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A STUDY ON FOREST COMMUNITY STRUCTURE AND SOIL QUALITY IN RELATION TO FOREST DENSITY IN ASSAM

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ABSTRACT

Forests play a crucial role in maintaining healthy environment by regulating the hydrological cycle, acting as natural filters by capturing and absorbing pollutants from the air, recharging groundwater reserves, reducing soil erosion, and preventing sedimentation in rivers and streams. Forests are natural carbon sinks and mitigate climate change by reducing concentration of greenhouse gas (GHGs). However, since the last few decades, forests all over the world are under tremendous pressure owing to deforestation, changing land use pattern, infrastructure development, over exploitation of forest resources etc. These problems are also prevalent in the Eastern Himalayan Region including Northeast India. In order to understand the dynamics of loss of forest cover and changing land use due to anthropogenic pressure and its impact on forest community structure, forest fragmentation and habitat loss, forest biomass and forest soil a study has been carried out in the twin reserve forest - Barduar Reserve Forest and Mayang Hill Reserve Forest (RF) of Kamrup West Forest Division, Kamrup District, Assam, India. The study area is located 64 km (approx.) away from Guwahati city in the Assam Meghalaya border enclosing the historic tectonic lake Chandubi beel. Forest cover mapping has been carried out using Landsat time series data (TM/EMT+/OLI) for the year 1990-91, 2000-01, 2010-11 and 2015-17 in GIS environment which found that there has been gradual decline of very dense forest (forest cover > 70%) by 413.04 ha, dense forest (forest cover 40 70%) by 203.44 ha. On the contrary, open forest (forest cover 10 - 40%) has increased by 254.05 ha and scrub (forest cover <10%) by 149.42 ha during the period 1990 2017. Agricultural land and rural settlement have expanded continuously. Bamboo brakes have been extracted to the extent of wiping it off from Mayang Hill RF during 2010 2017. The annual deforestation rate has been highest in the decade 2000 - 2010 with 0.0373% per year in very dense forest (cover >70%), 0.0099% per year in dense forest (cover 40- 70%). Deforestation is prominent in the low elevation, low slope regions of the two RFs and on 1km buffer area of the roadsides passing by the RFs. These have led to fragmentation of forests in the study area. There has been continuous forest fragmentation from 1990 to 2017, large core forest have witnessed decline from 2759.85 ha in 1990 to 1671.29 in 2017. Edge forest gradually increased from 1397.83 ha in 1990 to 1547.17 ha in 2017. Socio-economic conditions of the inhabitants of 17 Forest Villages (FV) grouped into 3 clusters was studied following random sampling through focus group discussion with the Gaon Bura (Village Headmen), questionnaire survey and personal interviews with the inhabitants to understand their social and economic condition and dependency on the forest and its resources for livelihood and sustenance which revealed that the diminishing status of bamboo brakes, very dense forest (cover >70%), dense forest (cover 40-70%) is due

to the collection of forest products (mostly NTFP) by the village inhabitants for meeting their energy and housing material requirement as well livelihood and sustenance. The average monthly income of the surveyed households is between 5,000 6,000 INR and they meet their additional livelihood requirements through forest resources. 59% of the 85 households surveyed collect firewood, bamboo, and wild edibles etc., from the forest. 39% collects only firewood and 74% of the households dependent on firewood from forest as fuel

Introduction

Forests are one of the most important renewable natural resources and it has significant role in human life and in maintaining environmental balance on Earth (Warring and Running, 1998). Forests play important roles in ecological, social, and economic services (FAO, 1995). In terms of ecology, forests provide habitat to a large number of flora, fauna and microbes. The people or indigenous communities living in proximity of forest or dwelling in forest villages have social values, practices and aesthetic values attached to the forests. Forests also provide source of livelihood to the people. Human beings are dependent on forest for economic services like timber, paper and pulp, rubber, firewood, building materials and other non-timber forest products (NTFP). Forests also have a key role in the hydrological regime of an area, such as maintenance of water retention capacity, ground water recharging, prevention of soil erosion, conservation of soil quality and cycling of nutrients etc. They reduce the diurnal and seasonal variations of surface air temperature in and around the forests. Thus, forests are integral to global weather system and oxygen supply. They act as major sinks of organic carbon also.

