IMPACT OF ANTHROPOLOGICAL STRESS ON FLORAL COMMUNITY STRUCTURE IN PAMBA RANGE OF PERIYAR TIGER RESERVE: AN RS AND GIS SUPPORTED BIODIVERSITY SURVEY

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INTRODUCTION

Biodiversity refers to the range of life forms on earth; include millions of plants, animals and microorganisms, the genes they contain and the intricate ecosystems of which they are a part. The indiscriminate anthropological activities result in devastating reduction in number and size of biodiversity. The natural resources of earth including the air, water, land, flora and fauna especially natural environment must be protected for the benefit of the present and future generations through careful planning and management.

Forests the main body of the terrestrial ecosystem, is a complete natural resource base, a stock of assets, serving as a source of scarce inputs that can yield utility through production or provision of goods and services. All over the world, especially in developing countries like India, the mounting population pressure has lie to poor carrying capacity of forest resources. Forest cover has dwindling and at present many countries have much less of its land area under forest cover than required to maintain its environmental stability and ecological security.

Forests are biologically rich areas and facing serious habitat fragmentation and species extinction. Majority of Indian forests are also facing serious anthropological stress. Western ghats region, which is one of the biodiversity 'hotspot' of the world also facing various types of threats.

In India pilgrimage tourism activities are inseparable part of culture and many rituals are related to natural resources such as rivers, hills ranges or forests. Recently with the advent of devotees to these shrines and also with the advent of 'Pilgrimage tourism' ecological problems are merged in all fronts, at almost every pilgrim centers.

Kerala is a conglomeration of diverse type of ecosystems, with various forest types. Lord Ayyappa's Sabarimala shrine, which is the most famous Sasta temple in Kerala attracting lakhs of pilgrims every year. The temple is located in the southern portion of Periyar Tiger Reserve (PTR) at an elevation of 467 m above Mean Sea

Level and with in the longitude of 9 ^{0} 25' 0" and 9 ^{0} 27' 0" N and latitude of 77 ^{0} 2' and 77 ^{0} 5" E.

Periyar tiger reserve is the largest protected area in Kerala established on 1978 as tenth tiger reserve in India. The protected area was located with in longitude 9^{0} 16' and 9^{0} 36' N and latitude of 76^{0} 57' and 77^{0} 25' E, and has an area of 777 sq. Km. The area was supporting rich and rare unexplored fauna and flora.

Sabarimala temple is situated in the west division and Pamba range of PTR. The temple and foot path from Pamba tirveni – Sannidhanam (5 Km.). Kalaketty-Pamba (22 Km.) and Pullumedu- Sannidahanm (12.8 Km) are passing through unique low altitude evergreen forest lands and many rituals of Sabarimala temple is related to these forest areas also.

Each year millions of devotees are visiting Sabarimala temple especially in ' Mandala- Makaravilakku season from mid November to mid January. For the development of infrastructure facilities large areas of forestland was cleared every year. During the festival season for the construction of temporary shelters, shops ad toilets and collecting fire woods by hotel workers have devastating effect on forest areas.

The transportation and traffic during Makaravilakku season have also causing much damage to forest areas. Because of the lack of sufficient sanitation facilities to cop up with the increasing demand, pilgrims use the sides of river and trek path for defecation purpose. Open defecation and flushing out of human excreta to the holy river is an every day seen at Pamba, during peak season. The problem draws more attension considering the fact that the pilgrims use the same water for bathing and even for drinking purposes. Conservation and eco restoration of this area is urgent for the future development of this fragile ecosystem.

The present mode and pose of development activities in the area was carried out with out considering the biodiversity richness of the area. However very little

studies has been reported on biodiversity richness and loss in the area. Extensive developmental activities are going to be implemented under Sabarimala master plan and Pamba action plan.

The present study was proposed in this background, in order to explore the ecological destructions on Pamba range of Periyar Tiger Reserve. The major objectives of the present investigation are to assess the plant diversity of Sabarimala and Karimala station in Pamba range of PTR and to compare the areas have the influence of Sabarimala pilgrimage with that of areas without the influence of pilgrimage activity; to prepare a disturbance zone map and to assess the decadal change in land use/ land cover of the study area using geoinformatics; to compare the soil nutrient status and associated microbial flora in both disturbed and undisturbed zones and to checked to correlate it with biodiversity loss. The study was limited with the shorter span of time, relatively small study area and small sample size. Absence of previous year data on biodiversity status also stands as a limitation of the present study. However this doesn't invalidate the significance of the data generated.

It is expected that the data may be useful for developing and implementing proper scientific preventive measures, in order to avoid further ecological disturbance in the area and can be suggest a conservation plan for the study area.

REVIEW OF LITERATURE

Biodiversity the sum total of plants, animals and microorganisms existing as an interacting and interdependent system on earth. The extent and nature of biodiversity on this planet has not remain static. Forest especially tropical rainforests are considered as rich biodiversity hotspots of the world. The environmental stability and ecological security of forest are severely affected by surmounting anthropological pressure.

Biodiversity exists on earth in eight broad realms with 193 biogeological provinces (Udvardy, 1975). Each province is composed of communities of living species, at a global level about 16,04,000 species of plants, animals and microorganisms (WCMC, 1992). However, it is estimated that there are around 179,80,000 species, but a working and realistic figure is about 122,50,000 species (UNDP, 1995).

Among biologically rich areas tropical forests of countries such as Ecuador, Indonesia, Madagascar and India are considered as 'Megadiversity' country (Heywood, 1995). The Indian subcontinent is known for its diverse bioclimatic region supporting one of the richest flora and fauna, the region is also a confluence point of three biogeographical realms also (Khoshoo, 1995).

Natural ecosystems worldwide are suffering massive alterations (Vane-Wright *et al.,* 1991). The increasing demand by human population are greatly threatened the forests and resources associated with them all over the world (Araujo, 2002). For instance between 1990 and 2000, the largest percent destruction of tropical forest occurred (FAO, 2001). As a result 331 vertebrates, 338 invertebrates and 92 plant species are now extinct since AD 1500 and 3521 vertebrates, 1932 invertebrates and 5714 plants are at the verge of extinction.

It is a fact that more than 99% of the protected areas of the world are experiencing serious threats, including poaching, encroachment, agriculture, ranching,

urban development, illegal and legal logging and collection of non timber forest products (World bank, 1999), pollution in environmental systems (Daehler, 2003) and global climatic changes (Consiglio, 2005).

International Union for Conservation of Nature and natural resources stresses the need to consider the fragmentation of forest as one of the major causes for habitat loss and species extinction (DOS and DOB, 2002). The extinction rate of endemic plants in biodiversity hotspots are found to be increased as a result of habitat loss and fragmentation (Lugo, 1995). Forest fragmentation is known to cause structural changes in habitats and increased the mortality (Hedge *et al.,*1996). It may leads to changes in environmental factors from microclimate to species composition (Walther *et al.,* 2002). Such changes are known to penetrate a few hundred meters or extended as far as several Kilometers into the forest (Pitman *et al.*, 2000). On the verge of this critical situation studies regarding deterioration of forests and related biological resources are reported all over the world.

Ganesh *et al.* (1996) observed construction of forest roads through forest increase the rate of species extinction and habitat loss in Costa-rica. The pollutant and nutrient accumulation in Millibrook, USA as a result of synergistic effect of forest fragmentation and wind was also reported (Weathers *et al.,* 2001). Biological dynamics of forest fragments project (BDFFP) initiated in Amazonian rain forests observed the critical size of forest become poor there as a result of forest fragmentation due to human encroachment (Laurance and Williamson, 2001).

Richards *et al.*(2002) reported the timber harvest in western Oregon forest in USA affects the ability of wildlife to disperse over large area. Hobson *et al.*(2002) established that forest fragmentation in Saskatchewan forests of Canada increased the extinction rate of Keystone species there. Bruna and John (2002) explained the consequences of fragmentation on demographic pattern of plants through reduced population density, alter population structure and reproductive effort.

The habitat fragmentation in Flandersin northern Belgium leads to genetic diversity within the species (Rossum *et al.,*2002) and such genetic diversities become leads to genetic erosion and as a result extinction of many (19- 46) endemic plant species had reported in neotropical regions of Ecuador over the last 250 years (Pitman *et al.,*2002).

The tree mortality in central Amazon region as a result of forest fragmentation was reported to cause the loss of many rare under story plants (Watkins *et al.,* 2003). The forest fragmentation in tropical dry deciduous forests of Mexico revealed that it affects flowering phenology and mating pattern of many plants by reducing pollinator activity, pollen deposition and out crossing levels (Fahrig, 2003).

The forest fragmentation and species extinction had reported that habitat fragmentation was worstly affected ecosystem functioning and stability of Canadian forest areas (Srivastava and Vellend, 2005). The rural suburban sprawl in Midwest, USA during last few decades, fragments the habitat in the forest boundary, which in turn negatively affects the biodiversity (Radeloff *et al.,2005*).

Consiglo *et al.*(2006) reported that the deforestation due to human settlements in forests of Madagascar threatened 25% of the endemic plants of the area. Deguise and Kerr (2006) observed the species extinction in Canadian protected areas as a result of agriculture and urbanization. Habitat fragmentation and species extinction due to various developmental activities are reported from southeastern forest in USA (Richardson *et al.,*2007), Kalinzu forest reserve in Uganda (Muhanguzi *et al.,*2007), Amazon forest (Michalski *et al.,*2007) and European temperate forests (Chabrerie *et al.,*2008).

The effect of invasive non-indigenous species on the native species and ecosystem have become one of the world's most serious conservation issue (Walker and Steffen, 1997; Wilcove *et al.,* 1998). The detrimental impacts of non-indigenous

species are likely to increase as a result of continuous land use changes for anthropological activities (Byers *et al.,* 2002).

Cully *et al.* (2003) reported invasion of exotic species in tall grass prairies of North America, as a result of extensive agriculture activities, which leads to the extinction and decline of native plants. Roads provide a major conduit for the spread of exotic plants into natural areas (Bugg *et al.,* 1997). The roads improvement through a grassland and woodland in south Utab in USA leads to the introduction of five exotic species (Gelbard,1999). The effect of roads on introduction of exotic species was also observed in National forest, Wisconsin, USA (Watkins *et al.,* 2003) also.

About 40% of the species in the Indian flora are alien, of which 25% are invasive (Raghubanshi *et al.,* 2005). Rao and Murugan (2004) discuss richness of Indian flora and presented a list of major adventive weeds which included Asteraceae weeds such as *Parthenium hysterophorus, Eupatorium adenophorum, E. odoratum, Mikania micrantha, Agiratum conyzoides and Galinsoga parviflora.*

Khanna and Singh (2005) reported *Parthenium hysterophorus* spead in Chattisgarh and considered it as an alien plant coming from tropical America in 1951 at Maharastra. Raghubanshi *et al.* (2005) reported the ill effects of *P. hysterophorus* pollen and the plants effect on soil nutrient pool. Sankaran and Sreenivasan (2005) reported that *Mikania micrantha,* a perennial fast growing weed of neotropical origin has become a major menace in natural forest plantations and agricultural systems in northeast and southwest India. Sharma . (2005) focused on *Lantana camara*, one of the ten worst weeds of the world, which is a native of tropical and subtropical America and was introduced to India during AD 1809- 1810 and is now become a plant parasite.

Kumar and Soodan (2006) reported the spread of *Parthenium hysterophorus* in Punjab and considered as the most noxious weed of the said area.

India one of the richest biodiversity hotspots of the world is having a diversity of ecosystems possessing rich flora and fauna and is a confluence point of the three

biogeographical realms (Rodgers and Pawar, 1983). There are 16 different types of forests are present in India with the highest area occupied by tropical moist deciduous forest (37%) followed by tropical dry deciduous forest (29%), tropical wet evergreen (8%), Subtropical pine(6.5%), tropical semi evergreen (4.1%), mountain wet temperate (3.6%), tropical thorn (2.6%), sub tropical dry evergreen(2.5%), moist alpine scrub (2.1%), littoral and Swamps (0.6%), subtropical broad leaved (2.5%), Himalayan dry temperate (0.3%), tropical dry evergreen (0.2%) and small areas of sub alpine and dry alpine scrub (Raju, 1997). According to FSI (2001) total forest cover in India is 6,75,538 sq. Km, that is about 19.4% of our total land area is only forest area.

Khoshoo (1993) described 12,618,8 species from India, among 74875 species are belongs to *Animalia* and 24886 are *Plantae.* Amongof globally recorded species 30% are endemic to India also (BSI, 1983). Indian sub- continent is also facing serious ecological destruction, as it was estimated that about 3000- 4000 plant species alone in Indian are under different categories of threat (Nayar and Sasthri, 1987). In India it was estimated that approximately 50 million people depend directly on forest for their livelihood, which increases the pace of destruction (Hedge *et al.,*1996).

Deluge of studies regarding forest destruction, habitat loss and species extinction are reported from India also. The forest degradation and habitat loss due to reservoir of Tehri dam in Garhwal Himalaya of Uttaranchal was reported (Rautela *et al.,* 2002). The shrinkage and degradation of West- siang district of Arunachal Pradesh, due to extensive shifting cultivation practice was studied (Singh *et al.,* 2002). Similar observations on forest degradation and fragmentation are made from deciduous forest areas in Sonitpur district of Assam (Srivastava *et al.,* 2002), Kalli hills of Eastern ghats (Jayakumar *et al.,* 2002) and Shervaryan hills of Eastern ghats (Balaguru *et al.,* 2003).

Arunachalam *et al.* (2004) observed forest degradation and fragmentation in Namdapha nature forest reserve of Eastern ghats as result of clear felling for human

settlements and massive extinction of non- timber forest products. The loss of species richness and diversity of six forest types of Uttaranchal, which in turn influenced by anthropological disturbances was well established (Ram *et al.,*2004). Pant (2004) reported the changes in carbon flux of Himalayan watershed as a result of excessive release of CO_2 to atmosphere due to extensive forest clearing. The effect of forest disturbance on fruit production, seed dispersal and predation of plants *Elaeocarpus ganitrus* (*Rudraksh*) in Arunachal pradesh was well established (Khan *et al.,*2005).

Gopalraju *et al.*(2005) assessed the impact of forest fragmentation due to anthropological activities in Vindhyan hills, which drastically decrease the phytodiversity of the area. Similar observations are also made from Eastern Himalayan region of Arunachal Pradesh (Ray and Behera, 2005), Grohills of western Meghalaya (Kumar *et al.,* 2006), sacred forests of northern Meghalaya (Laloo *et al.,*2006).

The human induced climatic changes are also reported to cause forest disturbance in Indian forests (Ravindran *et al.,* 2006). Similar observations of changes in tree species composition were reported in forests of Dadra and Nagar Haveli (Sen and Bisht, 2008).

Since the beginning of the 20th century tourism become one of the most remarkable socio- economic phenomenon (Neto, 2003). Biodiversity richness of countries influences the demand for tourism as a direct factor for sight seeing activities (Nijkamp, 1998; Nelson, 2000). Similarly tourism activities are found as a major reason for the species extinction and habitat loss (Freytag and Vietze, 2006).

Studies on ecosystem disturbance and biodiversity loss were reported from various regions. Negative impacts on wildlife especially on aquatic organisms, including elimination of rare aquatic plants, observation of rare aquatic plants, observations of rare diseases to fishes as a result of addition of wastes from sewage and cruise ships were reported in St. Lucia (St. Lucia's biodiversity country study

report, 1998). Worldwide, the largest number of documented extinctions, 23 species in 20th century was reported in islands Oceania, one among the Pacific islands as a result of increased human visit to the island (Kitakyushu, 2000). In Zakyanthos (Greece), the most important breeding site of the Loggerhead turtle (*Caretta caretta*), the coastal nesting grounds along sandy beaches are disturbed or destroyed due to tourism development (European communities, 2000). Worm *et al.*(2006) reported destruction of ocean ecosystem especially loss of coral reefs as a result of extensive tourism activities in Halifax, North Canada.

In India destruction on Himalayan ecosystem as a result of extensive tourism activities are reported, only 25% of original vegetation still remains there intact, rest of the area was disturbed by various human activities especially tourism(European communities, 2000). Threats to medicinal plants approximately 1748 species to Kumaon Himalayan region as result of tourism was reported (Dhar and Sumant, 2007).

Western ghats of the peninsular India is among the 27 biodiversity hotspots of the world, which is extended about 1600 Km., starting in the north form Tapti river and going down to Kanyakumari in the south (DOS and DOB, 2002). The area forms the major watershed in peninsular India with an average rainfall pf 3000 mm and as many as 58 major rivers originated from hills. This variation and complexity of hill ranges along with evenly spread high rainfall and subtropical temperature makes the area a 'Mega diversity' area of the world (Tewari, 1995).

Western gahts region is occupying forest types such as tropical wet evergreen, semi evergreen and moist deciduous forests (together 79%) and 21% area have tropical dry deciduous forests, mountain forests, grasslands and plantations (State of Forest report, 2001).

Floristically, the western ghats is one of the richest areas in the country, harbors as many as 400 species of flowering plants, with 2100 endemic plants, also 24 species

of bamboos, 77 herbaceous plants, 22 leguminous plants and 37% of totally recorded Orchids are belongs to the area (Nagendra and Gadgil
, 1998). Diversity as well as endemism of animals in area is also obvious as among plants, with 48 genera of Mammals, 275 genera of birds and 60 genera of reptiles (Tewari, 1995). Studies revealing status of forests and ecosystem functioning are well documented from western ghats part also.

Nair. (1991) studied the distribution pattern of 12 leguminous plants which are endemic to western ghats. Muraleedharan *et al.*(1997) had exploited non- wood forest products giving plants in western ghats, altogether 229 such products were reported. The insect diversity in selected disturbed and undisturbed forests of Western Ghats was studies and made a conclusion that disturbance directly affects the diversity of insects (Mathew *et al.,* 1998). The epiphytic flora endemic to Nilagiri biosphere was well studied, where 225 species of vascular epiphytes have been enumerated (Kumar, 1998).

Jha *et al.*(2000) reported habitat fragmentation and species loss in southern part of Western ghats as a result of extensive anthropological activities. The forest fragmentation and increasing fire frequencies in Mudumali wildlife sanctuary of Western ghats due to intensive human pressure was well studied (Kodandapani *et al.,* 2004). Seedling mortality of *Artocarpus hirsutus* and *Canarium strictum* plant species in sacred groves of Western ghats due to their edible fruit collection and extensive harvesting of heavily prized timber was reported (Varghese and Murthy*,* 2005).

The forest degradation due to extensive use of forest for collecting non- timber forest products by local community of Kogar and Shimoga divisions of Karnataka was observed (Davidar *et al.,* 2007). A comparative study on species richness and endemicity on both India and Sri Lanka part of western ghats was made and found both of these hotspots facing serious anthropological threats (Gunawardene *et al.,* 2007). Phyto- sociological study in disturbed and undisturbed areas of Anaikatty hills

of Western ghats reveals that disturbance on forest changes tree and under story plant diversity and community composition (Anitha *et al.,* 2008).

Kerala is one of the smallest state lying in the extreme southwest of Indian peninsula, where western ghats extend over a distance of 500 Km with an average height of 950 m, from which 44 rivers arises with a heavy rain up to 5000 mm (DOS and DOB, 2002). Forest survey of India report (2001) estimated Kerala has a total forest cover of 10,334 Km. Sq.(26.59%), out of which moist deciduous forest cover maximum area (14.33%) followed by evergreen (5.94%), semi evergreen (3.77%), dry deciduous (0.74%), degraded forests and scrubs (2%), plantation forests (2%) and grassland(3%).

Kerala, part of Western ghats is also an important biodiversity hotspot, harbors an excellent diversity of fauna and flora, with an estimation of 3000 flowering plants, of which 30% are endemic to the area (Nagendra and Gadgil
, 1998). A large number of studies revealing the rich biodiversity is reported from various pockets of western ghats region of Kerala also.

KFRI (1980) analyzed the man forest interactions in Attapady region and concluded that forest area remaining was unable to meet basic requirements of population, including housing, fuel wood and plants of medicinal value. The occurrence and distribution of 108 indigenous tree species are reported from forest of central circle of Kerala, where more than 20 species are threatened with extinction due to excessive human activities (Nair and Sasidharan, 1985).

Menon and Balasubramanyan (1985) established the structural and species relation aspects of moist deciduous forests of Trichur forest division, which form as a data bank for the area. Nair (1991) reported 250 medically important plants from Western ghats and studied their importance, distribution and use of various parts. Sasidharan (1997) reported 951 species of plants from Shenduruny wildlife sanctuary, of the estimated 100 species are belonging to different categories of threat.

Nair *et al.*(1997) analyzed the distribution of animals in Chinnar wildlife sanctuary , which reports 150 animals including 17 large mammals. Kumar (1998) reported 159 species of epiphytic plants from Sylvan valley area of Munnar. A comparative study on tree species at different forest types in Kerala reveals that abundance and density of trees are higher in shola forest, followed by evergreen forests, dry deciduous and moist deciduous forests (Chandrashekaran *et al.,* 1998).965 species of flowering plants are reported from Chinnar wildlife sanctuary, among them 114 species are endemic to the area and 8 species faces threat of extinction due to human interactions (Sasidharan, 1999).

Nair and Menon (2000) had done a comparative study on regeneration of arboresent endemic plants of Eravikulam and Silent valley shoals, where more number of seedlings crossed mortality state is at former station, showing comparatively undisturbed status of forests there. 254 species of micro lichens are reported from different habitats of Kerala, where evergreen forests show maximum diversity with 62 species (Kumar, 2000).

Habitat loss and species extinction are the severe ecological issues of present century, conservation issues are thought by many to be one of the most important pressing issue of our time. Globally, the importance of biodiversity conservation was recognized in Convention on Biological diversity (CBD) first presented at the Rio de Janeiro Earth summit by 168 countries (Secretariat of the Convention on Biological Diversity, 2004).

Conservation of biodiversity has been attempted principally two methods *in situ* and *ex situ,* the former involves the conservation of organisms under natural condition (Primark, 1993) and the latter is conservation of complete organisms or their relevant parts in any living conditions (Khoshoo, 1996).

