Impact of Habitat Fragmentation on Hoolock Gibbon (*Bunopithecus hoolock*) in Gibbon Wildlife Sanctuary, Assam, India

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1. Introduction

1.1 The Gibbon Wildlife Sanctuary

Gibbon WLS, (26^0 $40^/$-26^0 $45^/$ N, 94^0 $20^/$-94^0 $25^/$ E. and Alt100-120 m) which comes under the civil district of Johrat within the state of Assam was constituted in 1997 (**Fig. 1**).

It got the status of Reserve forest in the year 1881 and during this period, the Sanctuary was an integral part of the foothill forests of Patkai range (**Fig. 2**).

Fig.1 : Location of Gibbon Wildlife Sanctuary, Assam

Fig 2 : Gibbon Wildlife Sanctuary and Fragmented Forest Patches

After establishment of tea gardens during the period from 1880- 1920, the forest became fragmented with the other forest of the foothills. The forests during those days were covered by sporadic evergreen trees with dense Bojal bamboos (*Pseudodactylum sp*). To make a well stocked even aged regular forest, artificial regeneration started in the year 1924, since then plantations were regularly done. The plantation and the natural vegetation converted the area to a well-stocked forest, which attracted many life forms in the subsequent years. This

Sanctuary has the distinction in being one of those few places in Assam with highest density of gibbon populations. This is the only Sanctuary in the country named after the only ape species in India, the hoolock gibbon.

History: The GWLS used to be earlier known as "Hollongapar Reserve Forest", which was notified as a Reserve Forest vide notification No. 8 dated 27th August 1881. The original area of the Reserve Forest was 206 hectares, but in the year 1896, some of the areas of the Reserve were further de-reserved. Subsequently, more forest areas were added to this Reserve Forest and by the year 1997 the total area of the Hoolongpar RF rose to 2098.62 ha. This entire RF area was declared as Gibbon Wildlife Sanctuary by the Government of Assam vide notification no. FRS/37/97/13, dated 30-07-1997.

The Sanctuary is surrounded by tea gardens almost on all sides including few villages. These tea gardens are Katonibari, Murmurai, Chenijan, Koliapani, Meleng, Kakojan, Dihavelleoguri, Dihingapar, Kothalguri, Dissoi, Hoolonguri. The villages include Madhupur, Lakhipur,Rampur, Fesual A(the western Part), Fesual B (the eastern Part) Katonibari, Pukhurai, Velleoguri, Afolamukh, Kaliagaon. The tea gardens were established during the last part of 19th century whereas the villages were established during the 60's to rehabilitate the flood affected landless people of Majuli and adjoining areas. About 8 kms away from the Sanctuary, Dissoi Reserve Forest is located which is contiguous with Dissoi Valley Reserve Forest due to establishment of Kothalguri, Hoolonguri and Dissoi Tea Estate.

Gibbon Wildlife Sanctuary: a fragmented habitat: Gibbon Wildlife sanctuary (GWLS) is an isolated forest patch surrounded by tea gardens and human settlements. Once it was contiguous with large forest tract that extended to Nagaland state. The nearest forest areas of Dissoi Valley Reserve Forests of Nagaland are now separated by a vast stretch of tea gardens presenting a kind of barier for the effective migration of wildlife. The case in point is the straying elephants from GLWS while trying to take their age-old (as the people say) migration route to Nagaland state. In this attempt, many cases of elephant depredation are reported very frequently which also involve the labourers working the tea gardens. A railway line divides the Sanctuary in two unequal fragments without any effective connectivity between the two fragments. Confined in the smaller fragment is only one group of gibbon without any accessibility to the other fragment Moreover, the habitat in this forest is highly degraded due to continuous illegal felling and encroachment by the local people especially by the labourers of the adjoining tea gardens.

Vegetation: As per the Champion & Seth(1968) classification scheme, the forest type in the GWLS is Assam Plains Alluvial Semi Evergreen Forests /2/2B/C with wet evergreen forest patches present sporadically. The vegetation is composed of several canopy layers, most of the component species are evergreen in character.

