SPATIAL PATTERNS AND PROCESSES FOR SHIFTING CULTIVATION LANDSCAPE IN GARO HILLS, INDIA

Ashish Kumar[1], Bruce G. Marcot[2] and P.S. Roy[3]

[1]Project Tiger Directorate, Ministry of Environment and Forests, New Delhi, India

[2] US Forest Service, Portland, USA

[3] National Remote Sensing Agency, Department of Space, Hyderabad, India

ABSTRACT

We analyzed a few spatial patterns and processes of a shifting cultivation landscape in the Garo Hills of Meghalaya state in North East India, where about 85 % of land belongs to native community. The landscape comprised 2459 km^2 of land with forest cover and shifting cultivation patches over 69% and 7% area of landscape, respectively. The mean patch sizes ± standard deviations for forest cover and shifting cultivation patches were 0.17 ± 1.86 km^2 and 0.03 ± 0.04 km^2, respectively. The low fragmentation areas between adjacent PAs and RFs were identified as potential wildlife (elephant) habitat corridors and the Core Area (CA) model revealed 591 patches that held 1468 km^2 area inside 500m from nearest edge of patches. Landscape with >40% of forest cover and <30% of current or abundant jhum cover with <2% annual *jhum* have been reported to support higher elephant densities in study area.

Keywords: Shifting cultivation or jhumming, Forest fragmentation, Wildlife habitat corridors, Protected area network and Elephant habitat relationship

INTRODUCTION

The most North East Indian forests are under the tremendous pressure of exploitation due to unplanned traditional forestry practices especially the widespread use of slash and burn shifting cultivation (locally known as jhumming or jhum), in which native people clear and burn the old forest growth over a piece of land to get fertile land for raising agricultural crops for one or two years and then move on to clear fresh forest land. As per the 1979 report of North Eastern Council a total of 4116 km^2 was placed under jhumming, of which 760 km^2 of land was used at one point of time every year by 68000 jhummias, i.e., families involved in jhumming (DSWC 1995) in Meghalaya. The Meghalaya including Garo Hills is one of the richest botanical regions of India (Awasthi, 1999). The Garo Hills, situated in the western Meghalaya, represent the remnant of ancient plateau of the pre-Cambrian peninsular shield (Momin, 1984) and is prominently inhabited by the native Garo tribes. The major stressor to native forest biodiversity in the Garo Hills is the increasing anthropogenic conversion of mature and primary forests to jhum land. The South Garo Hills district including the Balpakram and the adjoining Nokrek Biosphere Reserve and National Park represent the specific study area (Figure 1). The specific study area hereafter referred to as landscape in present study represents the western-most hill ranges of Meghalaya state in North East India. The four PAs and four RFs (Figure 1) covering 15% of landscape area, offer excellent prospects of conserving native forest and associated biodiversity of the region. The PAs include the Balpakram National Park (BNP) (220 km^2), Nokrek National Park (NNP) (47.48 km^2), Siju Wildlife Sanctuary (SWS) (5.18 sq km^2), Baghmara Pitcher Plant Sanctuary (BPPS) (2.7 ha). The four RFs are the Baghamara Reserved Forests (BRF) (44.29 km^2), Rewak Reserved Forests (RRF) (6.48 km^2), Emangiri Reserved

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Forests (ERF) (8.29 km^2), and Angratoli Reserved Forests (ARF) (30.11 km^2). Like PAs, these RFs have been considered as elements of Protected Area Network (PAN) in present study due to absence of any dependency of native Garo community (Kumar et at. 2002). Till date, not much work has been done to evaluate the landscape, PAN, plant and animal communities of the Garo Hills except a few studies (Kumar & Rao 1985; Haridasan & Rao 1988; and Khan et al. 1997; Sudhakar & Singh 1993; Kumar & Singh 1997; Roy & Tomar 2001; and Talukdar 2004). Present study examines the spatial patterns and processes of the jhum-influenced landscape to identify and prioritise the wildlife habitat areas for conserving native biodiversity.

