CHAPTER-V
GENERAL DISCUSSION

The Rani Forest Range, the location where the present investigation is carried out falls under the jurisdiction of East Kamrup Forest Division which comprises of three reserve forests namely Rani Reserved Forest, Jarasal Reserved Forest and Kwasing Reserved Forest. The Rani Reserved Forest has become a place for visitors for its unique hills and forests with number of wild animal species though lately it has become a place of activities of smugglers of timbers and other illegal activities. The Rani Reserved Forests is more sensitive as compared to the rest of the reserves for having a common boundary with the state of Meghalaya in the south and for its 35 km of common boundary with the great Garbhang Forest on the eastern side. It is one of the largest and oldest reserved forests in the State of Assam. Its conservation history dates back to the year 1882 when it was proposed as “Reserved Forest” under the purview of the Indian Forest Act VII of 1878. The reserved forest besides having unique and rich species diversity also houses two focal animal species, listed as endangered, namely Hoolock gibbon (Bunopethus hoolock hoolock) and Asian Elephant (Elephas maximas) the conservation of which depends upon the conservation of the habitat. The Reserved Forest has northern boundary with Deepar Beel, the lone Ramsar Site in Assam and is endowed with rich floral and faunal diversity. Besides, it also attracts large number of residential and migratory birds. The area contains both seasonal and perennial streams and rivers which greatly influence the climate and subsequently the vegetation of the area. Besides, different tribes/communities reside in the fringe areas of the reserve and because of their poor socio-economic conditions, they traditionally dependent on different forest resource for most of their requirements. This has put an additional pressure on the different resources of the reserve and thereby changing the present landuse pattern of the area.
The findings of the study show that the Rani Reserved Forests are of moist mixed deciduous category having three storeyed forest community with top and middle strata comprised of various tree species of various height and ground strata is dominated mainly by shrubs, undershrubs, herbs and few tree seedlings. Older formation of the dominant tree species found in the undisturbed sites of the reserved forest have been found to play major role in habitat modification and litter input. Besides, they also play an important role in supporting other epiphytic plant species and provide shelter for a variety of smaller animals and insects. It is also found that due to excessive logging pressure, there is extinction of many tree species in certain sites. Present findings also show that the floristic composition of the Rani Reserved Forest is mainly dominated by trees and herbs with sparse occurrence of shrubs and undershrubs and epiphytes. There is however, moderate occurrence of climbers adding to overall floristic composition.

In the present investigation, based on the intensity of disturbances and their impact, three experimental sites are selected for phytosociological studies and landuse characteristics. The Site-I so selected is located in Satargoan and is free from major anthropogenic disturbances. It showed the canopy cover of 64.33 per cent during the year 2002 that declined to 47.89 per cent in the year 2005. The Site-II located in Chakardeo showed a moderate disturbances in the form of logging, grazing, looping etc. and also showed decline of canopy cover from 47.0661 per cent in the year 2002 to 39.594 per cent in the year 2005 while the Site-III located in the Matiya locality is severely disturbed in the form of excessive grazing, logging operations, earth cutting. It had canopy cover of only 16.35 per cent in the year 2002, showed a marginal increase of 16.6 per cent in year 2005, which may be attributed to the process of regeneration in some species in these exposed sites.
A disturbance of intermediate intensity may lead to increased diversity value while continued disturbed condition would result in depletion of species diversity. According to the hypothesis of intermediate disturbances (Connel, 1978; Decocq et al., 2004) the highest number of species is expected in areas with an intermediate frequency and amplitude of disturbances, a pattern described by Eggeling (1947). According to "non-equilibrium hypothesis" by Connell (1978), when there is exposure to frequent disturbance, the fast colonizing plant species mostly annual plants would have the chances to establish in a community before the reoccurrence of the disturbances and as the time interval between the subsequent disturbances increases, more specialist plant species are supposed to migrate into the existing community and this results in the increase in species diversity (Hobbie et al., 1994; Connell, 1978). The randomly occurring periodic disturbances caused by man made activities or through natural anthropogenic events are known to maintain high species richness and limit competition and exclusion (Brunnet et al., 1996); while low diversity has been observed in very high or low level of disturbances (Gillison, 2004).