Top Canopy: The top canopy is predominated by Hollong *(Dipterocarpus macrocarpas)* with clean straight boles 12mt to 30mt in length. The other associated top canopy with Hollong are Sam (Artocarps chaplasha), Amari *(Amoora wallichi)*, Sopas *(Mcheliai spp.)*, Hollong *(Dipterocarpus macrocarpa)*, Bhelu(*Tetramels mudiflora*), Udal (*Sterculia villosa)* and Hingori (*Castanopsis spp.*).

Middle Canopy: Nahar (*Mesua ferrea*) is the most prominent species in the middle canopy. It casts a fairly heavy shade on the forest floor covering

a wider area on account of its spreading crown. Other common species constituting the middle canopy are Bandordima*(Dysoxylum procerum)*, Dhuna *(Conarium resiniferum)*, Bhomora(*Terminalia belerica*), Ful Gomari (*Gmelina Sp.*) Bonbogri (*Pterospermum lanceafolium*), Morhal*(Vatica lanceafolia)*, Selleng *(Sapium baccatum)*, Sassi (*Aqualari agolacha*), Otenga *(Dillenia indica)*, etc..

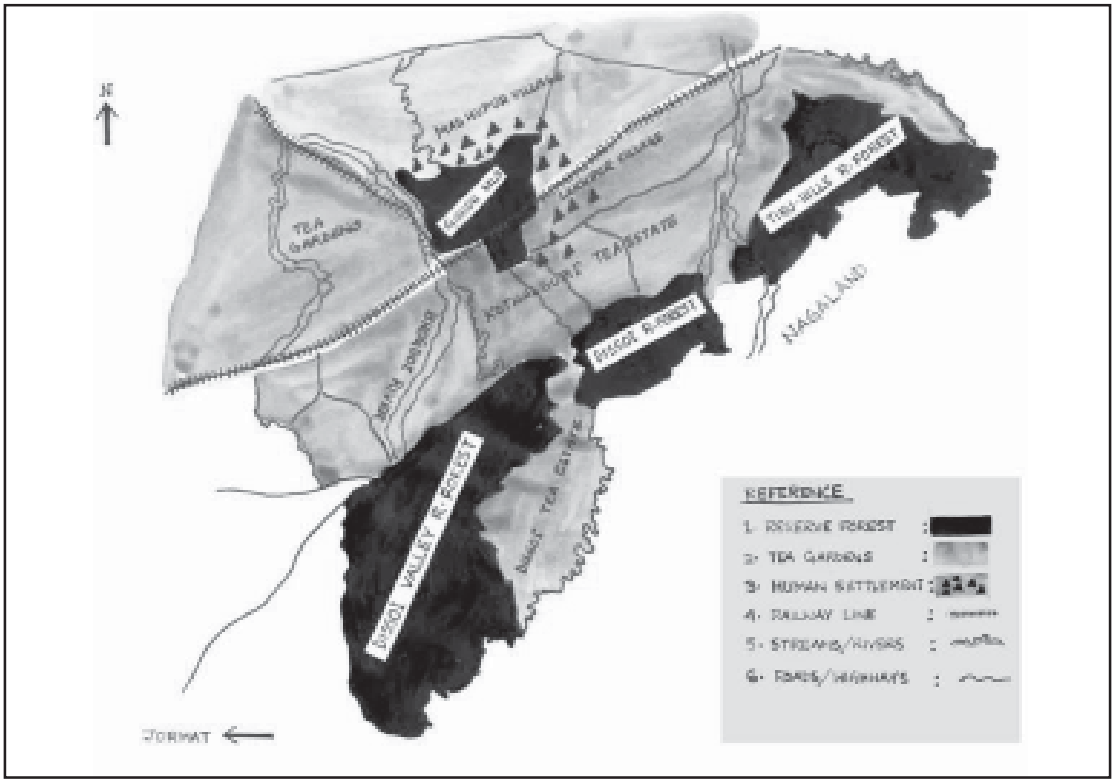
Lower Canopy: The lower and ground layers consist of a variety of evergreen shrubs and herbs. The most common among them are Dolu bamboo *(Teinosstachyum dullooa)*, Bojal bamboo *(Pseudostachyam polymorphum)*, Jengu *(Calamus erectus)*, Jati bet (*Calamus spp.*), Houka bet (*Calamus spp.*), Tora (*Alpinia allughas*), Kaupat (*Phrynium imbricatum*), Sorat (*Laported cremulata*) etc.

