Forest degradation in Kerala - Causes and Consequences: A case study of Peechi–Vazhani area

T. Jayanarayanan

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Contents

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Forest degradation in Kerala - Causes and Consequences: A case study of Peechi–Vazhani area

T. Jayanarayanan*

1. Introduction

Forest and forest wealth

Forest, in a linguistic sense, is an area outside of village boundaries and hence demarcated from human habitations. However, it includes essentially the natural habitat of tribesfolk. Botanically, forests are plant associations developing to climax vegetations. The flora and the fauna of varied natural ecosystems constitute the forest wealth of which the endangered and threatened species are protected in India in national parks and wildlife sanctuaries, the former by Central legislation and the latter by the States.

According to 'Forest Survey of India' estimates (1996), during the assessment period 1993-'95, the actual forest cover of the country stood at 633,397 sq. km, which is 19.27 per cent of the total geographic area (Forest Survey of India 1996 and 1998).

The total geographic area of Kerala State is 38,863 sq. km, which is 1.2 per cent of the geographical area of India. The forests of Kerala are estimated to be around 7,870 sq. km. They include the Southern Tropical Wet Evergreen and Semi evergreen forests that together cover an area of 3,470 sq.km. These forests are in various stages of degradation under the influence of biotic pressure (Sasidharan Nair, Nagesh Prabhu; 1998.)

Population and biotic pressure

During the 1951-1994 period, India's human population rose from 361 million to 880 million resulting in the decline of per capita forest area from 0.20 ha to 0.07 ha. Despite enforcement of various Acts (viz. Forest Act, Cattle Trespass Act, Land Encroachment Act, and Timber Transit Rules) the forest area is being subjected to tremendous biotic pressures to the extent that virgin forests are hardly retained with inherent vigour and growth, except in inaccessible areas.

Being the most densely populated State the situation in Kerala is worse. The population density in Kerala in 1991 was 749/sq. km as against 435 /sq. km in 1961, while at the national level, the corresponding figures are 257 and 110 respectively. During the last four decades (1951-1994) the livestock population in the country increased from 292 million to 450 million while the extent of grazing lands got reduced from 106 million ha to 75 million ha.

Imbalance

Data on forest area and biotic pressure show that the forest area in the country in general, and

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Kerala in particular is decreasing at quite an alarming rate. The increase in biotic pressure contributed significantly by the exponential growth in population density together with mounting grazing pressure, has resulted in a complex situation. The remaining forest cover is hence being subjected to unprecedently high biotic pressure and forest degradation and increase in biotic pressure jointly worsen the problem increasingly day by day.

The resulting imbalance warrants immediate attention and intervention. Considering the vital importance of protecting ecosystems and the irreparable damages caused to them, we find conservation the supreme need of the day. Nature and natural resources are invaluable assets borrowed from posterity. The present generation has to repay what it has inherited with little or no damage at all.

Rationale of the study

Legends would have it that Keralam is the land reclaimed from the Arabian Sea, by Parasurama who threw his axe from Gokarnam (near the present day Western coast of Kasargod) and that it fell near Kanyakumari, the southern end of peninsular India. The sea in-between receded and the land that emerged became a part of the mainland. The existence of patches of dense forests even today (though as relics) especially around urban areas suggests that the entire area was once thick forest. The condition of forests, both in area and quality, has undergone a sea change during the past three to four decades. The causes for such wanton destruction has remained almost undetermined. Forests were once considered an in exhaustible resource due mainly to exaggerated notions of their regeneration potential. However, the rate of forest exploitation was so high that our forests began deteriorating and disappearing. Immediate governmental intervention through its various departments - Forest, Revenue, Agriculture, and Environment – became inevitable. Being a State with high rates of literacy and education, several Non-Governmental Organisations also lent their support. Kerala Sasthra Sahithya Parishat (KSSP), Society for Environmental Education, Kannur (SEEK) and other organisations, especially in the Silent Valley controversy period, contributed much to the conservation of natural resources in Kerala.

However, scientific studies on forest degradation are only few. Even in the few studies made, an interdisciplinary approach was found lacking. The politics of deforestation was studied by Moench (1991) based on the Cardamom Hills of Kerala and he found that the relationship between ethnic and religious communities greatly influenced migration, forest encroachment and conflicts over the control of land. Pandurangan and Nair (1996) studied the changing pattern of floristic composition in the Idukki Hydro Electric Project Area. They identified various forest types of the area and examined the transitional changes taking place in the tropical evergreen, semi-evergreen, and moist deciduous forests. They also documented the decrease in bamboo brakes and reed vegetation. Valappil and Swarupanandan (1996) assessed the demographic aspects of natural regeneration dynamics of moist deciduous forests and concluded that fire, grazing, browsing and over-exploitation by human beings are the major constraints of natural regeneration in these forests. Though these were comprehensive studies on specific areas and under specific disciplines, studies on factors and problems of forest degradation, as well as on short term and far reaching influences are non-existent. The present study is a modest attempt in this direction.

Decrease and degradation of forests

Changes occurring in forests may be broadly classified into two: change in area (quantity) and change in their constituents (quality). The term degradation denotes the loss in both quantity and quality of forests: viz. loss in natural regeneration as well as all the changes caused due to over-exploitation including grazing, which may lead to a decrease or even complete extinction of some of the species, which ultimately results in the loss of bio-diversity.

Objectives

The major objectives of the present study are the following:

(i) Quantification and assessment of forest degradation;
(ii) Socio-economic survey on forest exploitation, encroachments and non-forestry operations;
(iii) Identification and assessment of political factors influencing encroachments;
(iv) Analysis of forest fragmentation effects;
(v) Discussion of anthropogenic disturbances; and
(vi) Evaluation of the Social Forestry Programmes.

Forest degradation is considered conventionally a social problem stemming mainly from population pressure. It was not subjected to intense studies mainly because forests were once considered a comparatively inexhaustible source of raw materials, and their regeneration potential, over estimated. Above all, ecological aspects of forest ecosystems, particularly their fragmentation effects, remained obscure till the 1980s. The Silent Valley issue may be considered an eye opener to this problem.

This study is the first of its kind in which the botanical, geological and economical aspects of forests and their degradation in Kerala, are systematically analysed. The present study is independent, inter-disciplinary, and holistic and seeks to identify factors, analyse processes, and suggest practical and effective measures to check and prevent forest degradation.

2. Area and Method

Area

The deleterious effects of forest degradation are crystal clear in places where human population surrounds the forest area. The biotic pressure in the form of manifold requirements of the population living in the boundaries and vicinities of forest areas including grazing, is better assessed in such locations. Peechi-Vazhani Wildlife Sanctuary is such an ideal location as it is encircled by Pananchery, Madakkathara, Thekkumkara, Wadakanchery, Chelakkara, and Elanad *panchayats*. The study area is selected mainly based on these considerations.

Selection of study area

The present study aims at analysing the various factors that contributed to degradation of forests and their implications in a forest- habitation interface over a span of three decades. The study area selected is a representative strip of forests of 125 sq. km extending between the catchment areas of two dams - Peechi and Vazhani. Government of Kerala, declared in 1958 [vide G.O. (MS) No. 871 dated 6-8-1958] this area as Peechi-Vazhani Wildlife Sanctuary by combining certain areas of Peechi, Pattikkad, and Machad ranges of Thrissur Forest Division. The code for the sanctuary is KER/141. Peechi dam, with a waterspread area of 12.95 km and Vazhani dam having a waterspread of 1.84 sq. km, are within the sanctuary.

Peechi–Vazhani wildlife sanctuary

It is located in Thrissur Forest Division of Thrissur district and falls within latitudes 10°30‘ and 10°40‘ N. and longitudes 76°15‘ and 76°25‘ E (Figure 2.1). The sanctuary consists of parts of Paravattani Hill Reserve, Machad Hill Reserve, and Bharanipacha Hill Reserve, and has a total area of 125 sq. km. The altitude varies between 30m and 500m. The highest peaks are Munippara (515 m) and Vellanimala (525 m) (Figure 2.2). The major rivers are Manali and Wadakanchery and the direction of drainage is east west. The Vazhani dam is in the northern and the Peechi dam, in the southern side of the Thrissur Forest Division.

Topography

Topographically the area can be divided into three zones. (i) The Machad Mala Ridge, which runs in the Northwest-Southeast direction having Chelakkara-Elanadu valley on the north and the Vazhani valley on the south, (ii) The Vellani Mala Ridge (Paravattani hills) running east-west with Thanippadam and Pananchery valleys on either side, and (iii) The foothills of Machad Mala Ridge and the Vellani Mala Ridge with settlements and encroachments.