There are varying definitions of forest all over the world according to country- to-country national laws, local situations, economic interests, and environmental stakes (Reddy et al., 2015). Lund, 2012 in his study found that there are as many as 800 different definitions of forest. United Nations Framework Convention on Climate Change (UNFCCC, 2001) defines forest as a land spanning between 0.05 - 1.0 hectare (ha) with canopy cover of 10 - 30% or tree height of 2 - 5 meters (m), it also includes plantation, and all young natural tree stands which have reached the height of 2 - 5 m or canopy cover of 10 - 30%. Food and Agriculture Organization (FAO, 2010) define ha, with a tree canopy cover of more than 10%, which is not primarily under agricultural or other specific non-forest land use. In case of young forests or regions where tree growth is climatically suppressed, the trees should be capable of reaching a height of 5 m in situ, and of meeting the canopy et al., 2013 in their study stated that forest refers to tree cover based on which the extent of global tree cover (loss and gain) was mapped from 2000 to 2012. Some countries again have different definitions of forests like in South Africa, forest is defined as an area with canopy cover >60%, in Russia it is >30% and >20% in China and Australia (Reddy et al., 2013). Forest Survey of India (FSI, 2011) defines irrespective any distinction between the natural tree stands or plantation or tree species whether native or alien. Act, 1927) during the colonial regime the status of which has been retained by the Government of India even after independence. A reserve forest or reserved forest and protected forest are forests with certain degree of

protection and the land rights are generally acquired and owned by the Government of India. However, reserve forests and protected forests are declared by the State Government unlike the National Parks or Wildlife Sanctuaries which are declared by the Central Government. The basic difference between reserve forests (RFs) and protected forests is that in RFs rights to all activities like grazing, hunting etc., are banned unless specific orders are issued; whereas in protected forests rights to activities like grazing, hunting etc., are sometimes given to communities living on the fringes of the forest, whose livelihood are partially or wholly dependent on forest resources or products. which is around 4 billion ha. However, this figure is lower than the pre-industrial time which records 5.9 billion ha. It also states that deforestation was highest during 1990s when the world lost approximately 16 million ha of forest each year. Although the rate of deforestation was highest but at the same time due to some plantation and natural regeneration expansion of the forest area took place bringing the global net forest loss to 8.3 million hectares per year. In comparison to the 20th Century, the first decade of the 21st Century reported slightly lower rate of deforestation but could not be any better than 13 million ha annually. The global net forest loss from 2000 to 2010 was 5.2 million ha per year. Asia has reported a decadal forest cover loss of 6 million ha from 1990 (576 million ha) to 2000 (570 million ha). However, the next decade i.e., 2010 the forest cover increased by 23 million ha (593 million ha). Unlike the Asian scenario, the global forest cover has decreased in the past three decades from 4,128 million ha in 1990 to 4,085 million ha in 2000 accounting for loss of 83 million ha which further reduced by 52 million ha in 2010 (4,033 million ha) and by 34 million ha in 2015 (3,999 million ha). Within a span of 5 years from 2010 to 2015 the reported net decrease of forest cover was 6.5 million ha. The global rates of forest cover reduction do not portray the occurring from construction of roads, selective logging, encroachment etc., is also compromising with the health of the remaining forests. Although every year plantation is carried out adding to the existing forest cover, but the actual or old forests are losing its quality or essence due to replacement of primary or old growth with monoculture of commercial, fast growing exotic species which in turn are also reducing biodiversity

Forest Type

Convention on Biological Diversity (CBD) defines forest type as a group of forest ecosystems of generally similar composition which can be readily differentiated from other such groups by their tree and under canopy species composition, productivity, and crown closure.

Merriam-Webster dictionary defines forest type as the similarity of composition and development of major tree species (as in two or more stands of trees) due to the impact of corresponding physical and biological factors. There are various types of forests present in different parts of the world. Forest type varies from region to region depending on the topographic factors such as latitude and longitude, climatic factors like temperature, rainfall, humidity etc., and edaphic factors or soil characteristics. Different latitudes have different eco-zones. Based on latitude, forest types can broadly be classified into Boreal forests located near the poles, tropical forests near the equator and temperate forests at mid-latitude.