Boundaries: The ecological boundary of the Sanctuary extends up to Dissoi Valley Reserve Forest, Dissoi Reserve Forest and Tiru Hill Reserve Forest. These are the dispersal areas of animals particularly elephants. In between the Reserve Forests and the Sanctuary there are three numbers of tea gardens, which fall within the ecological boundary of the wildlife. As stated above, the elephants of the Sanctuary frequently use these gardens as migration route. These tea gardens are Dissoi tea estate, Kothalguri tea estate and Hoolonguri tea estate, which are under private ownership. The growing population of the workers of these tea gardens forms a threat to the primate habitat (**Fig. 3**).

1.2 Study site and study group

Compartment 1 and compartment 2 were selected sites for intensive study under this project. As mentioned in the preceding paragraphs, a railway line divides the Sanctuary in two unequal fragments. The smaller of the two is the Compartment 1. This compartment has one group of gibbon with 4 individuals.

Fig. 3 : Landscape view of Gibbon Wildlife Sanctuary



This compartment is experiencing heavy biotic pressure due to its sharp edge formation with the tea gardens, villages and road. This forces the solitary gibbon groups to remain confined to the compartment. This group, therefore, has absolutely no connections with the other groups of gibbon in other Compartments located on the other side of the railway track. To make a comparison to the effect of fragmentation and biotic pressures on the conservation status of gibbon, compartment 2 was also selected as another study site from amongst the compartment located in the bigger fragment of the sanctuary across the railway track.

1.3 Objectives

The objective of the study was to document the impacts of habitat fragmentation on hoolock gibbon populations in two forest fragments to ascertain whether there is any observable difference in habitat use pattern, demography, feeding ecology, behaviour and home range.

2. Methodology

2.1 Preliminary survey

A preliminary survey was carried out in the two forest fragments to determine the number of groups, habitat type, habitat quality, home range, interaction among other members of the same species, interaction with other primate species, behavioral patterns, conservation threats etc. Morning songs were taken as indicators to ascertain the number of gibbon groups and their exact locations were recorded using GPS (Global Positioning System). Two gibbon groups, one each in compartment 1 and 2, were selected during this preliminary survey for intensive study.

2.2 Intensive data collection

Intensive data collection was carried out using scan sampling (Altman 1974) during the months February to May 2004.

- Scan sampling was carried out for six days during the first and third week of each month in Fragment 1, and second and fourth week of each month in Fragment 2.
- Vegetation sampling was done once every month
- Phenology study was done once in each fortnight.

Scan sampling: The study group was followed from dawn (when they wake up at their roosting trees) to dusk (when they finally retire for the given day on the roosting trees). The data on different activities and other aspects of their ecology, behaviour, etc were collected using a pre-designed format (**Annexure I**). The recording was done for every 5-minutes interval between the two consecutive observations.

Vegetation Sampling: Vegetation sampling was done to know the type of plant species present, so that vegetation of the area can be assessed qualitatively. Transects of 3 km length were laid in each compartment of the Sanctuary and observations were noted after every 500 meters distance of the line transect including number of trees falling within a circle of 10 m radius on both side of the transect alternatively. (**Annexure II**)

Phenology: Phenology study is done to classify the state of leaves and flowers (phenophases) and get information on the annual cycle of flowering and fruiting. This study is important because the chemical constituents of the leaves, stems and fruits change with season, age and

impacts of biotic pressure. What is regarded nutritionally important in one season may be toxic in another and almost indigestible in the third. Phenology study was done once every fortnight. The methodology includes studying the percentage presence of leaves, fruits and flower for all food plants of the gibbons in the study site. (**Annexure III**).

2.3 Study Animal

The hoolock gibbon was the study animal. The details on the hoolock gibbon are presented in Chapter I of this Volume.