METHODOLOGY

We prepared a base map of study area showing boundaries of landscape as well as all PAs and RFs at 1:50,000 scale with the help of Survey of India topo-sheets and other available maps from State Forest Department of Meghalaya (SFDM). We also prepared a land use and land cover (LULC) map using remotely sensed satellite data (IRS-1D LISS III, 23.5 m resolution) of February 1999. We computed select patch indices to reveal the landscape characteristics and forest fragmentation in area using LULC map. We identified various levels of forest fragmentation and the core areas at specified distances of 250m and 500m from patch edge with the help of Bio_CAP, a GIS based programme developed by Indian Institute of Remote Sensing, Dehradun. The fragmentation map was integrated with the base map and low fragmentation areas between two PAs and/or RFs were manually delineated as potential wildlife habitat corridors. Most villagers restrict their movements inside forests up to 2 km and 5 km for Non-timber Forest Products collection and jhumming, respectively, hence we considered the buffers of 2 km and 5 km around PAs and RFs as Zone of Influence (ZI). This ZI map was integrated with the LULC and Core Area maps and compared for significant differences of forest cover and core areas between ZI and other components of landscape including PAs/RFs, corridors and other ZIs within community land using Chi-square analysis. We also used secondary information on elephant census records of SFDM for years 1993 and 1998 and spatial information of Garo Hills (Talukdar 2004) for analyzing Elephant Habitat Relationship at landscape level. Also, the available information on jhum families and other socio-cultural and economic factors was integrated with primary data to help develop conservation strategies for biodiversity, productivity and sustainability of the ecosystem.

RESULTS

The LULC classes included the Tropical Moist Evergreen Forest (TMEF), Tropical Semi-evergreen Forest (TSEF), Tropical Moist Deciduous Forest (TMDF), Bamboo growth & Young secondary forests up to 6 years old, Shola type forests along with associated grasslands at Balpakram plateau, Habitation/abandoned jhum, Agriculture/sand, Shifting cultivation/ grasslands and Water-bodies especially rivers as visible through digital data (Figure 2).

LANDSCAPE AND JHUMMING

The landscape was a mosaic of 2,27,977 patches and constituted 2459 km^2 land, however, the majority of land base, *i.e.*, 84% of total landscape was confined within 20 914 big size patches (patches with ≥ 0.01 km^2 or 1 ha area). The mean patch size ($\pm$ standard deviation) was 0.10 ± 1.23 km^2 with mean edge length ($\pm$ standard deviation) for all patches was 3 ± 18 km. The overall patch and edge densities of landscape were 10 patches per/km^2 and 28 km/km^2, respectively. The largest patch occupied nearly 5% of entire landscape area and represented by the old forest growth, specifically, the TSEF. The jhum patches cover only 7 % of landscape area, but found sparsely distributed all over the landscape and affect the forest biodiversity of

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majority of community land of landscape. The mean patch sizes (± standard deviation) and mean edge length (± standard deviation) of jhum patches were 0.03 ± 0.04 km^2 and 1.32 ± 1.26 km, respectively. The overall patch and edge densities of landscape were 16, 17 and 33 patches/km^2, respectively. One-third of total families inhabiting landscape were engaged in jhumming (DSWC, 1995) over 47 km^2 of land area at a time for one cycle of jhum (Table 1). The land consumption per family for jhumming varied from 0.28 ha (for Rongra CDB) to 0.80 ha (for Chokpot CDB) at this landscape.

