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RESEARCH ARTICLE

DISTRIBUTION OF VEGETATION AND THE EXTENT OF LAND DEGRADATION IN RAID-MARWET REGION AN ANALYSIS THROUGH GEOGRAPHIC INFORMATION SYSTEM (GIS)

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ABSTRACT

Over past three decades, Remote Sensing has emerged as one of the most fascinating science. The overall state of the environment and Earth's observation through remote sensors has provided a vantage means of monitoring land surface dynamics and natural resource management. The increasing human activities with natural environmental systems have raised series of environmental issues. Remote Sensing has made remarkable progress in recent decades in solving many environmental issues. With the advances in the Geographic Information System with powerful computing systems, the studies have become easier. Distribution maps (based on GPS location and numbers of species present) through Inverse Distance Weighted of vegetation with their respective types and the extent of land degradation (hill cutting) in large scale maps (Survey of India) and (LISS-III IRS P6 satellite imagery) using GIS tools have proved significant. Hill cutting increased from 6.06 Km^2 to 10.75 Km^2 in site 1 and from 2.02 Km^2 to 4.6 Km^2 in site 2 during 2009. Dominating species belonging to family Poaceae among grass species, Asteraceae, Araceae, and Fabaceae among herbs/shrubs, and Fabaceae and Moraceae family among trees were found. The biodiversity of the region which can become locally extinct, if these act of land degradation continues henceforth.

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INTRODUCTION

Today cartography has acquired distinction of an interdisciplinary information management system dealing with spatial data relating to an object space. This conceptual revolution owes to the information and technological revolutions. "Remote Sensing and its associated image processing technology provide access to spatial information on a planetary scale. Furthermore, new detectors and image technology are increasing the capability of Remote Sensing to acquire digital spatial information at a very fine scale". (Elhers 1990) Remote Sensing and Geographic Information System (GIS) are both tools for managing spatially distributed information in large quantities and at a variety of scales. While representing the distribution and abundance of organism has been recognized for many years (Wiens1973), in large scale maps, it has been only in the last two decade, with the widespread availability of Geographic Information System technology, the ecologists have been using the tool to quantify large-scale patterns and relate them to the distribution and abundance of species.

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Similar efforts are made by ecologist to represent land degradation in large scale maps using GIS tools. Land degradation is a universal problem, which occurs all over the world, but it is of major concern for dry land regions. The Food and Agriculture Organization of United Nations (FAO) has defined forest degradation as changes within a forest that effect the structure and function of the stand or site and thereby lower its capacity to supply products and services. It is rather difficult to measure degradation than it is to measure deforestation. Simple measurements like measuring the amount of forest area lost, do not account for the more complex effects of degradation, such as fragmentation or in the ratio of perimeter to area i.e. edge effect. A 1988 estimate of the extent of degraded tropical lands was 2,077 million hectare, much of which was desertified dry lands also the reduction in vegetation cover and vegetation quality (eg. through changes in species composition) in dry areas is an essential element of desertification (Grainger 1992). This area was larger than the total known forest area of the tropics (FAO 1993). Human well-being and the utilization of natural resources are inversely related i.e. increased human well being results in decrease in natural resources. To fulfill the greedy needs of human, nature has limited stocks. But if utilized sustainably or wisely nature have unlimited goods and services. In the study area land degradation has little benefited to the handful of people but on the other hand the biological diversity of the region is the most affected. The act of hill cutting is for the sole purpose of selling the earth to the nearest metro city (Guwahati) i.e. for filling many wetlands and low-lying areas for construction business. The vegetation of the region is under human induced threat of hill cutting, which is accelerating day-by-day. This work will document vegetation belonging to different category of grasses, herbs/shrubs, and trees, which are available in the region. Hence, it can generate awareness among the indigenous communities about the evils of hill cutting and its consequences. Therefore the current study was carried out with following objectives a) Species distribution mapping based on GPS location and numbers of species in each location, b) Land degradation and its extent based on SoI Topographical Maps and satellite imagery of the region, and c) identifying and mapping major anthropogenic threats prevailing in the region.

MATERIALS AND METHODS

Study area

RiBhoi District is one of the Seven Districts of Meghalaya, carved out from the erstwhile East Khasi Hills District on 4th June 1992. RiBhoi District covers an area of 2448 km^2 with a population of 258,380 (2011 census). It lies between $90^0 55'$ to $92^0 05'$ E Latitude and $25^0 40'$ to $26^0 20'$N Longitude. This District is characterized by rugged and irregular land surface. It includes a series of hill ranges which gradually sloped towards the North and finally joins the Brahmaputra Valley. Raid-Marwet with total area of 155.318 km^2 is located between $91^0 43'$ to $91^0 53'$ E Latitude and $25^0 57'$ to $26^0 07'$ N Longitude. The region is bounded by Kamrup (metro) District of Assam in the north and east, Garbhanga Reserve Forest towards west, and whole of the southern boundary is comprised by the river Umtru. The study area is further divided into three sites i.e Site 1: North Raid Marwet, Site 2: South Raid Marwet and Site 3: Control Site to achieve the objectives of the study (Figure 1).

