

Chapter - VIII

SUMMARY AND CONCLUSION

Manas biosphere reserve which serves as habitats of many endangered and endemic flora and fauna has been facing excessive biotic pressure since 1988 due to continuous political imbalance started. The human impact on the eastern buffer of the biosphere reserve has resulted in severe environmental degradation and habitat fragmentation as well as other ecological problem of severe human elephant conflict and water scarcity for local people. To evaluate the present human impact on the forest community this study was undertaken with following main objectives i) to characterize the different forest communities in eastern buffer of Manas biosphere reserve ii) to investigate the forest community distribution in relation to soil type and climatological parameters iii) to identify the change in forest community structure due to anthropogenic activities iv) to evaluate the potential forest restoration initiated by local NGO and tribal communities.

The selected study site in eastern buffer zone of Manas biosphere reserve, covering an area of 98 sq. km. has 3 reserve forests namely Daodhora, Batabari, Subonkhata and one proposed reserve forest Dihira is located in Indo-Bhutan border district Baksa under Bodoland Territorial Autonomous Districts of Assam.

The climate of the biosphere reserve is subtropical in nature. The temperature ranges in between 6°-37° celcius while rainfall ranges between 3000 mm-4000 mm per year, attaining the peak during July and August that caused flash flood for short period. The coolest period is from late December to early January while hottest season is recorded in the month of May. The driest period of the season is in between late February to early March.

The topography is diverse in nature. The general appearance is of flat plain, yet undulating small hilly areas in the northern boundary, low-lying areas and some perennial and seasonal rivers and water bodies are the characteristics of the landscape. The rivers running through the biosphere reserve carry an enormous amount of silt and rock debris from the foothills, resulting from the heavy rainfall, fragile nature of the rock and steep gradients of the catchments. This leads to the formation of alluvial terraces, comprising deep layers of deposited rock and detritus overlain with sand and soil of varying depth, shifting river channels and swamps.

The general vegetation in the study site is comprised of *northern secondary moist mixed deciduous forests*, evergreen forests, low alluvium savannah woodland, eastern wet alluvial grassland, riparian fringing forest, khair sisso forests, secondary bamboo brakes and cane brakes.

Manas biosphere reserve harbours 61 species of mammals, 450 species of birds, 42 species of reptiles, 9 species of amphibians, 79 species of fishes and more than 200 species of butterfly and 100 species of invertebrates. The landscape supports (IUCN listed) one critically endangered, seven endangered, ten vulnerable mammals; five critically endangered, two endangered, eighteen vulnerable birds and four endangered and nine vulnerable reptiles. Besides, royal Bengal tiger, Asian elephant, wild water buffalo, Indian gaur, Pigmy hog, Capped langur and are the most important fauna of the biosphere reserve.

The eastern buffer area of Manas falls under Pagladia river basin that experienced some annual flood. There may be some geomorphological changes due to water current, siltation in river system or other factors. Flash flood is common as there is large scale forest destruction in the reserve forests resulting soil erosion. There are 14 major human made traditional channels from Pagladia river and their networks of several hundred sub channels for water harvesting purpose in the area covering

around 70 villages. During flood, villagers have to repair and maintain these channels locally known as Dong bundh since several decades.

With some improvement of the political situation, significant development has started in the Manas biosphere reserve for protection of biodiversity and natural resources. Several local NGOs has started work with support active community participation like converting wood cutters and poachers in conservation efforts and working wi the forest departments. In eastern buffer a local NGO has taken lead role since 2006 in protecting the existing forest and wildlife. They already restored about 5-6 sq. km. of forests in Subonkhata reserve forests as reported by the forest authority. The local NGOs are working for promotion of alternative livelihood options for forest dependents and ex-poachers families in fringe villages.

Amongst the 98.35 sq. km. of the study site, an area of 13.29 sq. km and 5.65 sq. km forests have been encroached for agricultural activities and human habitation respectively.

Daodhora RF is comprised of mixed deciduous forest (15.32 sq. Km.) scrub forest (2.02 sq km.) grassland (3.5 sq. km.) wetland/river (1.7 sq. km.), agricultural land (0.34 sq. km.) and human habitation (0.29 sq. km.) in southern side. Disturbance caused decrease of canopy cover from 50-60% to 5-20% while canopy heights from 6-10meter to 2-3meter.

