forest (b) Moist mixed deciduous dense (c) Moist mixed deciduous open (d) Edge matrix, monoculture & plantation area, (e) Scrub land area and (f) Degraded area.

(a)

(b)

(c)

(d)

(e)

(f)

Appendix 1. Distribution and demography of Golden Langur in different habitat zones of the study area. Zone (1= Dense; 2= Open; 3= Edge matrix area; 4= Village); Troop size*= Troop with pregnant Adult female; AM= Adult male; AF= Adult Female; SAM= Sub adult male; SAF= Sub adult female; JUV= Juvenile; INF= Infant
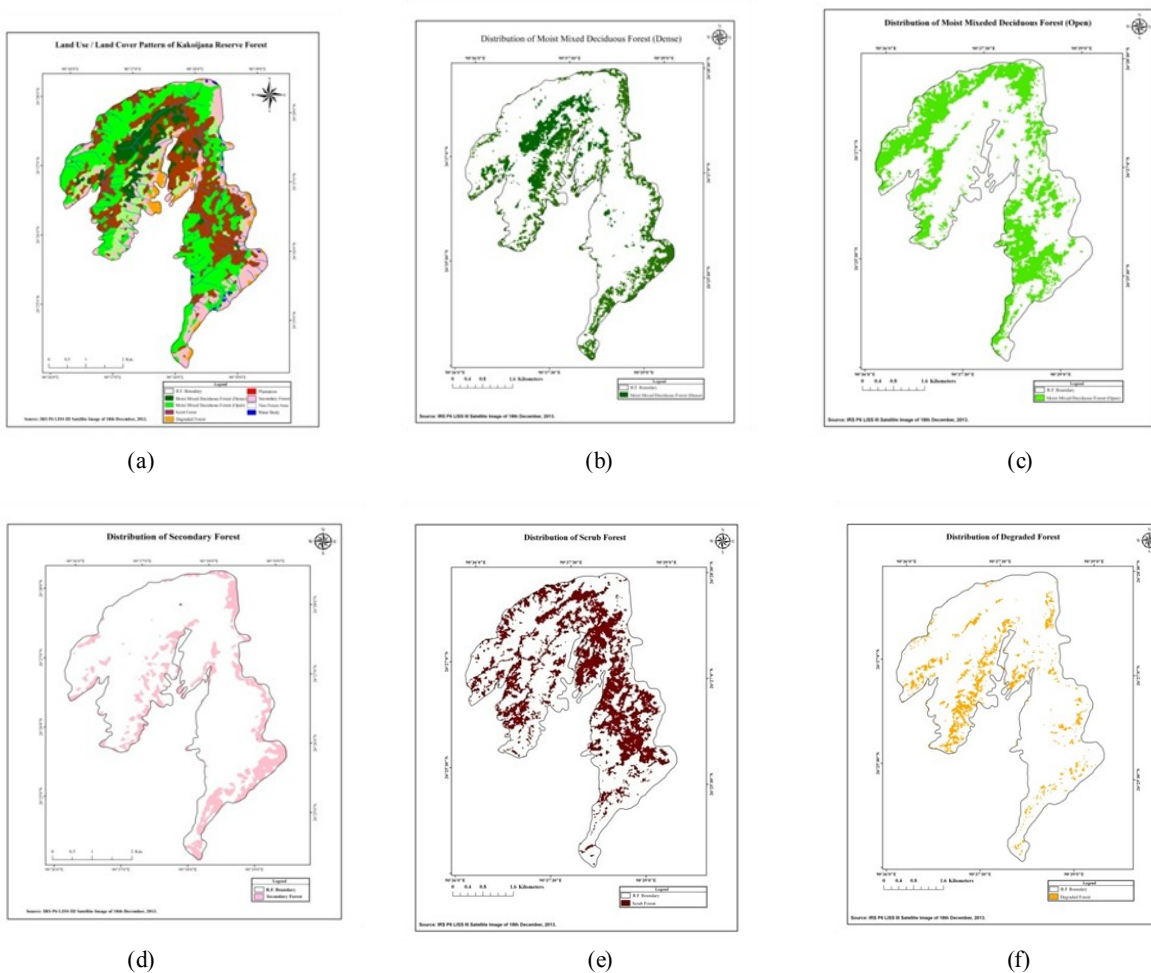
| | | GPS Location | | | | Composition | | | | | |
| | Troop I.D | Longi-tude | Latitude | Location site | Troop size | AM | AF | SAM | SAF | JUV | INF |
Zone											
2	K-1	26.45399	90.62788	Majer Pahar-Middle	12	1	4	1	3	3	0
2	K-2	26.44831	90.63224	Majer Pahar-North	11	1	4	1	2	3	0
2	K-3	26.45375	90.63326	Majer Pahar- Garden	20	2	5	2	4	6	1
2	K-4	26. 44124	90.64014	Jiaguri-Top	10	1	4	1	3	1	0
3	K-5	26.43257	90.64651	Khorapara-Rubber garden	13	1	5	1	2	4	0
2	K-6	26.42013	90.63578	Kathalguri- Tongsha	8	1	3	1	2	0	1
2	K-7	26.42459	90.64097	Lewchibari-Middle	7	1	3	0	1	2	0
2	K-8	26.43922	90.64071	Cilikijhora- Top	10*	1	4	1	2	2	0
2	K-9	26.43989	90.63611	Cilikijhora	12*	2	5	2	1	2	0
3	K-10	26.44376	90.63580	Deoghola- Tarkag-hola	6	1	2	1	2	0	0
2	K-11	26.44261	90.63735	Tarkaghola	12*	1	4	2	3	2	0
3	K-12	26.44844	90.63737	Tarkaghola- Be-lorguri	7	1	2	1	1	2	0
3	K-13	26.44122	90.63496	Cilikijgora- Bamboo	13	1	4	1	3	4	0
3	K-14	26.47182	90.63921	Hapachara Beat Of-fice	3	1	1	0	1	0	0
2	K-15	26.46662	90.63059	Kalikapat- Pateswari	11	1	4	1	2	3	0
1	K-16	26.46380	90.62604	Pateswari	15	3	4	1	2	4	1
3	K-17	26.46224	90.63142	Patabon	14	2	4	2	2	4	0
3	K-18	26.45445	90.62489	Saopota- South	7*	1	3	1	2	0	0
2	K-19	26.45564	90.62276	Saopota	3	1	1	0	0	1	0
1	K-20	26.44979	90.61869	Dhirenghola	12	1	4	1	2	2	2
1	K-21	26.44437	90.61750	Kantaghola	10	2	4	1	2	1	0
3	K-22	26.44185	90.61918	Ouguri	9	1	3	1	3	1	0
2	K-23	26.43969	90.61300	Dhongdhonga-Top	12	1	4	1	2	4	0
2	K-24	26.44338	90.61021	Patabari	11	1	5	0	1	4	0
2	K-25	26.44800	90.60606	Bomding	13	2	4	1	3	2	1
2	K-26	26.45005	90.61202	Patabari-Top	6	1	3	1	0	1	0
2	K-27	26.44812	90.61246	Patabari-Middle	11	1	4	2	3	1	0
2	K-28	26.45152	90.60570	Amjhora	11	1	4	1	2	2	1
2	K-29	26.46284	90.61626	Garopara	13	1	4	2	2	3	1
2	K-30	26.46687	90.61884	Garopara-Orange garden	10	1	4	1	2	2	0
1	K-31	26.45495	90.61231	Salbari-Top	11	1	4	1	2	2	1
1	K-32	26.45589	90.61318	Barogowali	13	1	4	2	3	2	1
1	K-33	26.45824	90.61656	Barogowali	16	2	5	2	3	4	0
1	K-34	26.45902	90.61913	Barogowali	7*	1	3	1	1	1	0
1	K-35	26.46342	90.62331	Barogowali	9*	1	4	1	2	1	0
1	K-36	26.45706	90.61906	Barogowali	11	1	3	2	2	3	0
1	K-37	26.45528	90.61819	Barogowali	11	1	4	1	2	2	1
1	K-38	26.45244	90.61395	Barogowali	13	1	5	1	2	4	0
3	K-39	26.42829	90.65475	Ujan Rabhapara	12	1	4	1	2	4	0
4	K-40	26.42943	90.65903	Ujan Rabhapara-Village	16	1	5	2	3	4	1
4	K-41	26.40738	90.63689	Nayapara	12	1	4	1	2	2	2
4	K-42	26.40929	90.62966	Kathalguri- Village	6	1	2	0	1	2	0
4	K-43	26.42360	90.61884	Siponsila	10	1	4	1	2	2	0
4	K-44	26.42772	90.61942	Kashibari	13	2	5	1	2	3	0
4	K-45	26.45672	90.60477	Chitkagaon	17	1	5	2	4	4	1