Boundaries

North and West: The North and the East legal boundary of the sanctuary starts from a point at an elevation of 370 m, about 3.2 km north of Vazhani dam site and the boundary runs

Figure 2.1 Forest of Thrissur district

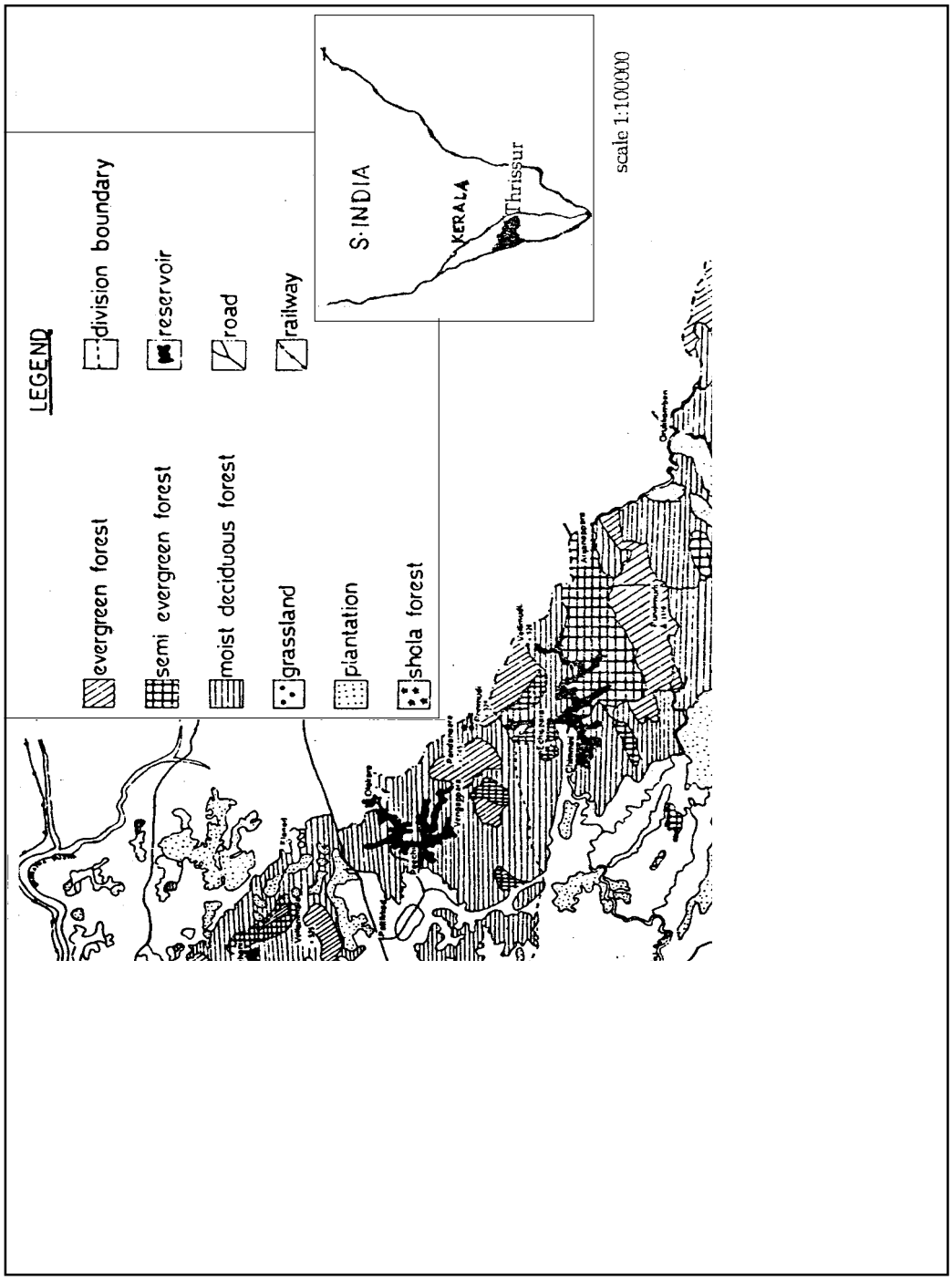
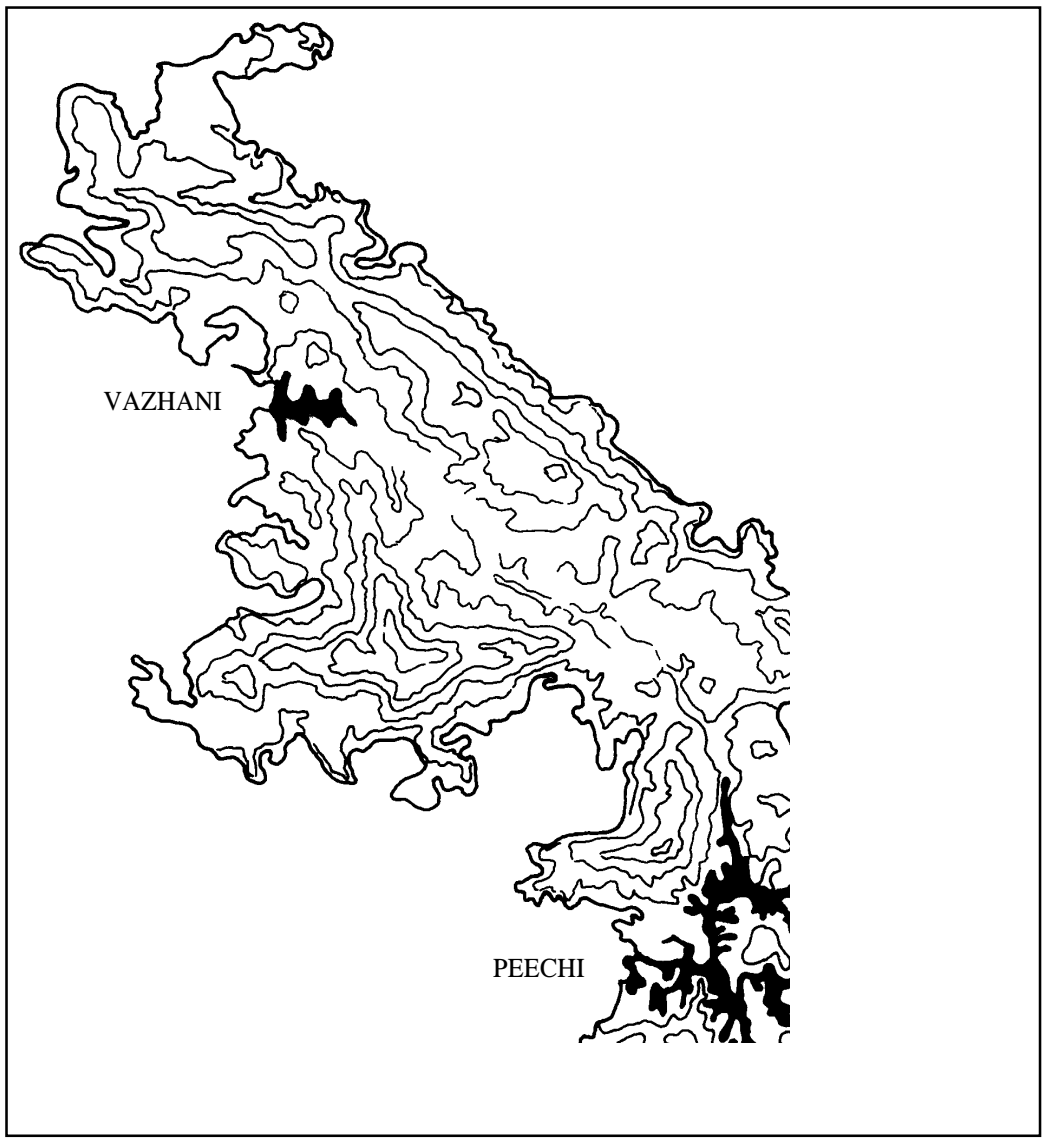