The Batabari reserve forest is comprised of mixed moist evergreen forest/Semievergren forest (8.86 sq. km.), deciduous forest (14.23 sq.km.), scrub forest (12.07 sq. km.), grassland 0.5954sq.km.), wetland/river (1.67sq.km.). The satellite based map also identified the agricultural land (4.05 sq.km.) and human habitation (2.62 sq.km.) as encroachment area in the southern side of the reserve. The canopy cover decreased from 60-75% to 15% while canopy heights from 6-12meter to 2-7meter.

The Subonkhata reserve forest is mainly dominated by scrub forest (6.69 sq. km.), while other area is covered by mixed moist evergreen forest/Semievergren forest (2.21 sq. km.) in northern hilly border, deciduous forest (0.08 sq. km.), wetland/river/riverine sand (2.43 sq. km.). Large encroachment as agricultural land (8.41 sq. km.) and human habitation (2.61 sq. km.) were also indentified that resulting fragmentation of the continuity of the Manas biosphere reserve in eastern buffer. The canopy cover decreased from 50-60% to 5% while canopy heights from 5-8 meter to 2-3.5 meter.

Dihira Proposed Reserve Forest is dominated by dense mixed moist evergreen forest/Semievergren forest (0.32 sq. km.), open mixed moist evergreen forest/Semievergren forest (3.38 sq. km.), scrub forest (3.33 sq. km.), wetland/river (0.138 sq. km.), encroachment as agricultural land (0.496 sq. km.) and human habitation (0.183 sq. km.) in southern side. The canopy cover decreased from 50-60% to 5% while canopy heights from 5 meter to 2 meter.

The phenology of the tree (25 species) and underground vegetation (15 species) indicated that most of the species on set flower during spring and rainy season though some also prefer winter season. The rainfall seems to slightly change the start of the flowering time during the study period. Depending on the change of the micro climate condition the flowering and fruiting periods vary accordingly.

The mixed moist evergreen forest/semievergreen forest is dominated by the tree association *Syzygium cumini*, *Lagerstroemia parviflora*, *Linnea grandis* and *Dillenia pentagyna* while *Bauhinia purpurea*, *Careya arborea*, *Dillenia indica* are rarely occurred. The forest floor vegetation is loosely distributed by *Calamus sp.*, *piper sp.* *Litsea salicifolia*, *Phlogocanthus thyriformis* etc.

The deciduous forest is comprised of *Sterculia vilosa* *Duabanga grandiflora* *Bombax ceiba* *Toona ciliata* *Callicarpa arborea*. The rare tree species in this category

are namely *Gmelina arborea*, *Bischofia javanica*, *Dillenia indica*, *Pterospermum acerifolium*, *Albizia lebeck*, *Bauhinia variagata*, *Oroxylum indicum*, *Alstonia scholaris*, *Holarrhena antidysenterica*.

The ground vegetation is generally comprised of *Clerodendrum viscosum*, *Leea asiatica*, *Chromaelena odorata*, *Drypteris species*, *Calamus sp.*, *piper sp.* *Litsea salicifolia*, *Phlogocanthus thyriformis* *Adhotoda vasica*, *Ageratum conyzoides*, *Clerodendrum viscosum*, *Litsea salicifolia*, *Drypteris species*, *Paspalum longifolium*, *Murraya koengeei*. *Mimosa himalayana*, *Solanum nigrum*, *cyperus*, *saccharum species* in riparian areas, *Glycosmis arborea*, *Costus specious* *Litsea salicifolia*, *Paspalum longifolium*, *Murraya koengeei*, *Cyperus species*, *Tabernaemontana divericata*, *Solanum nigrum* etc. The grassland is mainly dominated by *Saccharum spontaneum* in riparian side.

The epiphytic flora is formed by different orchid species namely *Dendrobium aphyllum*, *Vanda teres*, *Pholidota imbricata*, *Bulbophyllum ferrestii*, *Rhyncostylis retusa*, *Aerides odoratum*, and ferns like *Pyrrhosia lanceolata*, *P. longifolia*, *P. beddomenna*, *Microsorium punctatum*, *Asplenium nidus*. Other angiospermic epiphytes including climbers and lianas are *Vitis planicaulis*, *Merremia vitifolia*, *Thunbergia fragrans*, *T. grandiflora*, *Momordica dioica*, *Smilax perfoliata*, *Dioscorea bulbiflora*, *D. trifoliata* occurred in less disturbed areas.