FOREST COVER AND CORE AREAS

In case of forest cover classes, a total of 8921 patches were recorded, which constituted 75% of total landscape area. The mean patch size (± standard deviation) was 0.17 ± 1.86 km^2 with mean edge length (± standard deviation) of 4 ± 27 km. The overall patch and edge densities of landscape were 6 patches/km^2 and 24 km/km^2, respectively. The distinct forest types include TMEF, TSEF and TMDF, which all together constitute 68% of landscape. The TMEF represented the old primary forest growth and occupied about 14% of landscape. The TSEF growth mostly buffered the TMEF and occupied 26% of the landscape. The TMDF (29% of landscape) usually associated with the forest growth at fringes of human settlements or habitations and other land use subjected to frequent anthropogenic disturbances. The core area analysis revealed 2236 patches as specific core areas within old forest growth, covering an area of 561 km^2 of forested land, assuming a 250 m edge distance, which decreased to 644 patches with total area of 291 km^2 when the edge distance was doubled.

FRAGMENTATION AND CORRIDORS

The majority of old forest growth was intact or subjected to very low level of fragmentation, which accounted for 71% area of landscape. Only 1% of landscape was under high fragmentation, while medium fragmentation was observed over 21% of landscape (Figure 3). A total of 14340 patches were recorded within the corridor boundaries (Figure 3), of which 6944 patches (48% of all patches in corridors) constituted 92% of total corridor area with mean patch size (± standard deviation) 0.04 ± 0.63 km^2, however, the mean patch size (± standard deviation) was 0.003 ± 0.008 km^2 for all 7396 non-forest patches within the corridor boundaries. All seven potential corridors linked the BNP in the south to the NNP in the northern most range of landscape along with three reserved forests via one or more routes.

ZONE OF INFLUENCE (ZI)

The zones of influence within landscape represent the zones under the influence of biotic communities of protected area network and the biotic as well as cultural communities from surrounding community land. During present study, we considered two zones of influence at specified distances of 2 km and 5 km for further assessment of various land uses and forest types. Specifically, these two zones referred to as 2 km ZI (zone of influence at 2 km distance) and 5 km ZI (at the distance of 5 km). The most redeeming feature of ZI at a 2 km distance was the low proportions of agricultural, jhum and scrubland areas, suggesting that biotic pressures. The ZIs of BNP, SWS, and RRF overlapped when ZI was considered at 2 km distance (total area 135 km^2). Therefore, a combined ZI was calculated. The 5 km ZI had much overlap among the zones around BNP, NNP, SWS, BRF, RRF and ERF. Total area under this particular ZI increased greatly (seven times larger compared to that of 2 km ZI), however, the proportion of forest and non-forest is same as 2 km ZI. *i.e.,* almost 80% of the total 5 km ZI area was under old forest growth (TMEF, TSEF, TMDF). The overall land uses in this ZI comprised about 13% of land area of 5 km ZI.

COMPARING LANDSCAPE SEGMENTS

The results of chi-square analysis for testing the significance of difference among various segments of landscape for distinct forest types and land use activities (Figure 4) revealed that

- All landscape segments including PARF (ALL PAs and RFs), Corridors (as identified in present study), ZI1 (2 km ZI), ZI2 (5 km ZI) and ZI3 (outside 5 km ZI within community and) are not independent of three forest types (likelihood Chi square ratio = 411.472, df = 8 and $p << 0.001$). The old forest growth area varied significantly among various landscape segments with the highest proportion of area within ZI2.
- All Zones of influences including ZI1, ZI2 and ZI3 are not independent of three forest types (likelihood Chi square ratio = 180.260, df = 4 and $p << 0.001$).
- Zones of influences including ZI1, ZI2 and ZI3 are not independent of three land uses (likelihood Chi square ratio = 28.920, df = 4 and $p < 0.001$). In consideration of land use activities, all landscape segments varied significantly with the highest proportion within ZI3.