3. Results

3.1 Gibbons in GWLS

A total of 16 groups of gibbons were located in different compartments of the GWLS (**Table 1**)

3.1.1 Activity patterns

The activity pattern of the two study groups in the two fragments were compare . It was found that in Compartment 1, of the total activity time, the gibbon spent 35-40% feeding, 35% resting, 5% grooming, and 0-1% singing. This result does not show any significant difference from early studies (Alfred & Sati 1990; Islam 1992). The frequency of morning songs was found to be very low. The single gibbon group in the Compartment 1 sang only 2-3 times during the entire study period. This appears to be a departure and amount to be an abnormal behavior given the fact that normally the gibbons sing daily in varying frequencies, though. This may be due to the fact that this group does not have to communicate as there are no other group in this Compartment and this Compartment is separated from the others by the railway track.

Table 1 : Distribution of gibbon groups in different compartments in the GWLS

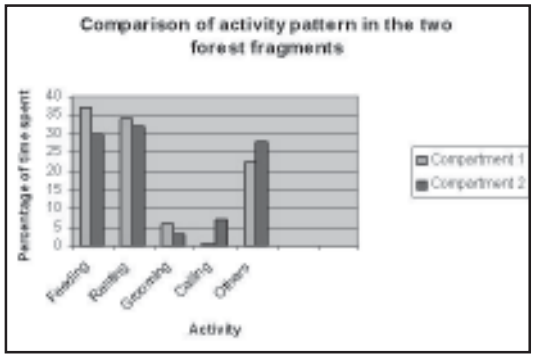
Compartment Number	Gibbon Groups (N)
1	1
2	6
3	4
4	3
5	2
TOTAL	**16 Groups**

In compartment 2 the gibbons spent 30% time feeding, 32% time resting, 5% time grooming, and 6% of the total activity time singing. There are six gibbon groups in this compartment. The singing frequency, (15-20 minutes every morning from 0730 to 0900 hours) thus, was found to be normal. Tilson (1979) and Gittins and Tilson (1984) have also reported the similar frequencies in their studies on gibbons. Presence of food comparatively in large quantity and diversity in compartment 2 make gibbons range less in search of food. This may account for more time spent resting by gibbons in this study site compared to compartment 1. (**Fig 4**).

3.1.2 Feeding

Plant part: Gibbons are predominantly frugivorous(Shrivastav et. al 1992). In this study, of the total time spent on feeding, the gibbons spent 50 -55% time feeding ripe fruits, 5-6% feeding unripe fruits, and 43-45% feeding leaves. Due to its anatomical and physiological

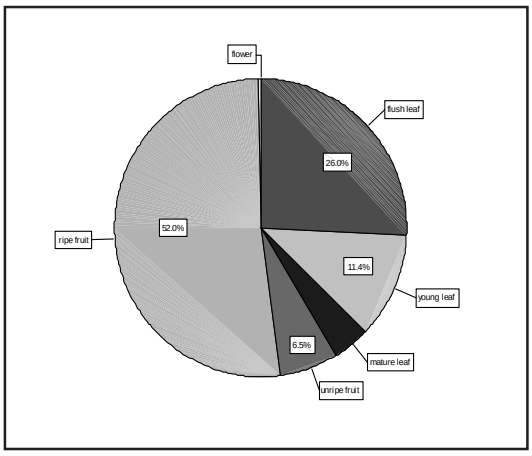
Fig. 4 : Comparison of Activity Pattern of gibbon in Comaprtment 1 and 2



needs, the gibbons are not natural folivorous, but the feeding results of this study show that leaves contribute substantially to their diet. As shown in **Table 3** there is no significant dearth of food plants that could have provided a rich frugivore diet to the gibbons similar to other studies elsewhere. This unusal feeding behaviour by gibbons in this study may probably be accounted for their inaccessibility to those fruit trees due to wide canopy gaps not facilitating gibbons to be able to reach to those fruit plants (**Fig 5**).