The contiguous four reserve forests shows above 60 percent similarity in tree vegetation while maximum similarity occurred in between Daodhora and Batabari. The lower similarity between adjacent Dihira and Subonkhata is related to influence of abiotic and biotic factors.

The average nitrogen and organic matter contents significantly are more in percentage in undisturbed (nitrogen 0.45, organic matter 1.57) evergreen and semievergreen forest including mixed deciduous forest in comparison to disturbed

(nitrogen 0.007%, organic matter 0.13%), scrubland, grassland and human habitation and agricultural sites.

There is no significant change of the average phosphorus, potassium contents and soil properties like sand, silt, clay, moisture percentage value if considered overall landscape of buffer areas Manas biosphere reserve despite human disturbance. This may be due to the diverse soil dynamics in relation to forest community structure that still has some good forest and self sustaining mechanism.

A detail study in the microhabitat level study in different forests confirmed that the soil texture of the all the 4 reserve forests namely Daodhora, Batabari, Subonkhata and Dihira proposed reserve forest are comprised of higher percentage of sand with low to moderate clay and silt particles depending upon the different landuse in different topographical variation. The sand percentage ranged between 37.2-71.4 percent in Daodhora, 34.5-69.2 percent for Batabari, 55.2-78.6 percent for Subonkhata and 58.9-69.2percent for Dihira proposed reserve forest. Interestingly highest sandy particles are observed in the grassland of the different reserve forest which turned to maximize in Subonkhata RF. This may be due to the excess loss of the forest in the riparian vegetation with undulating altitudianl variation.

Regarding canopy cover, canopy height, logging pressure average value significant changed was noticed in different forest types and disturbed lands.

The correlation between different soil properties indicated that sand showed significant negative correlation to clay. This may be due to opening of the forest resulting excess deposition of the sand particle during rainy season in disturbed site or landuse with low altitude.

The silt percent showed also significant negative correlation with potasium, while organic matter significantly changed the pH in the reserve. Silt percentage was

changed with the disturbance of the forest while Potassium stays with clay particle and favoured by plants for its metabolic activity. The organic matter deposited due to decomposition of litterfall and dead vegetation soil acidity or alkalinity. Phosphorus and Potassium showed significant correlation in the overall biosphere reserve.

Sand showed insignificant negative correlation trend for silt, organic matter, nitrogen and positively correlated to phosphorus, potassium and pH. The increase of sand may decrease the silt, organic matter, nitrogen at micro level.

There is slight improvement of the soil minerals in agricultural and human habitation vegetable garden. This is due to the use of cowdung in the agricultural practice by the local people.

The nitrogen and organic matter is low in disturbed forests and the sharp decrease was observed Subonkhata RF and Dihira PRF. This is due to the excessive opening of the forest by human activity in the Subonkhata RF and Dihira PRF having high slopping and altitude in comparison to Daodhora RF and Batabari RF resulting high speed of the water current and carrying of the large amount of soil to the low lying areas.

The human impact on the forest destruction in eastern buffer forests of Manas Biosphere Reserve leads to the opening of canopy cover of the diverse forest types namely evergreen, semievergreen forest including mixed deciduous forest and influenced the soil degradation in terms of organic matter content, nitrogen as well as accumulation of sandy particle in disturbed forests. The sandy nature of the disturbed forests are the result of drainage system and poor vegetation cover to accelerate soil erosion. The change in soil dynamic also leads to the poor growth of the forests in disturbed sites.