DISCUSSION

The land in Garo Hills was chiefly used for residential and agricultural purposes by society. The most areas around settlements were extensively used for jhumming till recent past, hence the degraded scrub areas were concentrated around villages or settlements. For agricultural purposes, all culturable land is being used either for settled permanent agriculture or jhumming. These permanent agricultural fields could not be differentiated with sandy river banks in valley plains due to spectral similarity of satellite data. Lower mean patch size and edge length of land use patches compared to those of forest cover patches suggested that fragmentation in the area is setting at its initial stages and the landscape still holds larger tracts of old forest cover. The higher patch and edge densities confirmed the findings revealed by mean patch sizes and edge lengths referred above. Several forest patches around existing protected areas and Baghmara, Angratoli Reserved Forests are the best examples of such area, which have been providing promising habitats to the hoolock gibbons, which gradually disappeared during past couple of decades and become locally extinct from these areas. The management may think to adopt some of such sites for implementing restoration programmes for locally extinct wildlife species. As per the report of Directorate of Soil & Water Conservation, Meghalaya (2001), a total of 7900 families (39500 people) used 68 km^2 land for jhumming in the South Garo Hills district for particular year. The annual jhum rate of jhumming was 3.67%, 4.35% and 1.97% for South Garo Hills distrcit (representing our landscape), East & West Garo Hills districts and entire Meghalaya state, respectively. The impact of *jhum* can be described by identifying the levels of forest fragmentation and the distribution over the landscape. Fortunately, 71% of landscape area accounted for low fragmentation level, while most of the medium or high fragmentation areas concentrated in the south-west corner of the landscape. This portion lies on the flat land in the south of Nokrek ridge and quite away from the Balpakram area, both having the important protected areas of the region. Unfortunately, the intact forest cover with low fragmentation area in *Garo* Hills decrease at faster pace than ever. The fact is well illustrated in a recent study, which revealed the significant reduction in the forest cover area from 51% to 17% between 1980 and 2000 (Talukdar 2004). The seven corridors identified in present study encompass three corridors earlier identified by Williams and Johnsingh (1996). It was observed that ARF was the farthest amongst all elements of existing PAN and did not have any connectivity with any other such elements now, however the evidences of historic connectivity between ARF and

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ERF were recorded in the field which once facilitated the movement of elephants across NNP in the north and plains of Bangladesh in the south. Such migratory routes could be restored with timely management interventions.

The existing coverage of PAs over 15% of landscape obviously does not seem adequate to conserve the rich biodiversity within these old forest growths of landscape. The higher mean patch size and lower patch density among PAs suggested lower fragmentation within PAs compared to RFs and community land, however, majority of forest cover (60% of landscape) was confined within community land. The ANOVA results suggested that these community forests were equally rich and diverse as far as the tree communities are concerned (Kumar 2005). The findings suggest that the ZI1 supported lower proportion of old forest growth with almost negligible area under various land use activities, while ZI2 supported the highest proportion of various forest types and the moderate land use activities, however, ZI3 was observed for the least proportion of TMEF and majority of TMDF, which represented more or less open/disturbed form of the old forest growth with highest proportional area of land use activities mainly represented by residential and agricultural (settled or jhumming) areas. Thus, conservation efforts in this particular ZI should focus more on restoration activities, which may be coupled with additional protection measures to help protect larger forest tracts within the community land, however, the ZI2 may just require the protection measures, since majority of land within this zone sustained the TMEF and TSEF growths with moderate proportion of TMDF with low land use activities. Most elephant populations were concentrated in Balpakram, Mahadeo, Chimitab, Siju, Baghmara, Nokrek and Samanda areas; however, a few noticeable meta-populations of this wide-ranging species were observed inhabiting other parts of Garo Hills, for example, Dambu, Dagal, Kherapara, Adugre, Ranggira and other areas (Marak, 1998). Therefore, examining such widely distributed species within the confines of specific study area would not be appropriate from landscape perspective, which essentially needs to be appropriately defined in terms of species of the interest or target of management options. Given these rationales, Marcot et al. (2002 and in press) analysed the data from elephant censuses during last decade (1993 and 1998) for this landscape as well as all Garo Hills area (Figure 5) using spatial information from work of Talukdar (2004) and developed two statistical models suggesting the following critical values of specific habitat variables affecting elephant density at the two scales.