Methodology

A multilayered GIS Database is constructed from Remote Sensing (RS), Global Positioning System (GPS) data, and data layer created by Geographic Information System (GIS) tools, which permits both spatial analysis and map production. Each individual layer is constructed from Survey of India Topographic sheets no. $78\frac{O}{9}$, $78\frac{O}{13}$, $78\frac{N}{12}$ and $78\frac{N}{16}$ (scale 1:50,000) which covers the study area and these topographic sheets were geo-referenced in Arc GIS 9.3 to delineate the study area boundary, regional location of the study area, land use/land cover, sampling locations, vegetation communities and environmental threats. The threats assessment is modified and simplified from a robust threats assessment methodology used by The Nature Conservancy (Fawver and Sutter 1996) and its network of global conservation partners.

In the field, the GPS is used to determine actual position on the earth, of the sites selected for the distribution of species in various quadrate sizes and data are collected for each quadrate. Against each data point, the attributes of types of vegetation, number of species observed, etc are integrated in GPS database. Further satellite imagery covering the study area from LISS-III sensor IRS-P6 (Resourcesat-1) with 24 meter spatial resolution, the data used was 13G46H16_ 09NOV09_b234, 13G46N09_ 09NOV09_ b234, 13G46N13_ 09NOV09_b234 and 13G46H12_09NOV09_b234 for the year 2009, November) and it's False Color Composite with their respective range of wavelength of the spectral resolution of 23x23m. This satellite image is analyzed using Arc GIS 9.3 for comparing the extent of anthropogenic activity in the study area with that of the Survey of India Topographic map of the year 1995/1997. To attain the desired results the process of georeferencing, digitization, and Inverse Distance Weight age were performed using the spatial analyst tool of ArcGIS.

RESULTS AND DISCUSSION

The enlisted floral species were reclassified as common (C) and uncommon (UC) species for all the three sites.

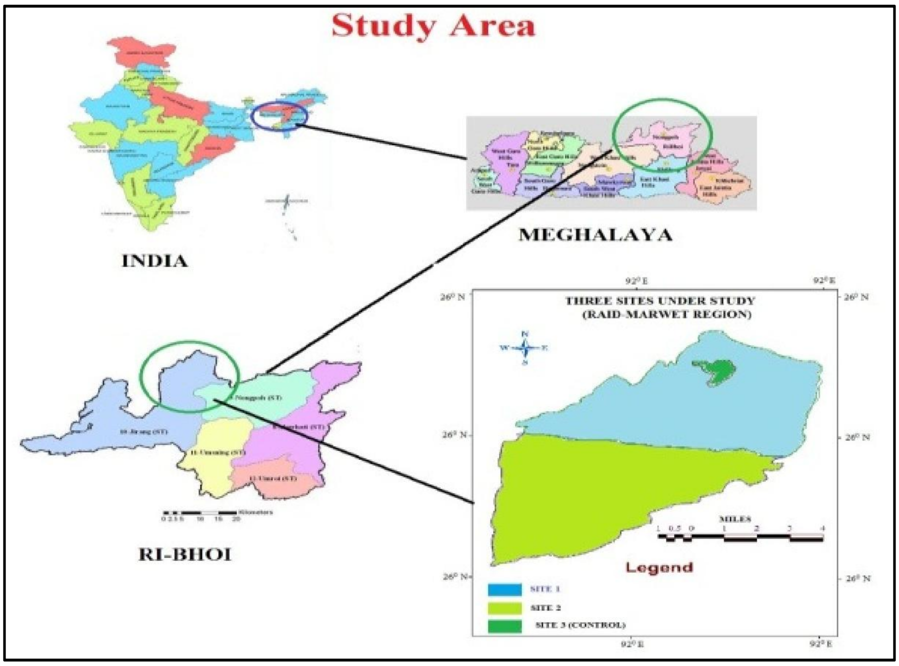

Fig. 1. Study area

That is the species which are available in all the sites is considered as common species, whereas if any of of the species is found deficit in either of the sites under study is concidered as uncommon species for this study. Figure 2(A) shows the distribution of common grass species found in the study area with some major land use / land cover. It is shown that the common grass species which are available in all the three different sites have a highest presence in the northern part of the study area i.e. in site1 and as well in control site (site3). The common grass species present in region are shown in Table 1.

Amongst the common grass species it is found that *C. ciliaris* L. has the highest number of occurrence (1288 individual species) followed by *C. rotundus* L. (869 individual species) in all the three sites. Uncommon grass species distribution is shown in Figure 2(B). It is seen that the control site, and site2 has the less number of uncommon grass species. Table 2 accounts the uncommon grass species of the region. Occurrence of individual uncommon grass species are more in the site 1 comprising of all total of 3490 numbers of species in comparison to the 1577 total number of uncommon grass species in site 2. The Inverse Distance weightage (IDW) mapped in Figure 2 & 3 shows that both the common and uncommon grass species are more prominent in Site 1,