The Human disturbances in Daodhora reserve forest resulted in change of canopy cover to 5-20% in disturbed forest from normal 50-65% recorded undisturbed one and canopy height to 2-3 meters in disturbed southern side of the reserve from 6-10 meters. The disturbance significantly changed the species diversity of Daodhora RF from 2.819 to 2.13. The natural tree association *Lagerstroemia parviflora-Linnea grandis-Dillenia pentagyna* converted to *Lagerstroemia parviflora-Dillenia pentagyna-Bridellia retusa*. Due to logging pressure trees like *Alstonia scholaris*, *Albizia procera*, *A. lebeck*, *Bischofia javanica*, *Dillenia indica*, *Gmelina arborea*, *Lagerstroemia speciosa*, *Pterospermum acerifolium* including medicinal plants *Hollarhena antidysenterica* & *Oroxylum indicum* were locally extinct in disturbed sites of Daodhora RF. The undisturbed ground vegetation dominated by *Clerodendron viscosum*, *Litsea salicifolia*, *Leea asiatica*, *Chromaelaena odorata*, *Adhotoda vasica*, *Ageratum conyzoides*, *Dryopteris paleacea*, *Calamus sp.* has been gradually replaced by *Leea asiatica*, *Clerodendron sp.* and problematic weed *Chromaelaena odorata*. The weed completely replaced sciophytes like *Adhotoda vasica*, *Costus speciosa*, *Glycosmis arborea*, *Litsea salicifolia*, *Murraya koenigeei*, *Phlogocanthus thyrsoformis*, *Piper diffusum*, *Piper longum*, *Calamus sp.*, *Tabernaemontana sp.* The other reason of vanishing of these herbs can be related to resource exploitation by villagers for medicinal and other economic uses. The disturbance also changed the undergrowth species diversity from 2.958 to 2.371 in the region.

In Batabari reserve forest 14 trees namely *Albizia procera*, *Albizia lebeck*, *Bischofia javanica*, *Bauhinia variagata*, *Careya arboea*, *Duabanga grandiflora*, *Dillenia indica*, *Gmelina arborea*, *Linnea grandis*, *Lagerstroemia speciosa*, *Pterospermum acerifolium*, *Terminalia bellirica*, were completely eliminated due to demand of timber and fuel wood in the nearby regions. The villagers goes for non timber plants like medicinal species *Holarrhena antidysenterica*, and *Oroxylum indicum* in absence of

potential trees resulting severe degradation of the surrounding environment and scarcity of ground water in the region. Similarly the *Lagerstromia parviflora-Linnea grandis –Dillenia pentagyna –Sterculia villosa* association has been changed to *Bombax ceiba- Dillenia pentagyna –Bridellia retusa-Callicarpa arborea* type indicating gradual shifting of non timber type of forest community in due course of time. The tree diversity changed from 2.84 to 2.28 which indicate severe decrease of tree species or local elimination. Regarding ground vegetation in Batabari the weeds like *Leea asiatica, Chromoelena odorata, Clerodendron viscosum* becomes more dominant and turned as major component by replacing the shade loving species like *Adhotoda vasica, Costus speciosus, Glycosmis arborea, Grewia sapida, Litsea salicifolia, Piper diffusum, Piper longum, Calamus sp, Tabernaemontana divericata* etc. In Batabari disturbance also changed the undergrowth species diversity from 2.94 to 2.191 in the region.

In Subonkhata RF, vast encroachment for agricultural land and human habitation resulted major fragmentation in the continuity of forest in the eastern buffer zone of Manas Biosphere Reserve. An area of 47.13% of forest land were encroached for agricultural and settlement purpose. The species diversity also changed from 2.69 to 2.39 in disturbed forest. The canopy cover in the disturbed forest community found to be 5% from normal 50-60%, while significant decrease of canopy height to 2 meters from 5 meters had occurred. The felling and smuggling of trees resulted in severe water crisis in the region and human-elephant conflict according to local people. The undisturbed forest community comprising of *Bombax ceiba- Lagerstroemia parviflora- Dillenia pentagyna Linnea grandis* changed to *Linnea grandis-Lagerstroemia parviflora- Bridellia retusa* type in due course of time. During the same period the *Albizia procera, Bauhinia variagata, Holarrhena antidysenterica, Pterospermum acerifolium, Sterculia villosa, Syzygium cumini, Terminalia bellirica* and bamboo (wild) species were totally

eliminated by the anthropogenic pressure. The ground vegetation *Clerodendron-Litsea-Dryopteris* type is changed by the weed *Chromolaena odorata* in disturbed habitat. Interestingly the undergrowth species diversity increased in disturbed forest (2.50) in comparison to undisturbed (2.39) region. This may be due to the invasion of large number of sun loving species in open forest area with less canopy cover.