Myers (1988) judged the need to identify the protected area network and 'Hotspots', together with future plans. However, many conservation oriented activities

and programmes have been planned, specific actions have not been taken to address the root cause of threats to biodiversity (Miller, 1992). Related laws and polices, which satisfy all biodiversity conservation objectives are considered as scarce (UNEP, 1993).

IUCN was taken task of biodiversity conservation in 1990s, but many socio economic factors all around the world overhide the conservation movement raised by them (Metrick and Weitzman *et al.,*1998). The socio economic causes driving against conservation movements are, increase in human population, increases in per capita consumption and decrease in efficiency of use of resources (Naidoo and Adomowicz, 2001).

The betterment of socio economic situation leads to development of infrastructures, which in turn become a conservation issue (Freytag, 2006) and an additional threat posed to biodiversity includes tourism, harvesting, introduction of exotics, global warming and environmental pollutions (Naidoo and Adomowicz, 2001).Hence we need more integration of environmental thinking into decision making about agriculture, forestry and infrastructure development of new century (UNEP, 1993).

As the rate of habitat and species destruction continues to rise inventorying biodiversity and monitoring efficiency of measures for its conservation have emerged as important scientific challenge of recent years (Johnson and Kasischke, 1998). For raising efficient conservation strategy biodiversity must be studied both on detailed level (Genes and Species) and general level (biotopes and landscapes) by understanding the effects caused through rapid changes (Tuller, 1991). It is almost impossible to have a complete biodiversity survey at regional level of 1- 100 sq. Km, so for monitoring biodiversity at general level homogenous consistent land cover information is now obtained through geoinformatics (Palmer and Fortescue,2003).

The land cover maps derived from remote sensing data helps us for identify 'hotspots' to facilitate field surveys (Turner *et al.*, 2003). It can be used as indirect

indicator of species number and distribution (Ray and Tomer, 2000). It provide opportunity to develop quantitative models on relationship between species diversity and diversity of land cover elements (Nagendra and Gadgil, 1998).

Various levels of applications of remote sensing and geoinformation system on biodiversity conservation and management are reported from all over the world. The extent of forest fragmentation induced by natural and man made features and disturbances, with the aid of aster imageries and GIS software (Riitters *et al.*, 1997). This techniques are effectively applied in forest fragmentation analysis in Ontario, Canada (Roberts *et al.,*1998), used for fragmentation analysis and to prepare a database of forests in entire USA (Petersen *et al.,*1999).

Buckley (2000) with the aid of geoinformatics proved forest fragmentation increases the susceptibility for the invasion of woody non native plants. Brown *et al.* (2000) identify and threatened areas in protected area through fragmentation analysis and suggest systematic conservation plannings in North America, Australia. Bernknopf and Halsing (2001) applied the some techniques in protected areas of USA . Warnecke (2001) using various temporal and spatial data had done detection and extent of forest fire severity and recovery. Similar works are also reported in all states of USA (Sandstorm *et al.,* 2002) and Mountarian forests in USA (Key, 2005).

The land use/land cover changes of an area through many years can be analyzed using Remote sensing and GIS data and data generated can be incorporated wit fragmentation analysis also (Stroke *et al.,* 1997). Land use/ Land cover change analysis are reported in Connecticut forest of USA (Hurd *et al.,* 2003), Handurans in USA (Southworth *et al.,*2003), Pacific region in USA (Diaz *et al.,* 2005) and estuarine region of Pacific in USA (Yang and Lu, 2005). The results of all these studies revealed that forest areas are declining drastically on comparing with conditions of decades back.

In India also applications of geoinformatics in forest management and landscape analysis was observed. Mohanty (1994) using aerial photographs and satellite data analyzed the urban sprawling towards forest areas in north Bhubaneswer, Orissa, the results of the analysis showed that human settlements are more at present than that of previous years, which drastically decreases the reserve forest area. Similar observations as a result of various anthropological activities are noticed in mountainous region of Himalaya (Ghosh *et al.,* 1996), Gohpara block of Madyapradesh over 30 years study (Jaiswal *et al.,* 1999), Dehlon region Punjab (Minakshi *et al.,* 1999) and in command areas of Khela district of Gujarat (Brambhatt *et al.,*2000).

Some other important applications including habitat susceptibility analysis of globally threatened bird species Nilgiri Laughing thrush in NIlgiri hills by integrating data from field study, satellite data with GIS tool and found to be 21.6% of study area is suitable for the bird (Zarri *et al.,*2005). Ravan *et al.*(2005) done a spatial analysis using RS data and GIS tools to establish the possibility for a corridor between spatially separated and genetically rich protected areas of Kanha tiger reserve and Achankumar wildlife sanctuaries in Madyapradesh. Kumar. (2005) reported the changes that occurred in the biodiversity pattern of mining landscapes of northern Chattisgarh, the result of the study revealed that mining activity fragmented the area and break the free movement of animal between areas.

Recently biodiversity assessment at landscape using geoinformatics was applied in Keala also. Menon (1991) had done the vegetation mapping of Parambikkulam wild life sanctuary was done in 1: 50000 scale by conventional field survey method and aerial photographs. Similarly vegetation mapping of Chimmony wildlife sanctuary (Menon, 1997), Eravikulam national park (Menon, 1997), Peppara wildlife sanctuary (Menon, 1999) and Aralam wildlife sanctuary (Menon, 1999) was also done at various scales using aerial photographs and satellite data.

In biodiversity assessment at landscape level the basic components of composition and pattern to measure species composition are to be considered (Sanchez, 1982). A number of indices are available for detection of vegetation vigor from remote sensing (Elvidge and Chen, 1995). The general principle behind the construction of vegetation indices is that they are mathematical combinations of two or more spectral reflectance and are expressed as ratios, weighed sums and normalized differences (Chen and Chilar, 1995).The best known classic vegetation indices are Ratio Vegetation Index (RVI) (Peterson and Miller, 1972) and Normalized Difference Vegetation Index (NDVI) (Rouse *et al.,*1972) which are based on the reflectance in the Red and near infrared part of the spectrum (Jaishankar *et al.,*2005). Among vegetation indices NDVI has widely and commonly accepted by many. It was applied to analysis of Vegetation vigor in Mississippi gulf coast (King , 2001), arid regions of western Rajasthan (Chakraborthy *et al.,*2001), mining areas of Chattisgrah (Joshi, 2006), Hazira region in Gujarat (Chauhan and Nayak, 2005) and Kerala part of Western ghats (Amarnath *et al.,*2003).

Large number of landscape level studies are to be depicting landscape characteristics through newly formed various indices like Patchiness, Porosity, Interspersion and Juxtaposition (Roy and Behra, 2002; Murthy *et al.,*2003; Singh, 2004 and Kshirsagar, 2004).

Similar to that of vegetation indices on geoinformatics, indices based on mathematical formulations are also there. Initially we understood biodiversity or species diversity as a number of species in a given area without proper analysis (Williams, 1964). A biodiversity index seeks to characterize the diversity of a sample or community by a single number (Magguran, 1988). All biodiversity indices are try to encompass the two dimensions of the concept richness and evenness (Roadweil, 1997). The difference between various indices lies in the relative weighing that they give to evenness and species richness (Magurran, 1988).

A large number of indices are worked out to establish successional status of forest ecosystems. The structural aspects of vegetation especially the successional status of the vegetation can be measured by maturity index (Pitchi and Sermolli, 1948). To evaluate environmental influence over vegetation continuum index was developed (Curtis and McInthosh, 1951). To assess the overall similarity or difference of different localities Similarity indices like Jaccard (1912) or modified Sorenson (1948) indices can be used (Muller- Dombios and Ellenberg, 1974). To compare and evaluate biodiversity Simpson's index based on proportion of individual can be used (Simpson, 1969). The most widely used index to measure species diversity is Shannon-Wiener index (1949) because it incorporates both species richness and abundance. Cimbined diversity indices to overcome the disparity that may occur while using these indices are also developed (Li and Krauchi, 2006).

Soil studies

Soil is one of the major abiotic factors which support life on earth. In general soil is a portion of earth surface which serves as a medium for the sustenance of the biosphere, it consists of minerals and organic matter, permeated by various amounts of water and air and inhabited by organisms, it exhibits peculiar characteristics impressed by physical and chemical actions of tree roots and forest debris. Forests plays a role in the formation and structure of soils.

One third of lithosphere consists of hundreds of type of soils and their subclasses, climate and vegetation of the area which determines the soil class and texture (Brady, 1984). At present the soil degradation, which in terms of qualitatively and quantitatively all around the world occurs through various processes such as erosion, wind blowing, salt affliction, water logging, sedimentation and socio economic activities including construction of permanent structures, mining and dumping of pollutants (Arora, 1961). Soil loss under different management practices in soil degradation such as breaking of soil structures, depletion of organic matter

content, reduction of operative soil depth and degradation of plant population (Bhatt and Gadgil, 1987).

Soil quality is a concept being developed to characterize the usefulness and health of soils and depends entirely on the soil components including minerals, organic matter, air, water and living organisms (Haugton,1994). The quality assessment of soil has been recommended as reliable approach for assessing sustainability of soil nutrient status which in turn, a major soil quality factor (Power, 2004) and also modifies the carbon and liter quality of a location, which also affected soil nutrient quality (Ojima *et al.,* 1994). Soil quality analysis giving stress to nutrient analysis was reported from world around.

Wick *et al.* (2000) investigated the soil quality change in association with the conversion of a native thorn forest in to silvo- pastoral systems in semiarid north east Brazil and found to be it decreases the soil nutrients, organic matter, microbial biomass and soil enzymes in the area. Rhoades *et al.* (2000) investigated the soil carbon difference among forests and agricultural systems in Ecuadorian Andes, the result of study indicates that conversion of forest land to agriculture or pasture land has leads to the loss of soil carbon and thus affects the nutrient availability to plants.

Zhong *et al.* (2000) analyzed the organic carbon content and distribution of soils under different land uses in tropical and subtropical China and found that soils of meadow, herbaceous swamps and coniferous soils have higher carbon density and nutrient availability than paddy fields, bush and coppice forests. Hart *et al.* (2002) done a comparative study of nutrient dynamics in annual grassland and young mixed coniferous forest in California and observed nitrogen mineralisation and recovery had directly related to surface liter and root but not microbial biomass.

Land use change from forest land to agriculture land is affecting mineralisation, nitrification processes in agricultural land in Dominician republic, these results suggested that land use is significantly affecting microbial activity and carbon storage

through its effects on soil organic mater quality and quantity (Temper, 2004). Sarah (2006) reported abnormal pattern of soil organic matter , among samples representing climatic regions in Israel, resulted in low soil aggregate stability, indicating land degradation and it is attributed to over grazing. Accelerated soil erosion caused by deforestation and soil degradation has become resulted in loss of soil organic matter in Ziwuling forest area of China (An *et al.* 2008).

Studies regarding nutrient balance is reported form India also. Soils in India are classified into eight categories namely alluvial soil, black soil, red soil, laterite soil, arid and desert soil, saline and alkaline soil and finally peaty and organic soil (Balfour, 1976). Anthropological soil degradation including soil erosion , desertification, salinisation, water logging, nutrient depletion due to intense farming and deforestation are major threats, which depletes soil quality in the country (Lal, 2007).

The increased anthropological activities in fragile ecosystem of Himalayan region with unstable geology and steep slopes have been reported to accelerate soil degradation in forest areas of Himalaya (Tiwari, 2000). The growing developmental activities like industrialization, road construction, mining and deforestation are reported to cause soil degradation in south east part of Himalayan region (Aswathy *et al.,* 2007). Hessel *et al.* (2007) reported surface soil erosion and loss of soil quality as a result of heavy rainfall in Arnigad catchments area of Himalaya in Uttarakhand, India.

Bajracharya *et al.* (2007) studied the changes in nutrient availability and organic carbon flux in soil of western Nepal region and found to be intense farming affected the top soil quality in the area. Soil property and quality changes in relation to land cover in Aringad watershed of Uttarakhand was analyzed and found to be degraded forest an agriculture lands contained relatively poor soil organic carbon an nutrients (Sharma *et al.*2007).

Ballia *et al.* (2007) studied the land use an cover changes of Galaundu an Pokhare khola watersheds in mid hill regions of Nepal in relation to surface erosion

and soil degradation and found to be forest converted areas vulnerable to soil erosion and land degradation. The recent fast economic, technological and institutional changes in western Himachal pradesh have forund to cause dynamic changes of area and intense farming practices are lead to poor nutrient and organic carbon status in soil (Sharma *et al.,* 2007).

Guptha (2007) established the extent of forest cover resources on land surface and decline of them and linked the results with the land degradation processes including soil erosionm and nutrient deficiency. Singh and Kashyap (2007) studied the effect of selected site composed of forest and savanna and the results showed that forest soil has significantly higher water holding capacity, organic carbon content, nutrients and bulk density than savanna land. Dinakaran and Krishnayya (2008) established that changes in land use pattern not only influence soil organic carbon content of the top layer but also in deeper layers and which also reduces the sink capacity of soil in tropical sanctuary area in Gujarat with human influence.

Along with the nutrient status of the soil, its microbial diversity and density are also considered as important index of productivity (Doyle and Doyle, 1990). Both the palnts and soil types influence the microbial diversity of the rhizosphere (Smith and Goodman, 1999). Studies regarding root zone association of microbes are scanty.

Mehdi and Saifullah (1992) isolated fourteen different taxa of fungi from soil in different parts of Korangi creek and Clifton mangrove forest of Karachi, including *Alternaria, Aspergillus and Bispora* with high frequency. Kuthubuteen (1991) isolated over 40 fungal taxa form root zone of major mangroves palnts in Malaysis the fungi including *Aspergilus, Choanephora, Curvularia* and *Fusarium* genus are dominant among them.

Mahmood *et al.,*(1993) isolated rhizosphere associated beneficial bacteria and fungi including *Pseudomonas and Bacillus, Azospirillium, Enterobacter, Azobacter and Acenetobacter* and fungi like *Aspergillus, Curvilaria* and *Fusarium* in Malaysia. Kader *et al.,*

(1999) identified cellulolytic soil fungi and bacteria throughout the expedition held at Bario high lands, among nine isolated fungi *Trichoderma* and *Aspergillus* was highly celllulolytic compared to rest. Cho *et al.* (2001) isolated *Phialimonium sp.* and *Phaeoacremonium sp.* from soil collected at different sites in California, USA. Azas and Pekel (2002) identified 84 different species and 12 sterile micro fungi from burnt and adjacent soil by soil dilution palte method among isolated fungi *Penicillium (*34 spcies*),* *Aspergillus (*16 species*),* and *Cladosporium (*5 species*)* are the richest taxa. Azaz (2003) isolated and identified 109 species of fungi and 16 different sterile fungi fiom irrigated field soils of Herran, Turkey. Singh *et al.*(2006) had done a preliminary investigation on psychrophylic fungi from soil in Schirmacher oasis, East America and isolated species in genus such as *Torulopis, Fusarium, Aspergillus, Cladosporium* and *Trichoderma*. Caretta and Piontelli (2008) examined keratinophylic fungi in 125 soil samples collected from Pavia, Italy and isolated number of species belongs to genus *Microsporum, Arthroderma, Ctenomyces* and *Chrysosporium*.

Dayal and Gupta (1968) made an attempt to study comparative soil fungal flora of different land uses in Varanasi, India and isolated fungi belongs to genus *Asoergillus, Penicillum, Fusarium* and *Cladosporum*. Koilraj *et al.* (1997) identified 35 species of sporulating and seven types of non- sporulating fungi from soil samples collected from six caves of South India. Sastri and Johri (1998) had isolted 89 species of Arbuscular mycorrhizal fungi from stressed soils of Bailadila iron ore sites of Madya Pradesh. Deshmugh *et al.* (2001) had identified many genus of fungi from soils of Mysore, India including genus *Penicillium, Aspergillus, Trichoderma* and many non-sporulating fungi. Sharma *et al.* (2008) analysed and compare soil microbial diversity in forest and open land along with nutrient status and found a comparatively higher fertility status and soil microbial diversity in forestland.

In Kerala forests also studies regarding soil nutrient status and soil microbial flora are reported. Alexander (1981) compare the first and second rotation soil profile

of Perinthomuzhi and Begur and the profile data reveals that rotation pattern not that much affect pH, organic carbon and Cation Exchange capacity of soil. Balagopalan and Alexander (1983) had done a comparative study on soil organic matter in natural forests and teak plantations, the results indicate that the plantation activities have not caused any drastic change in organic content of soil.

Sanker (1990) had analyzed the nutrient petitioning in evergreen forests in Kerala and reveled that element follow a trend of K>N>Ca> P>Mg in soil. Balagopalan (1989) analyzed the surface layer of soil in teak plantations and revels that organic carbon is positively correlated with available nitrogen and soil under teaks are fertile and there is a sound environment for growth and proliferation and microbes. Sankaran and Balasundaran (2000) studied the soil microflora of shola forest and grasslands of Eravikulam national park and found to be the colony count of actinomycetes and bacteria in shoal forests and grassland are lower compared to that in low elevation areas and in ll0 species of fungi belongs to 34 genera are isolated with dominance of genus *pencilla* and *Asprgilli.*

As the establishment of network of protected area become important to ensure conservation, India was constitute 605 protected areas in country consisting 96 national parks and 509 wildlife sanctuaries, of them 28 have been declared as tiger reserve (State Economic Review, 2007).

Periyar Tiger Reserve in Kerala was established as Nellikampetty game sanctuary in 1934, later in 1950 it was recognized as Periyar sanctuary and in 1978 it was brought under project tiger as Periyar tiger reserve (State Economic Review, 2006). The tiger reserve has a total area of 777 sq. Km., for this 670 sq. Km composed of various forests including evergreen forests, moist deciduous forests and Shola forests and remaining area habitat include grasslands and reed breaks (Kerala Forest Department, 2007). These habitats have composed of diverse type of flora and fauna Periyar tiger reserve was considered as one of the best-managed tiger reserve in

India, with the corporatin of 72 eco development committees (Malayala manorama daily, 2008). Even though people participation ensures in conservation, PTR was suffering serious ecological disturbances. Deluge of studies are reported in this aspect too.

The reconnaissance study in PTR to develop a management plan for the area, brought out the biodiversity status of the area composed of 32 mammals and 181 birds and found the tiger population is too low their (Vijayan *et al.,* 1979). A phytodiversity study in PTR reported 1272 endemic plants there, among three are exclusively endemic to this area and listed 150 species under different categories of threat (Sasidharan, 1999).

Arun (1999) studied the ecological structure and functional processes of fish assemblage in 26 sq. Km man- made Periyar lake in PTR and 75 Km. stream, totally 27 fish species were reported of these 14 species are endemic to areas and nine are under various categories of threats. Arun (2001) establish biodiversity conservation in PTR are relating with livelihood activities of tribes including movement, firewood collection and income generation. Gubbi (2006) had prepared an integral conservation and developmental activities for tiger habitats in PTR.

The temple at Sabarimala is one of the most visited in India and now outgrown all the accepted definition of a pilgrim center. The geographical, ecological and ritualistic uniqueness gives Sabarimala an entirely different dimension when compared with other centers of pilgrimage (CED, 1997). Sabarimala is situated in deep dense forests in southern portion and Pamba range of Periyar tiger reserve, at an elevation of 461 m above mean sea level and bears an inflow of more than Fifty lakhs pilgrims every year (KFD, 1999). The Pamba range of PTR was composed of forest types including tropical evergreen, semi evergreen, moist deciduous, wet reed breaks, plantations and grassland and the area was supporting a rich biodiversity including a large number of endemics (KFD, 2000). There are only few studies are reported on

the aspect that relating the pilgrimage activity in relation to habitat destruction in PTR.

The conservation of dense evergreen forest areas into areas in to highly degraded savannah or grassland as a result of firewood collection and pole cutting was reported (Mohanachandran, 1988). An impact survey revealing the impact of plastic littering along forest track up on the wildlife was well established (Tikadar, 1997). The impact surveys on firewood collection, pole cutting and road widening, which results in the conservation of dense forest area into degraded land was reported (KFD, 1997).

Ambat (1997) studied the upper catchments area of Pamba river basin, focused on the environmental status of region using satellite data and reported the changes of land use pattern and increase in pollution over years. Sasidharan (1999) reported on an average, 900 tones of night soil, 500 tones of coconut shells, 10 tones of plastics and various packing materials are generated during every season, with a per head generation of waste for each pilgrim is 166.67 grams of night soil, 92.59 grams of cocunut shell, 1.85 grams of plastics and 27.78 grams of fuel wood consumption. As result of the wastes generated inside the forest area death of animals especially deers, wild boar, sambar and elephants and other consequences are reported (Harikumar, 1997). Balasubramaniam (1999) conducted a study to collect baseline information on ecological impact of Eco development committee (EDC) intervention in Sabarimala pilgrimage and provide recommendations on eco friendly pilgrimage. Kuttoor (2004) reported an inflow of hazardous wastes in to river Pamba at Cheriyanavattom in the foot hills of Sabarimala. The unabated load of pollution from nearby shops and settlements to river Pamba was also reported (Nair, 2002). Varghese *et al.* (2007) reported an extremely high diversity of pathogenic organisms in Pamba river and adjoining drinking water resources, with a predominance during Makaravilakku season. The result of sociological and economical studies are also revealed that socio-

economic conditions has direct correlation with that ecosystem maintenance. Gurukkal and Raju (2002) studied the enclave management and suggest valuable recommendations for conducting eco friendly pilgrimage. The commitments and attitude of agencies of pilgrimage management was also looked into this matter (Balasubramanian and Karunakaran, 2003).

Baby (2003) studied the economics of Sabarimala pilgrimage with special reference to households in Erumely panchayath and reported the immense potential of pilgrimage to improve economy of central Travancore. Public Accounts Committee (2005) in their report to Loksabha mentioned about social impact of lack of cleaning water, hygienic food, medical facilities, shelters and toilets. The negative social impact of Sabarimala pilgrimage due to lack of facilities to pilgrimage including sanitation, drinking water and to stand in queue over hours to visit the shrine are also well established (Sasidharan, 2002).