Feeding height: The feeding height of gibbons in this study was found to be between 25 to 30 m. Gibbons generally utilize the top canopy trees for meeting their needs for food, cover, and movement by adopting to brachiatry. The canopy height of most of the trees (about 50%) in the study area also ranged between 20-35m (**Table 2**). therefore, there was no apparent

Fig. 5 : Proportion of Plant Parts in gibbon Diet



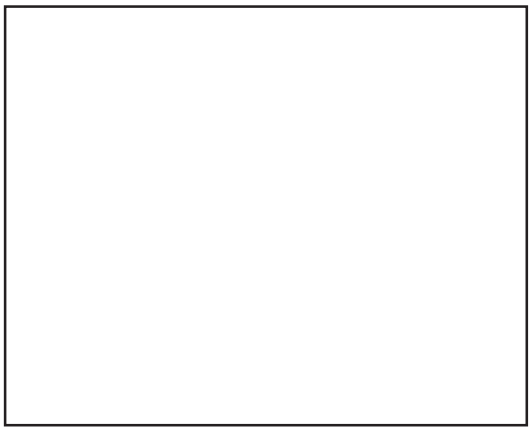
shortage of trees with appropriate height for gibbons to feed upon (**Fig. 6**).

Preferred food pants: The most preferred food plant of gibbons in the study area was *Artocarpus chaplasha, Castanopsis indica, Ficus sp, Dysoxylum procerum* etc. All these trees are quite abundant in the study area (**Table 3**). But due to canopy gaps and other kinds of biotic disturbances, the accessibility of gibbons to these food plants have decreased. As explained earlier, this poor accessibility has forced the gibbons to take to folivory (**Fig. 7**).

Table 2: Tree Height in GWLS

Height class (m)	Frequency	Percentage
0-5	10	0.30
6-10	26	0.77
11-15	843	25.17
16-20	793	23.67
21-25	1042	31.12
26-30	492	14.69
31-35	143	4.28
Total	**3349**	**100.00**

Fig. 6 : Feeding Height of Gibbons in GWLS



4. Discussion

4.1 Biotic Disturbance

Felling is the serious human disturbance in the study area. Other activites adversely affecting the habitat are collection of firewood, small wood and other non-timber forest products. Lopping of trees is also one of the most serious biotic disturbance in the study area. Rampant illegal

Fig. 7 : Important Food Species for Gibbons in GWLS

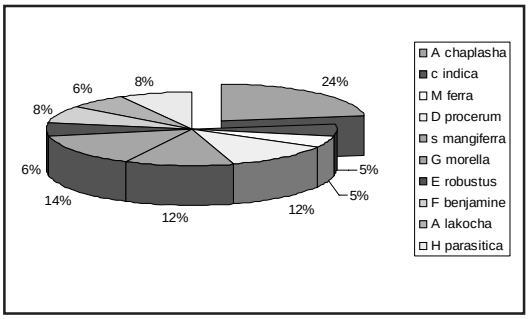


Table 3: Important Food Plants for Gibbons in GWLS

Plant species	Frequency	Percent
Dipterocarpus retusa	*3*	.2
Artocarpus chaplasha	*196*	13.0
Amoora wallichi	*28*	1.9
Michelia champaka	*14*	.9
Tetramelos nudiflora	*26*	1.7
Castanopsis indica	*60*	4.3
Mesua fera	*46*	3.1
Dysoxylum procerum	*143*	9.5
Terminelia bellerica	*26*	1.8
Gmelina arborea	*20*	1.3
Dillenia indica	*9*	.6
Lagerstromia flos reginae	*4*	.3
Spondias mangifera	*54*	3.6
Sapium baccatum	*23*	1.5
Garcinia morella	*133*	8.9
Gmelina sp	*24*	1.6
Eleocarpus robustus	*45*	3.0
Ficus benjamine	*83*	5.5
Artocarpus lakoocha	*145*	9.7
Talauma hodgsoni	*26*	1.7
Eugenia jambulana	*40*	2.7
Anthocephalus kadamba	*40*	3.1
Baceaurea sapeda	*12*	.8
Ficus racemosa	*104*	7.0
Litseaea polyantha	*9*	.6
Sterospermun chelonoides	*7*	.5
Hoya parasitica	*98*	6.5
Michenia sp	*71*	4.7
Total	**1489**	100.0

felling of important food trees of gibbon such as *Artocarpus chaplasha, Michelia champaca* has led to scarcity of food resources in the habitat. The study area is surrounded by villages and tea garden from all sides. This makes the area a safe heaven for the illegal fellers. Grazing is relatively less and encountered only in compartment 1 **(Fig. 8)**.

