



## Vegetation Cover and Plant Species of Degraded Landscape in the Extremely Wet Cherrapunji Area, North- Eastern India

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### Abstract

Vegetation and plant species of Cherrapunji area are increasingly recognised as an economical component of land cover. With the strong evidences of arrested vegetal growth due to unfertile leached soils of this area, there exists a clusters of mixed vegetation confined in the valley slopes, the grass species on centrally located flat lands and stunted trees representing savanna type dispersed in isolated patches in valley depressions. Vegetal cover has direct relationship with topography of the area which controls climatic and soil conditions of the area. In order to understand the spatial pattern of plant species in response to soil and topographic elements and anthropogenic factors, spatial variation of plant species have been broadly distinguished into three clusters/patches as the areas of valley slopes of dense evergreen forests, the flat uplands of tall grasses and stunted grasses of *Poecaeae* family. Increasing population increases occupancy of land and, consequently, there is slight change in land use because of deforestation. Tree species of dense canopy, namely, *Dunbanga grandiflora*, *Ficus spp.*, *Litsea spp.*, *Symplocos*, *Quercus spp.*, *Eurya acuminata* and *E. japonica*, are suitable in these heavy rainfall areas for regeneration of soils in this area.

*Key words:* degraded land, ecosystem, plant species, soil fertility, vegetal cover

### Introduction

There are numerous studies on ecological and geomorphic dimensions of degraded landscape in the Cherrapunji area. There in such prevalence of three ecosystems as: (a) the degraded grassland ecosystem because of extremely high rainfall with very high leached and degraded soils (Ram and Ramakrishnan 1988a, 19988b; Ramakrishnan and Ram 1988, Umashankar *et al.* 1991); (b) the forest system of protected areas and rainforests in the valley depressions and valley slopes (Khiewtam 1986); and (c) the agro-ecosystem which is developed in the form of shifting cultivation (slash-and-burn system locally called

as *jhun*) that shows poor soil fertility, low level of crop-yield and low biomass contents and humus in the soils (Toky and Ramakrishnan 1981, 1982, 1983a, 1983b). Geologists and geomorphologists also highlighted geo-environmental problems and land degradation of this area. A wide range of scientific investigations had been conducted on the general problems of environmental degradation (Chatterjee 1968), the details of geological structure and stratigraphy (Mazumdar 1978), the evolution of geomorphic feature in such conditions of heavy rainfall and concerned geomorphic hazards (Starkel 1972, 1996, Soja and Starkel 2007, Starkel and Soja

2008), the soil erosion and degradation of land (Froehlich et al. 2003, Froehlich 2004a, Budek and Prokop 2005, Prokop 2007) and the runoff conditions (Prokop 1999, Starkel and Singh 2004). Such investigations show an impact of intensive hydrological events on landscape functioning, the studies of changes in vegetal cover and soil properties and landscape ecology in response to hydrological processes. These studies conclude that there is poor soil fertility with fragile vegetal cover in its different patches. The practices of slash-and-burn cultivation also add another dimension of land degradation and short circuiting the nutrient cycle by reducing nutrients status of soil fertility (Toky and Ramakrishnan 1981). So diversity of landscape functions, which are implicitly related to soil degradation, influences directly or indirectly the vegetal cover. Overall, these studies and investigations indicate the fragility of ecosystems and degradation of natural resources in Cherrapunji area of extreme rainfall conditions. In spite of extending the studies towards landscape functioning, there is a need of an intensive investigation on vegetative cover and its specific features to understand the relationship between landscape functioning and plant species under this condition of degraded landscape. Thus, the attention is focussed here to study the distributional pattern of plant species and their causes of scatterings and fragility.