The opening of canopy cover in the natural forest as a result of various biotic interference paves the way for the entry of invasive species and this changed the species composition of the study sites. It is also observed that a species may regulate biogeochemical cycles (Vitousek, 1990; Zimov et al., 1995), alter the status of disturbance regimes (Dublin et al., 1990, D’Antonio and Vitousek, 1992) or modify physical environment (Jones et al., 1994; Naeem et al., 1994). Natural vegetation has been subjected to dramatic alterations, largely through human interference, like selective felling of trees which often leads to the removal of functionally important species especially the top canopy species that drives the forest ecosystems. In some place the native vegetation is altered to such an extent that it is difficult to recognize the potential
native vegetation and its constituent species. There is also general proposition that complex communities are less susceptible to invasion than simplified communities. The formation of forest communities is the result of effect of the successful competition of a group of the canopy species for space and energy. The results show that with the increase of canopy cover, there is shift in the species composition and structure of the community from heliophytic to more shade tolerant species. The canopy of trees thus perform the physical ecosystem engineering by directly influencing the light energy and indirectly, by influencing the nutrient status through their litter production and input. The canopy of the species besides being responsible for modifying habitat conditions and acting as ecosystem engineers also plays an important role in nutrient cycling. Frequency, intensity and spatial influence of disturbances determine the population response and simultaneously recover following perturbations. Localized and wild disturbances created “gaps” that plays a significant role in maintaining diversity of forest. The prevailing gap area in forest community has been gradually covered by regeneration of different species that resulted in the formation of close canopy of diverse vegetation during primary forest succession. Barik et al. (1992) reported that the seedlings of Quercus sp. resulted mainly in the small gaps and forest under storey while those of Schima wallichii were abundant in larger gaps and disturbed stands. The diversity was quite high in a rich canopy forest, while poor canopy occurred during continuous logging pressure and in this site there is less tree diversity. The findings of various workers show that canopy cover was positively correlated with species diversity (Hayashida et al., 1991; Lawson et al., 1999; Satoo, 1999; Brosofske et al., 2001). The presence of dense canopy cover limits sunlight and seed availability and seed bed are some of the important factors that maintain the density of tall tree composition.
Changes in canopy cover influence the ground vegetation and species richness of the subcanopy and undercanopy layers. Changes in canopy also have a strong impact on soil properties. It may cause increase in soil temperature, accelerate soil erosion due to increased surface run-off, cause decrease in soil moisture and ultimately it may affect the nutrient balance of the soil system (Schulze and Gerstberger, 1994). The presence of canopy species and other functionally important species is of paramount importance for the continuity of the ecosystem when faced with environmental shifts (Solbrig, 1994). Canopy species with their continuous canopy covering played a major role in controlling light regime and its distribution into other strata of the communities. They may be termed as physical ecosystem engineers (Jones et al., 1997) that are directly responsible for the existence of microhabitat types through their canopy effects and indirectly, influence the species richness in the lower strata of the forest vegetation. The saplings of pioneer species survived poorly under the dense canopy cover while survivor grew rapidly under sparse canopy. On the otherhand, an under canopy specialist survive poorly under dense canopy while the generalist showed higher survivality and slow growth rate under different canopy cover (Walden et al., 1991).

Present investigations show that many plant species viz Lantana camara, Chromolaena odorata, Michienia scandens, Melastoma malabathricum are found to invade in areas of clear felling for forest plantation. It is also found as ground cover in teak plantation. Heavy grazing pressure also creates micro sites that are invaded by different plant species such as Lantana camara, Argemone mexicana, Evolvulus nummularius and few grass species such as Auxonopus crassipes, Chrysopogon aciculatum. Thus, the preponderance of plant invasion takes place in the disturbed habitats and rarely in climax/mature communities also supports the results as reported by Thomson (1988).
The increasing human population, increased requirement of timber and fuelwood, expansion of croplands and change in other landuse practices, enhanced grazing are the various causes of deforestation. Forest fragmentation is associated with plant and animal extinction, damage to the ecosystem and loss of biodiversity. This has also resulted in net reduction of natural habitat availability and creation of forest patches at a distance which prevent movements of plant propagules and animals through forest corridors. Growing population and its dynamics such as immigration, urbanization, industrialization etc. are some of the fundamental factors that drives changing land use pattern. Different anthropogenic activities such illegal resource exploitation from the forest, illegal burning, earthcutting, mining operations, grazing and also phytoinvasion, all play a significant role in the development of plant diversity and community structure in Rani Reserved Forest. Removal of vegetal cover brings marked changes in the local climate of the area and brings about changes in rainfall, temperature, wind velocity etc. and this also leads to soil erosion. Dense forest has become moderate forest and subsequently moderate forest has gradually converted into open forest. Population density was considered as proxy for domestic demands for forest and forest based products (Polo and Mery, 1986). Deforestation is linked with different components of the population dynamics in the past (Bilsborrow, 1987). Topsoil provides supporting system for higher forms of life and act as medium for interaction of millions of micro-organisms to keep the soil in dynamic state. Plants and animals renew nutrients and improve the topsoil, each helping one another in this complex cycle of ecosystem. Topsoil lost in the form of soil erosion affects the productivity of soil and such soil needs additional inputs such as irrigation and fertilizers for consistent and higher production. The loss of topsoil reduces the organic matter and aeration and soil structure is adversely affected. Disturbed microclimate status of the topsoil is associated with reduced nutrient status and results in the loss
of whole organic system. Unscientific agriculture, construction of railways, roads, reservoirs etc., besides other human activities like indiscriminate felling of trees and faulty management of land and water all leads to degradation and destruction of soils. Deforestation, overgrazing, over cultivation, industrialization and unscientific cultural practices denude the land of its protective green cover, hastening the process of soil erosion, degradation, waterlogging and salinity. Deforestation particularly in slopes, that are carried out to meet the ever increasing demand of food, fuel and fodder brings about soil erosion and soil degradation. Deforestation have favored accelerated surface run-off, reduced ground water recharge and severe soil erosion resulting in deterioration of soil, loss of plant nutrients, lower yield and flooding of lowland areas.