In All Garo Hills, elephant densities are greater in landscapes with:

- < 30% current and abandoned jhum (current jhum < 5%, abandoned jhum < 25%)
- < 20% in high forest patchiness (caused by jhum)
- village density < about 0.4 villages/km^2
- annual jhum rates < 2% of the land jhummed/year
- evergreen, semi-evergreen, and mixed moist deciduous forest cover is > 40%

In South Garo Hills, elephant densities are greater in landscapes with:

- < 10% in bamboo and secondary forest
- less fragmented, larger, and more contiguous patches of native forest

The 2002 amendments in Wildlife Protection Act (1972) of Government of India bestowed the State Governments and Forest Departments with a strong tool through provisions of designating forest growth on private non-government lands (community land in present study) as the ‘Community Reserves’, while government lands may be designated as the ‘Conservation Reserves’. The landscape under investigation during present study offers excellent prospects for declaring community reserves and conservation reserves. Present study would help identify

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and delineate such sites for better management and conservation planning of landscape from biodiversity point of view.

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Table 1. Families engaged in Jhumming.

CDB	Total no. of Jhumia families	Jhum area (ha/family)	Total area under Jhumming (km^2)	Total Households
Chokpot	2991	0.80	24	5519
Baghmara	763	0.70	5	6175
Rongra	989	0.28	3	2698
Samanda	1960	0.75	15	5782
Total	6703	0.70	47	20174

Source: DSWC (1995)

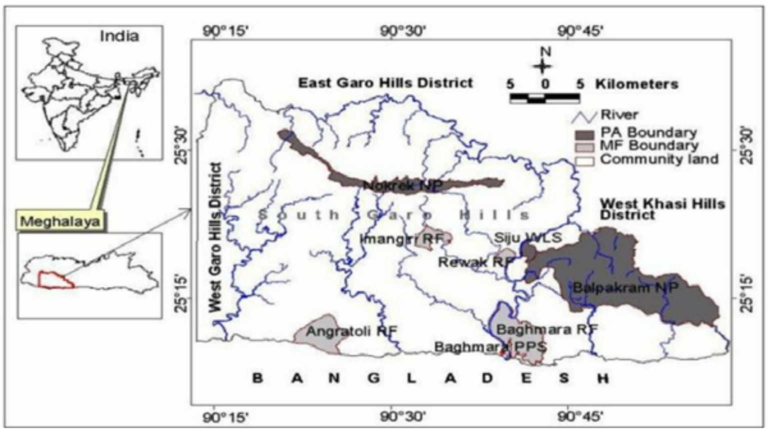

Figure 1. Study area map with geographical location within India and Meghalaya.
PA = Protected Areas, NP = National Park, WLS = Wildlife Sanctuary,
MF = Managed Forests, RF = Reserved Forests and PPS = Pitcher Plant Sanctuary.