Figure 2.2 Peechi-Vazhani Wildlife Sanctuary: Contour map

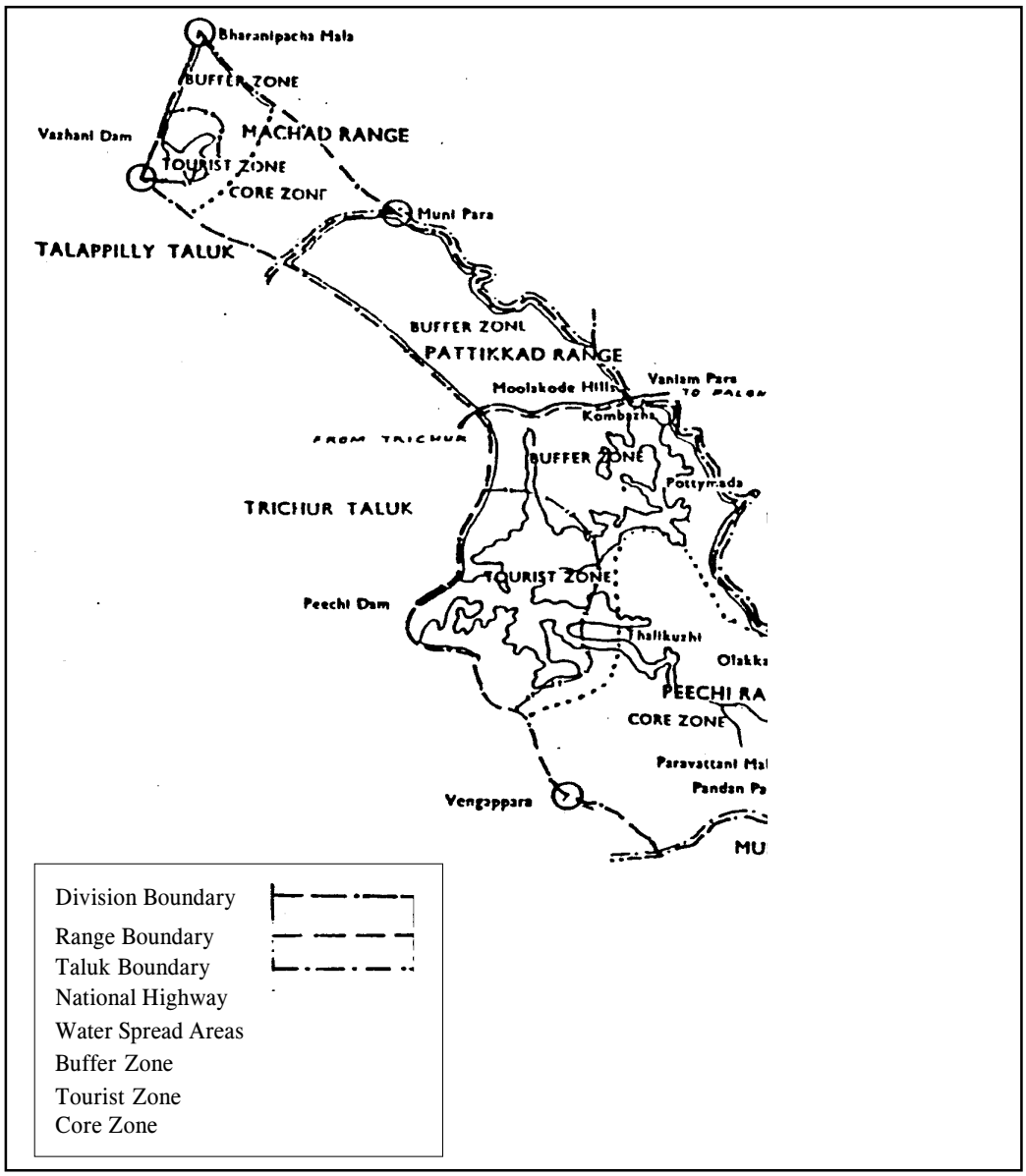


less Southeast along the eastern catchment boundary of Vazhani reservoir up to the common *taluk* boundary of Thalappilly and Thrissur *taluks* at Munippara (515 m); thence, it runs more or less in the same direction along the common *taluk* boundary of the said *taluks* up to the trijunction of Palakkad, Thrissur and Thalappilly *taluks* and further on along the common *taluk* boundary of Palakkad and Thrissur *taluks* up to the trijunction of Palakkad, Mukundapuram and Thrissur *taluks* at Ponmudi (914m).

South: From Ponmudi it runs more or less westward along the common *taluk* boundary of Mukundapuram and Thrissur *taluks* up to a point in the said *taluk* boundary about one km west of Mangattukomban (840 m).

West: Thence, it goes more or less in a north-westerly direction along the western catchment boundary of Peechi reservoir up to Peechi dam via Vengappara (555m) and the height points are 245m and 185m; thence it turns left and goes more or less north along the said catchment boundary till it meets Thrissur-Vaniampara road; from there it is first more or less a west-northwest direction that it takes, moving gradually to a north-northwest direction along the western catchment boundaries of Peechi and Vazhani reservoirs passing height points 200 and 205 m. and the Vazhani dam till it reaches the starting point (Figure 2.3).

Figure 2.3 Peechi-Vazhani Wildlife Sanctuary: Boundaries



Soil: The soil is deep blackish sandy loam type. It is slightly reddish loam on the lower slopes of Vazhani ridges of Machad hills. A fairly good amount of humus is present in evergreen and semi-evergreen forests.

The significant geological formation is the metamorphic gneiss series. The rock type occurring in this area is of crystalline nature of Archean age. Lateritic rocks are present on the Vellani hills and their lower slopes. Sheet rocks occur in considerable extent in several areas in Machad range and are exploited for quarry. The ground is bouldery in the deciduous forests.

Climate: Climate is of a warm humid type. The southwest and the northeast monsoons are the main sources of precipitation. The southwest monsoon during June-September contributes the major portion with peaks from mid-June to mid-July. The northeast monsoon imparts its share from October and extends up to November. Average annual rainfall ranges between 2000 and 4000 mm.

Trade winds accompany the southwest and the northeast monsoons. Apart from trade winds, warm whirlwinds blow through Palakkad Gap from December to February especially along the eastern borders. Relative humidity is usually higher than 55 per cent and reaches up to 100 per cent during monsoons. For the past few years Peechi has recorded an average maximum temperature of 41°C during April and an average minimum of 15°C during December. The hottest summer days are experienced between March and May and the coldest night temperature during December to early January (Table 2.1).

Table 2.1. Weather data at Peechi for the period 1996 March-1998 July

Month/year	Mean Temp	Rainfall	Month/year	Mean Temp.	Rainfall
Mar 96	34.5	1.6	Jun	26.7	518.4
Apr	30.45	89	Jul	25.1	763.6
May	29.25	140	Aug	25.5	657
Jun	26.8	428	Sep	26.3	147
Jul	25.65	580.6	Oct	26.7	188.5
Aug	25.85	384.6	Nov	26.4	240.8
Sep	26.45	533.4	Dec	26.7	17.6
Oct	26.6	236.4	Jan 98	26.8	0
Nov	27.15	9	Feb	27.6	0
Dec	25.91	112	Mar	28.8	27.6
Jan 97	25.6	0	Apr	30.1	18.2
Feb	25.6	0	May	29.3	107.8
Mar	29.1	0	June	26.2	789.6
Apr	29.1	0.8	July	25.5	795.4
May	28.6	67.6	Aug	25.9	495.4

Source: KFRI Weather Data

Vegetation: The forest environment is a conglomeration of atmospheric, topographic, and soil influences, often complicated by the interaction of the forest and its inhabitants and by

competition among individuals of the forest. Various ecological factors interact and eventually produce forest and other vegetation types. The study area is classified into cultivated land, open blanks, plantations and natural forests. The natural forests are of three types: moist deciduous, semi-evergreen and patches of evergreens.

Forest denudation: A study of the old records shows that the forests in the study area have been disappearing at an alarming rate. Apart from encroachments, repeated plantation failures coupled with the formation of grasslands and open lands due to break of continuity, have contributed much to the forest denudation. Construction of Peechi and Vazhani dams during 1950 -1960 had an indirect effect on encroachments. It is believed that most of the dam workers became encroachers-turned-settlers subsequently. Moreover, marginal lands over a width of about 500 m got damaged due to biotic activities.

Sites selected for study of tree layer (Permanent vegetation)

In order to study the tree layer, Vazhani-Vellani Hill tracts were divided into eight zones: Kuthiran, Chembuthra, Varikulam, Pullamkandam, Vazhani, Attoor, Kalappara, and Vellakkarithadam. (Figure 2.4). Representative samples of 10 m x 10 m quadrats were taken at two km apart. Representation of the type of vegetation occurring in the specific areas as well as accessibility was taken into consideration during the selection of quadrats.

Sites selected for analysis of understorey vegetation

The segments selected for the study of tree layers (permanent vegetation) were also studied for their corresponding understorey vegetation to assess the regeneration potential (Figure 2.5). 2m x 2m quadrats were fixed in these areas and the variations in species composition were recorded bimonthly to analyse the immigration and colonisation of various species and for calculating species richness.

Sites selected for Ecotone studies

Three locations (Figure 2.6) were primarily selected for ecotone studies viz., (i) Peechi-Palakkunnu area, which constitutes the catchment of Peechi reservoir, where teak plantations, moist deciduous forests and encroachments coexist, (ii) Kundukad-Chelappara area where encroachments, teak plantations, moist deciduous forests, semi-evergreen forests, and evergreen forest zones are found and (iii) Vazhani-Kakkinikkad area where Acacia plantations, encroachments, moist deciduous forests, and semi-evergreen forests occur in patches.

Thus the study area has almost fully covered both the levels of permanent and understorey vegetations, the former by 10m x 10 m quadrats and the latter by 2m x 2m quadrats. Data from 32 quadrats were collected for analysis of permanent vegetation (16 each from moist deciduous and evergreen locations) and data from eighty 2m x 2m quadrats were recorded bimonthly for analysis of species composition and immigration. Comparative data from moist deciduous and evergreen sites in the same locality would practically exclude climatic and edaphic variables to the extent possible. Above all, the