Thick plant cover formed by leaves and branches of trees and the vegetation cushion formed by the grasses retards the rate of removal of topsoil in the form of run-off by breaking the force of rain water and thereby holds the soil tightly with the root system. Destruction or removal of such cover leads not only to removal of topsoil but also form gullies, ravines, deserts etc. Results of the present investigation show that annual soil loss is maximum (3200.5 gm/m²/year) in bare soil without any plant cover where as minimum (534.7 gm/m²/yr) soil loss is noticed in plots under natural forest cover. Thus lack of vegetation cover and disturbances as a result of cultivation, grazing, unscheduled felling of trees, earth cutting etc. make the soil vulnerable to soil loss and to accelerated erosion and this expose the bedrock within a short span of time. This loss of soil takes place much faster than the formation of new soil. Natural erosion is a slow process but erosion through external interference is markedly devastating creating bare areas of depleted green cover besides poor quality of soil in terms of nutrient value and moisture regimes. Such areas are not conducive to revegetation. Thus, vegetation keeps the soil in natural state and protects it from erosion (Davis and Bemstan, 1991). Malthius theory (1798) also observed that
the growing population put pressure on various natural resources that are in limited supply including forest resources.

The landuse/land cover map prepared from the satellite imagery in the present study indicates that the reserved forest mostly consist of moist mixed deciduous forest. Some patches of evergreen and semi evergreen forest are also found in few locations along the fringe of rivers and streams. The degraded areas in the form of scrub forest are also seen to occupy a major portion of Rani Forest range. A comparison study of landuse/land cover map of the reserve of the year 2001 and year 2005 reveals that there is increase of degraded area in the form of scrub forest amounting to 15.03 hactare. Similarly, the dense forest has been reduced by 27.13 hactare, moderate forest decreased by 44.2 hactare and open forest increased by 53.13 hactare during the period 2001-2005. This increase in the degraded forest may be attributed to the substantial increase in the population density in the fringe areas and corresponding increase in grazing pressure from the livestock on the existing forest areas and opening up of the canopy cover of the forest. It is also observed that such increase in open areas is the main contributing factors for accelerated soil erosion process.

Soil types in different study sites under different landuse/land cover categories in Rani Reserved Forest were mostly of sandy-clay-loam in texture; while soil sample in degraded/bare land area is primarily of sandy loam texture. The concentration of different nutrients was fairly high in upper soil layers and gradually decreases with increasing soil profile depth under different landuse practices.