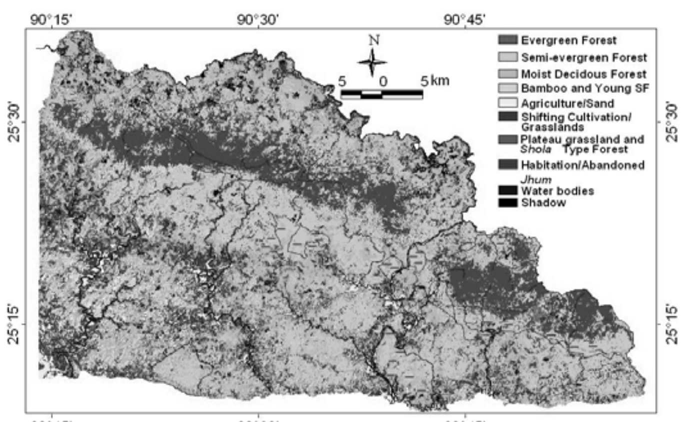

Figure 2. Land use land cover map of study area

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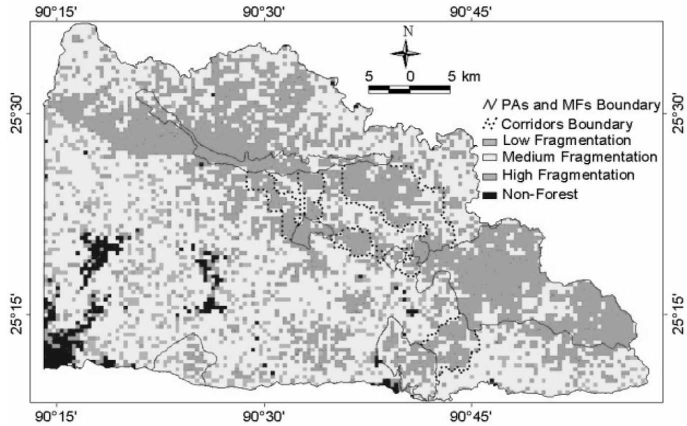

Figure 3. Forest Fragmentation maps. Please note the dotted lines showing potential wildlife habitat corridors.

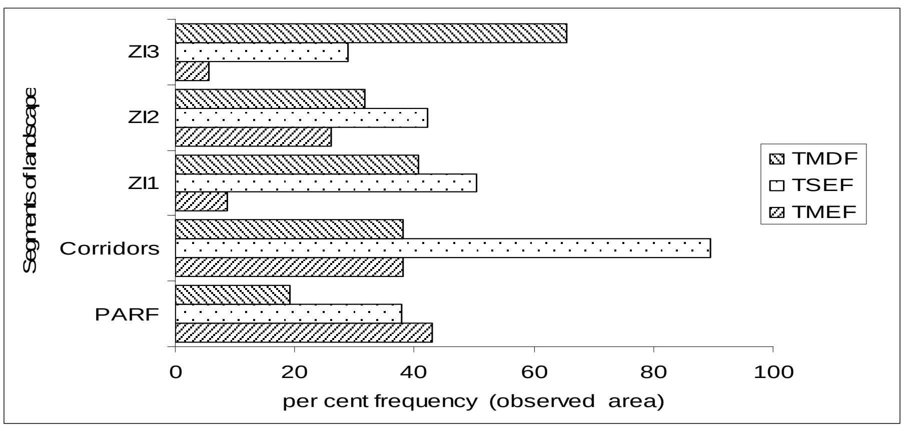

Figure 4. Observed per cent area of various forest types among various landscape segments; TMEF = Tropical Moist Evergreen Forests, TSEF = Tropical Semi-evergreen Forests; and TMDF = Tropical Moist Deciduous Forests.

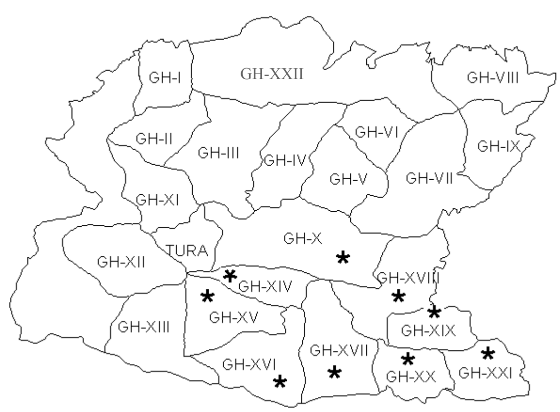

Figure 5. Elephant census zones in the *Garo* Hills (GH), western Meghalaya. The All Garo Hills area included all labeled census zones; the South *Garo* Hills area included zones marked with an asterisk (*). Source: Marak (1998), as digitized into ArcInfo GIS.

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