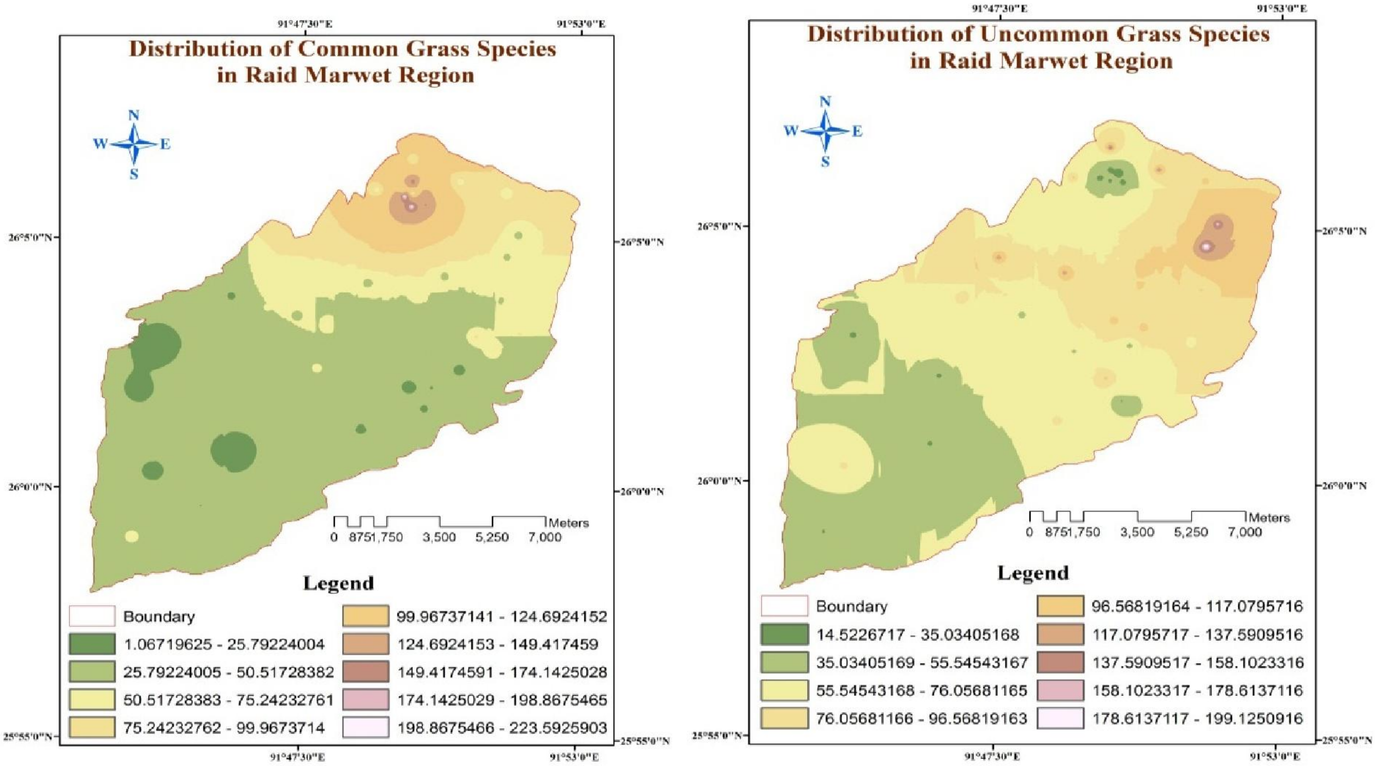

Fig. 2. Species distribution of (A) Common (B) Uncommon Grass species found in the study area

Table 1. Common Grass species observed in all the Quadrats

Common Grass species	Family	Site 1	Site2	Site 3
Bambusa tulda	Poaceae	26±1.6	38±2.8	25±4.6
Cenchrus ciliaris	Cyperaceae	384±19.2	271±21.2	633±53.5
Cymbopogon citratus	Poaceae	298±13.4	116±9.2	280±21.1
Cyperus rotundus	Poaceae	306±15.7	100±8.1	280±20.3
Heterepogon contortus	Poaceae	230±12.8	148±14.7	463±48.9
Paspalum notatum	Poaceae	224±7.7	74±7.7	280±14.4

Table 2. Uncommon Grass species in all the Quadrats

Grass Species	Family	Site 1	Site 2	Site 3
Arundo donax	Poaceae		85±6.2	
Axonopus compressus	Poaceae	285±16.7	88±13.6	
Chrysopogon aciculatus	Poaceae	219±13.4	112±10.4	
Coix lachryma- jobi	Graminaceae		12±1.6	
Cynodon dactylon	Poaceae	113±10.8	107±9.3	
Cyperus brevifolius	Cyperaceae	190±12.5	27±3.9	
Dendrocalamus hamiltonii	Poaceae			47±3.8
Digitaria milanjiana	Poaceae	316±14.7	68±7	
Echinochloa colona	Poaceae	185±12.7	204±10.2	
Imperata cylindrica	Poaceae	265±15.6	37±4.5	
Panicum repens	Poaceae	225±13.1	92±8.6	
Saccharum spontaneum	Poaceae	282±12.1	36±5.8	

whereas common grasses are highly dominating in Control site with respect to uncommon grass species. Species distribution of herbs/shrubs in the entire study area is shown in the Figure 3(A) which indicates that distribution of common and Herbs/Shrubs is high in site 1, but very low distribution is shown in the control site and Site 2. The following are the common herbs/shrubs species recorded in of the study area. As reported in the work of Villa *et al*. (1992), it is of human nature, that if they occupy any landscapes, they convert portion of the native vegetation to agriculture and urban development, and modify areas to varying degrees by harvesting natural resources, which results in differences in species composition and distribution.