## The Study Area

### (A) Topography and Environmental Set up

Cherrapunji, an area of extreme humid conditions, is situated on the southern slopes of the tectonic horst of Meghalaya plateau rising above 1800 m a.s.l. It is like

a table land located between the Bengal Plain in its south and the sub-Himalayan foredeep in the north (Figure 1). Cherrapunji located on the Southern edge of table land ( $25^{\circ} 15' N$ ;  $91^{\circ} 45' E$ ), where South-west monsoon hits it directly and intensively receives the highest annual rainfall over the globe. The geological structure controls the topography and relief features not only of the Cherrapunji spur but the whole of the plateau, which is formed by deep canyons and cirque- lake valley heads with waterfalls. Geologically, the area is built up of metamorphic rocks with igneous intrusion, overlain on the southern slopes with horizontally bedded sandstones and inter-bedding of siltstones and limestone of Cretaceous-palaeogene age. Cherrapunji is a small town locally called 'Sohra' located in the North Eastern parts of the spur of an elevation varying from 1200 m to 1400 m a.s.l. Because of orographic barrier of monsoon winds which flow from Bay of Bengal to the upper parts of Brahmaputra valley, Cherrapunji area receives extremely high rainfall of an annual average of 10,816 mm with a significant standard temporal fluctuation of 44 mm annually ( $10,816 \pm 43.6$  mm) (Soja and Singh 2004).

The areal difference in the micro-relief features and variation in slope gradients of the Southern part of Meghalaya plateau where Cherrapunji spur is located is major cause of variations in rainfall (Horel et al. 1989, Matsumoto 1988, 1992, O'Hare 1997, Singh 2007). There is spatial variation in annual rainfall within such areas of the most humid conditions. From the rainfall records of monsoon season of the four rain gauge stations located on E-W profile and of two stations on N-S transect of the spur (Fig.-1), it is found

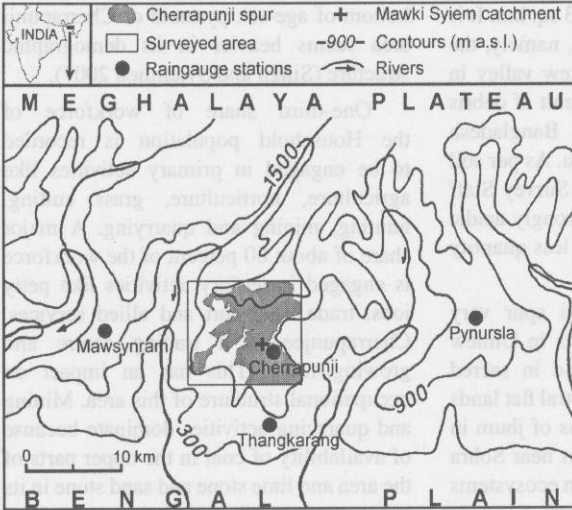


Fig. 1: Location of study area and rainfall gauging Stations

(Courtesy: Roman Soja)

that the annual amount of rainfall on E-W transect is received almost equal. On the other hand, there is a decreasing pattern of rain from south to north in Cherrapunji spur because of orographic effects. There is a marked seasonal variation in rainfall distribution. More than 80 percent share of annual rainfall is precipitated in summers (May-September). A dry season occurs between November and March. January is the coldest month with mean temperature of 10°C. Summers are wet with the moderate temperature of 20° C. There are four main seasons such as: (a) the Pre-monsoon season (mid March to late May). This is characterised mainly by low intensity rains with rare heavy downpours reaching even above 300 mm per day with a significant rainfall variation ranging from 100 mm to 1000 mm. the 'onset of monsoon' period

(late May to early June) when rain falls at an average depth of 1500 mm for several days during the season; (b) the wet summer season (July-September) when daily rain has significant fluctuations from 100 mm. to 300 mm. with the highest record of 3,017 mm. in 4 days during wet summer of the year 2006; and (c) the transitional season of Post- monsoon (September-October) when occasional rainstorms of shorter duration especially in the month of October with the start of dry autom; (d) the winter season of 4 months (November-February) (Soja 2007).

Surface of Cherrapunji spur is therefore fully exposed by the heavy rains and it has been deeply exposed somewhere upto its bed rock, especially on the flat- tops and protected by stony layers especially on the northern aspect of escarpments. Cherrapunji

spur covers an area of about 53 sq. km. It is bounded by two deep valleys, namely, the Umiew in its west and Umstew valley in the east deep vertical Dauki fault of debris flow in its south separates Bangladesh plains from Meghalaya plateau. As per soil taxonomy forwarded by Soil Survey Staff (1975), soils are humic but strongly acidic in nature (pH = 5.0-6.0) with less quantity of clay, litter and humus.