However, in recent years with the heavy flow of devotees, the event as a whole turned out as a tourism activity, especially considering the studies related commercial activities. But very little studies have been reported yet, on the related ecological impacts, specifically on Pamba river basins and forest ecosystems. The present investigation is proposed in this background in order to gather some primary data on the loss of biodiversity due to habitat fragmentation as a result of pilgrimage activity.

MATERIALS AND METHODS

Study period

The impact of Sabarimala pilgrimage on floral diversity was estimated through GIS analysis coupled with ground survey sampling study programme. The study was conducted during a period of six month from 1st April to 30th September 2008. Field studies and sampling were performed twice once in disturbed areas and second in undisturbed area of Pamba range.

Study area

Study area covers an area of 28 Sq. km of reserved forest area, coming under Pamba range covering Karimala and Sabarimala stations located between 77^0 10'- 77^0 50' E and 9^0 24'- $9^0$28' N. Field survey and sampling was carried out in disturbed and undisturbed zones of the area.

The Disturbed zone is defined as an area with direct human interactions, which is regularly recurring. An approximate area of 10 Sq km including area around Sabarimala Sasta temple and proximal areas of trek paths to temple are considered as disturbed areas. This zone has very high human intervention throughout the year at regular intervals and mere continuous during Mandala – Makaravilakku season (November - January). Forest cover has been almost cleared in this zone and soil is exposed. The area was facing serious environmental threats due to permanent or temporary constructions, pole cutting by hotel workers, Plastic littering, temple activities, open defecation chlorination and water pollution.

The undisturbed zone means the forest area with no such direct human interventions, but noise and air pollution that would have been occurred are not considered. An approximate area of 15 sq. Km was considered as Undisturbed zone . However no visible damage is not occurred in this area, an approximate area of 5 sq. Km area of buffer zone is left between the disturbed and undisturbed areas and with moderate disturbances.

a. **Sabarimala station:** This station has composed of an area of 20 Sq. Km. There are 12 quadrate points were in this station, among 8 are considered as disturbed zones and 4 are undisturbed zones.

b. **Karimala station:** This station area has composed of an area of 8 sq. Km. There are 8 quadrate points were in this station, among 2 are considered as disturbed zones and 6 are undisturbed zones.

A. Phytosociological analysis

A field study was conducted in order to find out the pilgrimage pressure on the phytodiversity and density of Pamba range of Periyar tiger reserve (PTR) through stratified random quadrate study.

Plot method: The quadrate sampling was conducted by following the method suggested by DOS and DOB (2002). Ten quadrate from both disturbed and undisturbed zones was selected with an area of 20 m x 20 m each. In this plot all large trees were counted and circumference breast height (cbh) was recorded. The individuals with cbh> 30 cm is considered as trees and with >17 cm and < 30 cm cbh as saplings. A 10m x 10m plot was laid with in the main plot by fixing any one corner in common, for counting the shrubs, seed link and sapling of trees. For herbaceous layer or ground flora the nested quadrate method with 1m X 1m plot size were taken in any two opposite corners.

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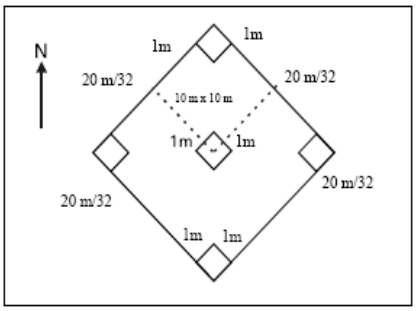


B. Disturbance analysis using Geoinformatics

A software base analysis conducted in order to find out Land use/ Land over changes over decades due to pilgrimage pressure and to prepare a disturbance zone map of Sabarimala and Karimala stations of Pamba range of PTR.

1. Data sets used

The study area is completely covered on the Survey of India toposheet 58 G/3 (1:50000 scale) surveyed on 1968- 1969 and is used to create the baseline data related to the survey area (Fig.1)

LANDSAT V (Thematic Mapper) image acquired on 24th January 1990 and IRS P6 (LISS III) image acquired on 19th February 2004 are the satellite data used for the study. (Fig.2)

Table.1. Details of satellite data used.

Satellites	Date of acquisition	Path / Row	Band
LANDSAT V (TM)	1990, 24th January	100/67	432
IRS P6 (LISS III)	2004, 19th February	144/53	432

2. Software used

Arc GIS 8.3 version, a software package generated and marketed by Environmental System and Research Institute (ESRI), California, composed of Arc GIS desktop, Arc GIS gateway and Arc GIS IMS software are used to perform GIS tasks.

ERDAS (Earth resource Data Analysis system) Imagine 8.5 version generated and marketed by ESRI, California and was used to perform both image processing and GIS analysis.

3. Analysis

a. **Thematic map preparation from scanned toposheet (58 G/3):** Shapefiles of layers boundary, drainage, contour, road and land use are prepared after georeferencing and rectification, then converted them to coverages of topology creation and projection. Digital Elevation Model (DEM) was generated from contour coverage.(Fig.3).

b. **Thematic map preparation from satellite images**: Shape files of layers road and land use are prepared from georeferenced TM and LISS III data and after topology creation and projection thematic maps are generated.

Table.2. Land use classes derived from datasets.

SI No:	Land use classes	
	Toposheet	Satellite Image
1	Forest	Forest
2	Settlements	Settlements
3	Barren area	Barren area
4	-	Grassland
5	-	Open forest

c. **Land use/ Land cover change analysis**

Overlay analysis was performed by 'Overlay' tool and Changes of years 1969, 1990 and 2004 was statistically calculated.

d. Normalised Difference Vegetation Index (NDVI) analysis.

NDVI was calculated from subseted images of 1990 and 2004 using ERDAS Imagine software and obtained NDVI image then reclassified and ranks were assigned for result of 2004 image.

e. Distance analysis

1. **Road distance analysis**: Distance analysis was performed for road in 2004 image and result obtained was divided in to six classes and ranked them based on disturbance due to road (Fig.4).
2. **Settlement distance analysis**: Distance analysis was performed for settlement land use in 2004 image the result obtained was divided in to six classes and ranked them based on disturbance due to settlements (Fig.5).

f. **Surface modeling for Important Value Index (IVI)**

1. The ground data (IVI) obtained through quadrate study was incorporated to GPS allocations and surface modeling was done with Inverse Distance Weighed (IDW) tool in Arc GIS . The image developed was reclassified into 7 classes and ranked based IVI value (Fig.6).

g. Landscape analysis

1. **Fragmentation**: It measures the number of forest and non- forest polygons per unit area. The 100 x 100 m^2 grid clipped LISS III image, which was already dissolved and analyzed using 'Identity' tool and Fragmentation per grid area, was statistically calculated.
2. **Porosity:** It measures the number of polygons of non- forest areas with in a forest area. The 100 x 100 m^2 grid clipped data was analyzed using 'Identity' tool and Porosity per unit area was statistically calculated. The value obtained was classified and given ranks.
3. **Patchiness:** It measures the density of polygons (both forest and non-forests) per unit area. The 100 x 100 m^2 grid clipped and undissolved data was analyzed using 'Identity' tool and patchiness per grid area was spastically calculated. The value obtained was classified and given ranks.

h. Forest Disturbance analysis

The forest disturbance was computed by adopting a linear combination of the defined parameters on the basis of probabilistic weightages.

Disturbance Index (DI) =$\int$ Settlement disturbance x Wt_1+Road disturbance x Wt_2+ IVI classified x Wt_3+ NDVI reclassified x Wt_4+ Porosity x Wt_5

Table.3. Weightages given to various thematic layers

SI No:	Layers used	Weightages (%)
1	NDVI	20
2	Settlement disturbance	30
3	Road disturbance	30
4	Important Value Index	15
5	Porosity	5
Total		100

Table.4. Precedence list of various thematic layers used of analysis

SI No:	Layers	Classes	Rank given
1	NDVI	- 0.13- 0.20	10
		0.20 - 0.30	9
		0.30 - 0.40	7
		0.40 - 0.60	3
		0.60 - 0.63	1
2	Road distance analysis	0 -100	10
		100 - 250	9
		250 - 500	8
		500 - 1000	6
		1000 - 2000	3
		2000 - >2000	0
3	Settlement distance analysis	0 - 25	10
		25 - 100	9
		100 - 250	8
		250 - 500	7
		500 - 1000	4
		1000 - >1000	0
4	Important Value Index	37 - 50	9
		50 - 65	8
		65 - 80	7
		80 - 100	5
		100 - 115	4
		115 -135	3
		135 - 200	0
5	Porosity	0	0
		1	5
		2	7
		3	9
6	Patchiness	1	3
		2	6
		3	9
		4	10

C. Soil studies

A sampling study was conducted in order to find out the changes in nutrient holding capacity and microbial status in disturbed and undisturbed zones of Pamba range of PTR through random sampling method.

1. **Soil sampling**

For nutrient analysis soils are collected by removing 20 cm of top soil and transferred to plastic containers and for microbiological analysis top soil by just removing humus layer were collected in sterile sample containers and transported to the laboratory.

2.**Nutrient analysis**

a. Organic carbon

It was estimated using rapid dichromate oxidation technique suggested by Walkey and Black (1934).

b. Organic Matter

It was estimated through multiplying the value of Organic carbon with the constant 1.72.

c. Available Nitrogen

It was estimated using Alkaline Permanganate mathod suggested by Subbaih and Ashija(1955).

d. **Available Phosphrous**

It was estimated using the Bray's II colorimetric method suggested by Jackson (1958).

e. **Available Potassium**

It was estimated by Morgan's extraction method followed by Flame Photometric analysis as per Jackson (1958).

3. Microbial Studies

The bacterial counting was performed in soil samples collected by serial dilution technique followed by Spread plate method in Nutrient Agar and kept at 24 hours and count the number of Colony forming units.

Fungal characterization was done using Spread plate method in Inhibitory Mould Agar (HM 246, LOT No.000000005047) and Colony forming units were counted. The developed colonies were subcultured on to Saboured Dextrose Agar(HM063, LOT No.WA162)and incubated at room temperature for seven days and sufficient colonies were identified by observing the microscopic and macroscopic features(Microscopic and Macroscopic features for fungal characterization is given in the Table.5).

D. Statistical analysis

The Density, Percentage frequency, Abundance, Basal cover, Relative frequency, Relative density, Relative dominance and Important Value Index for each species were calculated, from the quadrate data as per the following formula (Philips, 1959).

$$\text{Frequency} = \frac{\text{Total number of quadrates in which species occurred}}{\text{Total number of quadrates studied}} \times 100$$

$$\text{Density} = \frac{\text{Total number of individuals of the species (per quadrate)}}{\text{Total number of quadrates studied}} \times 100$$

$$\text{Abundance} = \frac{\text{Total Number of individuals of species occurring}}{\text{Total number of quadrates in which species occurred}} \times 100$$

$$\text{Relative Frequency} = \frac{\text{Frequency of a species}}{\text{Sum of frequency of all the species}} \times 100$$

$$\text{Relative Density} = \frac{\text{Density of a species}}{\text{Sum of density of all the species}} \times 100$$

$$\text{Relative dominance} = \frac{\text{Total stand basal cover of the species}}{\text{Total stand basal cover of all the species}} \times 100$$

$$\text{Basal Cover} = \frac{(\text{cbh})^2}{4\pi}$$

Sum of basal cover of individual plants of a species will yield total stand basal cover of that species.

Mean basal cover = Stand basal cover / density

Importance Value Index (IVI) = Relative Frequency + Relative Density + Relative Dominance

To bring species richness generated to a similar scale following Biodiversity Indices are worked out:

a. Shannon-Wiener1 information theory Index (H')

$$H' = -\sum Pi \ln Pi$$

To know about the structural aspect of the vegetation especially the successional status of the vegetation, The Maturity Index (Pich and Sermalli, 1948), for each locality were worked out using the formula.

b. Maturity Index $= \frac{\text{Total percentage frequency of a locality}}{\text{Total number of species present}} \times 100$

To assess the overall similarity of different localities with respect to species diversity, the 'Similarity Index' (Mountford, 1962) was worked out as it was designed to be less sensitive to sample size than other Similarity Indices.

c. Similarity Index (CM) = $\frac{a}{2\,b\,c - (b + c)\,a} \times 100$

Where 'a' is the species held common in both site and 'b' and 'c' are the number of species found at only one of the sites.

Combined indices are worked out to environmental changes over time and space in terms of native and non- native plant diversity.

a. Rs as a measure of species competition

The ratio (*R*s) of the current Shannon index (*H'*) and the maximum Shannon index (H_{max})

$$R_s = \frac{H'}{H_{max}} = \frac{-\sum_{1}^{N} P_i \ln P_i}{\ln N}$$

b. Rc as a measure of the species composition

It consists of the proportion of native plant richness (n/N), as well as the proportion of the cover or the number of individuals of species.

$$Rc = \frac{n}{N} * \frac{\sum_{1}^{n} P_i}{\sum_{1}^{N} P_i}$$

Where 'n' is the number of native plant species and 'N' the total number of plant species present in the area.

c. The combined diversity index (S)

It was derived in relation to the competition ratio (*R*s) and composition ratio (*R*c). combining the quantity (represented by *R*s) and quality (represented by *R*c) of the current vegetation state. It was calculated using the formula;

$$S = \frac{1}{1 + e^{(3 - 8 * Rs * Rc)}}$$

d. The relative change index (Ci)

It indicates the relative distance from the current vegetation state to the theoretical final stage ($S = 1$) for a given spatial scale.

$$Ci = 1 - S$$

The obtained results were tabulated, analyzed and discussed in relation to available and relevant scientific literatures.

Table.5. Key used for the identification of fungi

Sl. No:	**Fungus**	**Macroscopic appearance**	**Microscopic appearance**
1	*Absidia corymbifera*	Colonies white to grayish brown1. Reverse colorless to very slightly yellow to buff with age. Profuse woolly mycelium filling the dish within 2 to 3 days2. Optimum growth at 37oC. Maximum temperature of growth 45 - 52oC.	Broad hyphae, sparsely septate, hyaline with stolons and internodal rhizoids. Sporangiophores (400-450µm) solitary or in groups, arising from stolons, branched in corymbs (clusters) with each sporngiophore terminating in a sporangium1(20-80µm)Branches carrying smaller sporangia occur below the terminal sporangium.
2	*Aspergillus niger*	Colonies initially white, quickly becoming black consisting of a dense felt of conidiophores. Reverse white to pale yellow. Rapid growth.	Conidial heads radiate. Conidiophore stipes smooth-walled, hyaline or pigmented. Vesicles subspherical, 50-100 ìm diam. Conidiogenous cells biseriate. Metulae twice as long as the phialides. Conidia brown, ornamented with warts and ridges, subspherical, 3.5-5.0 ìm diam.
3	*Aspergillus fumigatus*	Colonies initially white, later smoky green with a slight yellow reverse. Lavender diffusible pigment may occur in some isolates. Texture woolly to cottony to some what granular. Rapid growth. Old colonies turn slate gray. Colonies (CzA) dark blue-green, consisting of a dense felt of conidiophores, intermingled with aerial hyphae. Colonies reaching 7 cm diam in ten days at 24-26ºC on CzA, spreading broadly, thin, bluish green, with strictly columnar conidial heads. Pigmented conidiophores with clavate vesicles arising from clearly differentiated	Hyphae septate, hyaline, conidial heads, strongly columnar. Conidiophores smooth walled, uncoloured, but can be quite short. Terminal vesicles dome –shaped. Uniseriate with closely compacted phialides occurring only on the upper portion of the vesicle, parallel to axis of conidiophore. Conidia smooth to finely roughened, subglobose2, 5. Conidial heads columnar; conidiogenous cells uniseriate. Conidiophore stipes smooth-walled, often green in the upper part. Vesicles subclavate, 20-30 ìm wide. Conidia verrucose, (sub)spherical, 2.5-3.0 ìm diam.

		thick-walled foot cells	
4	*Aspergillus flavus.*	Colonies granular, flat, woolly to cottony, often with radial grooves, initially yellow later becoming bright to dark yellow- green with age. Rapid growth rate. Reverse golden to red brown.	Hyphae septate, hyaline Conidial heads radiate to loosely columnar with age. Conidiophores hyaline, coarsely roughened near the vesicle, pitted, spiny, variable length, uncoloured. Vesicles globose to subglobose, metulae cover nearly the entire surface in biseriate species. Some isolates may be uniseriate with only phialides covering the vesicle. Conidia globose to ellipsoid, smooth to very finely roughened, pale green and conspicously echinualate
5	*Chrysosporium sp.*	Colonies attaining 50-60 mm diam in 14 days, white, felty, powdery, most dense at the centre, less than 1 mm high; margin not well defined, fimbriate; reverse pale creamy yellow. Growth temperatures: minimum 10°C, optimum 25-30°C, maximum 30-40°C. Keratinolytic.	Hyphae hyaline, thinwalled; aerial hyphae fertile, 0.5-3 μm wide; submerged hyphae sterile, 0.5-6 μm wide, the narrower occasionally being contorted. Racquet hyphae usually absent. Terminal and lateral conidia sessile or on short protrusions or side branches, solitary, subhyaline, smooth- and slightly thick-walled, obovoid to clavate, 1-celled, rarely 2-celled, 3.5-7.5 (10) x 3-4.5 μm, with wide basal scars (1.5-2 μm). Intercalary conidia not common, subhyaline, smooth- and slightly thick-walled, cylindrical to barrel-shaped, 3-4 x 6-10.5 μm, of the same width as or slightly wider than the supporting hypha. Chlamydospores (on oatmeal agar) subhyaline, smooth- and thick-walled, globose, 4.5-11.5 μm diam, with narrow basal scars.
6	*Curvularia geniculata*	Colonies expanding, black, hairy.	Conidiophores erect, up to 600 μm long, unbranched, septate, flexuose in the apical part, with flat, dark brown scars. Conidia smooth-walled, dark brown, 4-septate, the central cell being the largest; conidia broadly ellipsoidal, unilaterally flattened to distinctly geniculate, 18-37 x 8-14 μm.
7	*Microsporum*	Colonies flat spreading, suede to downy, gray white to tan1 woolly with radiating margin.Pigment may be	Hyphae septate, hyaline with extremely rare production of either microconidia or macroconidia. Generally only sterile and pectinate hyphae are seen with occasional

	audouinii	absent or pale pink to salmon or yellow to brown. Colonies on Sabouraud's glucose agar 50-60 mm diam. after 2 weeks at 25°C, flat or with a few radiating grooves, rather thin, velvety, whitish to very pale buff or rosy buff, slightly deeper buff in the centre; reverse pale buff to salmon or ochreous-salmon; 'dysgonic' strains, with very slow-growing, almost completely submerged colonies, also occur	terminal or intercalary chlamydoconidia Macroconidia usually very rare, irregularly fusiform, 30-82 x 8-14 μm, with 1-2 (rarely up to 9) septa and thick (up to 2-5 μm thick), smooth or verrucose walls, borne terminally on short branches arising at an acute angle from simple hyphae. Microcconidia pyriform to clavate, 3-8,5 x 1,5-3 μm, unicellular or rarely l-septate, sessile or on short pedicel, borne along the sides of simple hyphae, are moderately abundant in some isolates, rare in others. Spiral Hyphae not seen. Some isolates are completely sterile on Sabouraud's glucose agar, consisting only of mycelium containing numerous chlamydospores and 'nodular bodies' (small clumps of tightly interwoven hyphae). Nigerian isolates have been reported to form numerous macroconidia new isolates produced macroconidia when cultured on honey agar plus yeast extract and incubated at 25-27°C, while incubation at 29-32ºC was inhibitory. Vitamin requirements: Unlike M. canis, M. audouinii grows very poorly on polished rice grains, a characteristic frequently used for differentiation of the two species. growth of M. audouinli on rice grains was stimulated by Bacillus weidmaniensis the one strain of M. audouinii they studied was deficient for nicotinic acid. noted a deficiency for thiamine when casein hydrolysate was the nitrogen source, B. weidmaniensis or yeast extract stimulated growth macroconidium formation on honey agar, while pyridoxine stimulated macroconidium formation only and thiamine had no effect.
8	*Gliocladium sp.*	Colonies woolly to velvety, white to pale pink or greenish with an uncolored or pale yellow reverse. Rapid growth. Centre is at first white and turns dark green.	Hyphae septate, hyaline. Conidiophores branched in the upper portion with phialides occurring in brush like clusters. Conidia single-celled, smooth-walled, held together in a mass at the phialides to form large clusters or balls. Conidiophores mononematous, or forming determinate synnemata, branching biverticillate,

			terverticillate or quaterverticillate, frequently with verrucose or roughened walls. Synnemata, when formed, with a basal portion of textura intricata and a stipe of textura porrecta, pigments usually yellow, KOH reaction variable. Conidiogenous cells phialidic, cylindrical to subulate, in whorls of 3 to many, hyaline. Conidia produced in a slimy mass, aseptate or rarely 1-septate, ellipsoidal to cylindrical, symmetrical, smooth-walled, hyaline or rarely greenish.
9	*Phialemonium obovatum*	Colonies white to pale yellow initially, later pale ochraceous or slightly greenish, becoming darker in the centre with age. Colonies moist but not slimy, smooth or slightly floccose	Hyphae septate, hyaline. Conidiogenous cells usually without colarattes. Adelophialides and discrete phialides present. Conidia obovate(like an upside-down pear with the narrow part at the bottom), consistently straight,with an apulate and minutely truncated base . Chlamydoconidia present in very old culture.
10.	*Penicillium sp.*	Rapid growth. Colonies are radially sulcate velvetty and grayish-turquoise center with a white periphery Exudate pale to brilliant yellow or yellowish brown. Heavy conidiation often exists23.	Hyphae septate, hyaline comdiophores with thin, smooth walls. Penicillus typically terverticillate (3 branch points from the tip of the phialide to the stipe) Metulae short and appressed and cylendrical. Phialides ampulliform, conidia ellipsoidal to subglobose, smooth23. Conidiophore stipes smooth-walled, 200-300 μm long; penicilli usually terverticillate. Metulae 8-12 μm long. Phialides flask-shaped, 7-10 μm long. Conidia smooth-walled, ellipsoidal, 2.5-4.0 μm long, blue or bluish-green.
11.	*Penicillium janthinellum*	Colonies are radially sulcate or irregularly wrinided, floccose, centrally grayish green to dull green, with a white to grayish to pale yellow periphery. Small amounts of clear to brown exudates are also present. Rapid growth rate.	Hyphae septate, hyaline conidiophores smooth, thin walled and delicate, terminating in an irregular to regular verticel of 2-3 metulae. Phialids ampulliform, conidia globose, smooth to slightly roughened, born in medium length chains.
		Colonies are initially buff, becoming tan and eventually	Hyphae septate, hyaline. Supporting cells which branch vertically from the