Forest Types of India

India is a mega-biodiversity country located in the tri-junction of major bio geographic realms, viz. the Indo-Malayan, the Eurasian and the Afro-tropical regions. India possesses diverse vegetation and rich biodiversity due to its varied topographic and climatic regimes (Reddy et al., 2015). It has a rainfall regime varying from highest rainfall areas in the world to areas receiving very low rainfall and altitude raging from the highest mountains ranges in the world to the sea level. The vegetation of the country varies from the Himalayan Mountain ranges in the north to the Western Ghats in the south from the thorny warm desert vegetation in the west to wet-evergreen forest in the east. While studying the forest types of India, Champion and Seth, 1968 divided India into four (4) types of climatic zones based on temperature, viz. tropical zone (annual mean temperature >24oC), sub-tropical zone (annual mean temperature between 17oC - 24oC), temperate zone (annual mean temperature between 7oC - 17oC) and alpine zone (annual mean temperature below 7oC). Based on criteria viz., climate, topography, physiognomy, phenology, structure, function, plant association, flora, soil and biotic factors Champion and Seth, 1968 have identified 16 major forest types in India which are sub-divided into 221 minor types. Based on the association of species, Gadgil and Meher-Homji, 1986 distinguished 42 forest types in India. Both the studies of forest type classification have used field information or ground data to understand the pattern of vegetation and its types. However, these studies do not provide an explicit spatial boundary of the vegetation. Fortunately, satellite remote sensing and computer based geographic information system (GIS) provided the opportunity to map forest type based on its correlation with species or life forms (Guisan and Zimmerman, 2000). Multi-temporal satellite data has been widely used for various forestry purposes, mapping of different vegetation types from local to global levels (Fearnside and Barbosa, 2004).

Forest Types of Northeast India

Northeast India located between 89o46/ E to 91o30/ E and 21o57/ to 29o30/ N encompassing the Eastern Himalayas is a mountainous region with undulating topography. The average height of the region varies from 1000 m to 2000 m above mean sea level. The climate of the region is a warm humid, tropical, sub-tropical, and endowed with rainfall almost throughout the year, receiving maximum rainfall during monsoon. Average rainfall of the region varies from 1200 mm in Manipur to 11,000 mm in Meghalaya. The altitudinal variation and rainfall patterns of southwest and northeast monsoon play a significant role in the development of ecological niches in this region of India. Forest of this region is unique both in terms of its structure and species composition. Most trees of the region belong to tropical semi-evergreen, sub-tropical pines, and mountain wet-temperate and tropical moist-evergreen vegetation. Vegetation of the region is influence by the confluence of temperate east Himalayan flora, paleo- arctic flora of the Tibetan highlands and wet-evergreen flora of South-east Asia and Yunnan province of China forming a bowl of biodiversity. The hilly state, Arunachal Pradesh is the hotspot for the evolution of flora in Northeast India. The Brahmaputra valley of Assam, sandwiched between Eastern Himalayas in the north and the Garo, Khasi,

Jaintia Hill ranges and Mikir, Cachar and Barail Hill ranges in the south is the meeting ground of the temperate east Himalayan flora and the wet-evergreen and wet- deciduous floristic elements. The Khasi-Jaintia hills functions as a corridor of the South-east Asia elements into the Indian sub-continent through the Arakan arc. Champion and Seth, 1968 has classified Northeast India into 7 major forest types based on elevation **Forest Community Structure and Stratification**