Figure 2.4 Sites Selected for Tree Layer Analysis

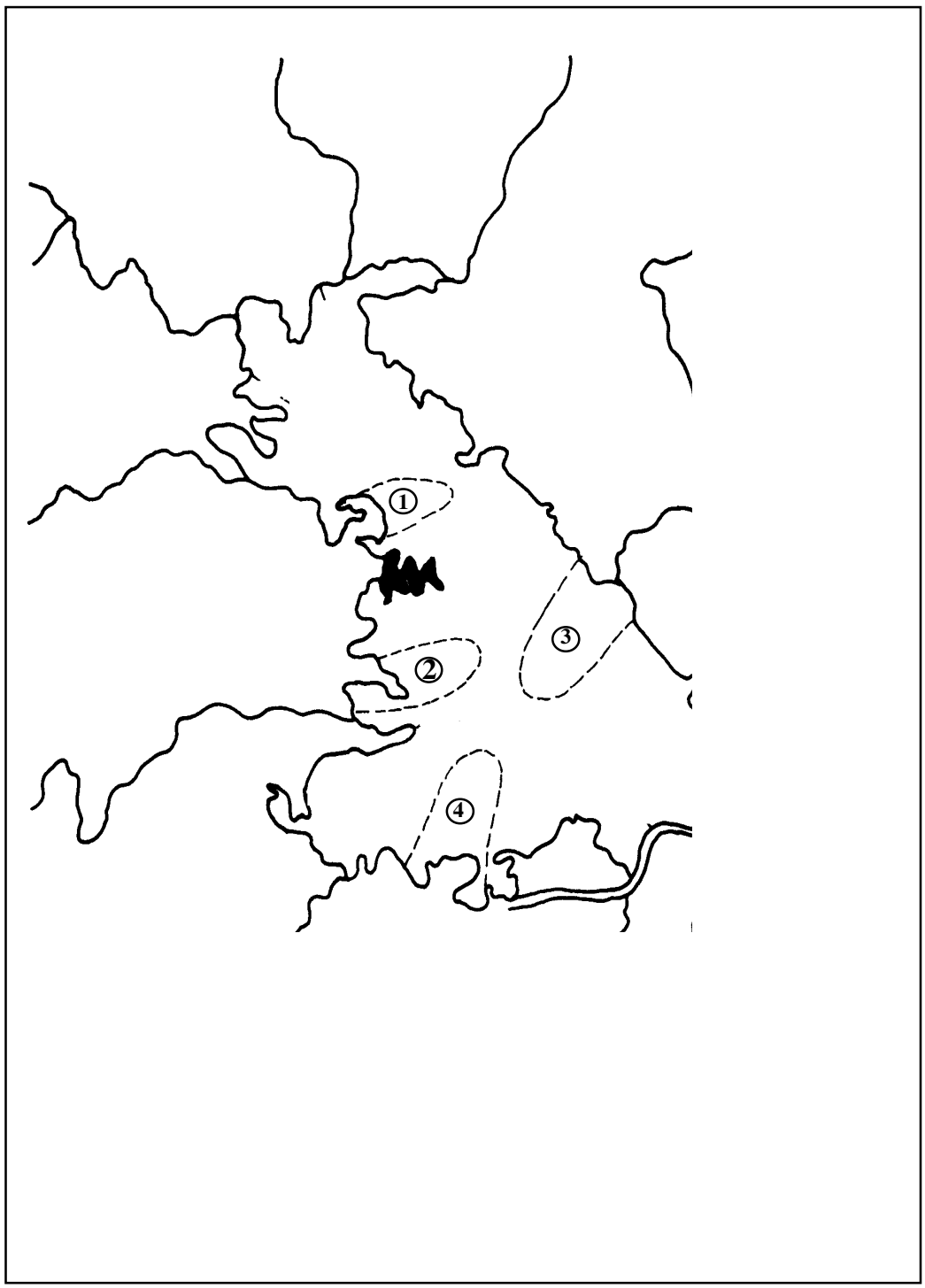
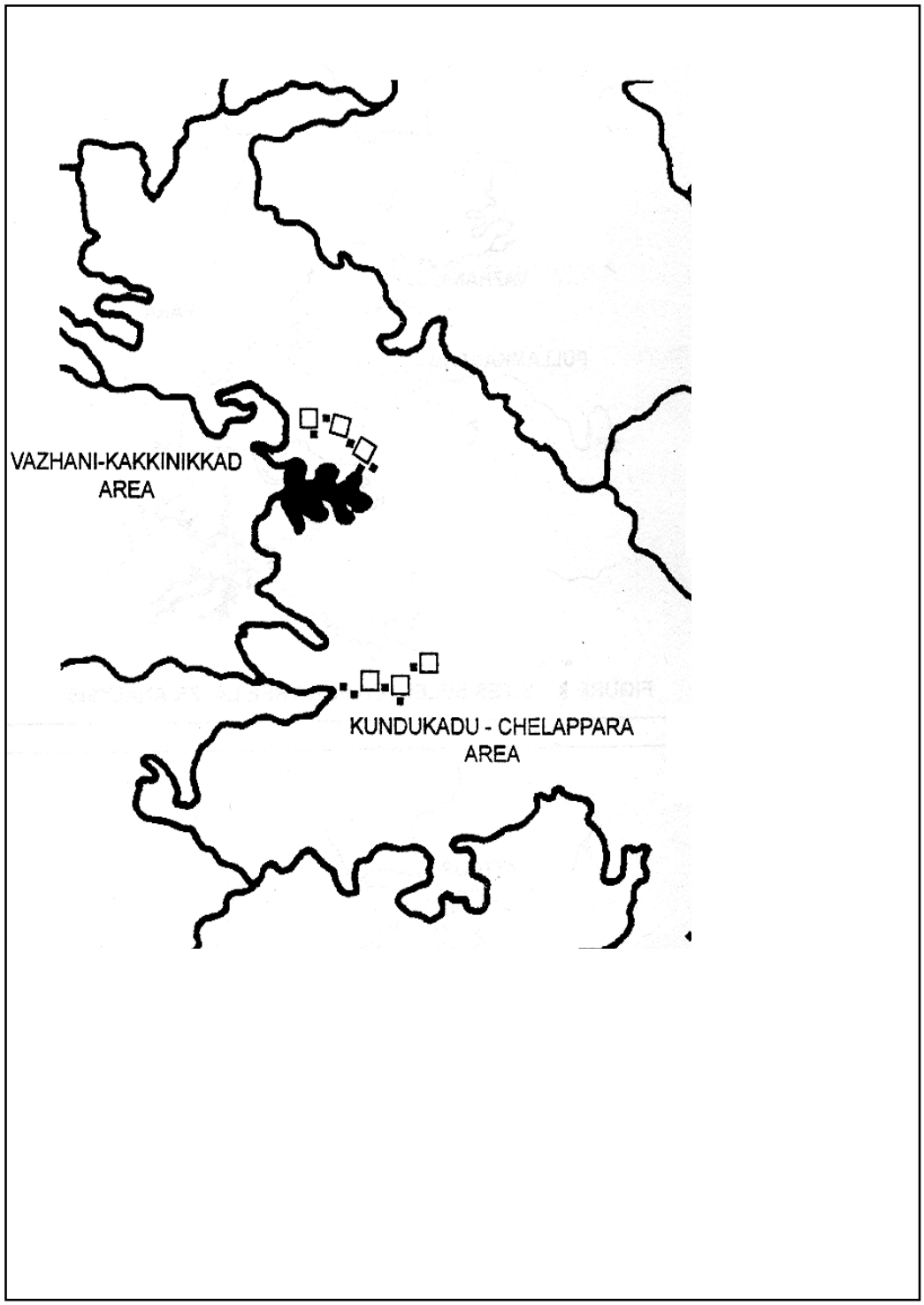


Figure 2.5 Sites Selected for the Analysis of Understorey Vegetation

Figure 2.6 Sites Selected for Ecotone Studies



data from various ecotones collected monthly for two years would give a detailed picture of the phytosociology of these areas.

Risk factors

Though the highest points of the sanctuary such as Munippara and Vellanimala are only around 525 m a large part of the forest areas is practically inaccessible. Though the moist deciduous forests are not so dense as the semi-evergreen and evergreen forests, accessibility is hindered to a large extent by the presence of highly poisonous snakes like cobras, vipers, kraits, etc. The recording of data was therefore hindered at several points.

Socio-economic studies: Locations

In order to estimate the extent of anthropogenic disturbances as well as disturbances caused by grazing animals, suitable socio-economic studies were conducted in the neighbouring *panchayats*. Data were collected on a census basis from two wards adjoining the sanctuary i.e., ward 10 of Madakathara *panchayat* (Pullamkandam) and ward 13 of Pazhayannur *panchayat* (Thrikkanaya)(Figure 2.7).

Similar data were collected from ward 2 of Madakathara *panchayat* (West Vellanikkara), which is situated far away from the sanctuary boundary for purposes of comparison. PRA techniques such as timeline, inflow-outflow, etc., were also utilised for getting valuable data on firewood collection (sampling from Thekkumkara and Kompazha area), - Minor Forest Produce (MFP) collection and medicinal plant collection, goat farming (sampling from Attoor, Kakkinikkad and Kompazha) encroachments, poaching and manure collection, rock mining, etc. The socio- economic conditions of tribal colonies situated in and around the wildlife sanctuary and the biotic pressures exerted by these communities were also studied separately as they belong to a special category. Tribal colonies at Kakkinikkad, Kalappara, Thrirumani and Olakara were also covered. The sites selected for such studies are shown in Figure 2.8.

Method

Forest degradation is a chronic and multidimensional problem in which human population and livestock contribute the lion's share. Hence a methodology was developed to assess its impact on the floristic composition of forest. Evidently, floristic composition is also subjected to intensive studies as it gives valuable data on the present conditions of the forests, especially their species richness. Estimation of the understorey strata, in particular, would give valuable data on grazing pressure. The present study attempts to analyse the impact of biotic pressures on village-forest interface during a span of three decades. The forest flora is assessed using quadrat studies for which the following method has been adopted.