According to Morison et al. (1952), land surface in tropics tends to be a mosaic of different soil types and shows a close relation with natural vegetation. Results of the present
investigations on physico-chemical characteristics of soil of Rani Reserved forest show that there are some significant variations in the quantity of sand, silt and clay fractions with the increasing profile depth and under different landuse practices. Finer salt and silt clay content increased with increasing depth of the soil profile confirming the observations of Lal et al. (1988). Results also show higher moisture content and water holding capacity value of 11.5 per cent and 43.1 per cent respectively in deeper soil horizon under natural forest as compared to other landuse/land cover condition. It is also observed that there is decrease in content of silt and clay fractions with increasing depth of soil profile under various land use condition. Soils under natural forest show pH value ranging from 6.3 to 6.5 as compared to 5.3 - 5.85 in the soil from degraded areas. Besides, soil samples from bare or degraded sites showed poor nutrient content with per cent of nitrogen content of value 0.002, phosphorous content of 0.06 kg/acre and potassium content of 15.22 kg/acre. This may be attributed to decrease plant cover, poor litter contribution and low mineral cycling and increased soil loss through various soil erosion processes. The soils under moist deciduous forest are seen to be relatively rich in organic carbon and nitrogen value. Barring the degraded/bare soil, the top soil of few centimeter depth in all soil of other land use conditions contain at least 2.5 per cent of organic matter as compared to 1 per cent organic matter content usually found in the soil depth of 30 cm. The results also show higher values of nitrogen, phosphorous and potassium content in soils having grass cover, plantation forest and sites under various conservation treatments. This may be attributed to effective soil binding capacity of grasses and plants of afforested sites or impact of various conservation treatments as a result of prevention of the nutrient loss through surface run-off and thereby contributing to a high turnover rate of the nutrients in soil. The greater accumulation of litter in the undisturbed forested sites results in better soil nutrient cycling as compared to disturbed sites and this may be
partly attributed to the change in state of dominance and invasion by some secondary plant species in the disturbed stands. The increase in organic carbon in different conservation treatments may be due to better nutrient turnover and mineral cycling of the deposited organic material, which substantiate the earlier findings of Ghildyal et al. (1962) under forest cover. Thus, chemical characteristics of soil depend on its salt content, pH, organic and inorganic nutrients such as Nitrogen, Phosphorous and Potassium. The condition of soil is also known to control by factors like topography, climate and organisms inhabiting in it. The heterogeneous distributional pattern of nutrients in soil can be attributed to variability of erosion forces on soil nutrients movements from different canopy cover and uptake and sequestration of nutrients in accumulated litter and soil organic matter under different canopy cover. Soil properties may also change due to different management practices or biotic and abiotic influences on soil properties.

In all the soil profiles studies under various landuse practices, organic matter content has shown a gradually declining trend with increasing soil depths, attaining the highest value in the top layer. This may be attributed to the availability and access to the principal source of soil organic matter in the form of surface deposit of leaf litters and mineral cycling under favorable forest floor condition, makes the soil horizon lying immediately beneath it most enriched. The quality and quantity of litter deposited in the soil also determine the differential levels of available soil nutrients. Moreover, higher litter production by certain species is due to various factors like age of the tree, leaf area, texture, canopy exposure, basal area etc. (Bell et al., 1978) and this contribute to higher nutrient return through litter fall. The low soil fertility in scrub forest and still very low in bare soil may be due to lesser organic matter return through litter fall as compared to rich fertility value of soil under natural forest through greater contribution of leaf litter. Thus, better understanding of profile characteristics such as soil texture, water holding
capacity, pH, organic matter content are very essential to determine the erodibility and utilization pattern of the land.

Rani Reserved Forest enjoys a subtropical monsoon climate. The subtropical forest are known to produce comparatively greater amount of leaf litters than the temperate forest and its rate of decomposition and mineral cycling is also faster (Singh, 1967). The data for the different soil characteristics such as available organic matter, nitrogen, phosphorous, potassium, moisture content and water holding capacity showed values of decreasing order viz Moist-Deciduous Forest > Teak plantation > Scrub forest > Barren land. It is seen that the nutrient status of soil varies considerably in different land use practices and depends mainly upon the rate of mineral cycling of organic matter of plant origin. Thus, a dominating species present in particular habitats regulates the physico-chemical properties of soil and also the soil microbial characteristics. Results show some differences in soil properties among teak plantation of different age groups. It has been observed that there is improvement in nutrient status with the increase in the plantation age. The soil organic matter also shows an increasing trend with increasing age of plantation which may be due to rich litter accumulation and greater period of mineral cycling contribution. Moreover, due to intense decomposition process, there is more soil humus availability for higher soil moisture content in the forest floor. Besides there is better infiltration of water and organic matter by the agency of percolating rain water to the root zone for better mineral uptake which is clearly evident in the soil nutrient value of old plantation sites. Due to dense canopy cover of Natural Forest, the value of soil moisture is found to maximum in comparison to scrub forest, plantation forest and deforested or barren sites. It is also observed that on opening up of canopy cover, the forest floor soil loses its ability to hold nutrients and solutes in the soil and nutrient capacity.
recovery starts only when secondary plant succession follows naturally or through human manipulation leading to development of mature forest ecosystem.

A number of streams and rivers that flows through the Rani Reserved Forest often carry large amounts of silt and sand particles mainly due to the direct or indirect impact of anthropogenic activities and deposits in Deepar Beel and other waterbodies. Besides, erosion in the fringe areas of Rani Reserved Forest may results in lowering the water depth of the Beel and correspondingly increases in the area of water spread. This also causes serious hindrance on the growth and survival of native floristic characteristics.