Vegetation of Cherrapunji spur vary from tropical evergreen forests in Umiew and Umstew river valleys and in sacred groves to grasslands in the central flat lands and further to agro-ecosystems of jhum in the hill slopes of its upper part near Sohra Rim village. The distinctions in ecosystems are observed due to differentiations in morphological and fertility status of soils. Less than 5.0 percent of the area is covered by Entisols identified as Lithic Udipsamments (Nair et al. 2005).

Degradation of grasslands is due to highly leached soils of poor physical qualities and low fertility. Large quantity of runoff declines concentration of some of the nutrients. It recovers during drier period (October-January) soon after monsoon (Ram and Ramakrishnan 1988). Low pH is attributed to the leaching of cations like Ca, Mg, K. Soils of the grasslands which cover 76% area of spur, are extremely deficient in nitrogen and phosphorus and that are supplied mainly through rainfall (Pandey et al. 1993). Such scenario of high rainfall influences the plant species through altering morphological and fertility status of soils.

#### (A) Socio-Economy

The socio-economic survey conducted in the month of November 2005 reveals that the

bottom of age-sex pyramid of Cherrapunji area seems heavier in its demographic structure (Singh and Syiemlieh 2007).

One-third share of workforce of the Household population is recorded to be engaged in primary activities like agriculture, horticulture, grass cutting, hunting, mining and quarrying. A major share of about 60 percent of the workforce is engaged in tertiary activities like petty jobs, trade, transport and allied services. Cherrapunjee is a trading centre and growing town. This has an impact on occupational structure of this area. Mining and quarrying activities dominate because of availability of coal in the upper parts of the area and lime stone and sand stone in its lower reaches. It has direct impact on land use practices and vegetal cover in the area.

A small section of society is engaged in shifting cultivation. Vegetables and paddy are main crops of the jhum fields generally situated on the valley slopes, while scattered permanent fields of paddy may be seen in river valley bottom (Prokop 2007). Coal mining, established during British regime (Oldham 1854). Limestone quarrying started fast after establishment of Mawmluh Cherra Cement Limited (MCCL) in lower Cherrapunji during the early 1960s. That are the major activities of the people in the central parts of the spur. Such activities increase land degradation and change land uses of this area. Under such condition, a typical land use/land cover pattern have evolved under heavy rainfall and leaching of soil nutrients. However, there are marked changes in the land uses during the 20th century (1910-2002). Decreasing trend of forest cover and increasing areas under Built up category of land use have been noticed during the

century (Table-1). Increasing number of queries of limestone may be major cause of deforestation and intensification of human activities and population increase are the causes of increase land under settlements and land use changes.

### Methods of Investigation

Present study of vegetative cover and plant species was conducted in Cherrapunji area on the south facing slopes of about 30 to 40 degrees incline by considering topographic, geomorphic and hydrographical features of landscape. Vegetal cover was analysed through Landsat 7 ETM+ multispectral satellite images for the year 2002. Maps were transferred into digital form and registered together with satellite image to the Universal Transverse Mercator coordinate system in raster GIS (ILWIS) environment. Visual interpretation technique was used for spatial differentiations of vegetal cover mapping and also to compare density of vegetal cover with topographic map of the investigated area. Survey of India topo sheets at R. F. 1: 25,000 scale were used to trace out topographic features. Comparison of topo features with vegetal cover was done by using simple 'map superimposition'

technique. There is marginal error in detection of categories of vegetal cover especially in deep valley areas where forest patches are under slope shadow. It is assumed that such areas are considered under the category of same canopy cover as depicted in its nearby areas.

A detail survey of plant species was conducted during December 2005 following landscape criterion of the collection of vegetation samples on its various sites so that the samples are to be true representatives of plant formation and plant species. This survey provides the comparison of toposequences and topo-features with vegetal cover and also with floristic composition of the taxa. There are different approaches of forest categorisation (Mittelman 2001, Heinimann *et al.* 2007). But we considered widely accepted general land cover classes approach for the purpose. An intensive site selection was done from each vegetation type. Most of the species are identified with their site specifications and topographic features from these areas of vegetal importance. GPS was used for finding the location of sample site. Plant characteristics were analysed in the laboratory of ecology, Department of Botany, North Eastern Hill University, Shillong (Appendix-I).