Identification of segments

Following the forest route map, the study area was divided into eight segments after considering the density and diversity of vegetation as well as accessibility. These segments are Kuthiran,

Figure 2.7 Peechi-Vazhani Wildlife Sanctuary and Neighbouring Panchayats: Ward Selected for Socio-economic Studies

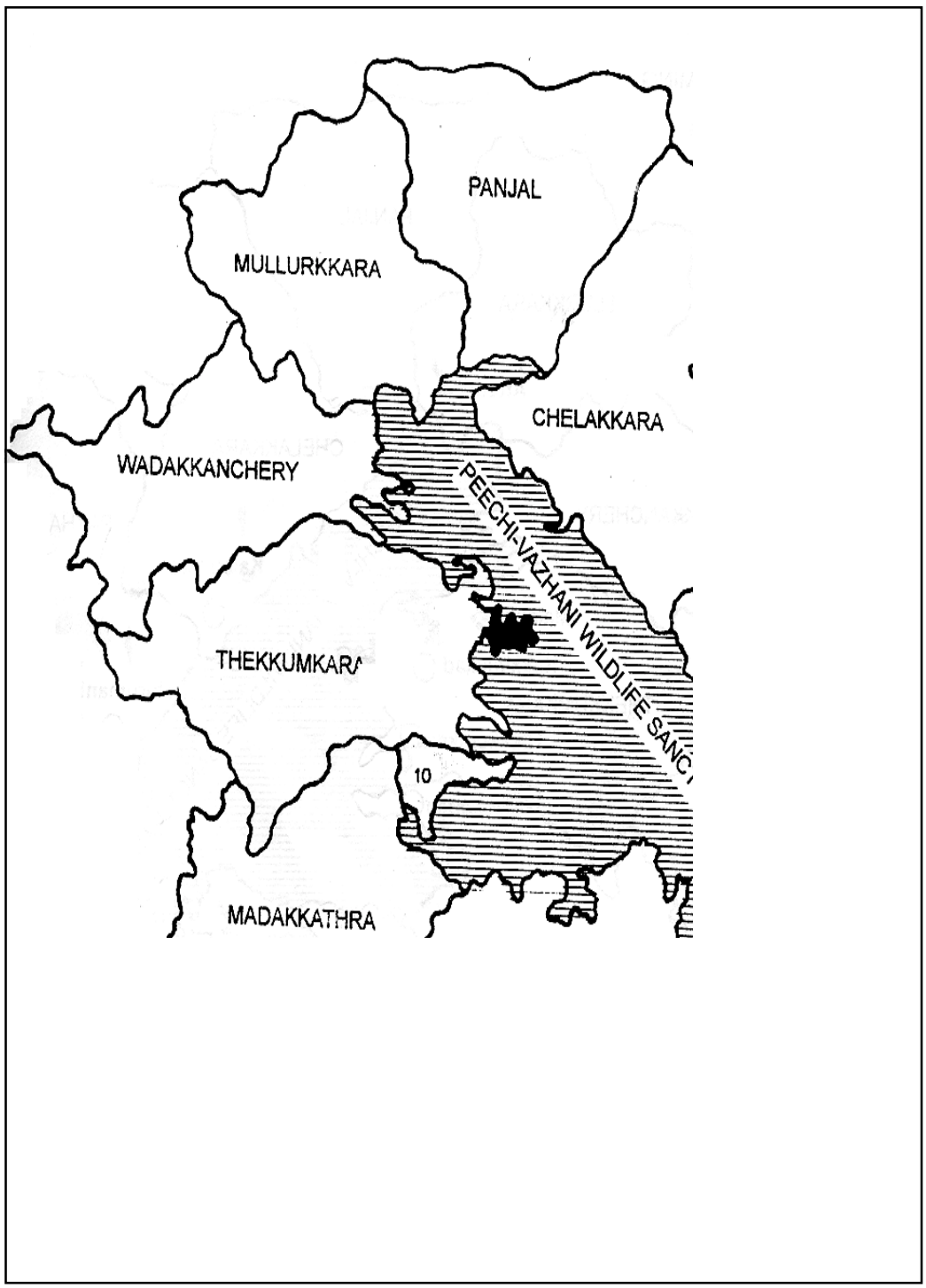
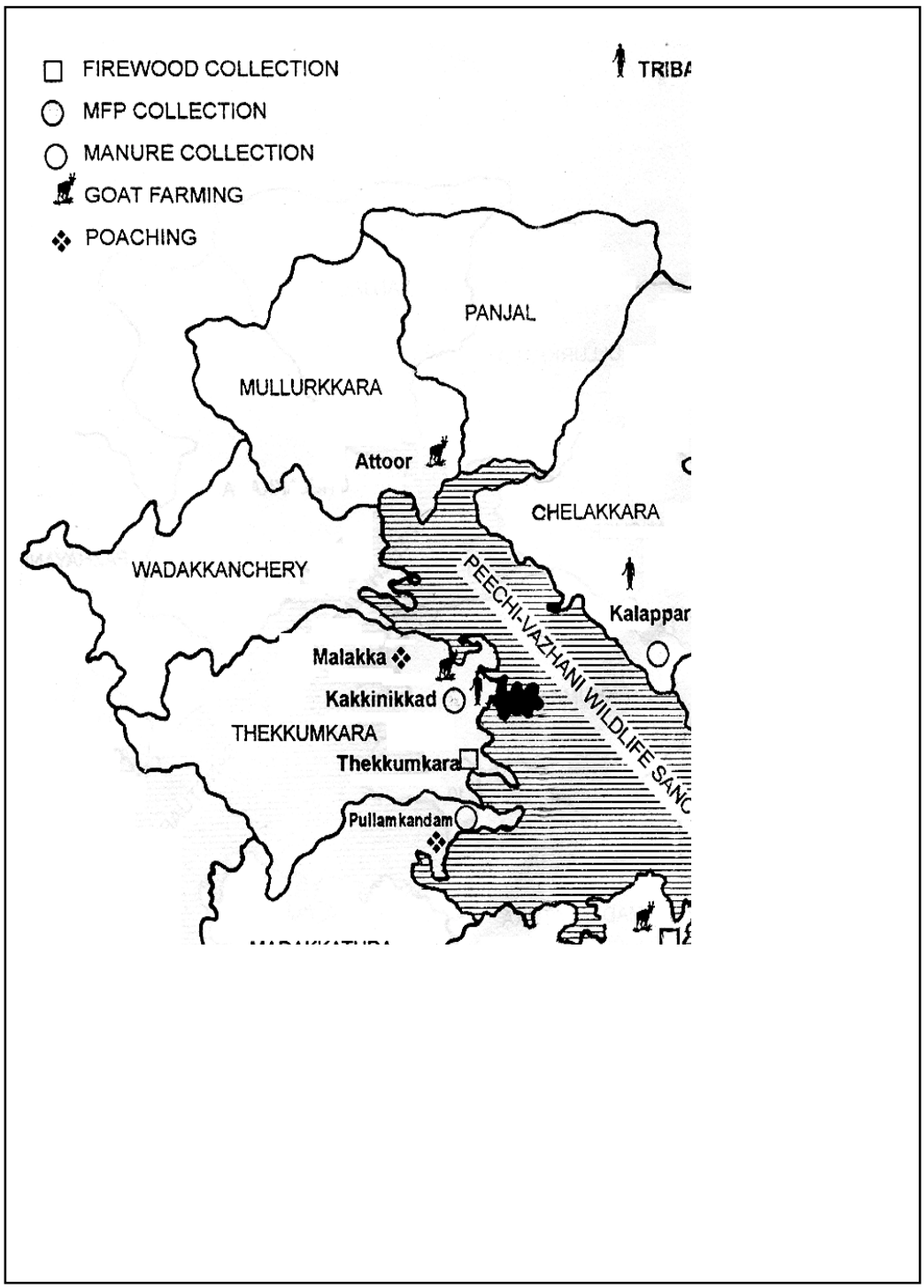


Figure 2.8 Socio-economic Studies: Areas selected for PRA



Chemputhra, Varikulam, Pullamkandam, Vazhani, Attoor, Kalappara, and Vellakkarithadam.

Analysis of tree layer

Phyto-sociological analysis of the tree layer (>15 cm GBH) was made by Census-quadrat method (Oosting: 1956). Eight quadrats of 10m x 10 m size were laid out in each of Kuthiran-Chemputhra, Varikkulam-Pullamkandam, Vazhani-Attoor and Kalappara-Vellakkarithadam areas, keeping a distance of approximately 2 km for data collection representing the various vegetation types (Menon and Balasubramanian: 1985).

Primary analysis

Primary analysis of the data with regard to tree layers in evergreen/semi evergreen, and moist deciduous forests was conducted to obtain significant values of parameters viz. Relative Density, Relative Frequency, Relative Abundance, Relative Basal Area and Important Value Index.

Secondary analysis

The data collected from primary analysis was further processed for specific requirements viz. for the calculation of Maturity Index and Distribution of Species.

Maturity Index

Maturity Index is used mainly to ascertain the successional trends of a population and is given by the following relationship:

Maturity Index (MI) = Total frequency of a community /
Total number of species present.

A climax stage is indicated by high MI value where the maximum is 100. When succession has entered a final stage, the total number of species will be reduced and those, which are adapted to the changing environment alone, will survive and multiply to form the dominant community. i.e.; higher the frequency percentage of a species and smaller the number of sporadic species, the more mature will be the community.

Fixation of the quadrats and collection of data

Ten 2m x 2 m quadrats were fixed in each of the eight segments. The sites were selected in each segment in such a manner that at least three quadrats were fixed in each of the important zones like evergreen/semi evergreen and moist deciduous forests and plantations. Species occurring in each quadrat were divided into two classes - height of the seedling / sapling above 1 m and those below 1 m classes. The number of species in such quadrats was counted separately and the process was repeated in alternate months from which the average number of species present in one year was determined. The immigrant species were recorded bi-monthly and the number of immigrant species in each forest type analysed accordingly.

Analysis of the understorey strata

Composition

Variations in species composition were analysed graphically using computer. The number of species showing higher relative densities was selected and the species composition of the same quadrat was recorded bimonthly. Quantification and interpretation of the species composition in various forest types for a period of one year was conducted using these data.

Variation in species richness

Variations in the species richness within a quadrat (alpha richness) and with quadrats in other zones (beta richness) were also studied using this method.

Identification of dominant and characteristic species

From the data obtained from 2m x 2 m quadrats, it was also possible to identify and list the dominant and characteristic species occurring in the different forest types. Information on species composition of understorey strata was collected monthly for a span of one year to include even the ephemerals that occur as immigrants.

Collection and analysis of data

Collection and analysis of data were done in the same way as described in the case of the analysis of 2 m x 2 m quadrats.