The results of slope induced soil erosion studies show that slope value of 5 per cent in the hill slopes of Rani Reserved Forest in the year 2003 could cause annual soil loss under different land use practices. In such situation, the site with Natural forest, teak plantation, scrub forest areas, barren land areas and grasses cover areas show soil loss value of 534.7 gm/m², 570.7 gm/m², 2650.3 gm/m², 3200.5 gm/m² and 670.5 gm/m², respectively. It is noted that there is wide range of variation in soil erosion status due to factors like slope per cent, canopy cover and run-off value. It has been observed that loss of organic carbon increases with the increase the degree of slope value from 5 per cent to 10 per cent. Similar results have been observed for soil loss with increased slope value. Therefore, erosion status confirms the state of ongoing deforestation in nearby place in one or other form. As a whole the extent of soil erosion and soil loss depend on different factors such as characteristics of soil type and soil depth, land slope value, organic matter content of the soil, duration and intensity of wind and precipitation, landuse practices.

Present investigation on the impact of run-off shows that in the slope value under 5 per cent there is maximum run-off and soil loss in sites devoid of plant cover followed in order by
sites in degraded scrub forest, teak plantation forest and Sal plantation forest. The minimum run-off and soil loss were observed in sites treated with mulch material of grass which may be attributed to reduction in velocity of run-off by 50 per cent as compared to bare areas where no soil conservation measures have been adopted.

It is seen that fine textured soil such as clay loam, the finer particles are arranged in crumbs that are porous and absorb water readily and are resistant to erosion. But in case of coarse textured soil like sandy soil, high infiltration and permeability results in rapid water absorption and are prone to erosion. Organic matter also helps in formation of better and more stable soil aggregates and keeps the permeability of the soil high and decrease in organic matter content leads to the erodibility of soil. However the removal of soil particles by run-off during erosion depends on amount, intensity, duration and frequency of the precipitation. Besides, the chances of erosion is greater when precipitation is not only heavy but concentrated in shorter time interval rather than light showers covering over longer periods of time because run-off rate exceeds infiltration rate in such case.

It has also been observed that soil loss in run-off is significantly reduced when such land is put under natural grass cover and this substantiates the findings of Bhatt et al. (1971) and Bhola et al. (1975). It is observed that native grass species when planted on degraded or barren sites, provides a quick hugging cover which act as some sorts of cushion against the impact of falling raindrops. Besides preventing dislodging of soil particles by their extended root system, it also reduced soil erosion process to a large extent as compared to sites under different land use practices. Such phytoremediation through grasses can also be combined with the mechanical measures for more effective soil protection as suggested by workers like Rege (1956). It is also observed that dense canopy and extended root system of grasses firmly bind the soil against
erosion process besides increasing the rate of infiltration and improvement of physico-chemical characteristics of the soil and soil stability. Such ability of the grass root system bind the soil particles together and providing excellent protection and structural ability to the mechanical measures is observed by Prajapati et al., (1973). The thicker emergent growth and presence of stolons are suggestive degree of ramification and have direct bearings on soil binding characteristics (Bhimaya et al., 1956). The grass root has also been found to improve soil structure by developing water stable soil aggregates and mean weight diameter (Nambiar et al., 1968). Grass cover has been employed in stabilizing earthen structure, protecting bunds, badly eroded areas and gully control. Perennial grasses are known to provide better protection to soil as compared to seasonal grass and monoculture species because of adequate soil cover and less soil disturbances. Present study also confirms that with increase slope per cent from 5 per cent to 10 per cent leads to increase of the soil erosion. This is in conformity with the findings of Woodruff and Smith (1930-35), Brost and Russell (1940), Hays et al. (1944) and Browning (1948). Thus, vegetal cover provides soil protection by intercepting the impact of the falling raindrops and reducing its impact on the soil surface and also reducing the velocity of surface flow.

The present findings also led to the conclusion that the saturated soil promotes marginal increase in run-off and soil loss value than dry or unsaturated soil because of increase in antecedent moisture content.

The type of vegetation cover and its density regulates the soil erosion by water factor. In Rani Reserved Forest many plant species are found to have extensive roots systems which includes having such characteristics are Daubanga grandiflora, Bauhinia variegata, Holarrhaena antidysenterica, Pithecellobium monadelphum, Careya arborea, Terminalia chebula, T. bellerica, Ficus religiosa, F. benghalensis, F. rumphii, Sapindus mukorossii,
Among herbs and shrubby plants which have also extensive root extensions include *Imperata cylindrica*, *Phragmites karka*, *Tabernaemontana divericata* are found commonly growing as undergrowth vegetation. These plants besides arresting soil erosion also help in building stable soil structure by increasing the porousness and infiltration of the soil for better absorption of rainwater thereby reducing surface run-off and soil erosion.