and the exotic species, similar result was also obtained in the study by Kerpez and Smith (1990). Uncommon species ofherbs/shrubs distribution assessed in the study area are not well demarkated in the site 2 and as well as in the control site, on the contary we could see more uncommon herbs/shrubs species distribution in site 1, Figure 3(B) indicates the distribution of uncommon species of herbs/shrubs & Table 4 accountsuncommon species of herbs/shrubs in the region. Although the LULC has also reveled that the northern part of the study area is stressed with immence humman pressure of hill-cutting and sourthen part of the study area inhabits traditional agriculture, Shifting cultivation and small portion of monoculture farming (plantations).

Table 3. Common Herbs/Shrubs species in all the Quadrats

Species	Family	Site 1	Site2	Site 3
Achyranthes aspera	Amaranthaceae	122±7.3	34±3.7	339±45
Bauhinia acuminata	Fabaceae	139±7	68±5.8	357±34.6
Chromolaena odorata	Asteraceae	155±8.6	94±7.5	29±2.2
Lantana camara	Verbenoceae	136±8.1	71±5.8	24±1.8
Leucas aspera	Labiatae	41±4.1	84±6.7	61±4.5
Mikania micrantha	Asteraceae	270±9.8	60±7.6	32±2.5
Mimosa pudica	Mimosaceae	278±11.6	58±4.7	11±0.9
Rauvolfia serpentina	Apocynaceae	27±2.2	7±1.2	15±1.2

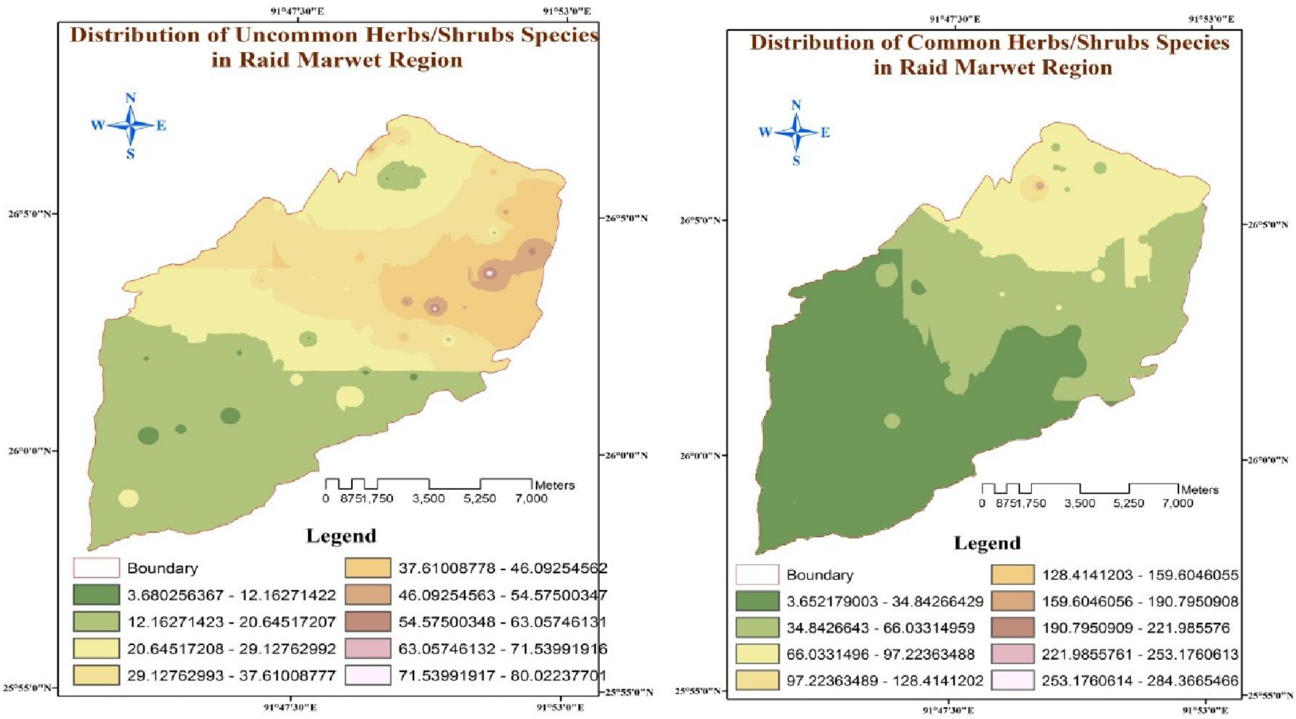

Fig. 3. Species distribution of (A) Common (B) Uncommon herb/shrub species found in the study area

Among the common herbs/shrubs species the highest number of occurrence is of Achyranthes aspera (495 individual species), followed by Mikania micrantha (362 individuals), Mimosa pudica (347 individuals), Chromolaena odorata (278 individuals) and Lantana camara (231 individuals), in all the quadrats under study. It is observed that fragmentation of natural landscape is often detrimental to the biodiversity because it involves the removal, reduction, and isolation of native vegetation as reported by Fahrig (1999). As a result, remaining populations of native wildlife becomes smaller and is exposed to anthropogenic threats due to human-dominated matrix which establishes a competition between the indigenous