12.	*Paecilomyces sp.*	yellowish-brown and have a powdery texture. Growth rate is rapid. Colonies on malt-agar usually growing rapidly, attaining a diameter of 8 cm within 14 days at 25° C; consisting of a dense felt of numerous conidiophores, giving a powdery appearance, sometimes floccose or funiculose or tufted, in older strains mostly with overgrowth of white aerial mycelium; colour variable depending on the strain, ranging from Deep Olive Buff to Dark Olive Buff or LightYellowish Olive, Yellowish Olive to Ecru-Olive with age changing to darker shades, in some strains with a dark cast due to abundant chlamydospores; odour sweet aromatic, pronounced with age. Exudate absent or consisting of colourless drops; reverse yellow to yellow-brown, in some strains dark-brown to almost black, from abundant dark chlamydospores. Optimal growth occurs at 35° C, some strains show a higher optimum at about 40° C minimum temperature about 50° C; maximum near 50° C.	conidiophores, each given rise to 2-7 phialides. Phialides have wide bases, tapering to form a long cylindrical neck. Conidia are elliptical to cylindrical and smooth, forming long branched chains. Vegetative hyphae hyaline, mostly thick-walled, smooth-walled or sometimes encrusted with yellow granules, 3.0-5.5 µm wide, submerged hyphae strongly inflated up to 20 µm. Conidiophores consisting of dense whorls of verticillately or irregularly arranged branches, each bearing 2 to 7 phialides, smooth-walled, slightly roughened or enwith granules, 35-90 x 3.5-7.0 µm, but occasionally up to 150 µm in length. Phialides in whorls or solitary, variable in size, mostly 12-20 x 2.5-5.0 µm, but also up to 35 µm long, consisting of a cylindrical or ellipsoidal basal portion, tapering abruptly into a long cylindrical, 1.0-2.0 µm wide neck, sometimes slightly bent away from the main axis; the phialides have apically an internal wall-thickening. In some strains the phialides may proliferate and form 2 to 3 lateral necks. Conidia hyaline to yellow, yellow-brown in mass, smooth-walled, variable in shape, mostly subglobose to ellipsoidal, in some strains ellipsoidal to cylindrical or clavate, dimensions varying from 3.2-5.0 x 2.0-4.0 µm in some strains to 3.5-15.0 x 2.0-5.0 µm in others. Chlamydospores usually present, especially in old cultures, singly or in short chains, mostly brown or dark brown, smooth-walled to slightly roughened, globose, subglobose to pyriform, thick-walled, 4.0-8.0 µm, sometimes up to 10 µm in diameter. Perfect state not produced.
13.	*Chrysosporium* sp.	Colonies usually white to buff to pale yellow, but may be pink or slightly orange. Texture powdery to woolly with a slow to moderate growth. May be spreading	Hyphae septate, hyaline, both aleurioconidia supported on short pedicels and persistant chains of alternating arthroconidia wider than the vegetative hyphae are produced. Conidia may form directly on the hyphae or at the ends of

		or compact, surface flat or raised. Reverse is usually white, yellow, tan or brown.	simple or branched stalk- like short or long conidiophores. Conidia are usually single-celled, clavate, with a rounded apex and broad flattened base; the walls may be thin or a bit thick and are most often smooth, occasionally rough. A fringe or remnant of supporting cell wall may stay on the base of the conidium after it matures and detaches.
14.	*Penicillium purpurogenum*	Rapid growth rate. Flat to radially sulcatc, ccntrally dark grccn with a bright yellow to red periphery. Exudate orange to red with a diffusing soluble pigment.	Hyphae septate, hyaline but often encrusted with pigmentation. Conidiophores are smooth walled, bearing terminal biverticillate penicilhi. Penicilli are narrow with appressed metulae and phialides of equal length. Conidia are ellipsoidal to subglobose at maturity, smooth or slightly roughened walls, born in short irregular chains.
15.	*P. verrucosum*	Colonies bright yellow green in the beginning and later turns to forest green with production of colourless exudate. Surface is highly verrucose. Reverse red-brown (terracotta).	Hyphae septate, branched or unbranched. Conidiophores with or without metulae. Conidia rough. Globose to subglobose. Phialides tapering. Conidiophores: Terverticillate, appressed elements, born from surface or subsurface hyphae Conidia: Rough-walled, globose to subglobose, 2.6-3.2 ìm. Phialides: Cylindrical tapering to a distinct collulum, 7-9 ìm x 2.2-2.8 ìm Metulae: Cylindrical, 8-13 ìm x 3-4 ìm.
16.	*Trichophyton schoenleinii*	Colonies growing rather slowly, waxy, later becoming velvety, folded, cereberiform and heaped with age, often cracking and splitting the agar, whitish to cream coloured to yellow or orange brown. Margin sometimes feathered due to the presence of favic chandeliers; reverse unpigmented or pale yellowish orange to tan. Growth is often submerged.	Macroconidia and microconidia usually absent. Antler like hyphae with dichotomously branched swollen tips (favic chandeliers) present in submerged margin of fresh cultures. Chlamydospores abundant. Hyphae septate, highly irregular and knobby.
		Surface is granular or fluffy; white to buff. Reverse is deep red or purplish,	Septate hyphae, tear shaped microconidia usually from singly all along the sides of the

17.	*Trichophyton rubrum*	occasionally it is brown, Yellow, Orange or even colorless in some isolates.Colonies (SGA) fluffy to cottony, white, sometimes becoming rose when ageing; reverse wine-red to olive, sometimes yellow.	hyphae. Macroconidia may be abundant, rare or absent, when present, they are long, narrow and thin walled, with parallel sides. Macroconidia may form directly on ends of thick hyphae singly or in groups. Macroconidia mostly absent, when produced thin-walled, poorly differentiated, of variable size, cylindrical to cigar-shaped, 40-55 x 6.0-7.5 ìm, with a tendency to disarticulate. Microconidia peg-shaped to pyriform, 3.0-5.5 x 2.0-3.5 ìm, sessile alongside undifferentiated hyphae. Occasionally only micro- or only macroconidia are present; cultures rarely sterile. Some strains consistently produce arthroconidia
18.	*Trichophyton longibracheatum*	Colonies star shaped, may become pinkish or yellowish. Powdery form exhibits concentric and radial folds. Colonies rapidly develop a dense fluff with little or no conidiation Colonies vary greatly, powdery to floccose greeny and cream coloured in zoophilic strains. White and fluffy in anthropophilic strains. Reverse pigment when present, may be yellow to red brown.	Hyphae septate, hyaline with numerous round to subspherial sessile microcondia found along the hyphae may be noted. Occasionally, slender clavate to cigar, multiseptate, 3-8 celled, smooth and thin walled macroconidia may be seen. Favic chandelier like structure and chlamydospores occasionally present. Nodular bodies in some strains.

19.	*Trichophyton ajelloi*	The colony grows rapidly as a thin, flat, powdery colony with a fringed border. The colony may also produce dense cottony mycelium. The surface of the colony is cream to yellowish tan with a reverse pigment that is colourless to red or deep blue-black. Colonies (SGA) expanding, flat, powdery to velvety, cream-coloured to ochraceous-buff; reverse yellowish, a dark purple pigment being exuded into the agar.	Hyphae septate, with many macroconidia that are long, cigar shaped, or cylindrical with tapering ends. The thick walled spores appear at the terminal ends of conidiophores and are smooth, a feature typical of Trichophyton sp. Microconidia are abundant in some strains and rare in others21. Macroconidia hyaline, smooth- and thick-walled, cigar-shaped, 8-12-celled, 40-70 x 9-12 ìm. Microconidia sparse or absent, ovoidal to pyriform, 3-9 x 2-5 ìm.

RESULTS

The impact of Sabarimala pilgrimage and related activities on floral diversity was estimated using ground survey coupled with remote sensing data. Data was collected from two separate zones identified as disturbed and undisturbed zones. A total of 102 species of plants including 45 species of trees 19 shrubs and 38 herbs were recorded from the disturbed zone. (Table.8). Among the recorded plants with higher abundance are *Xylia xylocarfre (*1650*), Anaclosa dentriflora (*1066.67*)* etc are recorded as trees, *Strobilanths sp.(*26000*), Acasia intrii(*1875*)* etc. are recorded as abundant shrubs and *Agiratum conisoides (*12650*), Parthenium hysterophores(*4900*)* etc. are recorded as abundant herbs.(Table.6).

In the undisturbed forest areas sampling survey fetched a total of 78 species of plants including 42 species of trees 14 specie of shrubs and 22 species of herbs were recorded (Table.8). Among the recorded plants *Dtsoxylum beddomei (*8044.44*)* and *Hopea parviflora (5200)* are recorded as abundant trees, *Bignonia sp.(25000)* and *strobilanthus ciliatus(*10000. are recorded as abundant shrubs and *Costus speciosus (4340)* and *Piper longum (3325)* are recorded as abundant shrubs. (Table.7).

In the disturbed zone 12 species of plants were recorded as invasives, with a prominent share of herbs (66.67%). where as no invasive plants were recorded in the undisturbed zone. (Table.8). Critical differences were observed in the floral diversity of disturbed and undisturbed zone. In the case of trees, 18 species of trees shows IVI above the weighted mean among them ten species having value above the weighted mean in the disturbed zone on comparing with the eight species of trees in disturbed zone (Fig.7). In the case of shrubs six species shows IVI above weighted mean among them four are showing higher values in undisturbed zone on comparing with the two species in disturbed zone (Fig.8). Ten species of shrubs are showing IVI value above the weighted mean among five species each in disturbed and undisturbed zones showing higher values on comparing (Fig.9).

Biodiversity indices were also estimated for both disturbed and undisturbed zones and Shannon-weiner index no significant between the selected areas. However Important value index showed significant variations with regard to the total flora (Table.9). The quadrate wise analysis on the IVI was also conducted and significantly law mean value was observed for disturbed zone than that of undisturbed zone (Table.10).

The Maturity of the floral community, from the final stage of the succession of the ecosystem to the current changes was also estimated. It is found that undisturbed area has a significantly higher Maturity index value than that of the disturbed zone (Table.11), which shows a smaller frequency percent of the species and higher the number of sporadic species in the disturbed zone.

The Similarity index (Mountford, 1962) between disturbed and undisturbed areas was evaluated in order to assess the overall similarity of the two locations with respect to species diversity and found that it shows a significantly low value of 11.24% (Table.11).

The species competition may be evaluated by using a measure, which combines the species richness and abundance, termed 'Rs' (competition ratio) was evaluated and found that undisturbed zone has higher value, which shows equitability or evenness of the species (Table.12). Disturbed zone also shows a higher value but it includes native and non-native species together.

The 'Rc' value (Composition ratio), a measure of species composition was also evaluated in order to find out the depth of appearance, establishment and spread of non native plants in the disturbed and undisturbed locations. In the undisturbed area, a maximum value of '1' was obtained which shows total absence of non native species. However in the disturbed area the proportion of native plant species showed significant reduction in terms of Rc measures (Table.12).

The Combined diversity index (S) in relation to the Rc and Rs which shows, the combined quality and quantity of current vegetation state was evaluated and a significantly higher index was obtained for undisturbed zone, very close to the theoretical maximum ($0.047 \leq S \leq 0.993$) (Table.12).

The Relative change index (Ci) which shows the relative distance from a current vegetation state to the theoretical final stage for a given spatial scale, was estimated and found that the vegetation of the undisturbed zone is very close to the theoretical final stage of succession but the disturbance zone is far away from that (Table. 12).

The changes in the landuse pattern of Pamba range (Sabarimala and Karimala stations) in PTR was evaluated using RS data and toposheet analysis. The land use pattern in the year 1967 is given in Fig.10 and Table.13. Landuse of 1990 in Fig.11 and Table.13 and Land use of 2004 in Fig.12 and Table.13 . The change in land use pattern from 1967- 2004 is shown in Fig.13. It is found that forest area is decreasing during the period whereas other geographical elements such as open forest and grassland showed significant increase in the area (Fig.13). The barren area and settlements due to human interaction also showed sharp increase. 44.16% of forest area has been reduced during the period 1967- 2004 while grassland showed a sharp increase of 34.17% in the area (Fig.15 and Table.14).

The NDVI was estimated using RS data for the year 1990 and 2004 and observed that both the maximum and minimum values sharply fallen indicating a decrease in forest cover and simultaneous increase in human induced disturbance (Fig.16 and Fig 17). No vegetation area increased from 0.110 Km^2 to 0.444 Km^2 and thick vegetation area decreased from 15.011 Km^2 to 7.078 Km^2 (Table.15 and Fig.018).

The forest fragmentation pattern in 2004 of the study area was evaluated using GIS data and given in Fig.18. High fragmentation zones are observed in Sabarimala

temple area. 8.71 Km^2 area is facing various levels of fragmentation (Table.16). The analysis on forest porosity in the study area showed that the density of non forest area inside the forest polygons were very high in temple area and Pamba Triveni region (Fig.19). 16.50 Km^2 area in the study area showed Porosity at various levels (Table.16). Similarly a high weightage of forest Patchiness per unit area was observed at Sabarimala temple region indicating a high density of non forest areas within the forest (Fig.20). 9.29 Km^2 area is facing Patchiness at various levels (Table.16).

The forest disturbance analysis was showing high disturbance at regions of temple area and trek path to Sasta temple (Fig.21). There is only 15.09 sq. Km area was only considered as disturbed zone, rest of the areas are facing disturbance at various levels (Table.17).

B. Soil Analysis

The nutrient quality and microbial density of the soil from disturbed and undisturbed areas were evaluated. The percent rate of organic carbon and organic matter and Available Potassium was higher in undisturbed area than that of disturbed zone, whereas Available Nitrogen and Phosphorus are high in disturbed zone (Table.18). However Available Potassium was significantly high in undisturbed zone.(Fig.23).

Eighteen species of fungi were isolated from the soil of disturbed zone while 19 species were isolated from undisturbed zone (Table.19). Genus wise analysis of isolated fungi showed that *Aspergillus* has highest share followed by *Penicillium* and the least represented genus is *Chrysosporium* in the disturbed area (Fig.24). In the case of undisturbed area also *Aspergillus* has the highest share followed by *Anthrographis, Trichophyton* and *Chrysospoium* (Fig.25).

The diversity index for soil fungi was also evaluated and both disturbed and undisturbed areas have almost equal values (Table.20). The quadratewise estimation for fungal density was also done and on an average it is significantly high in

undisturbed zone compared to disturbed zone (Table.21). A similar result was obtained in the case of bacterial count also (Table.21).

Table.6. Floral diversity of disturbed areas of Pamba range (Sabarimala- Karimala stations) in PTR. Kerala, during late summer, 2008.

(n=10)

SI No:	Scientific Names	Abundance	IVI
TREES			
1	*Aglaia barberi*	150	10.71
2	*Alianthus malabarica* *	150	5.83
3	*Anacolosa densiflora*	1233.33	5.32
4	*Antidesma lindieyana* *	100	5.83
5	*Aporosa lindleyana*	100	0.64
6	*Artocarpus hirsutus*	100	0.67
7	*Bombax ceiba* *	500	1.05
8	*Callicarpa tomentosa* *	100	6.94
9	*Calophyllum celeba*	100	32.18
10	*Calophyllum sp.* *	100	4.28
11	*Careya arborea* *	100	0.67
12	*Casia fistula* *	100	1.27
13	*Cissampelos pareira* *	500	2.18
14	*Dalbergia latifolia*	300	0.81
15	*Dysoxylum beddomei*	440	6.1008
16	*Elaeocarpus serratus*	100	1.58
17	*Enterolobium samanum* *	100	0.64
18	*Ficus religiosa* *	300	24.26
19	*Holigarna arnotiana* *	200	0.86
20	*Hopea parviflora*	100	0.79
21	*Hydnocarpus pentandra*	266.67	2.93
22	*Kingiodendron pinnatum* *	400	1.65
23	*Knema attennata*	100	1.34
24	*Lagerostromia sfeciose*	100	0.72
25	*Lagerstroemia microcarpa*	150	2.29

26	*Lagerstroemia reginea* *	100	1.56
27	*Macranga peltata*	200	0.82
28	*Mallotus tetracoceus*	100	0.64
29	*Myristica beddomei*	100	2.16
30	*Pierardia courtallensis*	200	3.78
31	*Polyalthia fragrans*	328.57	7.6
32	*Quesia indica* *	100	0.63
33	*Quesia sp.*	250	3.47
34	*Schleichera oleosa* *	200	0.8
35	*Steculia gultata* *	300	0.81
36	*Symlocos maerophylla*	200	0.83
37	*Syzygium cumini* *	100	4.11
38	*Tamarindus indica* *	500	0.96
39	*Tectonia grantis* *	300	3.92
40	*Terminalia chebula*	100	1.73
41	*Vatoria indica*	100	1.25
42	*Wrightia sp.* *	100	0.64
43	*Wrightia tinctonia* *	100	0.72
44	*Xanthophyllum arnottianum*	166.67	2.18
45	*Xylia xylocarpa* *	1650	6.74
SHRUBS			
1	*Acasia intsia* *	1875	0.24
2	*Ancistrocladus sp*	340	4.33
3	*Atlantia racemosa*	200	0.72
4	*Calamus thwaitesii*	500	2.84
5	*Callicopteris floribunde*	500	0.96
6	*Canavalia ensiforms* *	450	1.85
7	*Cinnamomum melabai*	100	1.27
8	*Elaeocarpus oblongus* *	100	0.75
9	*Glycosmis macrophylla*	100	0.64
10	*Helectores isora*	600	2.13

11	*Jasminum sp.* *	100	0.63
12	*Lytsia sp.*	100	0.65
13	*Maranta virgata* *	100	0.72
14	*Mimosa sp.* *	800	1.23
15	*Sida rhambifolia* *	600	1.37
16	*Sida sp.* *	100	0.63
17	*Smilax chine*	500	0.97
18	*Strobilanthus ciliatus*	26000	21.84
19	*Vitex utilisima* *	200	0.72
HERBS			
1	*Acantosia sp.* *	100	0.63
2	*Achyranthes aspera*	5033.33	30.41
3	*Adathoda vasica* *	2800	5.7
4	*Ageratum conisoides* *	12650	65.64
5	*Apama siliquosa* *	650	2.19
6	*Apama sp.* *	1500	3.56
7	*Axinopus compresses*	166.67	2.07
8	*Brassica juncea* *	350	1.68
9	*Centruosema pubescences* *	200	0.71
10	*Chessalia curviflora* *	100	0.65
11	*Clidemia hirta* *	16000	3.83
12	*Costus speciosus*	500	2.93
13	*Crimum sp.* *	100	0.638
14	*Curculigo orchioides*	233.33	2.23
15	*Curcuma rectacanda*	350	2.24
16	*Cyalthula prostrata*	500	0.96
17	*Cyelea peltata* *	250	1.52
18	*Dolichos trilobus* *	300	0.81
19	*Eupatorium odoratum* *	250	3.03
20	*Fern sp.*	300	2.4
21	*Girardinia diversiflora* *	500	0.98

22	*Hemidesmus indicus* *	300	0.81
23	*Komelina sp.* *	100	0.63
24	*Memcylon edule* *	100	0.64
25	*Mikania scandens* *	350	1.69
26	*Mimosa pudica* *	200	0.72
27	*Pandanus sp.*	900	1.32
28	*Parthenium hysterophores* *	4900	18.51
29	*Pennisectum sp.* *	620	5.31
30	*Physalis minima* *	100	0.64
31	*Pilea sp.* *	1650	3.81
32	*Piper longum*	600	1.05
33	*Piper mullesua*	1400	3.57
34	*Sizygum oenoglee* *	100	0.63
35	*Sizygum sp.* *	250	1.52
36	*Solanum sp.* *	1600	1.88
37	*Tiliacora acuminata*	300	0.81
38	*Viveria sp.*	800	1.21

** Indicate species present only at Disturbed zone*

Table.7. Floral diversity of undisturbed areas of Pamba range (Sabarimala- Karimala stations) in PTR. Kerala, during late summer, 2008.