Table 1: Areal Changes in Land Cover in Cherrapunji spur (1910 to 2002)

Land cover	Area in 1910		Area in 2002		Total Change (1910-2002)	
	Hect.	% Area	Hect.	% Area	Hect.	% Area
1. Forest	645.8	12.118	262.3	4.922	-383.5	-7.196
2. Grassland	4548.7	85.356	4553.9	85.453	+5.2	+0.097
3. Agriculture	16.2	0.304	15.0	.100	-1.2	-0.204
4. Built up area	118.4	2.222	454.3	8.425	+332.9	+6.203
5. Area under quarry	-	-	58.6	1.100	+58.1	+1.100

Source: Satellite digital data; Courtesy: Prokop (2007)

A classification of forest flora given by Champion and Seth (1968) and later on followed for the state of Meghalaya by Haridasan and Rao (1985), was followed for the present study to highlight the characteristic features of vegetation pattern. Almost all significant species are covered in survey. The species have been identified into three communities, namely, the grassland, the succession vegetation and the forests.

## Results and Discussion

### (A) Vegetal Cover

The prevalence of grasslands which occupies more than 85 percent land of Cherrapunji area is the main characteristic features of the landscape around Cherrapunji in 2002 (Fig. 2). Natural forests were by and large confined only to the steep slopes of deep gorges and limestone mesa with karst phenomena in the southern part of the spur. Small patches of sacred groves protected for religious reasons and preserved up to present days were scattered over spur. Grasslands represented varied level of site degradation with bare rock exposure.

There are two main reasons for diverse vegetal cover; first is the variations in weathering processes and soil types and secondly, the anthropogenic factors. Soils under grasslands are highly weathered and contain less feldspars with the dominance of *Dystric Cambisols* (Fig. 3). A micro-morphological study of soils in this area concludes that the soil of forest areas protect large amount of water because of larger number of pores which protect soil from surface erosion (Budek and Prokop 2005). Therefore, forest soils are deeper (up to 40-50 cm) with dominance of sand

particles than the depth of grassland soils (of 25-30 cm thickness) with dominance of skeleton especially in its upper layers.

It appears to be permanent deforestation in the central and south-west parts of Cherrapunji spur where there was no settlement and road network in early period of century. The villages were located on relatively flat land in the vicinity of spur edges. Their inhabitants may have opportunity to use upper barren part of spur for coal mining, animal husbandry and the lower steep forested slopes for small plantations, firewood and timber collection. Villages were small in size, except Cherrapunji town which had two centres: the upper (old one) on the hill side and the lower one located hundred meters below on the flat land being historically administrative headquarters since early 20th century. Agricultural land is confined to the narrow valley bottom in the upper and central parts of the spur.

Built up area covers about 8.5 percent land in 2002, which is almost equal to the national norms set by the Ministry of Agriculture, Government of India, New Delhi. The land under quarrying of limestone and sandstone extraction has been underestimated due to low discrimination accuracy on satellite image. However, expansion of limestone quarrying has a significant role to play in the land use pattern and vegetal cover changes. The coal mines were marked only as points on the maps. On the basis of the satellite image and fieldwork, it is possible to estimate that however most of the coal mines are located within degraded areas of grasslands.