Figure 5 represents various geographical attributes (land use/ land cover) of the study area. It shows that the practice of hill cutting forms the major anthropogenic activity followed by shifting cultivation patches (some are active and most of them are converted to permanent home gardens), permanent agricultural practice and few plantation farming plots has also been identified. Plantation farming includes: rubber plantation, orange orchards, teak plantation and sometimes periodical pineapple plantation has been identified in the study area. Though the act of hill cutting is dominating in the fringe area of the study site towards the north, whereas we could see that the central part of the region is pre-dominated by traditional agricultural practice and towards the south of the study area we could see the patches of shifting cultivation and barren uncultivable lands. An assessment of existing and potential threats to the vegetation types and species present in and adjacent to the study area are usually based on the observation made during field investigation. And the assessment is usually conducted during or shortly after the field work is completed. Table 7 shows the various stresses to the study area and their severiety.

It is noticed from the above table that habitat destruction (especially hill cutting and shifting cultivation), exotic species, and timber harvesting has great impact to the vegetation type of the region. Apart from these stress illegal hunting, removal of species for sale or consumption, and numerous beds for charcoal formation has moderately affected the region. And few stresses like plantation farming, garbage dumping sites, and tourism has low stress ranking i.e.(liklihood) the

Table 4. Uncommon Herbs/Shrubs species in all the Quadrats

Species	Family	Site 1	Site 2	Site 3
Ageratum conyzoides	Asteraceae	86±5.8	55±5.3	
Alocasia indica	Araceae	13±2		
Alocasia odora	Araceae	110±5.9		
Barleria prionitis	Achanthaceae	55±3.1	14±1.8	
Cardamine hirsuta	Brassicaceae		53±6.2	
Centella asiatica	Apiaceae	105±4.8	66±6.4	
Curcuma aromatic	Zingiberaceae			26±3.1
Datura metel	Solanaceae	10±1.4	8±0.9	
Desmodium caudatum	Fabaceae		5±1.1	
Diascorea alata	Dioscereaceae			24±2
Euphorbia hirta	Euphorbiaceae	65±3.5	80±8.8	
Flemingia strobilifera	Fabaceae	73±3.9	24±2.3	
Ipomoea batatas	Convoluvalaceae	29±2.2	14±2.3	
Luffa acutangula	Cucurbitaceae	15±2.8	14±1.5	
Parthanium hysterophorus	Asteraceae			9±0.8
Phyllanthus niruri	Phyllanthaceae			15±1.3
Senna sophera	Fabaceae		14±1.6	

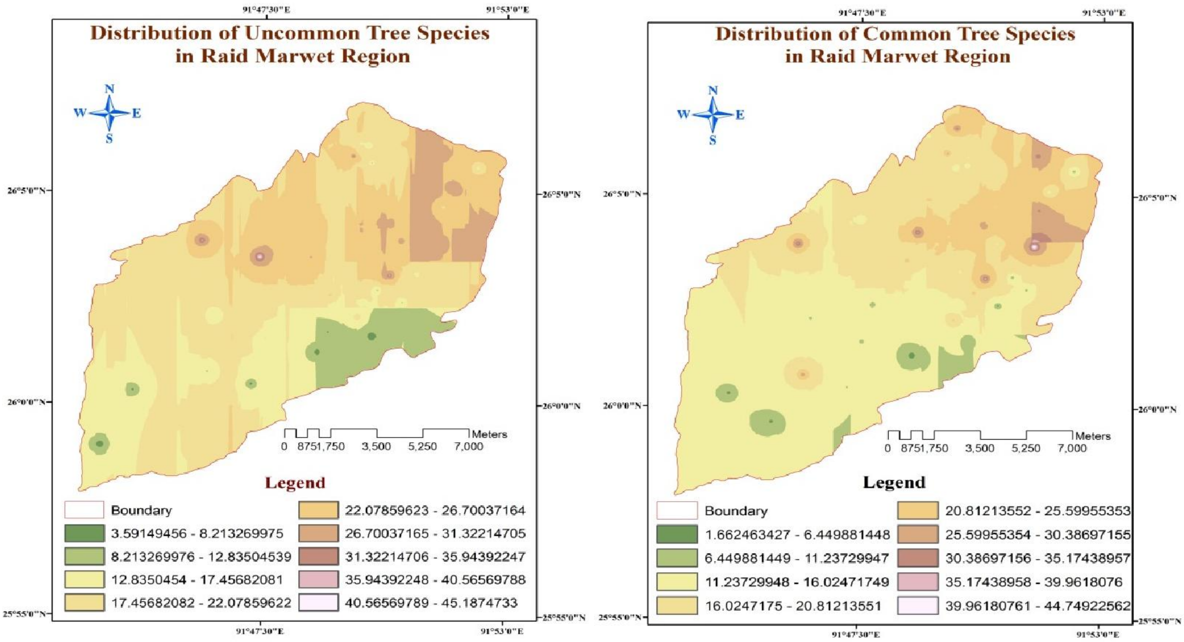

Figure 4. Species distribution of (A) Common (B) Uncommon tree species found in the study area