(n=10)

SI No:	Scientific Names	Abundance	IVI
TREES			
1	*Aglaia barberi*	200	1.23
2	*Anacolosa densiflora*	200	21.48
3	*Aporosa lindleyana*	150	3.12
4	*Archidendron monadelphum* **	100	1.06
5	*Calophyllum celeba*	700	0.85
6	*Carallia brachiata* **	100	1.86
7	*Caryota urens* **	150	1.19
8	*Chukrasia tabularis* **	100	0.73
9	*Croton klotzschianus* **	100	0.75
10	*Dalbergia latifolia*	500	0.77
11	*Diospyros candolleana* **	150	2.59
12	*Dipterocarpus bourdillonii* **	100	0.86
13	*Dysoxylum beddomei*	8044.44	45.86
14	*Dysoxylum malabaricum* **	100	0.58
15	*Elaeocarpus serratus*	200	2.02
16	*Ficus exasperate* **	100	0.57
17	*Flacourtia mountana* **	100	1.22
18	*Garcinia gummiguta* **	200	0.61
19	*Garcinia sp.* **	160	5.45
20	*Gmelina arborea* **	100	5.05
21	*Hopea parviflora*	520	8.36

22	*Hydnocarpus pentandra*	300	1.17
23	*Ixora sp.* **	100	1.46
24	*Knema attenueta*	175	3.53
25	*Knema sp.* **	200	5.98
26	*Lagerostromia speciose*	133.33	0.62
27	*Lagerstroemia microcarpa*	100	1.25
28	*Leea indica*	100	0.57
29	*Macranga peltata*	180	8.27
30	*Mallotus philippensis* **	1400	1.18
31	*Mallotus tetracoceus*	250	1.29
32	*Myristica beddomei*	133.33	4.28
33	*Pierardia courtallensis*	300	2.5
34	*Polyalthia fragrans*	570	14.83
35	*Quesia indica*	400	1.37
36	*Strichnos nuxvomicus* **	200	1.22
37	*Symlocos maerophylla*	100	3.21
38	*Terminalia chebula* **	1500	1.63
39	*Tetrameles nudiflora* **	342.86	5.05
40	*Tetramels sp.* **	100	3.21
41	*Vatoria indica*	280	8.82
42	*Xanthophyllum arnottianum*	400	1.77
SHRUBS			
1	*Ancistrocladus sp*	783.33	5.46
2	*Atlantia racemosa*	640	4.13
3	*Bignonia sp.* **	25000	1.6
4	*Blumia sp.* **	150	1.18
5	*Calamus thwaitesii*	200	1.33

6	*Callicopteris floribunda*	1000	0.99
7	*Coffea sp.* **	1933.33	4.29
8	*Cyprus sp.* **	300	1.31
9	*Helectores isora*	100	0.57
10	*Homonia sp.* **	100	0.57
11	*Ixora sp.* **	150	2.86
12	*Psychotrea sp.* **	1325	19.19
13	*Smilax chine*	200	0.61
14	*Strobilanthus ciliatus*	10000	18.23
HERBS			
1	*Achyranthes aspera*	100	0.57
2	*Axinopus compresses*	180	3.05
3	*Citrus sp.* **	300	1.99
4	*Costus speciosus*	4340	13.72
5	*Curculigo orchioides*	733.33	2.53
6	*Curcuma rectacanda*	100	0.57
7	*Fern sp.*	1885.71	9.85
8	*Hibiscus sp.* **	700	0.82
9	*Laportea bulbifera* **	4150	8.88
10	*Loganaceae sp.* **	2000	1.38
11	*Murraya sp.* **	200	1.21
12	*Narvelia zeylanica***	100	0.57
13	*Nephrolepis sp.* **	2700	1.63
14	*Orchid sp.* **	100	0.57
15	*Pandanus sp.*	100	0.57
16	*Piper longum*	3325	7.53

17	*Piper mullesua*	200	2.43
18	*Salacia reticulata***	100	0.57
19	*Sterculia guttata **	100	0.57
20	*Tiliacora acuminata*	133.33	1.77
21	*Trichilia connaroide **s*	233.33	1.88
22	*Viveria sp.*	200	0.61

*** Indicate species present only at Disturbed zone*

Table.8. Summary data on floral diversity in disturbed and undisturbed zones of Pamba range (Sabarimala- Karimala stations) in PTR. Kerala, during late summer, 2008.

(n=10 X 2)

Plants	Disturbed	Invasive/Weed plants in disturbed area	Undisturbed	Plants in common
Trees	45	2	42	22
Shrubs	19	2	14	7
Herbs	38	8	22	11
Total	102	12	78	40

Table.9.Shannon-weiner index and Important value index based on floral diversity of disturbed and undisturbed zones of Pamba range (Sabarimala- Karimala stations) in PTR. Kerala, during late summer, 2008.

(n=10 X2)

SI No:	Type of Plants	Shannon-Wiener Index		Important value Index	
		Disturbed	Undisturbed	Disturbed	Undisturbed
1	Total flora	2.921	2.938	386.191	298.731
2	Trees	3.439	2.539	159.656	175.003
3	Shrubs	1.009	1.284	50.869	62.311
4	Herbs	2.432	2.308	175.665	61.418

Table.10. Quadrate wise Important value Index for disturbed and undisturbed zones of Pamba range (Sabarimala- Karimala stations) in PTR. Kerala, during late summer, 2008.

(n=10 X2)

SI No:	Quadrates	Important value Index (IVI)
Disturbed zone		
1	Quadrate- 1	140.090
2	Quadrate- 2	37.431
3	Quadrate- 3	141.074
4	Quadrate- 4	118.479
5	Quadrate- 5	73.540
6	Quadrate- 6	51.809
7	Quadrate- 7	101.679
8	Quadrate- 8	199.898
9	Quadrate- 9	157.244
10	Quadrate- 10	112.822
Average		**113.41**
Undisturbed zone		
11	Quadrate- 11	143.323
12	Quadrate- 12	185.837
13	Quadrate- 13	142.992
14	Quadrate- 14	148.614
15	Quadrate- 15	124.586
16	Quadrate- 16	156.548
17	Quadrate- 17	142.430
18	Quadrate- 18	148.685
19	Quadrate- 19	139.675
20	Quadrate- 20	138.850
Average		**147.16**

Table.11. Maturity index and Similarity Index (Mountford, 1962) for disturbed and undisturbed zones of Pamba range (Sabarimala- Karimala stations) in PTR. Kerala, during late summer, 2008.

(n=10 X2)

SI No:	Zones	Maturity Index	Similarity index(Mountford,1962)
1	Disturbed	18.03922	C_M =11.24 %
2	Undisturbed	24.61538	

Table.12. Combined index of native or non-native plant diversity for disturbed and undisturbed zones of Pamba range (Sabarimala- Karimala stations) in PTR. Kerala, during late summer, 2008.

(n=10 X2)

SI No:	Zone	Rs	Rc	S	Ci(1-S)
1	Disturbed	0.631587	0.677753	0.604631	0.395369
2	Undisturbed	0.674405	1.00	0.916422	0.083578

* Rs - Competition ratio
* Rc –Composition ratio
* S – Combined diversity index
* Ci - Relative change index

Table.13. Land use\ Land cover pattern of years 1967,1990 and 2004 in Pamba range (Sabarimala- Karimala stations) in PTR, Kerala

Land Use Type	AREA		
	1967	1990	2004
	Km^2	Km^2	Km^2
Forest	26.66	17.78	14.72
Open forest	0	1.41	2.01
Grassland	0	6.73	9.24
Barren area	0.24	0.70	0.64
Settlements	0.15	0.43	0.44
Total	27.045	27.045	27.045

Table.14. Land use\ Land cover changes between years 1967,1990 and 2004 in Pamba range (Sabarimala- Karimala stations) in PTR, Kerala

Land use Type	CHANGE		
	1967-1990	1990-2004	1967-2004
	Area (Km^2)	Area (Km^2)	Area (Km^2)
Forest	-8.88	-3.06	-11.94
Open forest	1.41	0.60	2.01
Grassland	6.73	2.51	9.24
Barren area	0.46	-0.06	0.40
Settlements	0.28	0.01	0.29

Table.15.Change analysis of Normalized difference Vegetation Index of the years 1990 and 2004 in Pamba range (Sabarimala- Karimala stations) in PTR, Kerala

Vegetation vigor	Year	
	1990 Area (Km2)	2004 Area (Km^2)
Very low	0.11	0.44
Low	1.54	2.89
Moderately High	10.92	16.89
High	15.01	7.08

Table.16. Landscape analysis of the year 2004 in Pamba range (Sabarimala- Karimala stations) in PTR, Kerala

SI No:	Landscape anlysing Indices	Level of Disturbance	Area (Km^2)	Area (%)
1	Fragmentation	Low	18.63	68.89
		Moderately high	7.7	28.47
		High	0.68	2.51
		Very high	0.04	0.14
2	Patchiness	Low	17.76	65.67
		Moderately high	8.2	30.32
		High	1.01	3.72
		Very high	0.09	0.33
3	Porosity	Low	10.55	39.01
		Moderately high	16.1	59.53
		High	0.39	1.43
		Very high	0.01	0.04

Table.17. Disturbance zone analysis of the year 2004 in Pamba range (Sabarimala-Karimala stations) in PTR, Kerala

SI No:	Level of disturbance	Area (Km^2)	Area (%)
1	Undisturbed	15.09	55.80
2	Moderately disturbed	6.5	24.03
3	Disturbed	4.83	17.86
4	Highly disturbed	0.12	0.44
5	Settlements	0.46	1.70

Table.18. Quadrate wise Organic carbon and nutrient status for disturbed and undisturbed zones of Pamba range (Sabarimala- Karimala stations) in PTR. Kerala, during late summer, 2008.

(n=10 x 2)

OC: Organic carbon, OM: Organic matter, AN: Available Nitrogen, AP: Available Phosphorous, AK: Available potassium

SI No:	QUADRATES	OC (%)	OM (%)	AN (Kg/ha)	AP (Kg/ha)	AK (Kg/ha)
DISTUBED ZONE						
1	Q1	2.99	5.51	504.00	0.336	89.46
2	Q2	1.57	2.70	100.80	93.18	83.55
3	Q3	5.74	9.90	504.00	31.70	212.8
4	Q4	5.27	9.08	163.80	32.59	68.10
5	Q5	2.37	4.08	138.60	39.42	45.47
6	Q6	1.54	2.65	138.60	33.38	60.26
7	Q7	2.01	3.47	138.60	31.02	60.70
8	Q8	4.74	8.16	214.20	78.85	79.30
9	Q9	2.72	4.69	176.40	48.38	99.90
10	Q10	2.37	4.08	252.00	35.50	57.57
UNDISTUBED ZONE						
11	Q11	3.85	6.63	75.60	8.07	38.08
12	Q12	3.55	6.12	100.80	21.84	134.40
13	Q13	4.82	8.32	100.80	11.31	100.80
14	Q14	4.29	7.40	126.00	10.75	156.80
15	Q15	4.59	7.91	126.00	6.27	56.66
16	Q16	2.87	4.95	75.60	21.50	123.20
17	Q17	1.84	3.17	75.60	3.58	123.20
18	Q18	2.72	4.69	75.60	28.34	123.20
19	Q19	3.34	5.77	75.60	11.65	89.60
20	Q20	4.03	6.94	50.40	34.94	100.8

Table.19. Fungi isolated from disturbed and undisturbed zones of Pamba range Sabarimala- Karimala stations) in PTR (. Kerala, during late summer, 2008 (n=10 X2)

SI No	Fungi in Disturbed zone	Frequency of occurrence	SI No	Fungi in Undisturbed zone	Frequency of occurrence
1	*Absidia corymbifera*	10	1	*Absidia corymbifera*	10
2	*Andrographis cuboidea*	20	2	*Andrographis cuboidea*	10
3	*Aspergillus flavus.*	20	3	*Aspergillus fumigatus*	10
4	*Aspergillus fumigatus*	10	4	*Aspergillus niger*	60
5	*Aspergillus niger*	20	5	*Aspergillus carbamarius*	30
6	*Aspergillus sp*	10	6	*Aspergillus flavus*	30
7	*Chrysosporium sp.*	20	7	*Chrysosporium sp.*	10
8	*Gliocladium sp*	10	8	*Penicillium sp.*	10
9	*Microsporum audouini*	10	9	*Curvularia geniculata*	10
10	*Monocillium sp.*	20	10	*Phialimonium obovatum*	10
11	*Mycelia sterilia*	20	11	*Gliocladium sp*	10
12	*Paciliomyces sp.*	10	12	*Penicillium janthinellum*	10
13	*Penicillium oxalicum*	20	13	*Trichophyton scholeni*	10
14	*Penicillium purpurogenum*	20	14	*Penicillium verucosum*	10
15	*Phialemonium obovatum*	10	15	*Trichophyton rubrum*	10
16	*Trichophyton longibracheatum*	10	16	*Trichophyton verucosum*	20
17	*Trichophyton rubrum*	10	17	*Trichophyton ajelloi*	20
18	*Trichophyton scholeni*	10	18	*Morierella sp.*	10
			19	*Mycelia sterilia*	30

.

Table.20.Shannon-weiner index based on fungal diversity of disturbed and undisturbed zones of Pamba range (Sabarimala- Karimala stations) in PTR. Kerala, during late summer, 2008.

(n=10 X2)

Zones	Shannon-Wiener Index
Disturbed	2.707
Undisturbed	2.717

Table.21. Quadrate wise Bacterial and Fungal counts for disturbed and undisturbed zones of Pamba range (Sabarimala- Karimala stations) in PTR Kerala, during late summer, 2008.

(n=10 x 2)

SI No:	Quadrates	Fungal count	Bacterial count
Disturbed Zone			
1	Quadrate- 1	16×10^3	13×10^7
2	Quadrate- 2	7×10^3	9×10^7
3	Quadrate- 3	10×10^3	10×10^7
4	Quadrate- 4	4×10^3	8×10^7
5	Quadrate- 5	11×10^3	13×10^7
6	Quadrate- 6	3×10^3	15×10^7
7	Quadrate- 7	8×10^3	18×10^7
8	Quadrate- 8	8×10^3	15×10^7
9	Quadrate- 9	16×10^3	14×10^7
10	Quadrate- 10	7×10^3	5×10^7
Average		**9 x 103**	**12.78 x 10 7**
Undisturbed Zone			
11	Quadrate- 11	26×10^7	36×10^3
12	Quadrate- 12	20×10^7	17×10^3
13	Quadrate- 13	18×10^7	22×10^3
14	Quadrate- 14	21×10^7	31×10^3
15	Quadrate- 15	22×10^7	23×10^3
16	Quadrate- 16	30×10^7	16×10^3
17	Quadrate- 17	29×10^7	18×10^3
18	Quadrate- 18	24×10^7	16×10^3
19	Quadrate- 19	33×10^7	$16x\ 10^3$
20	Quadrate- 20	19×10^7	27×10^3
Average		**24.78×10^7**	**22.22×10^7**

Fig.7. Comparison of tree having IVI above weighted mean in disturbed and undisturbed zones of Pamba range (Sabarimala- Karimala stations) in PTR. Kerala, during late summer, 2008.

(n=10 x 2)

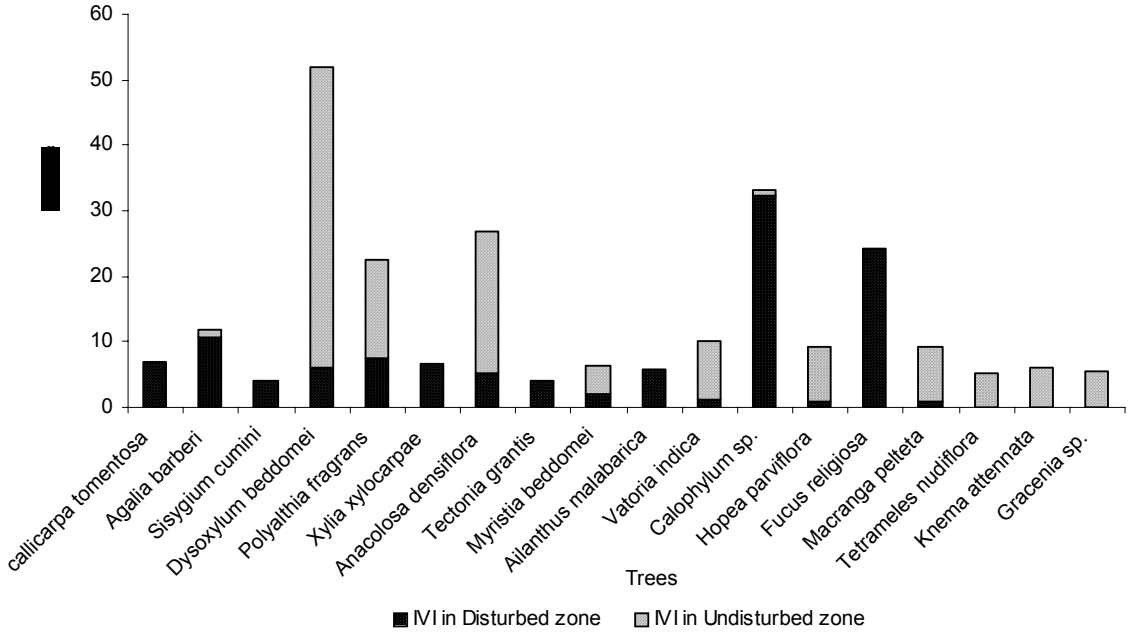


Fig.8. comparison of Shrubs having IVI above weighted mean in disturbed and undisturbed zones of Pamba range (Sabarimala- Karimala stations) in PTR. Kerala, during late summer, 2008.

(n=10 x 2)

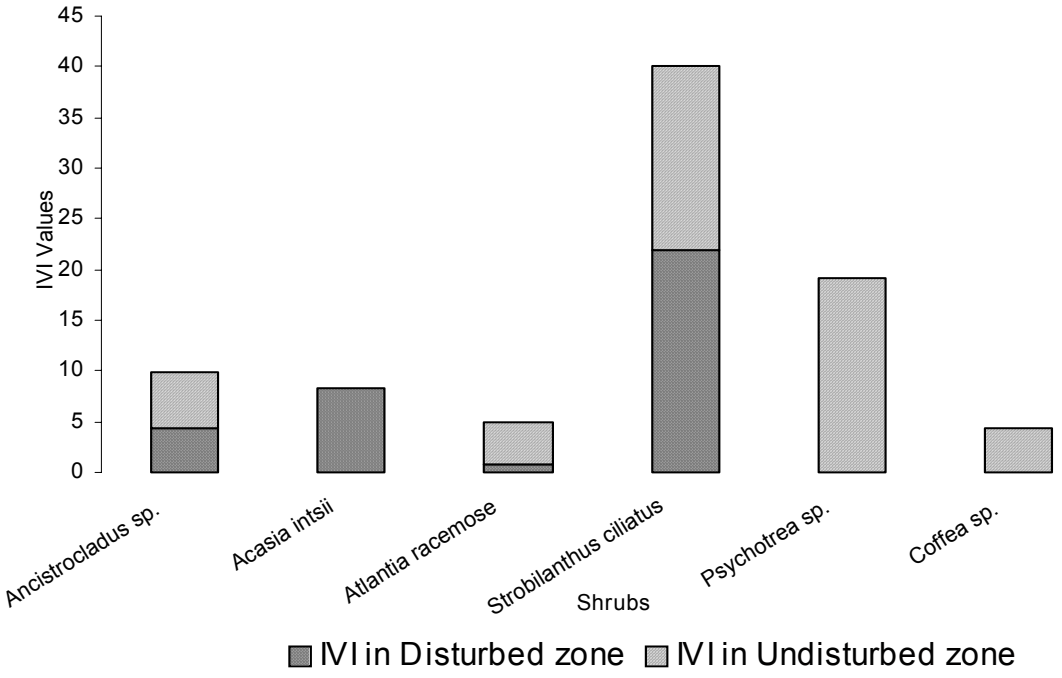


Fig.9. Comparison of Herbs having IVI above weighted mean in disturbed and undisturbed zones of Pamba range (Sabarimala- Karimala stations) in PTR. Kerala, during late summer, 2008.

(n=10 x 2)

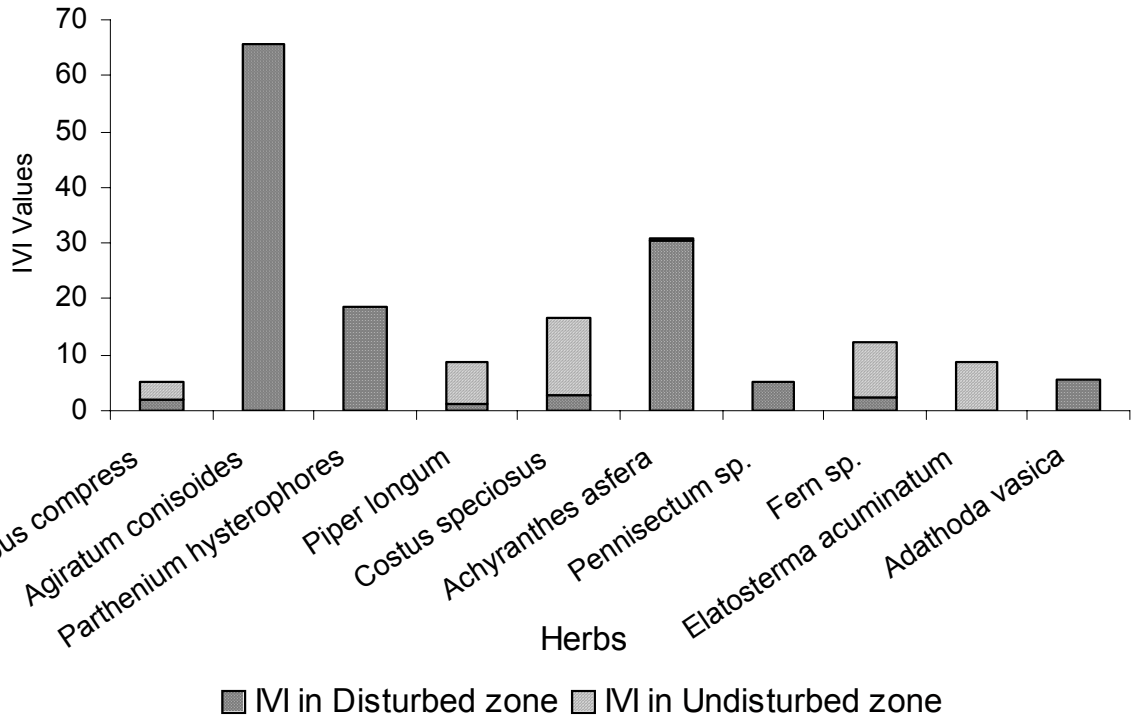


Fig.14. Change in land use pattern of Pamba range (Sabarimala- Karimala stations) in PTR. Kerala, during 1967-2008