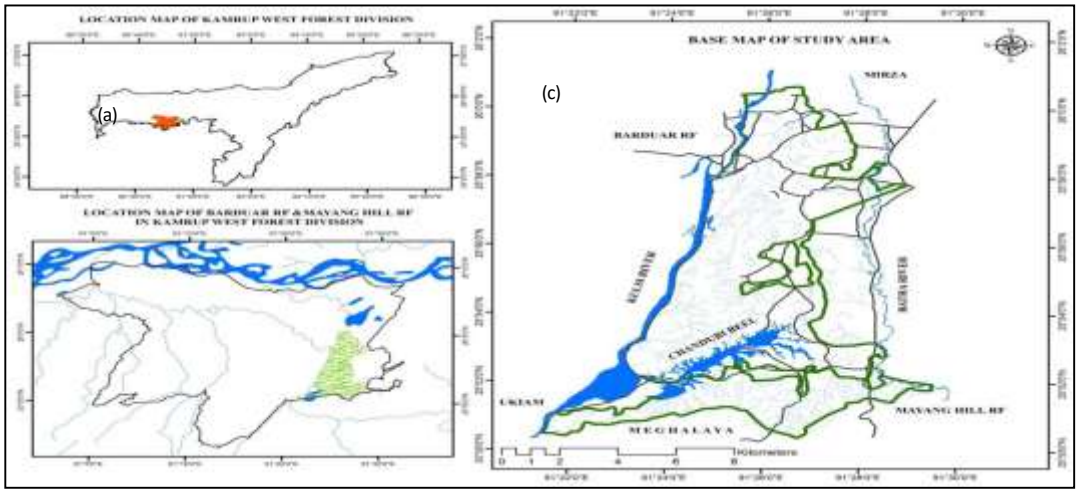
In nature, different kinds of organisms grow in association with each other. A group of several species (plants/animals) living together with mutual tolerance and beneficial interactions in a natural area is known as a community. In a community organism share the same habitat growing in a uniform environment. Forest, grassland, desert, pond etc., are the examples of natural communities. A community has its own structure, developmental history, and behaviour. All these characteristics are in correlation with the environmental factors. Communities may be large or small. Larger ones extend over areas of several thousands of square kilometres such as forests, others such as deserts are comparatively smaller with dimensions in hundreds of kilometres and meadows, rivers, ponds, rocky plateaus etc., occupy a restricted area. Forests are not particulate by nature. They are probably most accurately considered in terms of gradient patterns, their segmented geographic appearance being due to local steeping in rates of gradient change, at least in the absence of disturbance (Rowe, 1960). Whenever one type of forest community abuts another distinctly different type of forest community will be found. This abrupt change will be related to abrupt change in site conditions or to a completely different vegetation history of the two communities. The boundary between two communities is usually a belt rather than a sharp line. It is a belt or zone though it may vary markedly in width. The transition zone between two communities is termed as ecotone. It usually embodies some of the ecological features of the two communities, but often has a site-specific characteristic of its own. variety of the forest canopy from bottom to top. While referring to a forest stratum (sing.) or different forest strata (pl.) the characteristics that are generally asserted are structure, species, or environment, at different heights of the canopy which might serve as identifiable zones representing that the canopies differ in organization (Parker and Brown, 2000). When a forest is said to be stratified or layered, there are different perspectives to it such as stratifications based on height, different life forms or age class at different heights indicating plant life forms grouped into trees, shrubs, and herbs (Hussain et al., 1994) or grouped into different age class, trees,

ForestType	Altitude(m)	ImportantSpecies
Alpine Temperate	Above3500	*Rhododendronspp, Are nariaspp, Saxifragaspp.*
Subtropical Pine	3500-1000	*Pinusroxburghii,P.merkusii, P.wallichiana*
Subtropical Broad Leaved	1900-900	*Castanopsisspp,Quercusspp, Micheliaspp,Alnusspp,Schimaspp.*

Tropical Wet Evergreen	Upto900	South Bank of Brahmaputra-*Dipertoarpus macrocarpus, Shorea assamica* North Bank of Brahmaputra-*Mesua ferrea, Altingia excelsa.*
Tropical Wet Semi-evergreen	Upto600	*Terminaliamyriocarpa,Bombax ceiba, Canarium strictum, Ailanthus grandis*
Tropical Moist Deciduous	Upto300	*Shorearobusta,Tectonagrandis, Gmelinaarborea,Dilleniapentagyna.*