Ecotone studies

Relevance

According to Braun (1950), forest environment is a combination of atmospheric, topographic, and soil influences often complicated by the interaction of the forest and its inhabitants and by competition among individuals of the forest. Any attempt to study forests in arbitrarily fixed parameters may over-emphasise certain aspects (like evergreen, moist deciduous, and grassland) and exclude some vital aspects. Reviewing all these facts, a transect study was designed at three locations – Peechi, Kundukad, and Vazhani starting from the very periphery of the forest and ending nearer to climax vegetation. This study has revealed the 'edge effects'. The gradual changes in the floristic composition could also be monitored using transect data.

Theoretically, ecotones possess more species than the two adjacent zones. In that respect, the study attempts to analyse the vegetation as a continuum.

3. Floristic Studies

Forest degradation has far reaching influence on the floristic component of the forest. Hence evaluation of floristic component is an integral part of the present study. It gives data on the conditions of the forests and helps estimation of the Maturity Indices of forest types viz. Evergreen, semi-evergreen, and moist deciduous forests and plantations. Details regarding species richness of the above forest types, especially at the understorey strata, would be essential to establish the loss in species richness due to grazing.

Floristics

The present study being socio-economic as well as ecological in perspective, floristic studies are limited to observations, recording and identification of the taxa present in various quadrats located in different ecological zones. Detailed taxonomical studies in the area, for the span of a decade and the results in published form are available (Sasidharan and Sivarajan: 1996). Further, floristic studies to cater to the present requirements, using standard herbarium techniques for identification of taxa present both at tree and understorey levels, also exist. Floristic studies are broadly treated under two heads - of trees and of understorey stratum. The understorey stratum is of special importance as it depicts the regeneration potential of the forest types. The effect of grazing pressure is more on the understorey stratum. Composition and species richness are also estimated in order to quantify the impacts of grazing pressure on understorey stratum.

Tree layer

The tree layer may be broadly divided into 1-3 canopy levels; for the sake of quantification, it may be considered a single category comprising all taxa above 15 cm gbh. Similarly, though the vegetation may be subgrouped into evergreen, semi-evergreen types 1, 2 and 3 and moist deciduous types 1, 2 and 3, it is treated only as two categories to facilitate quantification. The above inter-grades of forest types do occur in one and the same locality with intermingled patches that make their identification difficult (but can be distinguished and designated using satellite imageries). Here, for practical purposes, the tree layer is treated under evergreen and moist deciduous types having physiognomy and hence boundaries.

Dominant and rare species

The study shows that in the moist deciduous forests, trees like, *Millennia pentagonal, Terminally aciculate, Xylia xylocarpa, Grewia tiliifolia, Helecteres isora, Holarrhena pubescens, Lagerstroemia microcarpa, Miliusa tomentosa, Naringi crenulata*, and *Strychnos nux-vomica* dominate while the evergreen forests are characterised by the presence of trees such as *Walsura trifolia, Aglaia spp., Holigarna arnottiana, Mitrephora grandiflora, Mussaenda laxa, Myristica dactyloides, Polyalthia fragrans, Spondias indica, Leea indica,* and *Pterocarpus marsupium*.

Taxa like *Canthium travancoricum, Careya arborea, Casearia wynadensis, Leea indica, Macaranga peltata, Phyllanthes emblica, Pterocarpus marsupium, Sterculia urens,*

Stereospermum chelonoides, and Streblus asper, etc., show rare occurrence while taxa like *Litsea spp., Mastixia arborea, Mesua ferrea, Nothopegia spp., Palaquium ellipticum, Persea macrantha, Pterygota alata, Sapindus laurifolius, Spatholobus spp.,* and *Zanthoxylum rhetsa* are met with in evergreen forests rarely (Table 3.1).

Table 3.1 Vazhani-Vellani hill tracts: Moist deciduous and evergreen forests: Comparison - tree layer

Moist deciduous forests	Evergreen forests
Dominant species	
Dillenia pentagyna	*Walsura trifolia*
Terminalia paniculata	*Aglaia spp.*
Xylia xylocarpa	*Holigarna arnottiana*
Grewia tiliifolia	*Mitrephora grandiflora*
Helicteres isora	*Myristica dactyloides*
Rare species	
Canthiun travancoricum	*Litsea spp.*
Careya arborea	*Mastixia arborea*
Caseria wynadensis	*Mesua ferra*
Leea indica	*Nothopegiea spp.*
Macaranga peltata	*Palaquium ellipticum*

Dominant and rare families

Members of the families *Combretaceae, Apocynaceae, Euphorbiaceae, Mimosaceae, Sterculiaceae, Dilleniaceae, Verbenaceae, Annonaceae, Loganiaceae, Lythraceae* are fairly common in moist deciduous forests. In evergreen forests families like *Euphorbiaceae, Anacardiaceae, Meliaceae, Annonaceae, Myristicaceae, Sterculiaceae, Rubiaceae, Rutaceae, Sapindaceae,* and *Flacourtiaceae* are well represented.

Taxa belonging to *Ulmaceae, Moraceae, Leeaceae, Lecythidaceae, Flacourtiaceae, Fabaceae, Bignoniaceae, Sapindaceae, Oleaceae, asnd Caesalpiniaceae* are comparatively negligible in moist deciduous forests and similarly members of the families *Sapotaceae, Eleagnaceae, Cornaceae, Capparaceae, Arecaceae, Lythraceae, Verbenaceae, Apocynaceae, Combretaceae,* and *Xanthophyllaceae* are not common in the evergreen forests (Table 3.2).

The above observations are made, however, based on limited samplings, unlike in the case of understorey vegetation. Moreover, the forests of the area are subjected to constant and increasing anthropogenic disturbances from eight *panchayats* surrounding the area with the result that some species which are economically important, especially those yielding timber, poles, firewood, bark, are being removed quite frequently. Such practices would influence their density and distribution in forests.

Peechi-Vazhani Wildlife Sanctuaries at present are having only degraded forests; forests now occur only in inaccessible areas.

Table 3.2 Vazhani-Vellani hill tracts: Moist deciduous and evergreen forests - comparison - tree layer

Moist deciduous forests	Evergreen forests
Dominant families	
Combretaceae	*Euphorbiaceae*
Apocynaceae	*Anacardiaceae*
Euphorbiaceae	*Meliaceae*
Mimosaceae	*Annonaceae*
Sterculiaceae	*Myristicaceae*
Rare families	
Ulmaceae	*Sapotaceae*
Moraceae	*Elaeagnaceae*
Leeaceae	*Cornaceae*
Lecythidaceae	*Capparaceae*
Flacourtiaceae	*Arecaceae*

Importance Value and Maturity and Continuum Indices

The Importance Value Index of average species in moist deciduous forests is 15.47 and that of evergreen forests, 12.20. The Maturity Index of 46.94 found in the moist deciduous forests indicates that the stands are not mature enough with occurrence of large numbers of sporadic species. This fact is also reflected in the Continuum Index value of 2051. The Maturity Index of evergreen forests is 39.04 compared to a Continuum Index of 1877 (Table 3.9).

Plant density and species richness

The Plant Density for an area of four sq. m is 0.13 in moist deciduous forests compared to 0.11 in evergreen forests. This value corresponds to understorey vegetation with plant densities of 71 found in moist deciduous forest and 39 in evergreen forests.

The Species Richness expressed as the ratio of number species to total number of species (Menhinick index) is found to be higher in evergreen forests both at tree layer and understorey stratum. In moist deciduous forests the value is only 0.0036 for four sq. m while in evergreen forests it is 0.0054. At understorey level, they are 0.229 and 0.254 respectively. Though plant density is higher in the moist deciduous forests both at tree and understorey levels, Species Richness is high in the evergreen forests.

Understorey stratum

Study area: Locations

Floristic studies on understorey are confined to the species occurring in 2m x 2m quadrats

fixed at different locations viz. Kalappara (KLP), Attoor (ATR), Vazhani (VZN), Peechi (PCH), Varikulam (VKL), Chemputhra (CHP), Kuthiran (KTH), and Pullamkandam (PLK). In these locations quadrats were fixed evenly representing various forest types present (Table 3.3). Four locations were covered every month and the data were collected bimonthly for one year (August 1997-July 1998).

Collection of data

The total number of plants present in the quadrats (Plant density) and the number of species present were noted. This exercise has enabled estimation of the immigrant species invading the quadrats

Table 3.3 Vazhani-Vellani hill tracts: Understorey strata location of quadrats and forest types

Location	Plantation	Moist deciduous	Semi-evergreen	Evergreen	Total
KLP	1	5	2	2	10
ATR	1	3	1	1	6*
VZN	2	4	2	2	10
PLK	2	2	1	5	10
VLK	3	3	2	2	10
CHP	2	3	2	3	10
PCH	1	9	-	-	10
KTH	2	5	2	1	10
Total	14	34	12	16	76

* Four quadrats were abandoned due to biotic disturbances

Taxa recorded from forest types

The species present in the understorey are broadly divided into four categories: those present in plantations, [mainly of Teak and Wattle (Acacia)], moist deciduous forests, semi-evergreen forests, and evergreen forests. About 99 taxa were recorded from plantations while 149 from the moist deciduous forests, 85 from semi-evergreen forests, and 77 from evergreen forests were recorded.

Taxa in plantations

Further studies on their density, frequency, abundance and the AF ratio provided important results. In the plantations *Curculigo orchioides*, *Hyptis suaveolens,* and *Ichnocarpus frutescens* showed highest densities followed by species like, *Mimosa pudica*, *Dioscorea bulbifera*, *Chromolaena odorata*, *Helecteres isora*, *Desmodium triflorum*, *Teramnus labialis*, and *Hemidesmus indicus*. The dominant families in the understorey include, *Fabaceae, Acanthaceae, Euphorbiaceae, Apocynaceae, Asteraceae, Mimosaceae, Convolvulaceae, Sapindaceae,* and *Sterculiaceae*.