Dihira proposed reserve forest has some potential to upgrade to reserve forest. The major tree association is comprised of *Lagerstroemia parviflora*, *Dillenia pentagyna*, *Callicarpa arboria*, *Linnea grandis* and *Bombax ceiba* in the undisturbed sites. However excess timber logging resulted local elimination of the tree species like *Alstonia scholaris*, *Albizia procera*, *A. lebbek*, *Bauhinia variegata*, *Careya arborea*, *Sterculia villosa* etc.

An area of 6.69 sq km. i.e 29.82% of encroached land was converted to regenerating forest in Subonkhata reserve forest during 2006-2012 periods. The restored forest patch was identified in between the Diring and Pagladia river having more than 80 years old man made channels. The man made channel networks and protection of recovered land through the service of dong bund committees and local conservation NGO respectively helped in natural regeneration of the forests.

It is significant that regenerating forest with canopy height of 1-2.5 meters, are mainly dominated by *Linnea grandis* (IVI 53.97), *Lagerstroemia parviflora* (IVI 42.50) and *Bridelia retusa* (41.98) while moderate species like *Bombax ceiba*, *Dillenia pentagyna*, *Duabanga grandiflora*, *Toona ciliata* are also located along with low IVI value of *Bauhinia purpurea* (9.44), *Trewia nudiflora* (12.55) and *Terminalia chebula* (14.92). Some species like *Pterospermum acerifolium*, *Albizia procera*, *Bauhinia variegata*, *Hollarhena antidysenterica*, *Sterculia villosa*, *Syzygium cumini* are found in adjacent undisturbed forest patch along with bamboo species.

A comparison of undergrowth vegetation of disturbed forest and restored forest with poor canopy cover indicated that there are 20 species in restored stands while only 15 species in disturbed stands. The disturbed plot has been covered by mixture of heliophytes and schiophytes like *Clerodendrum viscosum* (IVI 61.76), *Dryopteris sp.* (IVI 39.93), *Litsea salicifolia* (49.88), *Murraya koenigeei* (IVI 23.23), *Paspalum longifolium* (IVI 20.02) and *Setaria palmifolia* (IVI 28.51) etc. The restored zone is generally dominated by common weed species *Chromolaena odorata* (IVI-89.59) and *Lantana camara* (IVI 27.76). Other species like *Ageratum conyzoids* (IVI 18.59), *Clerodendrum viscosum* (IVI 15.16), *Dryopteris species*, *Mimosa himalayana* (15.20), *Setaria palmifolia* (15.96) were also found along with *Chromaelana-lantena* association in the same area indicating potential of restoration of tree and undergrowth vegetation if protection continue further.

Four different stands namely encroached barren land, 2 years old vegetation, six years old vegetation and six years old stand in riparian side showed significant restoration potential in Subonkhata areas in terms of increase of plant diversity and soil environment improvement. There is significant increase of vegetation cover (5 percent to 45 percent), species number (3 to 20) vegetation height (0.5 feet to 5 feet), nitrogen content (0.0045 to 0.0058 percent) phosphorus (0.426 kg/acre to 1.34kg/acre), potassium (33.12 kg/acre to 57.06), organic matter content (0.15 to 0.48%), clay (11.58 to 18.54 percent) silt (14.57 to 23.46%) with support protection of the areas by the conservation volunteers. Meanwhile, significant decrease of sandy soil (73.85 to 58%) also indicates the improvement of the organic matter that may be come from the dead materials of the growing vegetation over the six years. The riparian area has more potential of restoration while soil nutrient has positive correlation of the restoring vegetation cover in Subonkhata RF.

The human impact in restoration of forest in Manas biosphere reserve is an unique example of success where different local communities and NGOs have been working together for sustainable use of the natural resources as well as come forward to promote natural forest restoration processes in Indo-Bhutan area.

The human impact of forest community in the eastern buffer of Manas biosphere reserve has resulted environmental problems like water scarcity, human elephant conflict, biodiversity loss through the effect of forest loss, change in the natural forest structure at tree and undergrowth level, degradation of soil texture and nutrient contents. However some positive initiative in a few pockets using active community participation has resulted in forest restoration which may be modified and helped in the future management of the Manas biosphere reserve.

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