Table 5. Trees species (common) observed in all the Quadrats

Species	Family	Site 1	Site2	Site 3
Acacia auriculiformis	Fabaceae	84±5.6	14±4.6	53±5
Anthocephalus cadamba	Rubiaceae	19±1.5	17±1.8	7±0.6
Artocarpus heterophyllus	Moraceae	18±1.5	9±1	17±1.4
Cassia fistula	Caesalpinaceae	57±3.6	9±1.1	11±0.9
Dalbergia sissoo	Fabaceae	72±4.8	20±2	9±0.8
Dillenia indica	Dilleniaceae	19±1.5	6±0.6	14±1.5
Erythrina stricta	Fabaceae	36±2.5	19±1.6	11±1.2
Mangifera indica	Anacardiaceae	1±0.2	8±0.9	6±0.66
Tamarindus indica	Fabaceae	29±2.1	5±0.65	8±0.68
Tectona grandis	Lamiaceae	85±5	54±5.5	7±0.67
Terminalia bellirica	Combretaceae	29±1.9	4±0.5	13±1.1
Terminalia chebula	Combretaceae	14±1.2	4±0.5	9±0.68

Table 6. Trees species (uncommon) observed in all the Quadrats (10m X 10m)

Species	Family	Site 1	Site2	Site 3
Aegle marmelos	Rutaceae	10±0.68	6±0.8	
Albizia lebbeck	Fabaceae			18±1.6
Alstonia scholaris	Apocynaceae	26±1.7	16±1.5	
Annona reticulata	Annonaceae	25±2.2	14±1.2	
Artocarpus chama	Moraceae			12±1.2
Averrhoa carambola	Oxalidaceae	29±2.3	6±0.8	
Azadirachta indica	Meliaceae	5±0.5	3±0.36	
Bauhinia variegate	Fabaceae	38±2.3	7±0.8	
Callicarpa arborea	Lamiaceae	26±2.1	19±1.5	
Cinnamomum tamala	Lauraceae	17±1.6	18±2.1	
Citrus maxima	Rutaceae	34±2.4	8±1.1	
Corymbia maculate	Myrtaceae			
Croton joufra	Euphorbiaceae	43±3.4	17±1.8	
Delonix regia	Fabaceae		24±2.4	
Duabanga grandifolora	Lythraceae			4±0.9
Ficus racemosa	Moraceae		1±0.2	
Ficus benghalensis	Moraceae		1±0.2	
Ficus benjamina	Moraceae		2±0.3	
Ficus elastica	Moraceae	6±0.8	5±0.6	
Ficus hispida	Moraceae	15±1.6	6±0.8	
Ficus religiosa	Moraceae	3±0.36	2±0.3	
Jatropha curcas	Euphorbiaceae	16±1.5	12±1.4	
Lagerstroemia parviflora	Lythraceae			14±1.3
Lagerstroemia speciosa	Lythraceae			11±1
Lannea grandis	Anacardiaceae	31±2.4	12±1.4	
Lawsonia inermis	Lythraceae		13±1.4	
Litchi chinensis	Sapindoideae			7±0.8
Moringa oleifera	Moringaceae	27±2	14±1.2	
Psidium guajava	Myrtaceae	15±1.6	6±0.8	
Schima wallichii	Theaceae			7±0.7
Senna siamea	Fabaceae		4±0.5	
Sterculia villosa	Malvaceae	36±2.5	11±1.3	
Terminalia myriocarpa	Combretaceae			14±1.2
Thevetia peruviana	Apocynaceae		8±0.9	
Vachellia farnesiana	Fabaceae	60±2.9	20±2	
Ziziphus mauritiana	Rhamnaceae	17±1.7	13±1.3	