Sterculia urens, *Crotalaria striata*, *Desmodium spp*., *Strobilanthes spp*., *Rauwolfia serpentina*, *Vernonia cinerea*, *Knoxia corymbosa*, *Canthium dicoccum*, *Cleistanthes collinus*, and *Phyllanthus kozhikodianus* are found in plantations, but rarely. Some of the rarely represented families in plantations include *Annonaceae, Bombacaceae, Caesalpiniaceae, Combretaceae, Commelinaceae, Cucurbitaceae, Cyperaceae, Hypoxidaceae, Lamiaceae,* and *Leeaceae* (Table 3.4.)

Table 3. 4 Vazhani-Vellani hill tracts: Understorey strata

Dominant species	**Rare species**
Curculigo orchioides	*Sterculia urens*
Hyptis suaveolens	*Crotalaria striata*
Ichnocarpus frutescens	*Desmodium sp.*
Mimosa pudica	*Strobilanthes sp.*
Dioscorea bulbifera	*Rauvolfia serpentina*
Chromolaena odorata	*Vernonia cinerea*
Helicteres isora	*Knoxia corymbosa*
Desmodium triflorum	*Canthium dicoccum*
Teramnus labialis	*Cleistanthus collinus*
Hemidesmus indicus	*Phyllanthus kozhikodianus*
Dominant families	**Rare families**
Fabaceae	*Annonaceae*
Acanthaceae	*Bombacaceae*
Euphorbiaceae	*Caesalpiniaceae*
Rubiaceae	*Combretaceae*
Apocynaceae	*Commelinaceae*
Asteraceae	*Cucurbitaceae*
Mimosaceae	*Cyperaceae*
Convolvulaceae	*Hypoxidaceae*
Sapindaceae	*Lamiaceae*
Sterculiaceae	*Leeaceae*

Taxa in moist deciduous forests

The understorey in moist deciduous forests is found to be similar to that of plantations with regard to dominant families. But the species component varies significantly with the presence of *Eranthemum capense, Piper longum,* and *Biophytum sensitivum*. *Helicteres isora* is found to be a common species occurring in both plantations and moist deciduous forests. It is indicator species providing excellent information if the area is suitable for teak plantations. Several species not present in plantations do occur in moist deciduous forests like *Garcinia spicata, Pterospermum reticulatum, Streblus asper,* and *Gmelina arborea*. Accordingly, the families represented rarely vary to a large extent (Table 3.5).

Table 3.5 Vazhani-Vellani hill tracts: Understorey strata

Moist deciduous forests	
Dominant species	**Rare species**
Chromolaena odorata	*Garcinia spicata*
Eranthemum capense	*Pterospermum reticulatum*
Piper longum	*Streblus asper*
Biophytum sensitivum	*Syzygium sp.*
Helicterse isora	*Desmodium triquetrum*
Phaulopsis imbricata	*Asparagus racemosus*
Thespesia lampas	*Gmelina arborea*
Naregamia alata	*Rauvolfia serpentina*
Commelina paludosa	*Emblica officinalis*
Synedrella nodiflora	*Gloriosa superba*
Dominant families	**Rare families**
Euphorbiaceae	*Amaranthaceae*
Fabaceae	*Amaryllidaceae*
Acanthaceae	*Anacardiaceae*
Asteraceae	*Arecaceae*
Malvaceae	*Asclepiadaceae*
Mimosaceae	*Balsaminaceae*
Rubiaceae	*Bombacaceae*
Apocynaceae	*Clusiaceae*
Poaceae	*Cucurbitaceae*
Sapindaceae	*Dilleniaceae*

Taxa in semi-evergreen forests

The taxa found in semi-evergreen forests are quite characteristic to that forest type viz., *Stachyphrynium spicatum, Bauhinia anguina, Derris eualata,* and *Ventilago bombaiensis*. However, some species like, *Lepisanthes tetraphylla, Piper longum*, and *Leea indica* are found to be common in these forest types. The dominant families in semi-evergreen and evergreen forests are found to be similar (Tables 3.6 and 3.7) corresponding to their similarity in physiognomy to a great extent.

Taxa in evergreen forests

Species like, *Dimocarpus longan, Elatostemma acuminatum, Alseodaphne semecarpifolia,* and *Nothopegia colebrookeana* are found in this type. Though many of these are also found in semi-evergreen forests, families like *Alangiaceae, Ancistrocladaceae, Araceae, Capparaceae,* and *Dichapetalaceae* represented in this area are those not present in semi-evergreen forests (Table 3.7)

Table 3.6 Vazhani-Vellani hill tracts: Understorey strata

Semi-evergreen forests	
Dominant species	**Rare species**
Eranthemum capense	*Adianthum spp.*
Schleichera oleosa	*Arisaema murrayi*
Stachyphrynium spicatum	*Curcuma ecalcarata*
Piper longum	*Holostemma adakodien*
Bauhinia anguina	*Knoxia corymbosa*
Leea indica	*Chromolaena odorata*
Derris eualata	*Ludwigia spp.*
Glycosmis pentaphylla	*Spondias indica*
Ventilago bombaiensis	*Cissus discolor*
Globba ophioglossa	*Anthocephalus cadamba*
Dominant families	**Rare families**
Rubiaceae	*Acanthaceae*
Sterculiaceae	*Alangiaceae*
Apocynaceae	*Annonaceae*
Rutaceae	*Asclepiadaceae*
Fabaceae	*Asteraceae*
Anacardiaceae	*Bignoniaceae*
Dioscoreaceae	*Caesalpiniaceae*
Euphorbiaceae	*Capparaceae*
Sapindaceae	*Clusiaceae*
Verbenaceae	*Combretaceae*

Table 3.7 Vazhani-Vellani hill tracts: Understorey strata

Evergreen forests	
Dominant* species	**Rare* species**
Piper longum	*Pterospermum reticulatum*
Dimocarpus longan	*Wrightia tinctoria*
Lepisanthes tetraphylla	*Adianthum spp.*
Elatostemma acuminatum	*Desmodium gangeticum*
Ventilago bombaiensis	*Holigarna arnottiana*
Mallotus aureo-punctatus	*Clerodendrum infortunatum*
Alseodaphne semecarpifolia	*Orophea spp.*
Leea indica	*Cassia spp.*
Nothopegia colebrookeana	*Ophiorrhiza spp.*
Caryota urens	*Arisaema murrayi*

Dominant families	Rare families
Fabaceae	*Acanthaceae*
Rubiaceae	*Alangiaceae*
Annonaceae	*Amaryllidaceae*
Sterculiaceae	*Ancistrocladaceae*
Caesalpiniaceae	*Apocynaceae*
Euphorbiaceae	*Araceae*
Rutaceae	*Arecaceae*
Sapindaceae	*Capparaceae*
Anacardiaceae	*Dichapetalaceae*
Clusiaceae	*Dioscoreaceae*

* based on density

Based on AF ratio, the following plants are found to be dominant in their distribution (Table 3.8).

Phytosociological studies		
Dominant plants* in forest types		
Species	**Families**	**A/F ratio**
Plantations		
Holarrhena pubescens	*Apocynaceae*	7.14
Spermacoce articularis	*Rubiaceae*	94.5
Glycosmis pentaphylla	*Rutaceae*	280.0
Piper longum	*Piperaceae*	210.0
Desmodium triquetrum	*Fabaceae*	192.5
Moist deciduous forests		
Spermacoce articularis	*Rubiaceae*	476.0
Murdannia japonica	*Commelinaceae*	229.5
Lantana camara	*Verbenaceae*	204.0
Cymbopogon citrates	*Poaceae*	170.0
Desmodium laxiflorum	*Fabaceae*	170.0
Semi-evergreen forests		
Piper longum	*Piperaceae*	54.67
*Glycosmis pentaphylla***	*Rutaceae*	53.89
Eranthemum capense	*Acanthaceae*	53.03
*Clerodendrum infortunatum***	*Verbenaceae*	48.19
*Bauhinia anguina***	*Caesalpiniaceae*	45.33
Evergreen forests		
Elatostemma acuminatum	*Urticaceae*	496.0
Capparis rheedeii	*Capparaceae*	80.0
Piper nigrum	*Piperaceae*	80.0
Aganope thyrsiflora	*Fabaceae*	64.0
Derris spp.	*Fabaceae*	64.0

* based on A/F ratio ** Since the above species are not typical their presence can be ascribed due to degradation

In plantations *Holarrhena pubescens* (Apocynaceae), *Spermacoce articularis* (Rubiaceae), *Glycosmis pentaphylla* (Rutaceae), *Piper longum* (Piperaceae), and *Desmodium triquetrum* (Fabaceae) show high AF ratio.

With regard to moist deciduous forests *Spermacoce articularis* (Rubiaceae), *Murdannia japonica* (Commelinaceae), *Lantana camara* (Verbenaceae), *Cymbopogon citratus* (Poaceae), and *Desmodium laxiflorum* (Fabaceae) have high AF ratio values.

In semi-evergreen forests *Piper longum* (Piperaceae), *Glycosmis pentaphylla* (Rutaceae), *Eranthemum capense* (Acanthaceae), *Clerodendrum infortunatum* (Verbenaceae), and *Bauhinia anguina* (Caesalpiniaceae) are found to have high AF ratio values.