In the present investigation, treatment with mulches of grasses, tree leaves and other locally available plant materials are found to reduce the run-off rate and amount of soil loss to great extent thereby minimizing onslaught of soil erosion. Under 5 per cent slope value the rate of run-off reduced from 28.3 mm to 13.7 mm and soil loss reduced from 65.34 gm/m² to 22.4 gm/m² respectively as a result of vertical grass mulching technique of treatment compared to exposed bare sites. It has been observed that decomposition of mulching material add to the turnover of organic matter to the soil and prevents crusting by reducing the exposed soil surface area to the impact of raindrops, decreases the velocity of water by imparting roughness to the soil surface and thereby resisting the normal flow of run-off of rain water. Besides, mulching have been found to promote growth of trees in degraded soils. The mulching material binds the soil particle, regulate the surface evaporation and thereby increasing the status of soil moisture. Thus, mulches provides surface protection against erosion and maintain soil moisture content by promoting infiltration. It can thus act as effective tool and can be supplemented for the costly mechanical measures like contouring and graded bunding.

The study sites comprises of bare areas or exposed lands are highly prone to erosion hazards due to steep sloped landscape, lack of adequate plant cover, wrong landuse practices, overgrazing etc. Such areas serve as nuclei for development of surface deformities like rills and gullies mainly due to lack of vegetal cover and depleted infiltration rate.
Mining operation in the Rani Reserved Forest is another human factor that has multi-dimensional impact on the ecology of the area. It leads to damage of the fertile topsoil and water resources. Deforestation leads to landslides and erosion problems and soil loss which are further aggravated by steep, sloppy landscape.

Therefore, proper landuse practices as well as soil and water conservation practices need to be adopted to arrest further environmental degradation of the soil. An observation was made by Singh et al. (1990) that slopes more than 50 per cent should be brought under permanent vegetation of suitable fuel-fodder tree species and grass bed, with soil conservation measures like contour trenching and contour furrows. It is also suggested that afforestation with different local plant species when carried out in degraded and barren/fallow land after necessary soil amendment will increase the forest cover, fulfil many growth requirements of forest and reduce the adverse impact of population pressure. Regeneration of species in disturbed sites or as undergrowth in forest plantation occurs through regrowth of vegetative propagules including soil seed bank resources. Ecophysiological attributes like resource allocation patterns, nutrient relations provides explanation for relative abundance of native and non-native species under different disturbances regimes. Species which has the attribute of fast growth and greater reproduction facilities render some plants as successful invaders and colonizers (Saxena and Ramkrishnaan, 1984).

It is also observed that clearing of forest by the encroachers and fringe area people led to changes in vegetation resulting in preponderance of secondary growth of species different from those of primary forest. Besides, there is depletion in nutrient availability due to replacement by the fast growing species of the secondary forest coupled with slow rate of mineralization as has been observed by Saxena and Ramakrishnan (1986). The nutrient stress as well as limited
availability of light source results in lower net primary production in the plants of later successional stages.

The results of study on various stages of plant succession in different experimental sites under different land use practices show that the Site-I is natural forest of 100 years old and most of the species found here are representatives of the climax stage. This includes different species of trees, shrubs, undershrubs, herbs and climbers. The plants found are mostly the characteristics of moist mixed deciduous category, besides the occurrence of few evergreen species of trees such as Sterospermum chelonoides, Phoebe goalparensis, Syzygium cumini, Garcinia pendunculata. The Site-II is represented by secondary scrub forest and originated from earlier primary forest as a result of various factors including the anthropogenic activities and therefore its vegetation bears some similarity with the earlier elements of natural forest due to its close proximity and other allied factors. The Site-III, on the other hand is a recently form degraded forest area and the pioneer species that colonizes here are different grass species like Imperata cylindrica, Phragmites karka, Saccharum spontaneum, Thysanolaena agrostis and found to be tolerant of deficient water and nutrient condition. The sparse canopy cover in such area promote the migration and growth of various exotic and gregarious weeds such as Chromolaena odorata, Lantana camara, Michenia scandens etc and establish themselves successfully. As a result of their aggressive nature and efficient nutrient extraction capacity, these weeds overgrow the native vegetation and hinder the regeneration process of many of the native species. The dominance of weeds in the forested area results in biomass reduction as well as increased proportion of foliage (Bhatt, 1989). Here seedlings and saplings of some tree species such as Sterculia villosa, Cassia fistula are also found amidst the secondary vegetation though plant growth is inhibited in such adverse conditions found in degraded area owing primarily due to top
soil removal, high eroded condition, low organic matter content and nutrient supply as stated by Meyer (1973). Besides, various biotic disturbances, many forested areas retrogressed to early successional condition leading to more exposure of forest floor to drought, wind current, run-off forces and soil erosion. The availability of soil nutrients and more often nitrogen availability, determines the direction of succession process (Tilman, 1988). Nitrogen may accumulate, especially during primary succession and this accumulation may drive the successional sequence (Tilman, 1985). In other pattern of succession, light source is found to be the main limiting that regulates successional process (Shugart, 1984; Tilman, 1985).