Some of the plant species which are useful for gibbons to meet their food, cover and movement requirements are also extremely useful for the local people and their subsistence economy. A list of few such plant species is presented in **Table 4**.

4.2 Degradation of habitat

Compartment 1

- The total area is 260 hectare, of which 65 hectare (25%) is degraded along the southern and western parts.
- The disturbance on the Western boundary is due to the presence of sharp edge with Kothalguri Tea Estate.
- The remaining 185 hectare is considerably good habitat with dense patches of *Artocarpus chaplasha* plantation. This species make up for a rich gibbon diet in this habitat.
- The gibbons are seen to avoid the area up to 500 m distance from the National Highway. This renders rich habitat inaccessible in spite of the presence of rich food and canopy trees.
- One gibbon group with 4 individuals inhabit an area of about 0.3 km^2 on the Northern side of this Compartment. Although, there is no competition to this group in Compartment, but this group is forced to confine to this small area of about 30 hectare due to biotic pressures. This suggests that mere presence of good habitat is not enough unless it is made available to the species for fulfilling its needs food, cover, and water.
- The presence of railway track has caused destruction over an area of about 2.6 km^2. This is calculated keeping in mind the effective width of the Compartment all along the track getting impacted due to presence of track. This is besides the fact that this railway track has already

Fig. 8 : Human Disturbance in GWLS

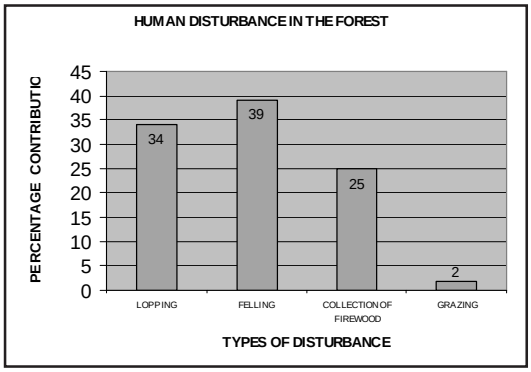


Table 4 : Economically Important Plant Species in GWLS

Local Name	Scientific name	Parts used
Sassi	*Aqualaria allogacha*	Stem
Sam kathal	*Artocarpus chaplasha*	Timber and fruits
Sopa	*Michelia champaka*	Timber
Gomari	*Gmelina Sp*	Timber
koroi	*Terminelia bellerica*	Timber and barks

isolated the gibbon group in Compartment 1 (**Fig. 9**).

Compartment 2

- Total area of this compartment is 900.62 hectare (9.6 km^2) Of this total area, about 1.8 km^2 along the western and southern border is degraded due to its formation of sharp edge with Kothalguri and Kotanibari tea estates
- The primate density is very high in the this compartment. There are 6 groups of hoolock gibbon, two groups of capped langur (Trachypithecus phayrei), and one group of pigtail macaque (Macaca nemestrina).

Fig. 9 : Compartment Number 1

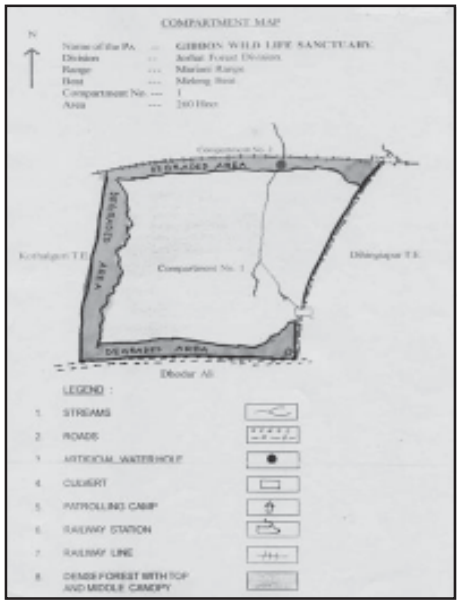
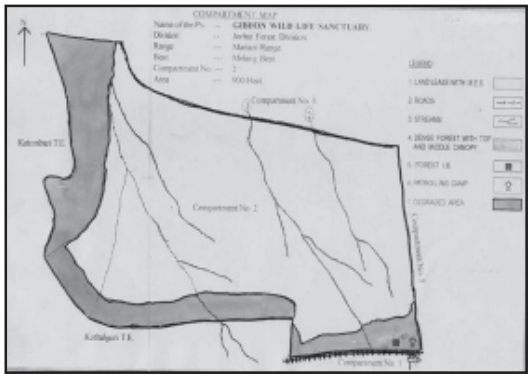