GEO-ENVIRONMENTAL SETTING OF THE STUDY AREA

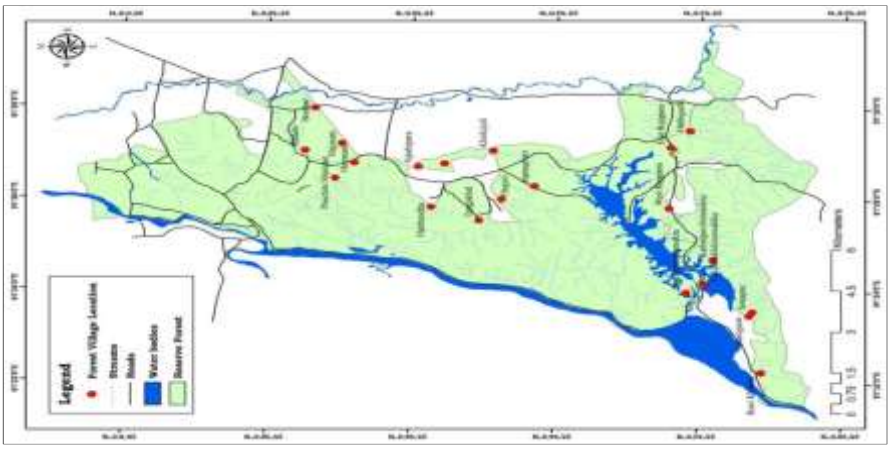
The study area is a continuous forest stretch of 92.40 sq.km (9240 ha) comprising of Barduar Reserve Forest and Mayang Hill Reserve Forest in Loharghat and Kulsi Forest Range under Kamrup West Forest Division (Kamrup District) of Assam. Kamrup West Forest Division comprises of six (6) Forest Ranges and thirty-five (35) Reserve Forests (RFs). Of the 35 RFs, Barduar RF and Mayang Hill RFs were chosen for this study owing to its unique ecological setup wherein the physiography of the place plays a role in human interaction with the forest. Batha and Kulsi River flowing to its east and west separates the study area from the rest of the RFs of Kamrup West Forest Division. The historic tectonic lake, Chandubi beel (lake is called beel in Assamese) is sandwiched between the Barduar RF and Mayang Hill RF creating a discontinuity between the forest stretch. This discontinuity has kept Mayang Hill RF partially away from human interaction than Barduar RF. Such scenic combination of forest and water body makes it home to a good number of wildlife populations and a popular tourist destination as well.

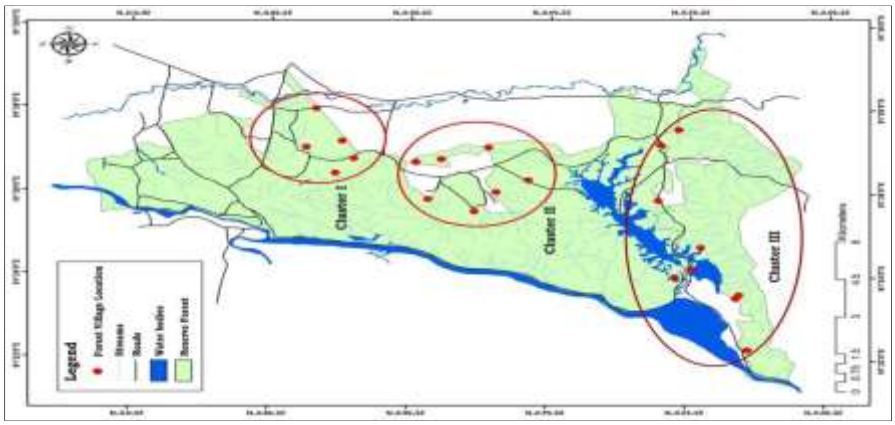


saplings, and seedling layers (Craig, 1993). The other forms of stratification are based on general variability in plant matter, based on vertical distribution of continuous foliar surfaces (Spies and Franklin, 1991), based on vertical distribution of foliage (Hubbell and Foster, 1986), based on forest crown limits (Richards, 1952), based on clumped leaf area with height (Koike et al., 1990; Terborgh and Petren, 1991; Ashton and Hall, 1992; Koike and Syahbuddin, 1993), based on species with different leaf heights (Wierman and Oliver, 1979; Bicknell, 1982; Guldin and Loriner, 1985; Oliver and Larson, 1996), based on species with different top heights (Palik and Pregitzer, 1993) and based on index of vertical structure (Mills et al., 1993; Terborgh and Petren, 1991; Spies and Cohen, 1992; Ashton and Hall 1992). However, in the present study we shall stratify the forest based on its canopy closure refered to as forest cover or forest density in the succeeding chaters and forest type (species composition and phenology) referring to the forest crown of different species (Smith, 1962; Oliver and Larson, 1996; Whitney, 1990).