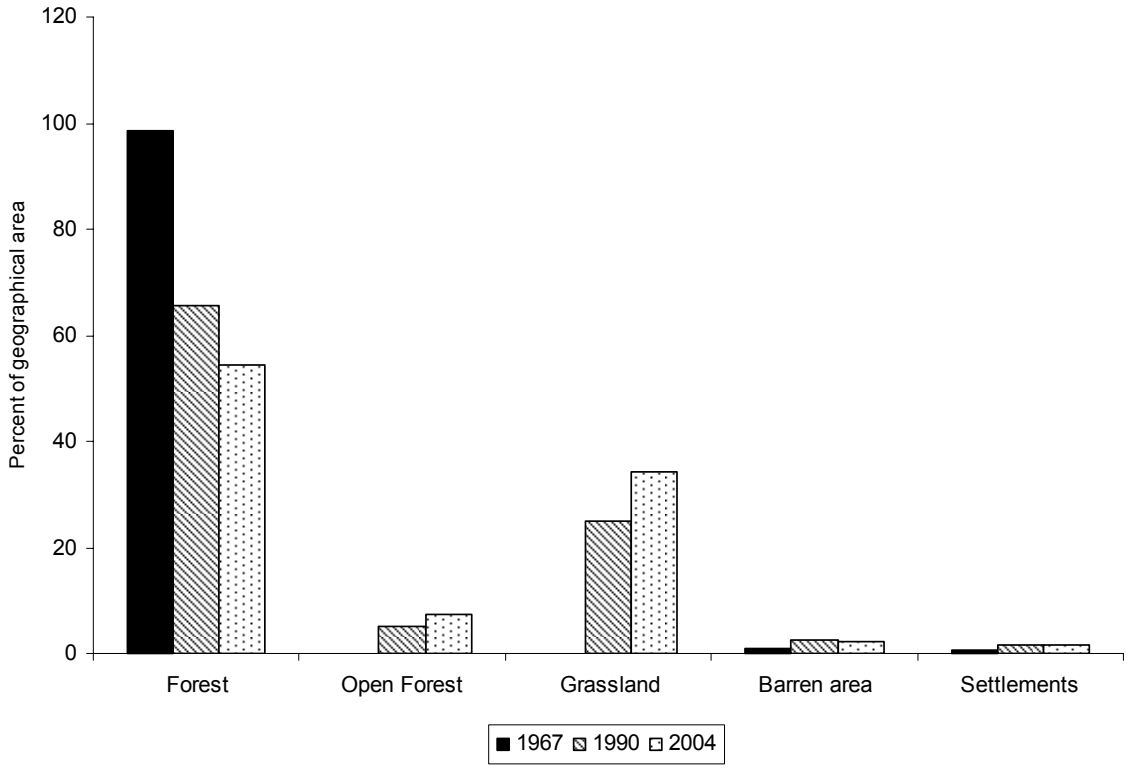


Fig.15. Percent change in land use pattern of Pamba range (Sabarimala- Karimala stations) in PTR. Kerala, during selected time periods

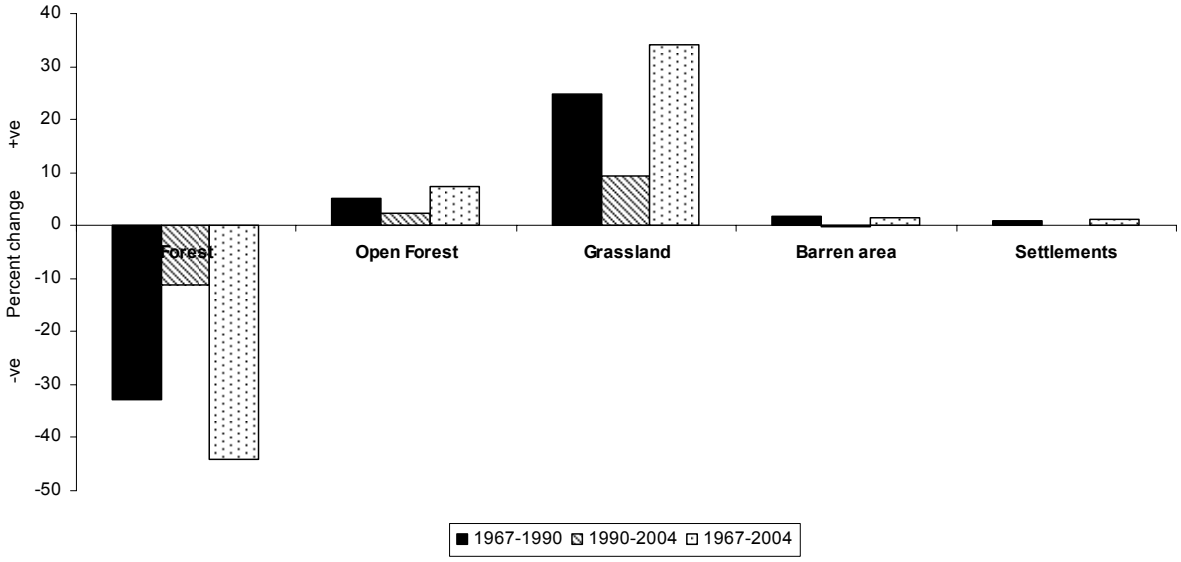


Fig.018. Percent change in Normalized Vegetation Index during 1990 - 2004 of Pamba range (Sabarimala- Karimala stations) in PTR., Kerala.

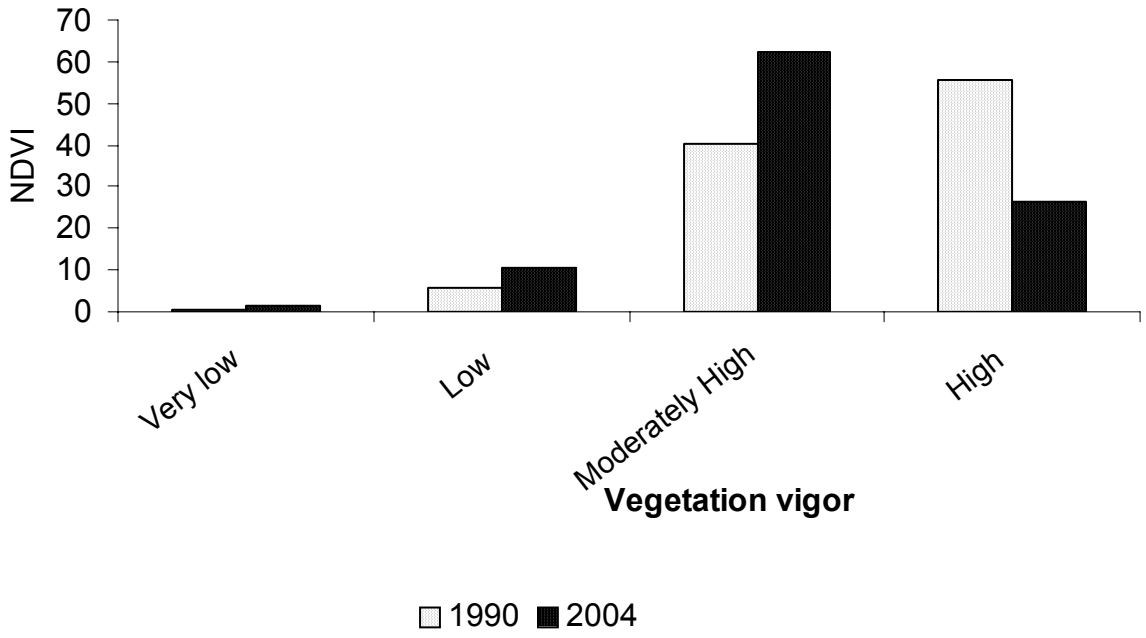


Fig.23 . Comparison of average amount of Organic carbon and Available nutrients in soils of disturbed and undisturbed zones of Pamba range (Sabarimala- Karimala stations) in PTR. Kerala, during late summer, 2008.

(n=10 x 2)

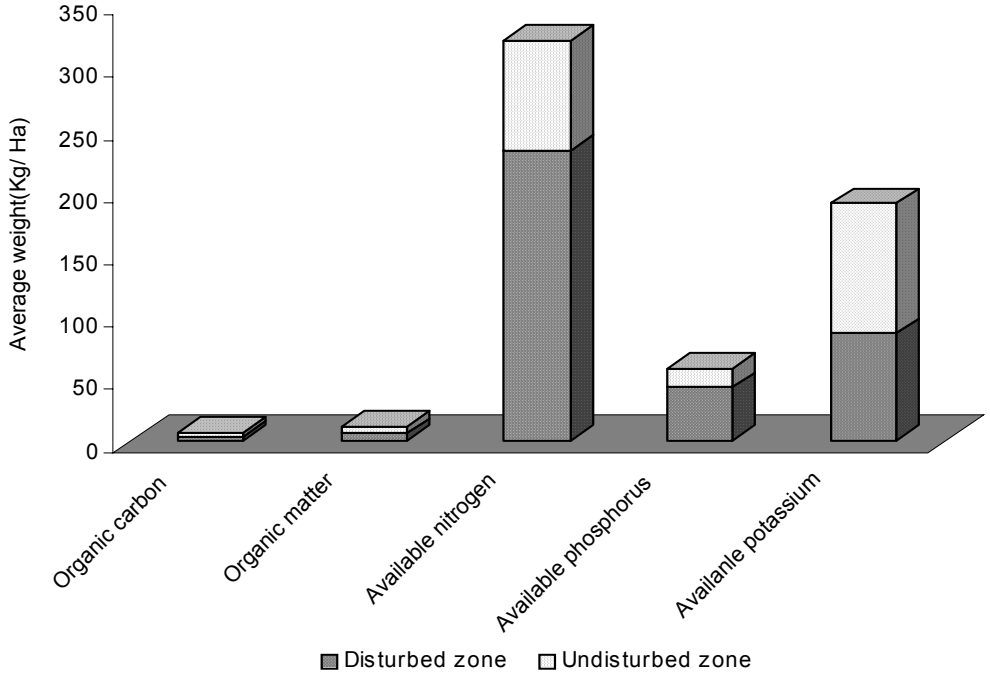


Fig.24. Genus wise analysis of fungi isolated from disturbed zones of Pamba range Sabarimala- Karimala stations) in PTR during late summer, 2008 (n=10)

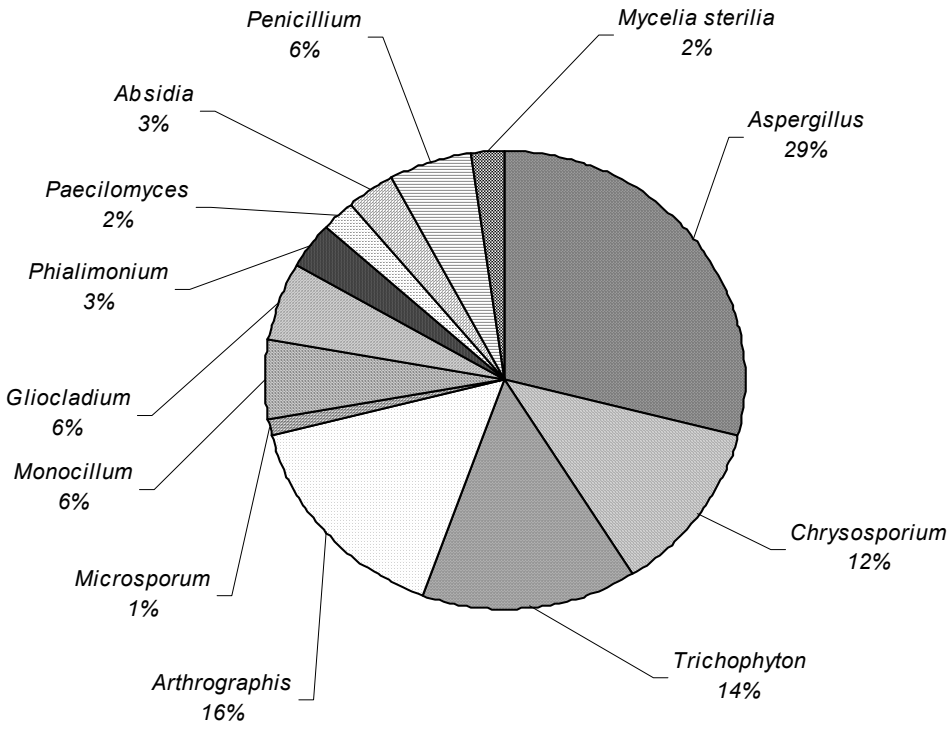
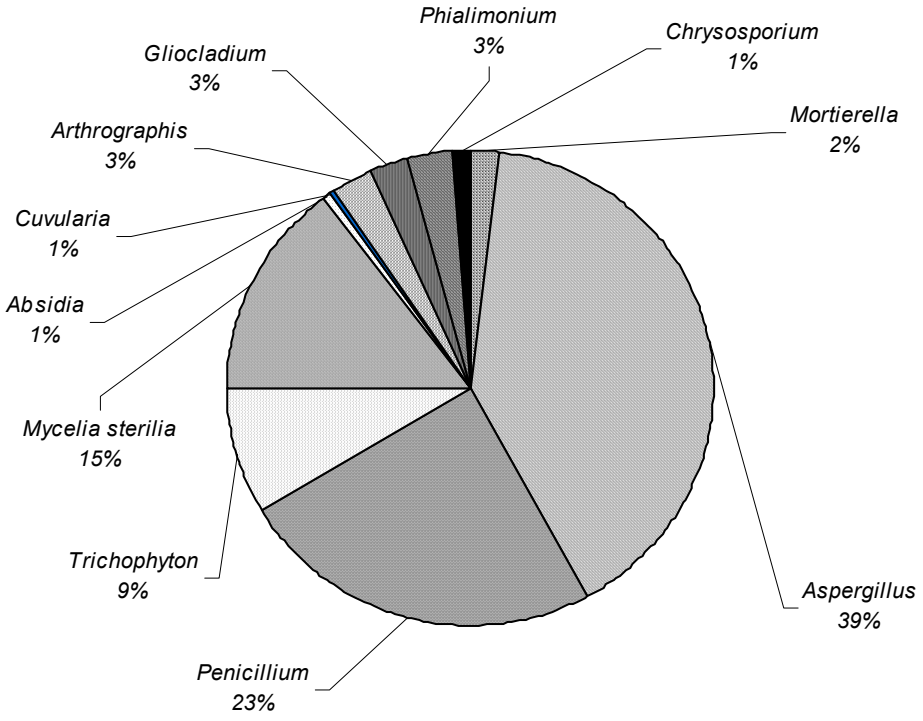


Fig.25. Genus wise analysis of fungi isolated from undisturbed zones of Pamba range (Sabarimala- Karimala stations) in PTR during late summer, 2008 (n=10)



DISCUSSION

The increasing human demand threatened biodiversity and resources associated with them. Since the beginning of last century tourism activities was become one of the major reason for the species extinction and habitat loss. Sabarimala a unique pilgrimage center with ritualistic, geographical and ecological peculiarities become a major 'Pilgrimage tourism' center, visited by more than 50 lakhs pilgrims every year. The ever-increasing commercial activities and development of infrastructural facilities have been created several ecological issues. The present study, though it is limited with short duration of study period and sample size, primarily analyze the biodiversity richness and soil quality of disturbed area in Pamba range of PTR due to Sabarimala pilgrimage and undisturbed areas of the same forest.

A total of 102 species of plants including 45 species of trees, 19 shrubs and 38 herbs were recorded from disturbed zone and a total of 78 species of plants including 42 species of trees, 14 species of shrubs and 22 species of herbs are recorded from undisturbed zone (Table.6). The higher number of plants in the disturbed zone may be due to the edge effect. Available reports suggest that the fragmentation or corridors formed inside the forest patches are causing edge effect (Pickette and White, 1985; Reed *et al.,* 1996). It is well established that this type of edge effect bring higher species richness and greater number of exotic species to the area (Ranney *et al.,*1981; Brothers and Spingram, 1992). The higher species diversity in disturbed area of Pamba range, where Sabarimala temple and trek path to the temple may be due to the edge effect in the area. Edge effects is favorable temperature, wind, moisture and light availability to the ground cover especially on herbal layer evolved in that area for such a change (Euskirchen *et al.,*2001).

Among the reported 102 species of plants in disturbed area 12 species are weed or invasive plats. *Agiratum conisoide, Parthenium hysterophores, Acacia intsia* and *Eupatorium odoratum* are abundant weeds in this area. All of these plants are well recognized as

invasive and considered as dominant invasives too (Rao and Murgan, 2005). *Agiratum conisoide, Parthenium hysterophores, Acacia intsia* and *Eupatorium odoratum* belongs to family *Asteraceae* and these are dominant weeds in the disturbed zone. The significant share of floral cover includes weeds such as *Agiratum conisoide,* and *Parthenium hysterophores* are highly successive invasive plants that make luxuriant growth at the cost of other ecosystem components.

Parthenium hysterophores, which is considered as on of the noxious weed has got wide distribution all over the country through grains and got significant feature of high propagule pressure and dispersal rates (Lonsdale, 1999). This plant may have reach to the Sabarimala region through food grains brought by pilgrims and commercials to prepare food. *Parthenium hysterophores* have many deleterious effects on soil environment especially on soil nutrient pool and health of organisms including human pulmonary problems like Asthma and even death also (Raghubanashi *et al.,* 2005). The plant reported zone of *Parthenium hysterophores* in disturbed area was an animal free movement area in non- pilgrimage season. This may create serious health problems for both wildlife and man who will exposed to the plant.

The weedy shrub *Acacia instia* has the highest IVI among the reported flora. This is a commonly identified liana in all disturbed ecosystems in south India, and the characteristic growth pattern of this plant can terminated the growth of even large trees also (KFD, 2004). The occurrence of heavy ground cover of this shrub was a clear indication of degradation of the ecosystem in disturbed zone of Pamba range.

The presence of invasives such as *Brassica juncia* and *Tamarandus indica* are also a clear evidence for anthropological stress in the area. As these plant seeds are important ingredients for taste and odor in many south Indian dishes (Morton, 1987), it is evident that the plants have been reached here through food preparation of pilgrims coming from Tamilnadu, Karnataka and Andhrapradesh. The presence of the tree *Enterolobium samanum,* which is a native of tropical America and now widely

spread throughout the humid and sub humid tropics as a promising agro forestry species (Durr, 2001). Most probably this may be planted by Kerala forest department as part of social forestry programme

The other predominant plant species present in disturbed zone, except exotic are trees like *Dysoxylum beddomei, Anaclosa densiflora, Calophyllum celeba* and *Ficus religiosa;* shrubs such as *Strobilanthus ciliatus* and *Achyranthes aspera* and herbs including *Adathoda vasica* are well recognized endemic plants of Western ghats of India (Jayarajan, 2004). In the undisturbed zone no invasive plants are reported. Predominant plants in undisturbed areas, are trees alike *Dysoxylum beddomei, Polyalthia fragrans, Anaclosa densiflora, Hopea parviflora;* shrubs like *Strobilanthus ciliatus, Ixora sp.* and herbs like *Costus specious, Laportea bullifera* and Piper longum. All these are reported widely from evergreen forests of Western ghats (DOS and DOB, 2002; KFD, 2004).

The Important Value Index (IVI) analysis of total flora and quadrate wise analysis showed very significant variations in their values. Forty species of plants were found common in both disturbed and undisturbed areas, however the IVI for total flora was significantly high in disturbed area than that of undisturbed area. This is mainly due to extreme high IVI observed for herbs in the disturbed area, in which most of the species are invasive weeds. It should be noted that the significantly high IVI for trees and shrubs observed in undisturbed area includes the higher density, frequency and basal cover area of native forest plants. The quadrate wise IVI analysis for disturbed and undisturbed zones also showed a significantly higher value for undisturbed zones, which again establishes high density, frequency and basal cover area of native group of plants.

The species density , frequency and basal cover area of predominant plants in Pamba range were compared among disturbed and undisturbed zones on the basis of weighted mean of IVI and found that 55.56% of trees have significantly more distribution and density in undisturbed zone than that of disturbed zone (Fig.7).

Similarly 80% of shrubs have also more distribution as well as density in undisturbed zone (Fig. 8). However in the case of herbs 50% of species only have more distribution and density in undisturbed zone (Fig. 9). This comparison clearly reveals that though the plant species are represented in the undisturbed area, their density and distribution are significantly confined and reduced in disturbed zone because of extremely high human interferences, which are totally damaging the ecosystem too (Starfingr, 1998).

The Shannon- wiener index of index of plant diversity for disturbed and undisturbed areas show that no significant variations in the biodiversity status of the two areas. Contradictory to the normal expectation that a higher diversity index for undisturbed zone than that of disturbed zone, the present result showed that the species composition is not recognized by this index. The disparity in result may the result of the formula does not separate the diversity of native or non- native plants from the total diversity of species present (Haeupler, 1995; Krebs, 2001).

The Maturity index value for disturbed and undisturbed areas give significantly a higher value (24.62) in undisturbed zone than that of disturbed zone value (18.04). The analysis was based on the principle that when succession has entered in to a final stage, the total number of species will reduce and those which are adapted to the changing environment alone will survive and multiply to form the dominant community (Puri and Jain, 1961). Interestingly in the present study also such a situation with reduction in species number and hike in number of individuals are observed in the undisturbed zone than that of disturbed zone, hence the higher value was obtained there.

Similarity Index (Mountford, 1961) was also calculated and showed a significantly low value of 11.24%. As the index was based on the ' Community coefficient concept' and centered on the presence – absence relationship between the number of species common to two areas and total number of species (Jaccard, 1912),

the disturbed and undisturbed area show significantly lower similarity. It was observed that only 40 species of plants are common to both these disturbed and undisturbed areas, hence such a low similarity Index value was obtained. The low similarity value shows the extremely high levels of changes that happen in the disturbed zone and related disintegration to the diversity. The high level of disturbances occurring within conserved forest area poses serious threat to the undisturbed area too (Stapanian *et al.,* 2008).

Analysis were also done in order to incorporate the role of invasive species, that exempted in diversity index analysis. Competition ratio 'Rs' was calculated to check the equilibrium or evenness of all species present together (Krebs, 1999). Rs value for undisturbed area was closer to maximum value (1) but in the undisturbed area it is relatively low (0.67). This clearly shows that the diverse species found in the undisturbed zone have an almost equal density and distribution while in undisturbed area this equity lacks. The undisturbed area has a stabilized climax community, where as the disturbed area has a unstable, changing population of plants due to the continuing human interactions.

The Composition ratio 'Rc' was also measured. As the species composition is more important than species number and is affecting a range of ecosystem properties (Hooper and Vitousek, 1997) 'Rc' value is very much important. The present study give the 'composition ratio' of one in undisturbed area hence there is no invasive plants. The non- native plants at a given locality seems to be caused many modifications in the plant composition (di Castri, 1989; Chropoulos and Christodulakis, 2000), hence the 'Rs' value in disturbed zone give a value of 0.678 only. A higher value of 'Rs' means there is less competition between individuals as well as between species, which indicate relatively full use of the limited space and a stable climax community (Krebs, 1999).