On the whole, vegetal cover spatially varies as per the variation in the topo-

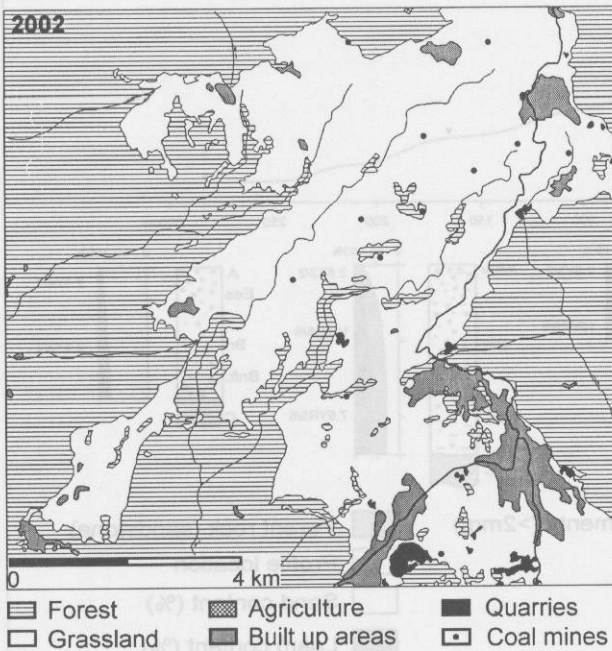


Fig. 2: Vegetal cover of Cherrapunji spur, 2002

(Courtesy: Pawel Prokop)

sequences of the area. The dense forest cover (NDVI > 0.6) in valley slopes, the scattered deciduous and tall grasses (NDVI between 0.2 and 0.3) on upper flats of about 1000 to 12000 m a.s.l. and the barren lands with minimal and thin grass cover (NDVI between 0.1 and 0.2) are clearly marked features of topographic relationships with vegetal cover in the area (Prokop 2007). Soil catena of flat spur also influences vegetal cover. In grasslands around Cherrapunji settlements, the soils of hill- flats are thin (40 cm deep) with dominance of skeleton in its upper layers and deep (up to 90 cm)

in the valet slopes of watersheds located in the undulating flats (Fig. 3).

Thickness of the soil tends to increase downslope. The variability of thickness is connected with slope gradient and geomorphic position. The thick remnants of old, red coloured weathered material are preserved on concave sections (Starkel 2004). Along the headwater sections with steep slopes, the washed coarse grain waste occurs up to 40 cm thickness. The waste material is often lacking in the horizon A while debris cones occupy the base of the slopes. The eroded soil is deposited over

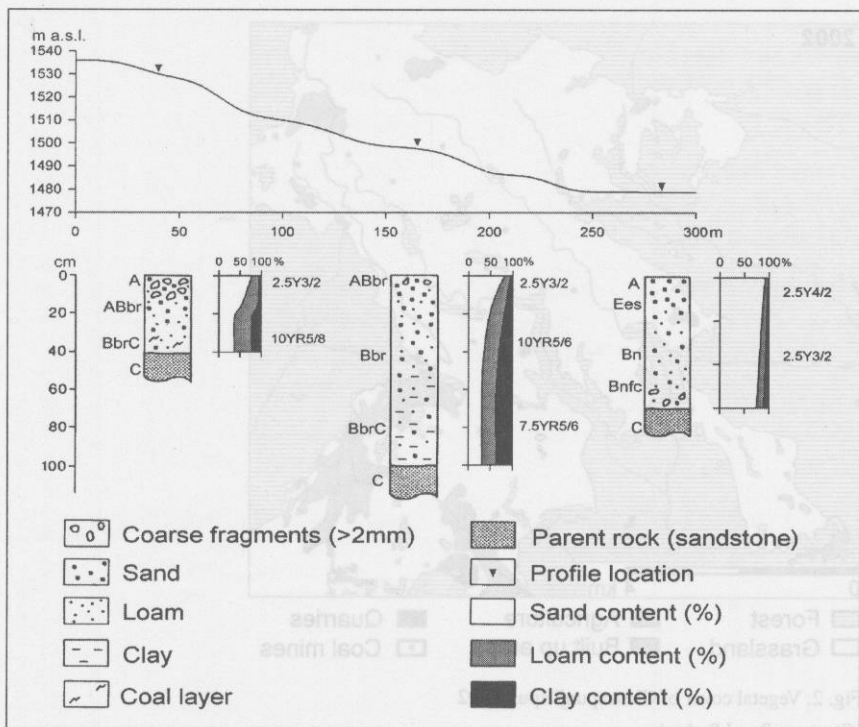


Fig. 3: Typical soil catena near Cherrapunji

(Courtesy: Pawel Prokop)

the very narrow zone at the foot of the slopes (Froehlich 2004a, 2004b). Besides stone pavement and dense roots of grasses, the retreating of slopes is stabilised by blocks sliding from the more resistant beds (Starkel 1996, Starkel and Singh 2004).