ANALYSIS OF SOCIOECONOMIC CONDITIONS OF THE FOREST DWELLERS AND THEIR DEPENDENCY ON FOREST RESOURCES

Communities living in and around the forests have unique socio-economic conditions that are dependent on forest resources. This dependency manifest in various ways like providing subsistence or income opportunities from firewood, fishing, wild fruits, roots, nuts etc., and practicing shifting cultivation. Forest dependent communities have indigenous knowledge and belief systems that have evolved in harmony with forest ecosystem. But these communities also face serious challenges and vulnerabilities because of their traditional way of life and excessive dependency on forest resources alters the forest ecosystem. Nearly 1,96,000 villages exist in the forests or on the forest fringes in India (Senthilkumar, 2015). The inhabitants of these villages are dependent of forests for their livelihood and sustenance. In the beginning, these inhabitants were mainly dependent on forest products for their sustenance; but later they started settling for agriculture, domestication of animals and other manual jobs. Gradual increase in population of the forest dwellers and other population fluxes brought pressure to forest lands for conversion to agriculture land, settlement areas, industries etc. Moreover, other activities such as illicit felling of trees for timber extraction, fuel wood, collection of NTFPs, hunting and poaching, fishing, livestock grazing have altered forest cover and paved paths for other landuse in many protected areas of India (Gadgil and Guha, 1992; Kothari and Suri, 1995; Somanathan and Borges, 2000; Rahmani, 2003). Depletion of forest in the past decades to fulfil the need of agricultural expansion and housing the growing population adversely affected the sustenance of forest dependent communities (Geist and Lambin, 2001, 2002; Kaimowitz and Angelsen, 1998; FAO, 2016). Encroachment of the forest land for agriculture, human settlement etc., have resulted in habitat fragmentation and shrinkage of wildlife habitats Karanth, 2006). Such reduction of wildlife habitats due to encroachment and fragmentation have resulted in human-wildlife