Fig. 10 : Compartment Number 2



- The presene of many primate species in good density poses stiff competition for resources sharing among themselves.
- The gibbons of this compartment migrate occasionally to compartment 5 (**Fig. 10**).

Compartment 3

- The total area of this compartment is about 380 hectare (3.8 km2). Of this total area, about 10% area (40 hectare) along the northern boundary is highly degraded.
- This compartment has the most degraded habitat on its edge with Madhupur village.
- There are 3 gibbon groups in this compartment. These groups were noted migrating to these compartments at times (**Fig. 11**).

Compartment 4

- The total area of this compartment is about 358 hectare (3.58 km^2)
- Almost 60% (214 hectare) of this total area along the Northeastern boundary

Fig. 11 : Compartment Number 3

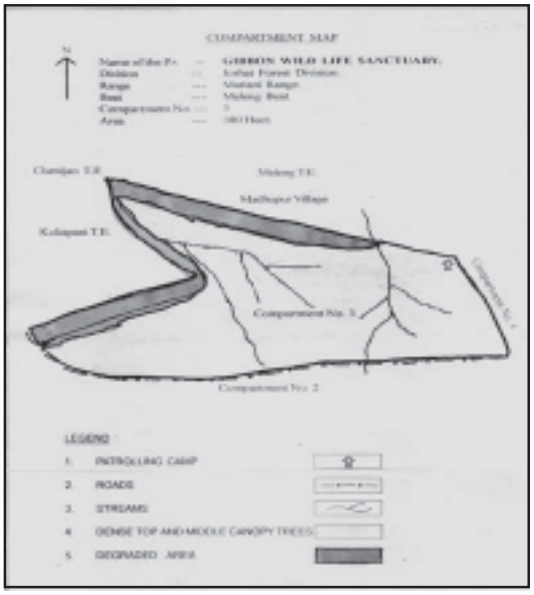
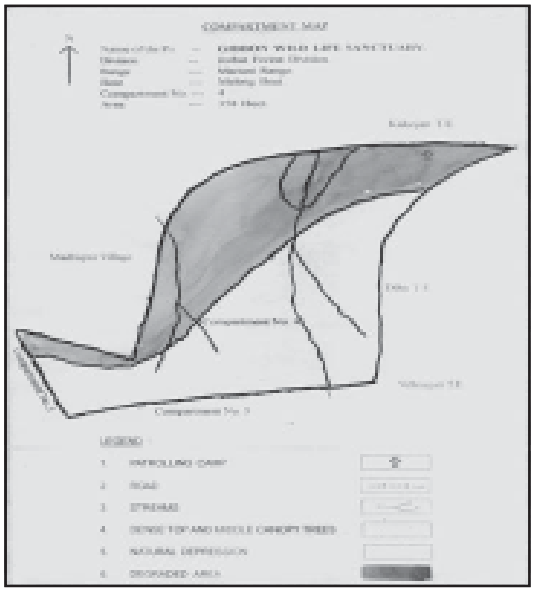


Fig. 12 : Compartment Number 4



with Madhupur village and Kakojan tea estate is highly degraded (**Fig. 12**).

- This Compartment has 3 groups of gibbon and one group of stump tail macaque (Macaca arctoides).

Compartment 5

- The total area of this compartment is roughly 200 hectare (2 km^2).
- It is relatively less disturbed compared to other compartments as described above. Only about 5% of the total compartment area may be counted as degraded.
- The compartment has 2 groups of gibbon which are seen migrating at times to Compartment 2.
- In this compartment the canopy continuity is insufficient and poor, which forces gibbons to range into other areas of the forests to meet their requirements (**Fig. 13**).