Appendix 2. Age- sex composition of Golden Langur in different habitat zones of the study area. (Zone-1= Dense habitat area, Zone-2= Open habitat area, Zone-3= Edge matrix/ Monoculture, Plantation area, Zone-4= Pastoral village area. AM= Adult male, AF= Adult female, SAM= Sub adult male, SAF= Sub adult female, JUV= Juvenile and INF= Infant, Pop= Population).

Age-sex	Overall Pop.	% Pop.	Zone 1	% Pop	Zone 2	% Pop	Zone 3	% Pop	Zone 4	% Pop
Adult male	54	11.04	15	11.72	22	10.84	10	11.90	7	9.46
Adult female	170	34.76	44	34.38	73	35.96	28	33.33	25	33.78
Sub adult male	51	10.43	14	10.94	21	10.34	9	10.71	7	9.46
Sub adult female	93	19.02	23	17.97	38	18.72	18	21.43	14	18.92
*Juvenile	106	21.68	26	20.31	44	21.67	19	22.62	17	22.97
*Infant	15	3.07	6	4.69	5	2.46	0	0.00	4	5.41

Appendix 3. Population density of different age-sex classes of Golden langur in different study zones

Population	Density in Forest	Zone 1	Zone 2	Zone 3	Zone 4 (Village)
AM	2.73	9.09	3.43	8.00	0.80
AF	8.44	26.67	11.39	22.40	2.84
SAM	2.56	8.48	3.28	7.20	0.80
SAF	4.60	13.94	5.93	14.40	1.59
JUV	5.18	15.76	6.86	15.20	1.93
INF	0.64	3.64	0.78	0.00	0.45