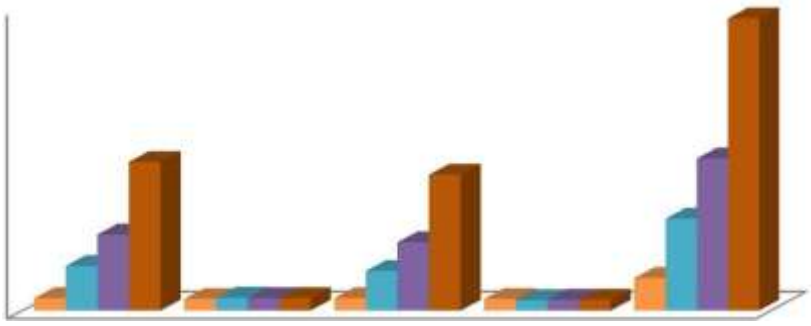


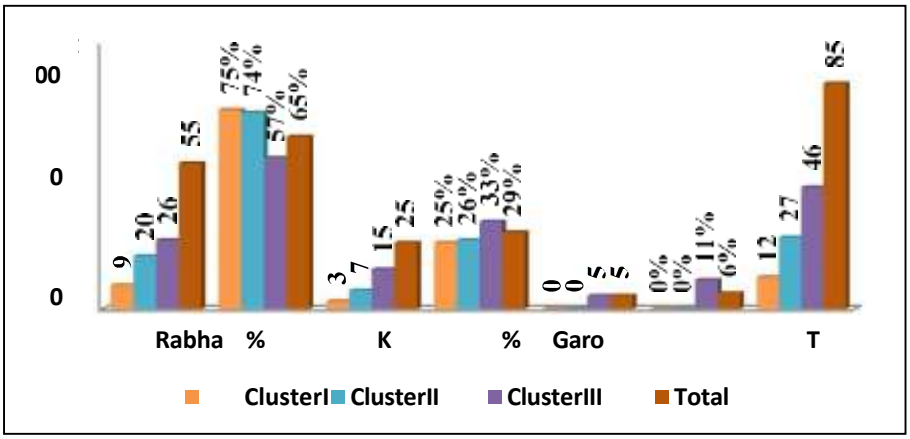
Results and Discussion

The number of households surveyed in each village of the respective cluster has been presented in Table 5.2. The numbers of representative households in the clusters of villages were not uniform as the number of villages and population both vary with clusters. In cluster I, II and III, the numbers of representative households were 12, 27 and 46 respectively totalling 85 household altogether. The households encompass a total population of 773, wherein 52% (403) is male and 48% (370) female as depicted in Figure 5.4. Gender representation in Cluster I is equal with 50% on both sides, Cluster II has majority male population i.e., 53% and 47% female population. Cluster III also has majority male population i.e., 52% and 48% female population.

Cluster	ForestVillages	HouseholdSurveyed	Cluster Total
I	Borjhar	4	12
	Hajarani	2	
	Horurani	2	
	PaschimManipur	2	
	Sildubi	2	
	HatibandhaGhilabari	6	
	Jupangbari	6	

II	Khirkijuli	2	27
	Ouguri	5	
	Sipahipara	3	
	Tengakhal	5	
III	BaregaonSonapur	5	46
	EastRajapara	11	
	Hathigarh	3	
	Joramukhia	4	
	RaniKhamar	8	
	WestRajapara	15	
GrandTotal		**85**	





Cluster	Family Composition								Total
	5-7	**%**	**8- 9**	**%**	**10-11**	**%**	**12-13**	**%**	
Cluster I	4	33%	4	33%	4	33%	Nil	Nil	12
Cluster II	3	11%	12	44%	9	33%	3	11%	27
Cluster III	9	20%	22	48%	14	30%	1	2%	46
Total	**16**	**19%**	**38**	**45%**	**27**	**32%**	**4**	**5%**	**85**

Religion	Christianity	%	Hinduism	%	Total
Cluster I	Nil	Nil	12	100%	**12**
Cluster II	Nil	Nil	27	100%	**27**
Cluster III	5	11%	41	89%	**46**
Total	**5**	**6%**	**80**	**94%**	**85**

CONCLUSION

Since last few decades, forests are under tremendous pressure and threat all over the world due to overexploitation of forest resources, conversion of forests into other land uses for expansion of agricultural land, urbanization, mining, infrastructure development etc. Large-scale clearing of forests and unsustainable logging without proper management or reforestation measures leads to deforestation causing lot of problems such as srinking of forest area, forest fragmentation, thining of forest density or forest cover, habitat loss, biodiversity loss, increase of soil erosion, soil quality degradation, decrease of carbon stock, purtarbation in hydrological regieme and local or regional climate, etc. These are the most common problems for most of the forests distributed over the globe. These problems are also common in the forests of Eastern Himalayan region including Northeast India. From this viewpoint, there is a need to address properly the forest related problems of this region also. In this context, a case study of the twin reserve forests Barduar and Mayang Hill Reserve Forest located in Kamrup district of Assam in the Brahmaputra valley has been carried out to know its present status including human pressure on it, loss of forest cover due to degradation and deforestation, soil quality, forest fragmentation, habitat loss leading to man-animal conflicts, etc. In the study both primary and secondary data were collected along with intensive survey of literature, articles and books related to the study to have a clear idea of the topic of research and problem. At the onset of the study, existing information from literature, Department of Forest, Govt. of Assam, Statistical Handbooks, traditional knowledge system (TKS) etc., were collected as secondary data for the study. Then a preliminary field survey was conducted in the Barduar Reserve Forest and Mayang Hill Reserve Forest to understand the forest cover or forest density, other landuse, existing tree species, human settlement pattern in and around the Reserve Forests and their interaction with the forest,

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