Present investigation on vegetation recovery through natural process of succession and regeneration in degraded land reveals that the abandonment of degraded site for more than 10-12 years has comparatively greater number of species than sites with 5-6 years and 2-3 years fallow period. The reason for this can be attributed to creation of suitable habitat condition by early colonizers for successive seral communities. Moreover, physicochemical properties of soil are also found to improve considerably with increasing interval of abandonment. The nutrient content increases with increasing time interval of abandonment of the sites and this change habitat condition leads to change in species diversity leading to development of stable community. These findings corroborates with the results of Pandey et al. (1988). This may be attributed to natural regeneration in the experimental sites and correspondingly greater litter contribution, better canopy coverage and other allied factors. It is also noticed that low organic matter and low nutrient status as well as shallow soil profile depth act as limiting factor in growth and survival of tree species. However, the conversion of abandoned area into forest takes place at a relatively faster rate if human intervention in the form of plantation of indigenous plants is carried out so as to boost the natural recovery process. Forest plantation of indigenous
and exotic plant species also plays a positive role towards ecosystem rehabilitation by facilitating
direct natural successional processes. Such plantations reverse the process of degradation by
stabilizing soils, increasing organic matter input, moderation of pH and improvement of soil
fertility (Singh et al., 1990; Parotta, 1992). Results of present study show that establishment of
woody species can be successfully carried out in facilitating recovery by enhancing seed dispersal
and shading out pasture grasses. Thus, degraded areas can be reclaimed through some soil
management and cost effective investments leading to establishment of permanent vegetation
which in due course of time will stabilize soil structure and check erosion and soil loss.

Ecological investigation on the process of natural vegetation succession in degraded land
sites provides information on future trends of succession. In this different agro forestry landuse
system for moderately and highly disturbed sites, models may be prepared for restoration of
degraded sites like plantation of nitrogen fixers along with suitable grasses which stimulate rapid
development of multistoreyed forest. This requires suitable soil and water conservation and
management and proper afforestation policies and plant selection that will allow organic matter
enrichment, speed up the nutrient cycling and reduce soil erosion.

Studies on ground vegetation under teak forest plantation of different age interval show
that number and kind of undergrowth species in young teak plantation was found to be maximum
and here the species that cohabit with teak plant were Chromolaena odorata, Biophytum
sensitivum, Desmodium gangeticum, Imperta cylindrica, Clerodendrum serratum besides some
climbers such as Cissampelos pareira, Argyreia speciosa, Smilax macrophylla. In teak
plantations of more than 15 years age, less number and kind of species were noticed. This may
be mainly due to shade effect inside the old plantations besides heavy deposits of litter that
adversely affect seed germination and growth of ground flora. Results also show that there is
similarity of undergrowth species between teak plantations of different aged period. It is also observed that not only macro-environmental condition but also the nature of plant species change the microclimate and soil properties that in turn affect floral diversity of the ground vegetation. Moreover, the soils under forest plantation usually contain high organic matter, adequate moisture availability and this accelerates the decomposition process (Maithani et al., 1996). In normal case this high fertility level under forest plantations may be attributed to less biotic and abiotic interferences as opined by Kunhikannan et al. (1998). The better fertility status of soil under forest plantation of different age period may be not only due to better cycling and sustainability of forest floors and favorable environmental conditions but also efficient soil conservation mechanism assisted by multifacical benefit obtained from undergrowth vegetation.

It is also observed that forest floor when exposed to direct sunlight could lead to rapid decomposition of nutrient rich forest floor litters losing many volatile components in the process. In such cases, the forest floor soil is more prone to erosion even to a moderate surface run-off. It is also seen that the degraded forest areas degenerate into scrub growth and generally comprise of aggressive shrubs and weeds with few tree growth represent the remnants of earlier forest.