### Status and Distribution of Plant Communities and their Floristic Composition

(A) *Grasslands*: The grass-land areas have generally tall grasses with sedges and few herbs. Heights of the grasses are observed about 20 cm to 100 cm with linear leaves

of about 10-65 cm. Most of the plants of this area are categorized under the *Poaceae* family. It means the grasses in this area have fibrous root system with thick netting and restrict to surface within the 5-10 cm on the top of rocky areas (Shankar et al. 1991). It has characteristics of *Xerophytic* ecological group of plants. In spite of its growth in the dry climate, such plants species are also observed here in the highest rainfall area of the globe. It means such plants may survive in humid tropics. Most dominant grasses belong to *Arundinella* genus followed by *Cyperaceae*. In addition to these species,

weedy species commonly grow which indicate the biotic (especially human and cattle) disturbances. These are resistant to the thick soil and have stunted growth because of frequent fire during dry winter season (December to March).

Some of the important herbs grow luxuriantly in this area along tall grasses. These are hardly plants which sustain in the hilly landscape and extreme climate which prevalent in the Cherrapunji area. *Adiantum* is a type of vascular non-flowering plant and has strong net of rhizome system which tolerates even heavy downpours. It survives in weak regoliths in rocky areas also.

Many thorny plants which are not expected to grow in such extreme landscape conditions of the Cherra area are also seen. However, they are commonly found in some pockets of the southern slopes of heavily degraded lands near the frontal face of SW monsoon and marginal lands of Nohkalikai area. *Solanum* sp: (*S. sisymbriifolium* and *S. khasianum*) are growing with the hard spines and thorns. It is an indicative of Xerophytic characteristics because of moderate temperature with less availability of water in the soil especially during the winters in this area when it grows faster.

There is another Xerophytic dominant species *Pandanus odoratissimus* (*Pandraciae*) which is found in the river valley slopes and in the nick points of escarpments in flat degraded lands. It is comparatively tall (2.00 m in its height) and hard woody thorns which survive throughout the year. It can grow in thin gravelly soils. At the margin of forest there exist a habit group of under shrubs. The under shrubs have generally height of about 50-100 cm with ovate to lanceolate

shape of the leaves (1.5-9.0 cm length and 0.3-0.6 cm width).

In the areas of such grasses, there is a shola type of community with scattered trees (i.e. called savannah in its broader sense). However, these trees have stunted growth due to degraded soils. Shola type of forest patches are important in the area which can be seen among the grassland and in depressions. These patches contain characteristic species namely: *Ligustrum robustum*, *Castanopsis indica*, oak species: *Quercus tribuloides*, *Q. dealbata*, and *Engelhardtia spicata*. Such species of tall tree are present even in sacred forests *Ka Law Kyantang* near Ramakrishanan Mission in Cherrapunji (Tiwari et al. 1999).

**(B) Shrubs:** The successional vegetation with the major species of *Eupatorium adenophorum*, *E. Odoratum*, *Macranga denticulata* appear only on and around limestone quarrying areas. Such species are disturbed locally by quarrying and fire by local people after dry winters (Fig. 4).

**(C) Forests:** In general, natural dense vegetation with tall trees is found on the steep valley slopes and valley floors of the main streams. Moist thick gravelly soil cover with a significant quantity of humus is most characteristic which allows growing dense forests in this area. Such dense forests can be classified into two types:

(a) The evergreen forests located generally in the Mawmluh – Tyrna area of the lower part of Um Tinghang stream (Pynjugithuli nala) which is the upper part of the Umiew river catchment. The main tree species are *Dunbanga grandiflora*., *Ficus* spp., *Litsea* spp., *Symplocos*, *Quercus*