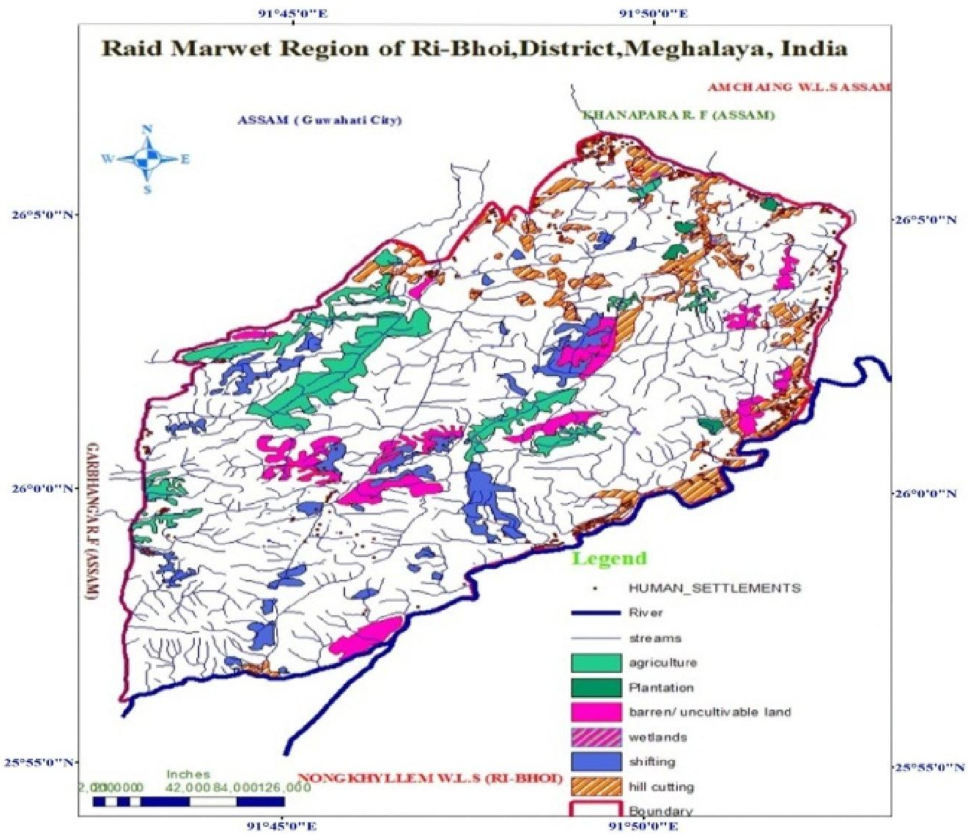

Fig. 5. Land use/land cover along with the ecological sensitive area nearby the study area

Table 7. Threat Assessment in the Study Area

Stresses	Stress Ranking(The Nature Conservancy, 1997)	
Habitat destruction		
i) Hill cutting	(V)	Severity (Potential Impact)
ii) Shifting cultivation	(H)	Scope (Geographic scale of impact across site)
iii) Plantation Farming	(L)	Likelihood (Probability of occurring)
iv) Garbage dumping Sites	(L)	Likelihood (Probability of occurring)
Exotic species	(H)	Scope (Geographic scale of impact across site)
Illegal hunting	(M)	Reversibility (Restoration potential)
Removal of species for sale or consumption	(M)FC	Immediacy (Current or Potential)
Charcoal beds	(M)	Reversibility (Restoration potential)
Tourism	(L)	Likelihood (Probability of occurring)
Timber Harvesting	(H)	Scope (Geographic scale of impact across site))