4.3 Suggestions and recommendations

Similar to many other protected areas in the country in general and in Assam in particular, this Sanctuary also presents almost all those factors responsible for degradation of the habitat therein. However, the land-locked nature of this small Sanctuary further compounds its problems due to biotic disturbances.

Illegal felling of trees has created canopy gaps, which the gibbons find difficult to negotiate. This makes them vulnerable to predators and also increases the risk of falling from the heights. Rampant illegal felling of important food trees of gibbon like *Artocarpus chaplasha, Michelia champaka*, etc. has made a scarcity of food resources in the habitat. The study area is surrounded by villages and tea garden from all sides, which besides directly impacting the area adversely, provides a safe heaven to the illegal fellers. Grazing is relatively less and encountered only in compartment 1, which remains out of sight of the staff due to its far away distance from the nearest forest beat

Fig. 13 : Compartment Number 5

office. The use of pesticides in the tea gardens will have a serious effect on the habitat in the future due to its leaching out to the habitat with rainwater in this heavy rainfall habitat.

First and foremost measure to tackle the situation in this Sanctuary is to render effective patrolling across the Sanctuary. Stringent protection measures are must to check any further degradation of the habitat due to encroachments and frequent presence of human populations all across the sanctuary to withdraw natural resources in highly unsustainable manners. A suitable connectivity between compartments 1&2 has to be established facilitating migration of gibbons across the railway track. This can be attempted by using bamboo poles connecting the trees at regular intervals. Similar efforts have been successfully made in Indira Gandhi WLS, Pollachi, Tamil Nadu for lion tailed macaques (*Macaca silenus*). The railways authorities may be persuaded to reduce the speed of trains while passing through the Sanctuary area. This will lessen the noise pollution and also check on deaths of other animals being run over by the train while crossing. The degraded patches in both the Compartments have to be filled up by gap plantations of species that are favoured by gibbons for food and cover. The dependency of local people residing in the adjoining villages on the forestry resources can not be removed overnight. Therefore, attempts need be taken by the forest authorities in association with NGOs and other organizations to switch this dependency to non-forestry resources as much as possible. Ecodevelopment and Joint Forest Management programmes are already in vogue with the forest department to make use of for this purpose.

Nothing much could be done to blunt the sharp edges that these compartments share with adjoining tea gardens, villages and roads. However, the tea estate owners can be convinced to create a buffer belt of plantations all along the interface between sanctuary and tea estates to reduce the negative impact to some extent. The forest department can help the tea estate owners in developing this buffer zone through their tehnical expertise on the choice of species, etc.

As is discussed in preceding paragraphs that even though the Compartment 1 is good in gibbon habitat, yet, due to severe biotic pressures this entire good habitat inside the compartment is not availability to the gibbons for their use. Therefore, special emphasis is to be given to keep the gibbon habitat free of all kinds of disturbances so that gibbons can use the entire habitat for their survival.

Conservation education programme should be taken up in this sanctuary, which is the only one in the country named after gibbon species. Being in proximity to the Kaziranga National Park, many visitors can be attracted to disseminate the message for gibbon conservation. The local village committees may be encouraged under exodevelopment and

other programmes to undertake volunteer protection works for the sanctuary. Generation of employment opportunities for the local youths will also be a huge incentive for local people to actively participate in protection .

This sanctuary has the highest known population of hoolock gibbon in Assam, and therefore should be managed as a center of gibbon conservation in Assam.

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Annexure - I

Scan Sampling data Sheet

Parameters														
Time														
Animal sex														
Activity														
Tree sps														
Food plant														
Tree ht														
Plant part														
Canopy Ht.														
Canopy Width														
Animal Ht.														
Group Dispersal														
Other primates														
Other animals														
Human activity														

Date Location Weather Group composition

Annexure - II

Vegetation Data Sheet

Tree Species	Number of trees	Tree Height	Canopy Cover (%)	Canopy Continuity (%)	Visibility	Undergrowth cover (%)	Species composition of Undergrowth	Number of cut stumps	Human activity

Date Location Weather

Annexure - III

Phenolgy Data Sheet

Date Location Weather