The Combined diversity index (S) are also calculated, to assess scale and environmental change over time on varying scales (Barbour *et al.,* 1998). As 'S' value show relative change of current state to the theoretical final maximum value, which was indicating less disturbance in this zone on comparing with disturbed zone.

Interestingly the relative change Index (Ci) which give relative change in phytodiversity of an area with that of the theoretical maximum value one (Barbour *et al.,* 1998) also gave proof to the stability maintaining in the undisturbed zone. The relative change is only 0.084 on comparing with 0.40 value of disturbed zone. The higher rate of disturbance lead to the relatively unstable populations in the disturbed zone. The natural cyclicity of plant development and growth also have been severely interrupted due to the heavily inflow of about 50 lakh pilgrims in to the forest area during every annual pilgrimage season.

The degree of forest degradation and loss in diversity was also estimated using GIS and RS data. Most of the inferences of this analysis are complementary to the findings of the ground survey. The comparative analysis of the Normalized Difference Vegetation Index (NDVI) values of the year 1990 and 2004 for the Sabarimala and Karimala stations showed that vegetation vigour in 'Very low' and 'Low' categories are increased and 'Moderately high' and 'High' categories are decreased (Table.15). The drastic decreases in area of high vegetation vigour are denotes extensive deforestation during the period in the study area. Similar observations od decrease in vegetation vigour over years was made by NDVI analysis of Western Rajastan (Chakraborthy *et al.,*2001), Hazira region of Gugarat (Chauhan and Nayak, 2005) and Coal mining areas of Kobra, Chattisgarh (Joshi *et al.,*2006). The anthropogenic activities are the major cause for forest degradation in all these locations. In the present study the area converted to 'Very low' and 'Low' categories are mostly confined to Sabarimala temple and Pamba triveni region, which shows a direct correlation of pilgrimage activity that lead to forest degradation.

The Land use/ Land cover change analysis of the study area also done using RS and GIS data. The results of Overlay analysis revealed that significant extent of forest area was converted to other land uses over decades. The forest area decreased from 98.58% in 1967 to 54.43% in 2004 revealed sporadic anthropogenic influence over the period in the selected region. The forest area in this period of time converted to other land uses like settlements, open forests, grasslands and barren area. Mainly the open forests and grasslands showed considerable increase in area, indicating direct human intervention into forest lands by clearing unde cover completely and top canopy to an extent.

The expansion of open forest area is more in period 1990- 2004. The number of pilgrims also increased during this decade than previous years (Sathyapalan, 2002). It is well evident that increasing human pressure is directly correlated to decreasing natural forest cover. This type of gradual degradation of forest land to arid regions due to anthropod\genic stress was observed in mining areas of Kobra, Chattisgarh also (Joshi *et al.,* 2006). Hence it may be noted that the increasing pilgrimage activity will exert more pressure on forest land and in the absence of proper conservation measures the damage will be extended to neighbouring forest in PTR too.

Several finding from different categories and even from various parts of India are available which are in agreement with the present observations. The decrease in forest cover over years due to anthropogenic activities are observed in forest areas USA (Peterson *et al.,*1997), forests in Durban areas of Africa (Palmer and Fortescue, 2003), in Mexican forests (Yang and Liu, 2005) and western Himachal pradesh (Sharma *et al.,* 2007). The decrease in forest area and increase in other land uses including settlements and open forest area was mainly noticed in Pamba triveni region, trek path to temple and vicinity areas of temple indicate the direct influence of pilgrimage activity in Land use/ Land cover pattern.

The landscape analysis of study area using indices like Fragmentation, Patchiness and Porosity data of RS and GIS was carried out. It is found that 8.71 Sq. Km. (31.11 %) of study area (Sabarimala and Karimala stations) was fragmented. As it is the measure of density of forests and non forest patches in a given area, forest fragmentation is the index of disturbance due to human disturbances (Buckely, 2000). Krishnasagar (2003) also made similar observation of comparatively higher fragmentation area in forest patches of Jhabua and Ratlam districts of Madya pradesh, India. Fragmentation in the present study was more along trek path to temple area and around the temple shrine and evidently due to pilgrimage related activities.

Patchiness, which is the measure of density of patches of all types in a unit area (DOS and DOB, 2004). 9.29 Sq. Km (34.28%) of the selected area was found as Patchiness at various levels. The more the patchiness in an area, the lesser is the biodiversity (Mathew, 1999). The current data also is in agreement with this notion and considerable loss in biodiversity has been noted. Similar observations on forest Patchiness are made in Western ghats region of Tamilnadu (Amaranth *et al.,* 2003).

Forest Porosity, which is a measure of the number of polygons of non forest areas within a forest area shows comparatively higher value on comparing with other two indices. The higher Porosity value indicate higher interaction among landscape elements, heterogeneous in nature and highly fragmented the habitat (Singh, 2004). The present study observed 16.50 sq. Km (61.01%) area have facing porosity at various levels which indicate higher fragmentation and habitat change in the area. Forest porosity in relation to habitat destruction and higher fragmentation was studied and more similar observations in Holdsworth USA (Tyrrell and Butler, 2003).

The Disturbance index map created revealed heavily disturbance at Pamba-Triveni to Sabarimala and near by areas. Only 15.09 Sq. Km. Area remain undisturbed there. The Disturbance index image obtained gives a clear picture at both anthropogenic and natural disturbances and their spatial extent in various levels (Roy

and Mehra, 2002) and shall be used for decision makers to planning and implement conservation measures.

The biodiversity characterization of Sabarimala and Karimala stations of Pamba range using ground survey and remote sensing data analysis showed that Sabarimala pilgrimage and related commercial activities have serious impacts on local flora and environment especially at disturbed zone in Pamba range. The Sabarimala pilgrimage and related activities has been caused significant loss and changes of the biodiversity pattern of the area, which have definite long term ecological impacts. The floral diversity of the disturbed zone showed significant changes in its diversity as well as density.

The presence of many invasive plants like *Parthenium hysterophores* are typical evidence for the man- made ecological succession in the area. Interestingly no invasive plants were observed in undisturbed forests, though it is very close to disturbed zone. It should be noted that succession of invasive plants in disturbed zone is maintained by recurring human activities. However the increasing human pressures in disturbed zone will extent the disturbance into more areas and as a result significant portion in the PTR may be occupied with invasive species that lead to changes in biodiversity pattern. Most of the plants, which are common to both disturbed and undisturbed forest areas show predominance in undisturbed area, indicating less adaptable conditions in the disturbed area.

The vegetation indices raised also gave a clear indication of degradation of the native flora due to the extremely high levels of human interferences in the area. The fragmentation, Patchiness and Porosity analysis showed that the forest is highly fragmented in Pamba range due to the pilgrimage and pilgrimage related activities. The Patchiness is confined to the trekking path, temple and Pamba triveni areas but various data showed that this will be increasing year by tear and may lead to the total disintegration of the Pamba range of PTR. Strict management and control measures

are essential to arrest the disturbing trend and to conserve the existing forest biodiversity. NDVI values also showed the loss in vegetation vigor over the years (1990- 2004), hence the pilgrimage activity in PTR will be regulated in tone with existing legal measures, in order to conserve the rich biodiversity of the area.

In brief the present study revealed that Sabarimala pilgrimage has caused severe damage to the floral diversity of Sabarimala region and it is increasing year by year with the rise in intensity of pilgrimage activity. Strict implementation of conservation rules at the tiger reserve and National Park level is recommended.

Soil studies

Soil is the central organizing entity in the terrestrial ecosystem and major abiotic factor which support life on earth. Soil degradation both in forest and non-forest land is ever increasing all over the world and now one of the most significant ecological issues too. Modern agriculture, expanding industrialization and urbanization have significantly altered the quality of the soil, all over the years.

Soil quality usually refers to usefulness and health of the soil and depends on soil nutrients, organic matter, soil moisture, air and the interaction of organisms. The forest soil in Sabarimala and Karimala stations were tested for their quality and analyzed in terms of comparative status of disturbed and undisturbed forest areas.

Various soil nutrient components were estimated quantitatively and found that undisturbed area has more organic carbon/ organic matter (3. 59/ 6.17 %) than that of disturbed area (3.13/ 5.38 %) in Pamba range of PTR. The level of organic carbon/ organic matter in soil is mainly depend on the deposition of such things in the soil due to the biological activities and this is more in soil of undisturbed area naturally.

The low organic carbon/ organic matter is an indicator of degree of soil degradation (Lal, 2007). The low organic carbon/ organic matter level in disturbed areas may be due to the loss of equilibrium between the rate of supply of organic

matter as a result of forest clearance and land use changes (Lal, 2004). The loss of floral diversity and density especially that of large trees and exposure of surface soil due to regularly recurring human activities are the main reason for low organic carbon/ organic matter content in soils of disturbed areas. The land use/ land cover map of the study area revealed that large areas of forests are converted to other land uses in disturbed area.

The slope, altitude and aspect may influence the soil organic content by regulating soil- water balance, temperature, soil erosion and deposition processes (Singh and Lal, 2004). The change that may due to the land use pattern of the forest area especially in trek path and temple area may have serious impact on the slope and aspect of Pamba range. Available reports are in agreement with this findings that, decreased organic carbon/ organic matter level is due to land use/ land cover changes are observed in tropical forest areas (Dinakaran and Krishnayya, 2008).

The available nitrogen , Phosphorus and Potassium of soils at both disturbed and undisturbed areas are also evaluated. The Available nitrogen and Phosphorus show comparatively higher values at disturbed areas than undisturbed areas. The higher average values of two major nutrients in disturbed areas 233.10 Kg. N/ ha and 42.44 Kg. P2 O5/ ha, indicate severe nutrient pollution in the disturbed zone. The reports shows that around 900 tones of night soil and 500 tones of cocunut shells and 10 tonnes of various other wastes are generated in forests of Pamba range of PTR during every pilgrimage season (Sathyapalan, 2002). This may be the reason for severe ' nutrient pollution' in the disturbed zone. The changes in the floral pattern especially invasive plants like Parthenium hysterophores of the disturbed forest area may have the reason for the deleterious changes in the soil especially on soil nutrient pool (Raghubanashi et al., 2005).

Nandakumar et al.(2004) reported a range of 31.73 to 272.40 Kg/ ha available nitrogen and 3.86 to 4368.67 Kg/ ha available Phosphorus from various locations of

western ghats. The average values of these parameters in present study are at par with this report and hence this values may be considered as standard values of nutrient rich tropical forest soils. Interestingly the available nitrogen in two sampling sites (Q1 and Q3) showed extremely high values which are above this range (504 Kg/ ha) and it may be due to the extreme faecal contamination and degrading organic waste dumping was reported as a major reason for nutrient pollution in soils.

The available Potassium, analysis of soil reveals that the mean Potassium (Kg/ ha) value gave highest value in undisturbed area (104. 67 Kg/ ha) than that of disturbed area (85.71 Kg/ ha). Reports shows that evergreen forests in general have high value of available Potassium due to the presence leaf litter (Brady, 1984). In the case of undisturbed area of Pamba range of PTR, phytosociological studies showed more abundance of tree cover. The abundant tree cover provides thick leaf litter layer in the area and there by high available Potassium. Nandakumar (2004) reported available potassium in western ghats of Kerala ranging between 30. 67 to 248 Kg/ ha. The current data on the level of available potassium in the soil of Pamba range is also within this range. The slight hike in the available potassium level at undisturbed zone may be due to the relatively high density of litter cover in this area compared to the disturbed area. Similar result of high available potassium concentration in dense evrgreen forests are reported form Bhetagad watershed in central Himalayan region (Joshi, 2004) and in small catchment areas in Indian Himalayas state of India (Hessel et al. 2007).

It may be concluded that the increase in available nitrogen and available phosphorous in disturbed zone, clearly reveals the influence of human activity taking place in the area. While the organic carbon/ organic matter and Available Potassium are high in undisturbed area, shows the healthy nature of soil there.

The microbial diversity and density analysis was also done for the soil of disturbed and undisturbed areas. A total of 18 species of fungi comprising 12 genus

are isolated from soil in disturbed zone and 19 species of fungi comprising 11 genera are isolated from undisturbed areas of Pamba range of PTR. Even though , the species isolated are almost equal in number, the mean colony forming units (CFUs) are very high in undisturbed area (24.78 x 107) than that of undisturbed zone (9 x 103) . The relatively higher diversity and density of fungi in undisturbed area shows good health of the soil, that supports maximum diversity. The highest organic matter in the soil, which provide an optimum physical conditions for the growth of mycelia (Sharma et al., 2007) may be the reason for higher fungal diversity in undisturbed area. The genus wise analysis of fungi reveals that genus Aspergilli shows highest abundance in both disturbed (29%) and undisturbed (39 %) areas. Followed by Anthrographis (16 %) and Chrysosporium (12 %) in disturbed zone and Penicillium(23 %) in the undisturbed zone. The present inferences are in agreement with available reports too. Kader et al.(1999) isolated cellulolytic fungi from soil in Bario islands, with the abundance of genus Aspergilli. Similarly Azas (2003) isolated fungi including genus Aspergilli, Penicillium and Arthrographis from soil in Harran plains of Turkey.

Among the isolated fungi 10 species are common to both disturbed and undisturbed areas, where genus Monocillium and Microsporum , which are present in disturbed area are considered as an indicators of stressed conditions and are sensitive to ecologically negative conditions (Reaves et al., 1990).

The Shannon- weiner index for fungal diversity in Pamba range of PTR showed almost equal values, both in disturbed (2.70) and undisturbed zones (2.72). Even though, the abundance of isolated fungi are low in disturbed zone, an almost equal number of species of fungi (18 in disturbed and 19 in undisturbed zones) may be the reason for the result. However, Satish et al. (2007) are also reported higher value for Shannon– Weiner index at undisturbed areas of forest in Mudumali than that of disturbed areas.

Another interesting factor, observed in fungal analysis was the abundance of more keratinophylic fungi in disturbed zone than that of undisturbed zone. In disturbed zone keratinophylics are reported by genus Trichophyton (14 %) and Microsporum (1 %) while, in undisturbed zone only the genus Trichophyton (9 %) was the representative. The capacity of keratinophylics to invade in epidermal cells and hair and nail are well established (Simpanya, 2000). The abundance of more Keratinophylics in disturbed area is definitely due to the richness of keratin remnants of human and animal origin (Ulfig, 2000). In the disturbance zone of Pamba range lakhs of pilgrims and donkey herds are spending considerable time and hence the soil has more keratinophylics.

The bacterial colony forming units are also counted in both in disturbed and undisturbed zones. On comparison, undisturbed area (24.78 x 107) have very higher values than that of disturbed area (12.78 x 10 7). The higher values of bacterial count indicate healthy nature of soil that support soil microbes as well (Sharma, 2008). This may be the reason for higher bacterial count in undisturbed area, where soil have optimum nutrient availability also.

The soil studies clearly revealed that disturbed area receives huge quantity of organic materials in the form of food waste and human excreta, which lead to an elevated level of available nitrogen and available phosphorus However in the undisturbed forest areas soil showed high level of vitality indicated by elevated organic carbon/ organic matter.

The microbial analysis also showed abnormal floral pattern in disturbed soil, with an extremely high share for Keratinophylic fungi. In brief it may be concluded that the pilgrimage activity and related human interactions have significantly affected the soil nutrient balance too. The alteration in soil composition in the disturbed zone may lead to adverse changes in the neighbouring undisturbed forest areas also. Scientific

management practices should be implemented in order to regulate the changes happening in the pedological environment of the area.

CONCLUSIONS

- The Sabarimala pilgrimage and related activity has been caused significant loss and changes in the biodiversity pattern of the area, but it is confined to areas with direct human interactions only.
- The disturbed area of the PTR showed (11.76 %) of invasive species but more in the undisturbed forest areas though they are very close to pilgrimage activity.
- The NDVI analysis showed the loss in vegetation vigor of the study area over the years (1990- 2004). If the trend continues the disturbed areas become totally a non- forest patch and gradually extended to forest areas too.
- The Fragmentation (31.12 %), Patchiness (34.37 %) and Porosity (61 %) measures showed high values indicate the loss of forest cover, density and diversity in the trekking path, temple and Pamba triveni areas.
- The land use/ land cover change analysis over the years (1967- 2004), observed drastic conversion in dense forest area into other land use like settlements, open forest, grassland and barren area for the development of infrastructure of pilgrimage area.
- The soil studies revealed that undisturbed forest areas maintain its vitality indicated by high level of organic carbon and organic matter. Ironically disturbed area showed high level of available nitrogen and phosphorous as result of heavy nutrient pollution from Sabarimala pilgrimage.
- The microbial analysis showed typical soil micro flora in undisturbed forest areas while in disturbed areas high diversity and density of pathogenic dermatophytes such as keratinophylics fungi is observed.

RECOMMENDATIONS

- The Sabarimala pilgrimage programme inside the PTR should be scientifically managed, considering the importance of the rich natural biodiversity of the area.
- Strict measures should be implemented to confine the pilgrimage activity with in the currently disturbed areas of the Pamba range.
- The entry of pilgrims or others into forest areas should be prevented at any cost.
- The dumping wastes including food wastes should be banned inside the forest area and scientific waste management programme should be implemented. This would be beneficial for preventing entry of new invasive species to forest areas.
- The invasive species in the disturbed zone should be removed and native forest plants should be planted in disturbed area..
- A tree belt consists of native forest trees such as *Polyalthia fragrans, Anacolosa densiflora* and *Dysoxylum beddomei* should be made on the both sides of the trekking path and resting places. This will help to prevent further encroachment of disturbed zone into forest areas.
- Open defecation in the forest and non- forest areas also should be banned. Huge biogas plants coupled to organic fertilizer units may be a good option for scientific disposal of human excreta.
- The soil nutrient balance has been totally upset in the disturbed zone mainly due to the excessive deposition of food wastes, human and animal excreta and other organic wastes. Non- biodegradable wastes like plastic are also play a vital role in regulating the nutrient balance of the soil system. Hence a comprehensive waste management programmes is essential for entire Pamba range.
- The removal of floral cover in the trekking path and adjoining areas has been causing soil erosion to an extent too. Scientific programme should be implemented to curb erosion of soil from the forest and non- forest areas.

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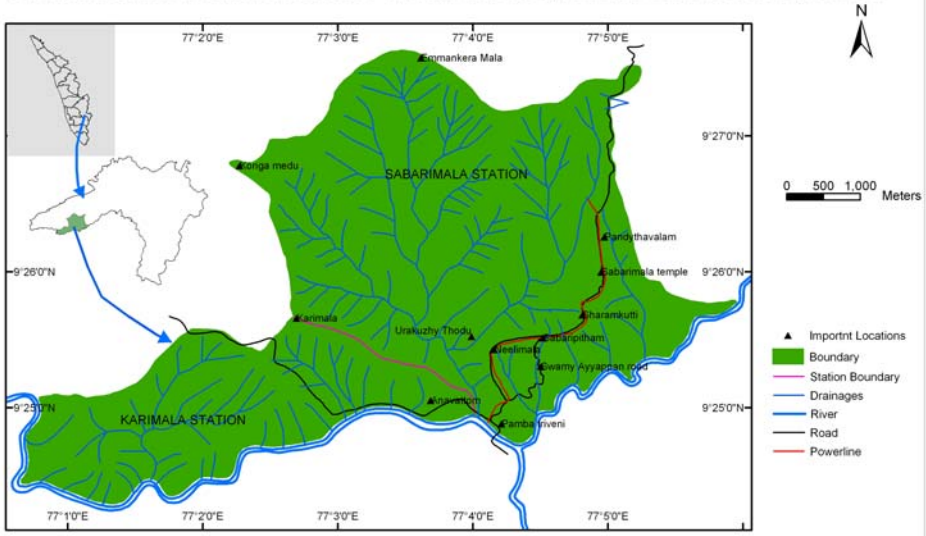
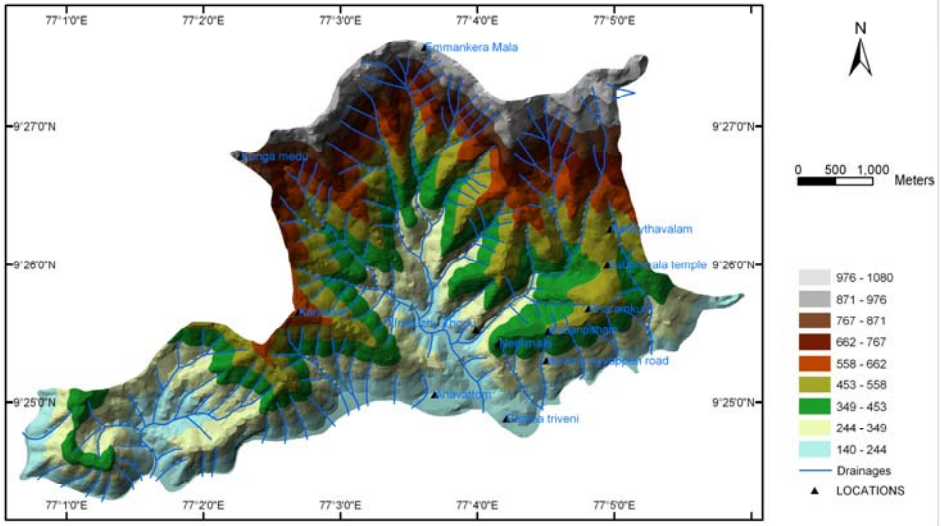
STUDY AREA