VH= Very High, H= High, L= Low, M= Medium, (M)-FC= Medium- Future Concern

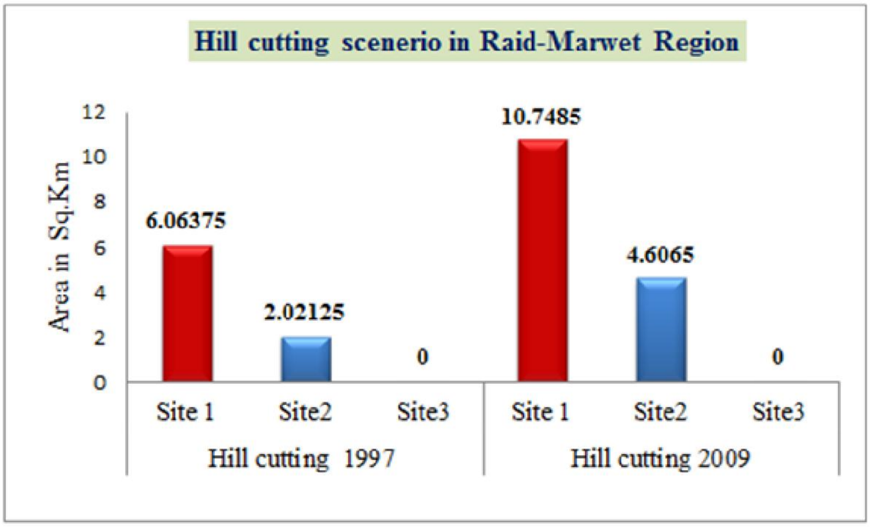

Fig. 6. Hill cutting scenerio in two different time period

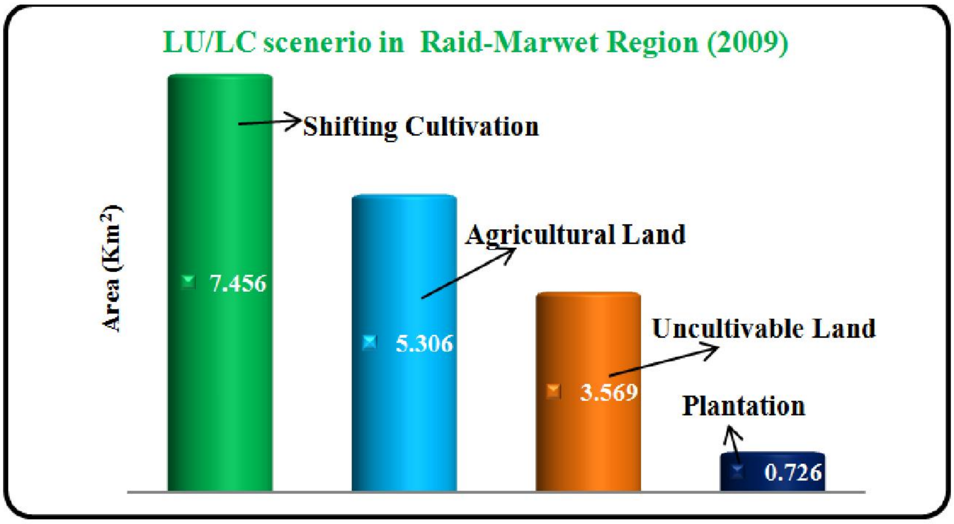

Fig. 7. Human induced land use/ land cover in Raid-Marwet Region

probability of occuring stress. Hill cutting solely dominates the potential impact (severity) of the degradation in the region followed by shifting cultivation, exotic species and timber harvesting- which has a scope (i.e. geographic scale of impact across site). Reversibility (restoration potential) stress are accounted for illegal hunting and charcoal beds, that means their seriousness is not yet felt. And in future if these affect the ecosystem then it is assumed that it has the potential to be resolved. A unique category of medium-future concerned is assigned to the category of stresses- removal of species for sale or consumption. It is because the indegenous community which are solely dependend on the nearby forest for their livelihoods. Thus it is concidered as immediacy i.e. it has a potential or current impact on the ecosystem which cannot be overlooked. As in the beginning when the act of hill cutting was not pre-dominating in the area. Only the landlords' clears their land for housing and construction of cattle sheds. But slowly factories, industries, fuel stations, godowns, etc started emerging in the region and the demand for even land increased. Figure 6 shows the scenario of hill cutting in the study area. In the year 1997 approximately 8.085 Km^2. of hill was completely lost, North Raid-Marwet (S1) with 6.06375 Km^2. and South Raid-Marwet (S2) with 2.02125 Km^2. After more than a decade i.e. in 2009, this figure climbed to approximately 15.355 Km^2 with high increase in S1 (10.7485 Km^2) and S2 (4.6065). This aspect deserves immediate attention in the interest of restoration and reclamation of the ecosystem of the area.

Other land use/land covers of the region, where human intervention is much detrimental. The act of shifting cultivation holds the second place (Figure 7) in the act of anthropogenic activities, calculated to be approximately 7.456 Km^2. It is not always true to say this pattern of cultivation as shifting in the real sense at present. But the indigenous community of the region has started with the concept of shifting cultivation, but at present those plots of land slashed-and-burned for cultivation are now either converted to permanent home gardens, or leave it as fallow land if the productivity is not fruitful to the households. And sometimes it is also seen that people are utilizing the same plot of land for plantation crops. The agricultural land in this region has not shown any increase; rather minimal decrease in area has been accounted by the construction of houses and cattle farms. Though there is no scope for the extension of land for agricultural purpose due to the undulating topography of the region will small hills and hillocks all around. It is calculated to be about 5.306 Km^2. and in near future if the act of hill cutting continues these available lands for cultivation will also lose it existence for sure. Few patches of uncultivable land has also been identified in the study area, approximately about 3.569 Km^2., these are due to encounter of big mass of rock underneath which has prevented the growth of proper vegetations, and few patches among them are assigned as dumping sites of many small/big scale industries present in the area. No doubt monoculture has also spread its roots in this area but not to that extent. We could find few pockets of land under this category. Plantation crops like rubber, broom grass, orange orchards, pineapple etc. for generating income. Only 0.726 Km^2 of the land has been covered under this category till the year 2009. And this concept of plantation farming is gaining its acceleration in comparison to the conventional agricultural and shifting cultivation.

Conclusion

Many maps are typically produced which has documented the vegetation cover with sampling efforts, which tries to present results of the same, and no doubt these maps will often prescribe proper management strategies for the conservation and protection of local vegetation under threat, due to various anthropogenic activities. These maps showing both vegetation cover and major land use pattern will serve as the basis for the threat assessment, information integration and formulation of recommendations and suggestions. The vegetation types and their locations becomes the basis for reporting most species-level results as well. Vegetation types and species have spatial footprints and lend themselves well to mapping. Threats to biological diversity, often do not have an intrinsic spatial dimension and are more often difficult to produce it on map format. Thus, it is well tried to characterize, to the extent possible, the overall existing levels of threats to the integrity and persistence of all vegetation types in the study area. All land use information is well studied and this information is incorporated in the analysis. The ecological implications of the earth are very complex, rather the effects on land use/land cover are straightforward i.e. increasing human settlement will result in habitat fragmentation. Many authors have reported that, once continuous mosaics of negative vegetation's surrounded by matrix of cements, grass, crops and degraded lands (Mayer and Turner 1992; Marzluff and Hamel 2001;Vitousek *et al*., 1997), which results in heightened disturbance and species mortality from human activities (Johnston and Haines 1958; Knight and Gutzwiller, 1995; Evans 1998). The biodiversity of the region which can become locally extinct, if these act of land degradation continues henceforth. As we have already seen the distribution of vegetation in the region which structure and functioning will promise other diversity in the region. As faunal diversity is directly related to the vegetation cover i.e. healthy vegetation will house diverse faunal diversity concluding the better functioning of the ecosystem. This informations generated in the study can be used to priortize sites and inform conservation-based management planning. The generated maps on the vegetation cover of the study area will contribute to understanding of the conservation and restoration of the degraded area if needed and biological importance of plants and vegetation types. Major threats identified through threat assessment could be the focus of conservation-based management planning for abatement of threats.

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