A correlation is also found to exist between soil profile depth and physical characteristics of soils. The clay content, water holding capacity and moisture content all show an increasing trend with depth but the silt content show a decreasing trend under different landuse condition. Moreover, with the increasing soil depth, the concentration of different nutrients such as nitrogen, phosphorous, potassium etc. show a gradual decrease.

The results show that organic matter is maximum in soil under natural forest cover and least in bare exposed soil. However if the organic matter is allowed to retained, it improves the
physical texture and structure of the soil through binding of the soil particles, by improving infiltration capacity of the soil and regulating surface run-off, facilitates and permits root growth and reduces the impact of raindrops thereby reducing erosion and increasing the water-retention capacity and permits percolation that ultimately improves in recharging of ground water.

The field study was supplemented by Remote Sensing technology with use of aerial photographs and satellite imagery. It is observed that area under Moist Deciduous forest is decreasing and it is converted into various land use practices. The scrub forest on the other hand shows an increase in area during the period 2001-2005. Certain measures like engaging degraded land into agriculture activities or allowing it to remain free from external disturbances may lead to ecorestorations of such areas. For this, different plant species has been screened out from the local flora of Rani Reserved Forest areas. Since the process of natural regeneration is a very slow process, interference by man is necessary to quickly upgrade the ecosystem and climax vegetation. Several shrubs, herbs and grasses such as Calotrophis gigantea, Datura stramonium, Lantana camara, Imperata cylindica, Phragmites karaka and Teprosia purpurea are good soil binders and organic matter enrichment. They also provides protection and stability to soil and seedlings of other plants through mulching effect.

Conservation-oriented farming practices are required to maintain soil health, particularly in areas of intensive cropping and where soils are marginal for agriculture. Secondly, soil health can be maintained or improved in regions where landuse and management practices have been tailored to address soil resource and climatic influences that may combine to produce local problems of soil degradation. Finally, declines in soil health occur rapidly, often most dramatically in the first 10 years following conversion of undisturbed land to agriculture, but improvements to soil quality take place slowly and at greater cost than maintaining a good soil in
top condition. For afforestation of degraded areas or bare land, the choice of species should be such that the demand for inputs is least and attention needed is negligible. The species chosen should have deep and extensive root system, fast growing and hardy. This will help in reconstructing the lost topsoil and bring the much needed rest and respite to the soil from the forces of erosion. Apart from the selected species and grasses, there are many shrubs and trees that are natural colonizers which help in controlling erosion and degradation.

The results of CCA applied to the transect data for both tree species and undergrowth in different study sites show inconsistent results based on tree and undergrowth diversity. The Satargaon site which is a natural forested area with minimum disturbances shows a very slight increase in rare species, Chakardeo site is more or less similar to Satargaon site, while Matiya site which is heavily disturbed, shows a gradual decline in rare trees that are replaced by common tree species from the year 2002 to 2005. The ordination of species shows the presence of component species of semievergreen and evergreen nature that are scattered in the moist deciduous forest. Satargaon site is characterized by Cedrela febrifuga, Matiya site by Firminia colorata and Tectona grandis, while Chakardeo site by different tree species such as Cassia fistula, Flacourtia cataphracta etc. Replanted and regenerated species are more common in Matiya site, where as in Satargoan and Chakardeo sites, original and old growth is retained up to large extent in spite of disturbances.

Present investigation show that different environment parameters when fitted to the ordination in CCA shows that the natural forested site (Satargaon) are rich in different minerals and organic carbon and show an increase in pH, moisture content and water holding capacity. Clay content is also found to be more here. This is due to more litter contribution from various types of trees and corresponding high rate of decomposition and mineralization under favorable
environmental conditions. On the other hand in the Matiya site, nutrient status and other properties of soil are poor. An increasing trend is also observed in regard to sand and silt per cent which can be attributed to increased annual run-off (ARO) and total soil loss (TSL) under 5 per cent and 10 per cent slopes. The vegetation composition of Matiya site, which is completely degraded, contributes to these factors and are clearly reflected in the ordination. Chakardeo site on the other hand, does not show significant changes in the nutrient status of the soil. Annual run-off and total soil loss also does not differ much between 2002-2005.

Good land use is the best of all conservation practices. If the principles of soil conservation are followed strictly, the process of erosion can be retarded to large extent, if not altogether halted. The method of conservation comprises safeguarding all kinds of land from vagaries of weather. Steeper land with shallower soils should remain undisturbed, but should remain in its natural state as it the source for underground water table and a home for wildlife. Adoption of soil and water conservation measures for efficient utilization of land, water, vegetation and human resources is the only solution to meet the ever increasing demand of food grains, fodder, fuel wood and fibre for the ever growing human population.