SABARIMALA AND KARIMALA STATIONS OF PAMBA RANGE, PERIYAR TIGER RESERVE ,KERALA



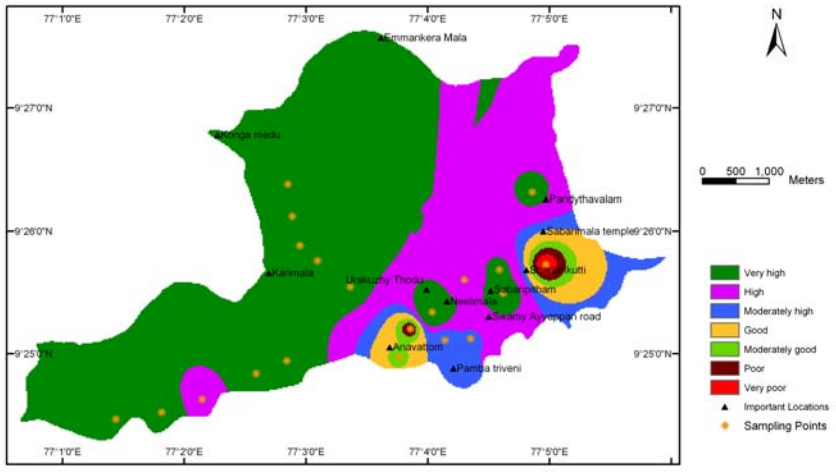
DIGITAL ELEVATION MODEL

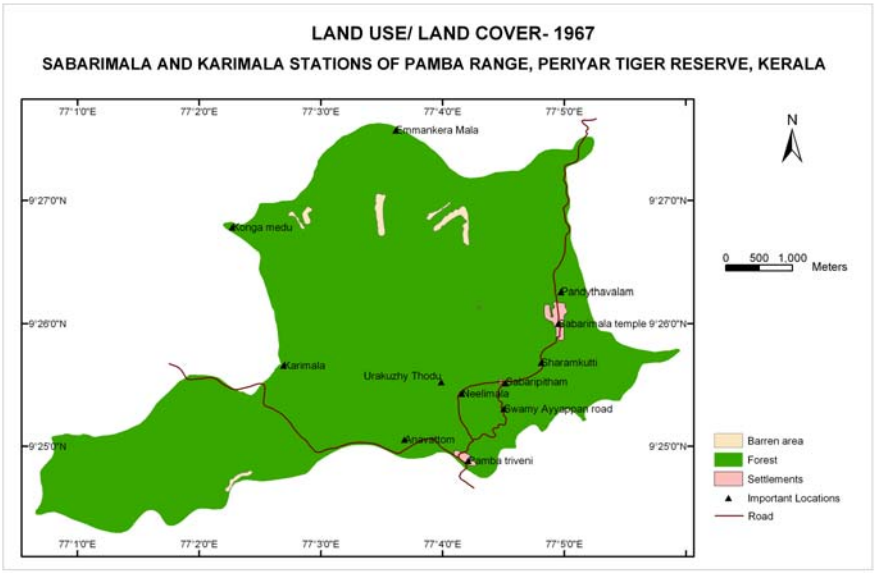
SABARIMALA AND KARIMALA STATIONS OF PAMBA RANGE, PERIYAR TIGER RESERVE, KERALA

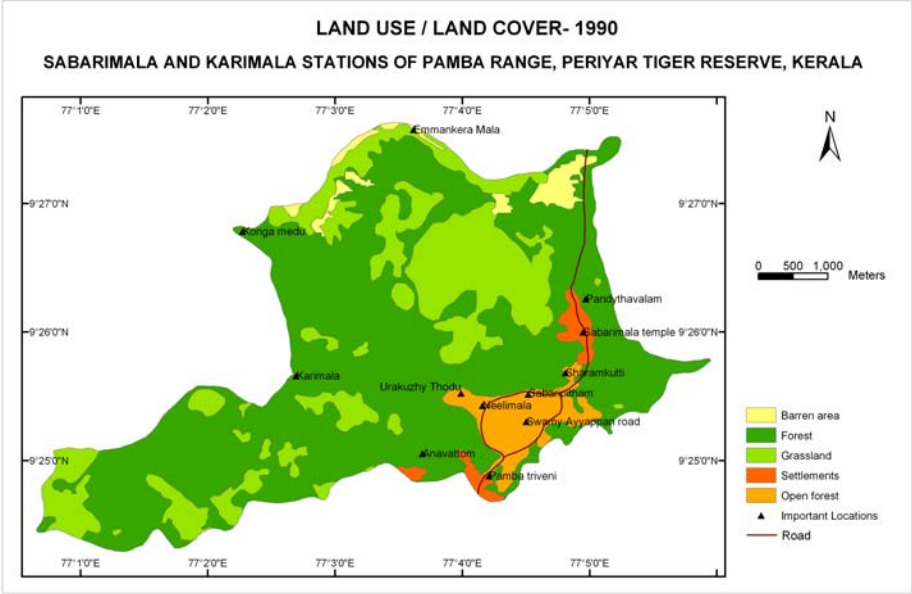


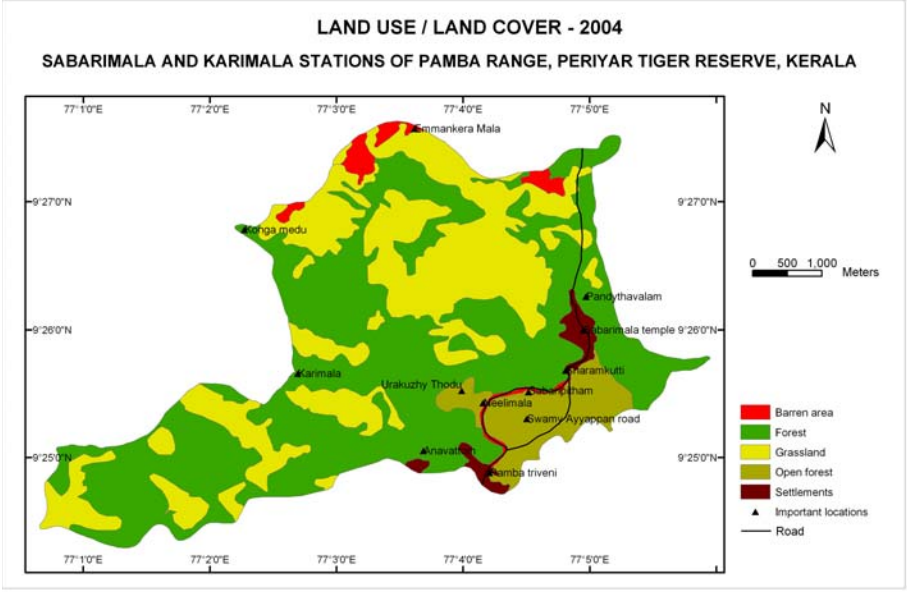
IMPORTANT VALUE INDEX OF VEGETATION- 2008

SABARIMALA AND KARIMALA STATIONS OF PAMBA RANGE, PERIYAR TIGER RESERVE, KERALA



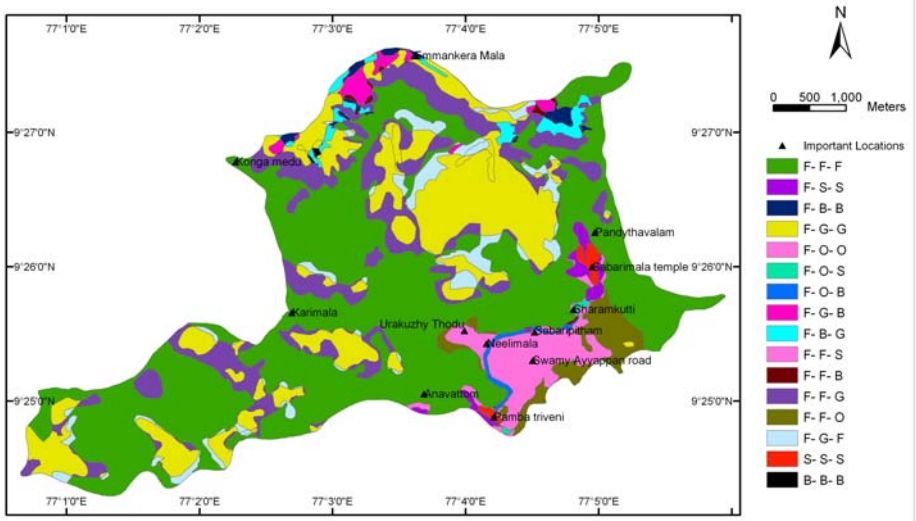

LAND USE/ LAND COVER- 1967
SABARIMALA AND KARIMALA STATIONS OF PAMBA RANGE, PERIYAR TIGER RESERVE, KERALA
77°1'0"E
77°2'0"E
77°3'0"E
77°4'0"E
77°5'0"E
9°27'0"N
9°26'0"N
9°25'0"N
Emmankera Mala
Konga medu
Pandythavalam
Sabarimala temple
Karimala
Urakuzhy Thodu
Sharamkutti
Neelimala
Swamy Ayyappan road
Anavattom
Pamba triveni
N
0 500 1,000 Meters
Barren area
Forest
Settlements
Important Locations
Road


LAND USE / LAND COVER- 1990
SABARIMALA AND KARIMALA STATIONS OF PAMBA RANGE, PERIYAR TIGER RESERVE, KERALA
77°1'0"E
77°2'0"E
77°3'0"E
77°4'0"E
77°5'0"E
9°27'0"N
9°26'0"N
9°25'0"N
Emmankera Mala
Konga medu
Pandythavalam
Sabarimala temple
Karimala
Urakuzhy Thodu
Sharamkutti
Neelimala
Swamy Ayyappan road
Anavattom
Pamba triveni
N
0 500 1,000 Meters
Barren area
Forest
Grassland
Settlements
Open forest
Important Locations
Road


LAND USE / LAND COVER - 2004
SABARIMALA AND KARIMALA STATIONS OF PAMBA RANGE, PERIYAR TIGER RESERVE, KERALA
77°1'0"E
77°2'0"E
77°3'0"E
77°4'0"E
77°5'0"E
9°27'0"N
9°26'0"N
9°25'0"N
Emmankera Mala
Konga medu
Pandythavalam
Sabarimala temple
Karimala
Urakuzhy Thodu
Sharamkutti
Neelimala
Swamy Ayyappan road
Pamba triveni
N
0 500 1,000 Meters
Barren area
Forest
Grassland
Open forest
Settlements
Important locations
Road

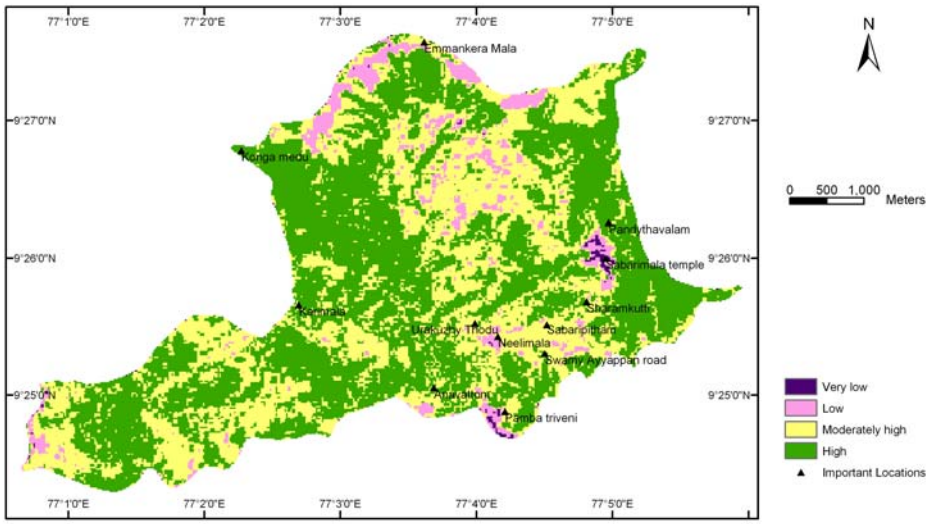
CHANGE IN LAND USE/ LAND COVER : 1967 - 1990 - 2004

SABARIMALA AND KARIMALA STATIONS OF PAMBA RANGE, PERIYAR TIGER RESERVE, KERALA



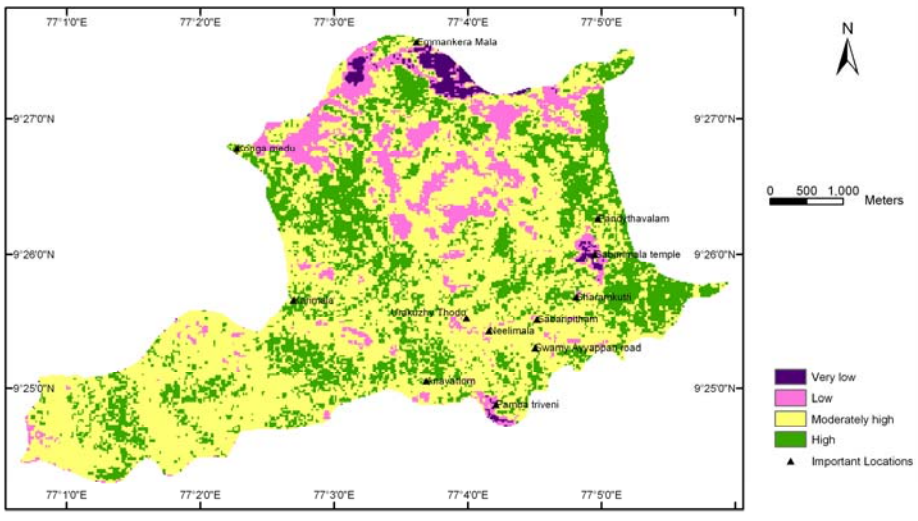
NORMALISED DIFFERENCE VEGETATION INDEX- 1990

SABARIMALA AND KARIMALA STATIONS OF PAMBA RANGE, PERIYAR TIGER RESERVE, KERALA



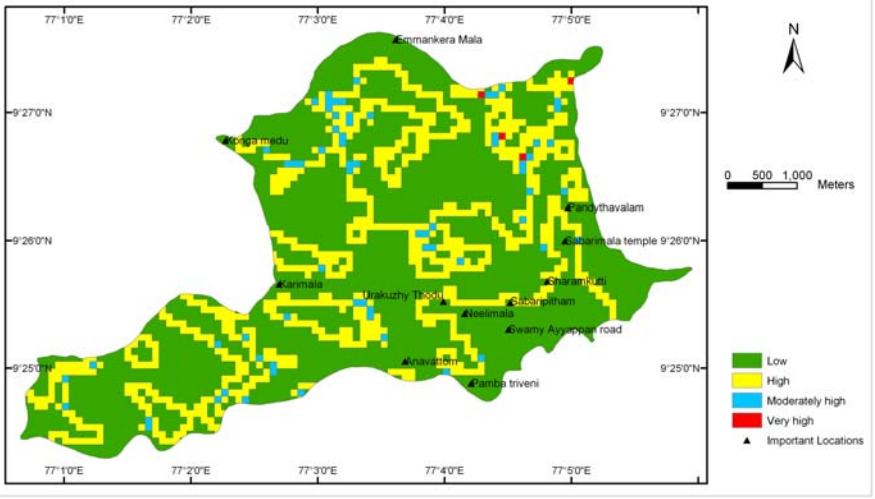
NORMALISED DIFFERENCE VEGETATION INDEX - 2004

SABARIMALA AND KARIMALA STATIONS OF PAMBA RANGE, PERIYAR TIGER RESERVE, KERALA



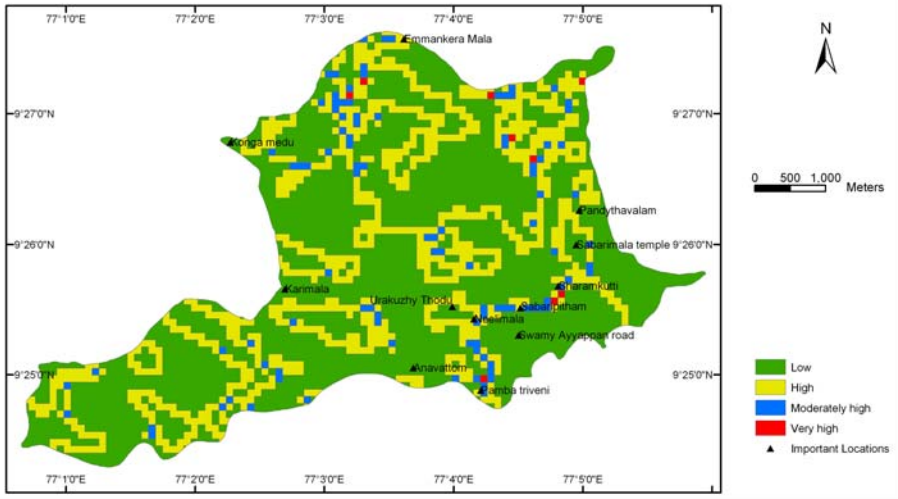
FOREST FRAGMENTATION- 2004

SABARIMALA AND KARIMALA STATIONS OF PAMBA RANGE, PERIYAR TIGER RESERVE ,KERALA



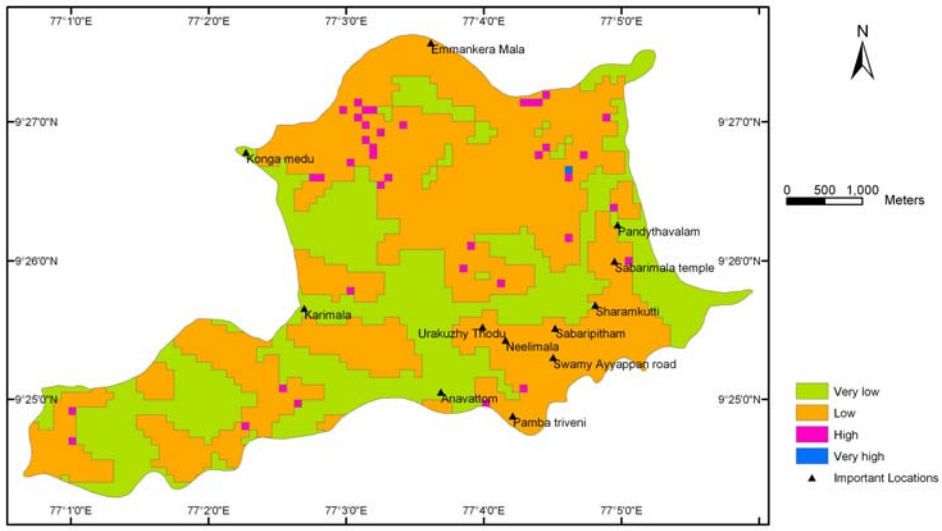
FOREST PATCHINESS - 2004

SABARIMALA AND KARIMALA STATIONS OF PAMBA RANGE, PERIYAR TIGER RESERVE, KERALA



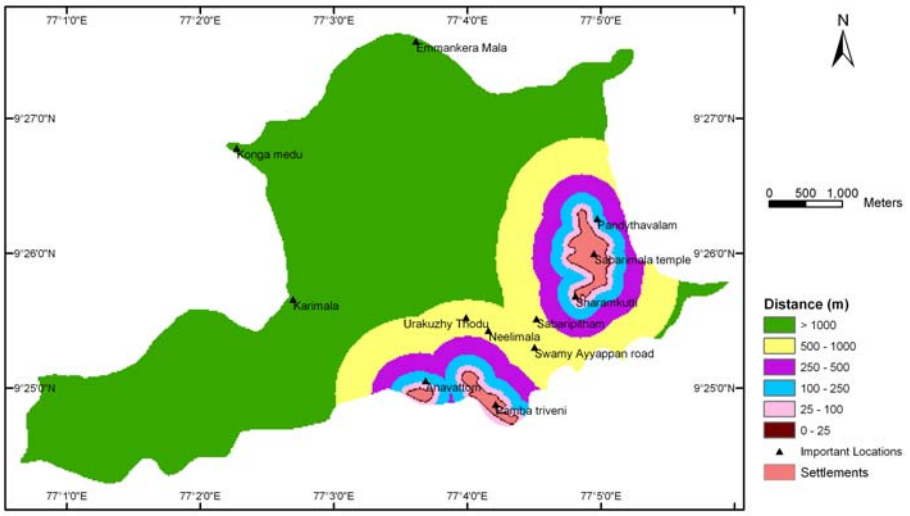
FOREST POROSITY - 2004

SABARIMALA AND KARIMALA STATIONS OF PAMBA RANGE, PERIYAR TIGER RESERVE, KERALA



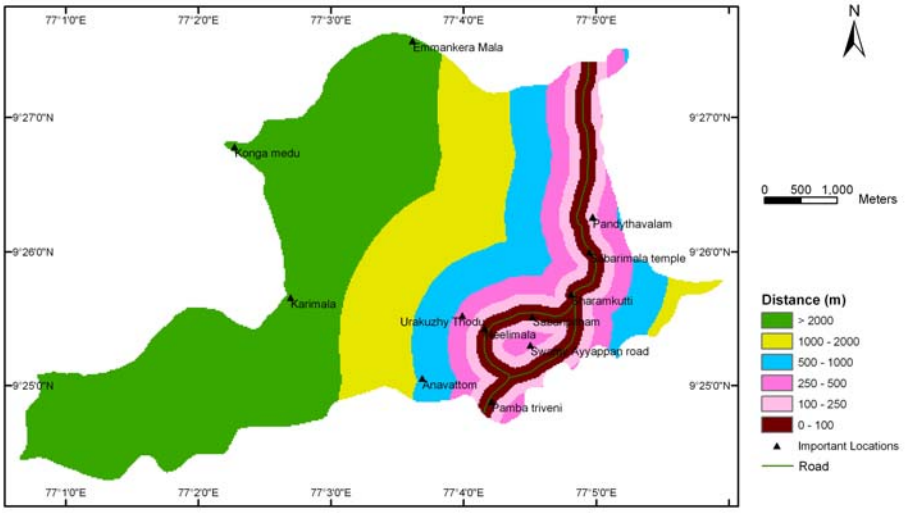
DISTANCE FROM SETTLEMENTS

SABARIMALA AND KARIMALA STATIONS OF PAMBA RANGE, PERIYAR TIGER RESERVE, KERALA



DISTANCE FROM ROAD

SABARIMALA AND KARIMALA STATIONS OF PAMBA RANGE, PERIYAR TIGER RESERVE, KERALA



DISTURBANCE ZONES

SABARIMALA AND KARIMALA STATIONS OF PAMBA RANGE, PERIYAR TIGER RESERVE, KERALA