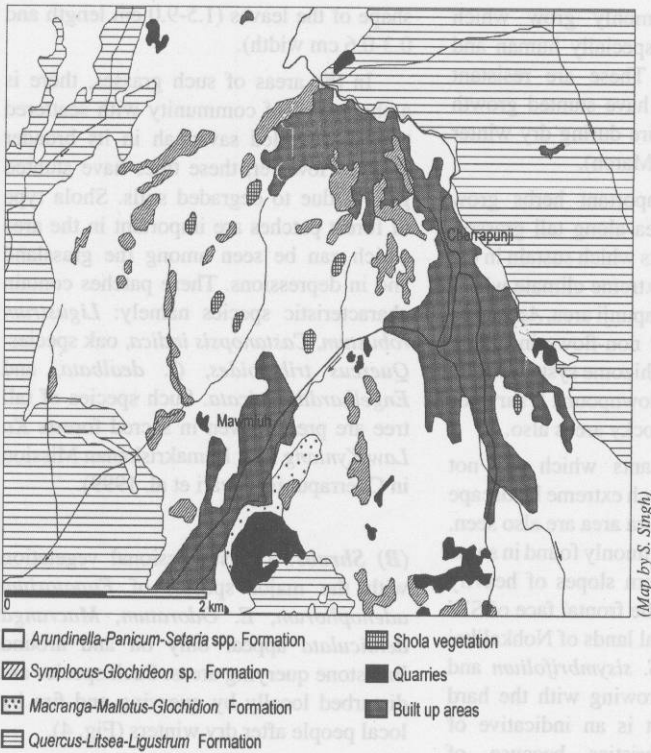


Fig. 4: Plant formations and dominant plant species

spp., *Eurya acuminata* and *E. japonica*. Such species are tall with dense canopy and buttres stem. Below the sub-canopy, there is dense layer of small trees and tall grasses (Jamir *et al.* 2006). They can survive in high rainfall and windy climate with their luxuriant growth. They retain soil moisture throughout the year and also stabilize temperature in the valleys.

(b) The mixed forests are located in river valley slopes in eastern parts of Cherra

area and in the lower part of Um Stew river valley. The major species observed are *Engelhardtia spicata*, *Ligstrum* and *Litsea* spp. Similar species are also found in the sacred groves around Cherrapunjee. They are densely populated due to less human interference (Tiwari *et al.* 1999)

Changes in spatial pattern of species composition are observed due to interference of human activities like wood cutting, fire practices in dry season,

enhancement of limestone quarries and coal mining in this area. Accessibility of forests from settlements is one of the major factors for spatial variation of forest degradation and thinning process of dense forests and fragmented patches of trees starts. A survey of fuel consumption carried out in the month of November 2005 in this area shows that more than two third families of rural areas consume an average of about 8.70 kg forest wood/day/HH in this area. The firewood consumption is very high (22.0kg/day/HH) in the villages which are located in the close vicinity of forests (0-1 km). The consumption diminishes significantly to 7.0 kg/day/HH in the least accessible forest areas of 4-5 km. (Singh and Syiemlieh 2007).

## Conclusions

Land cover patterns are grassland dominated while the spatial variations of vegetal cover and plant species have, in general, close relation with topographic features and toposequences in the Cherrapunji area. However, thinning of dense forests in river valleys and fragmentation of isolated forest patches on the flat lands are particularly associated with expansion in human activities because of enhancements land under settlements. There are a few important inferences drawn from the present analysis.

(a) Formation of forest species of dense canopy like *Dunbanga grandiflora*., *Ficus spp.*, *Litsea spp.*, is taking place in the valley slopes and valley floors, while grass species like *Arundinella* and *Panicum* are dominant in degraded lands of the upper part of Spur.

(b) Thinning of forests and fragmentation of tree patches in the

grasslands become operative due to increase in the consumption of traditional domestic wood fuel especially in the villages located in the close vicinity of dense forests.

(c) Use of various forest species and herbs like *Arundinella* genus (that are resistant to sterile soil- ecosystem) by local people for domestic purpose and development of traditional knowledge system, is based on 'location- specific environment' (Ramakrishnan 2003). It may be developed to link it with formal knowledge system for proper use of available plant species in this area. For example, many plant species have medicinal values, their stems, branches and leaves are economically valuable and easily tradable. Many grasses belonging to different herbs grow generally in the central flat lands may be developed in strong formal knowledge system for human wellbeing. However, the landscape of this area is favourable for development of fruiti-culture, eco-tourism and medicinal plant collection.

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