Evergreen forests show high AF ratio with regard to species like *Elatostemma accuminatum* (Urticaceae), *Capparis rheedii* (Capparaceae), *Piper nigrum* (Piperaceae), *Aganope thyrsiflora* (Fabaceae), and *Derris spp*. (Fabaceae).

AF values show that each forest type has distinct understorey vegetation. However, there are certain species like *Glycosmis pentaphylla* and *Piper longum*, which are common to plantations and semi-evergreen forests.

Phytosociology

Overview

Phytosociology of the moist deciduous forests has been studied both at the level of trees (Permanent Vegetation) as well of as understorey vegetation so as to get an almost complete assessment. The latter (i.e.; the understorey vegetation) indicates the probable nature of the future vegetation under prevailing environmental conditions of the corresponding area and so gives the 'regeneration potential' of particular forest zones. Regeneration studies on forest types of Kerala are at the preliminary stages; the present study provides data for further ecological and vegetation studies.

Tree layer has been analysed using 10m x 10m quadrats representing various forest types i.e., plantations, moist deciduous, semi-evergreen, and evergreen forests. Attempts were also made to study the understorey stratum (herb- shrub layers) and to represent the plant density variations (number of plants recorded in 2m x 2m quadrats in alternate months), variations in the number of species in the above quadrats as well as immigration of new species into these quadrats. The data provide the Species Richness (SR) of the understorey vegetation which is expressed in Menhinick's Index.

The data collected for the above studies have come from different localities, which differ according to various abiotic and biotic factors. So another set of data collected for comparative studies in moist deciduous and evergreen forests of Chelappara area near Kundukad and elsewhere has been used for calculation of Similarity Index (Sorenson's Index).

Apart from analysis of tree and understorey vegetation, efforts were made to quantify the

species occurring in different areas among the forest zones, which reveal the edge effects in the area (Ecotone studies).

Considering all the above facts the discussion is attempted under the following subtitles viz., Tree layer, Understorey vegetation, Comparative studies, Ecotone studies, and Species richness.

Discussion

Tree layer

The general physiognomy of the study area is imparted jointly by the tree layer and the understorey stratum. Vegetation dynamics are closely associated with competition and pattern of development. With the exception of absolute limits of species boundaries, distribution of plants depends on physico-chemical and environmental factors. So, for effective assessment, information both on tree layer and understorey strata are required.

The upper canopy influences the understorey directly and indirectly to the extent that the tree layer and the understorey found in forest types apparently belong to distinct and characteristic species. In order to analyse these aspects, tree layer is further studied to understand its structure and composition, Continuum and Maturity Indices and also to determine the dominant and rare species and families.

Collection of data

The data gathered from specimens above 15 cm of gbh. from 10m x 10m quadrats were further pooled and quantified in 400 sq. m (as 20m x 20m). Such data were collected for moist deciduous forests and evergreen forests separately from four areas viz., Kalappara, Vazhani, Chemputhra, and Pullamkandam.

Comparison of moist deciduous and evergreen forests

The data collected from the above four areas were then processed to determine the Importance Value, Continuum, and Maturity Indices.

Importance Value Index (IVI)

With regard to moist deciduous forests, the average IVI value for the whole study area is found to be 15.47 though it is 18.36 at Chemputhra and as low as 10.10 in Pullamkandam. The evergreen zones show little fluctuations in IVI values showing a general homogeneity with an average of 12.20 (Table 3.9).

IVI indicates the total picture or sociological structure of a species in a community. So, its average value gives the general nature of constituent species compared to other areas.

Table 3.9 Vazhani-Vellani hill tracts: Tree layer moist deciduous and evergreen for ests - Comparison

Moist deciduous forests			
Area	**IVI***	**Maturity Index**	**Continuum Index**
Chemputhra	18.36	45.59	2288
Pullamkandam	10.10	42.71	1557
Kalappara	15.80	42.11	2304
Vazhani	17.65	57.35	2053
Avg	15.47	46.94	2051
Evergreen forests			
Area	**IVI**	**Maturity Index**	**Continuum Index**
Chemputhra	12.50	35.42	1772
Pullamkandam	11.54	39.42	2061
Kalappara	11.11	34.26	2286
Vazhani	13.63	46.74	1387
Avg	12.20	39.04	1877

* Importance Value Index

Maturity Index (MI)

The Maturity Index for moist deciduous forests is found to be 46.94 while for Vazhani taken separately, it is 57.35. It indicates that moist deciduous forests at Vazhani are better developed than in other areas. The same pattern is found in the case of evergreen forests as well, 46.74 against an average of 39.04 calculated for the whole study area. MI values show that the stands in the study area of neither moist deciduous nor evergreen forests are mature enough. The number of sporadic species is so close to the dominants that the value is near 50 per cent, as the mature community usually shows high frequency of dominant species and smaller number of sporadic species.

Continuum Index (CI)

The CI value for the moist deciduous forests is found to be 2051 and that for evergreen forests only 1877. The CI value for moist deciduous forests at Pullamkandam is 1557 while that of evergreen forests in Vazhani is as low as 1387. As mentioned earlier, a higher value of adaptation number means better adaptation to all the prevailing environmental conditions. This indicates that moist deciduous forests at Pullamkandam and evergreen forests of Vazhani are stress-prone to the extent that the species in these areas are not able to develop to the level attained by the rest of the areas. The study also reveals that the present environmental conditions are not ideal for the development of moist deciduous forests in Pullamkandam and evergreen forests in Vazhani areas. Forests in Vazhani generally are of the moist deciduous type. Menon and Balasubramanian (1985) view these zones as dry deciduous type. In this

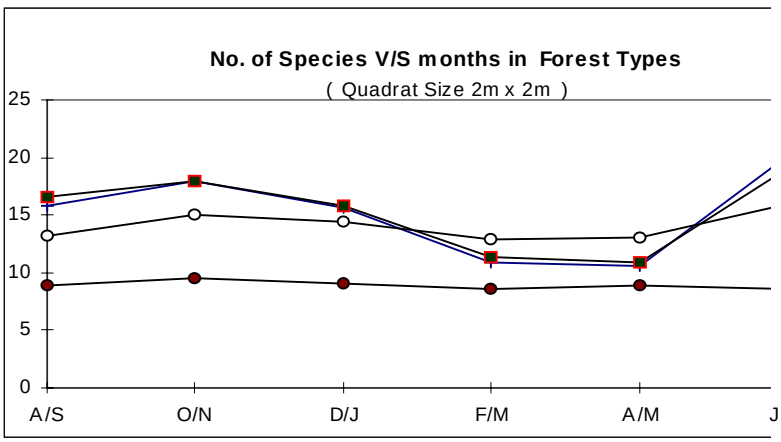
background, the dwindling of evergreen vegetation at Vazhani is in conformity with the above facts.

Understorey stratum

[Regeneration studies]

The data for analysis of understorey stratum have been collected from eight locations (Figure 3.1) and each area was covered by ten 2m x 2m quadrats. The number of species in these quadrats was recorded on alternate months for one full year starting from August 1997.

Figure 3.1 Plant density variations in forest types



The analysis of data reveals the structure and complexity of shrub and herb layers and regeneration potential of various forest types. Four forest types were met with in the study area, i.e., plantations, moist deciduous, semi-evergreen, and evergreen. Each type possesses characteristic physiognomy with which they can be distinguished in all the eight zones - Kalappara (KLP), Attoor (ATR), Vazhani (VZN), Peechi (PCH), Varikulam (VKL), Chemputhra (CHP), Kuthiran (KTH), and Pullamkandam (PLK). The understorey vegetation was further analysed based on the riders viz., density of plants in the quadrats occurring in alternate months, number of species present as well as immigration of new species.

Number of plants (plant density)

Plant density denotes the number of plants of a particular species present in a quadrat. Four locations were recorded in one month and the other four locations in the next month and the data collected were pooled for the months August-September (A/S), October-November (O/N), December-January (D/J), February-March (F/M), April-May (A/M), and June-July (J/JL), in order to include even the ephemerals that may appear in the subsequent season. The unidentified species were theoretically treated as a separate group to include these species as well. The data so collected were again processed species-wise to calculate the average density in different forest types - plantations, moist deciduous, semi-evergreen, and evergreen forests (Table 3.3)

The data from all quadrats with fixed-in plantations of a particular locality were then pooled to get the average value with regard to plantations of that zone. Similar data were also collected for other forest types i.e., moist deciduous, semi-evergreen, and evergreen.

The graph thus prepared indicates the variations in plant density in plantations, moist deciduous, semi-evergreen, and evergreen forests in quantified terms. Though the quadrats were fixed mainly on the physiognomy noticed in a preliminary survey, the graph clearly segregates the understorey vegetation into four forest types (Figure 3.1).

Density of plants

Plantations

The number of plants in the quadrats shows marked variations as between different seasons. It shows peaks during June-July (J/Jl) as well as during August-September (A/S) and reaches the minima during April-May (A/M). However, plantations at Kalapapra and Kuthiran are slightly different from those in the other locations.

Moist deciduous forests

By and large, the moist deciduous forests of the area show fluctuations in the density of plants to those of plantations, the Kuthiran area showing the maximum variations.

Semi-evergreen forests

Fluctuations in plant density are still lower in the Semi-evergreen forests of the study area. It is found to be the maximum in the Attoor and the minimum in Kuthiran.

Evergreen forests

The variation in plant density is found to be the lowest in the evergreen patches of all zones. In Pullamkandam plant density is the minimum, while at Chemputhra it is the maximum.

Density variations in forest types

Plantations and moist deciduous forests show greater variation in the number of plants in various quadrats. However, slight variation is noticed in the quadrats of fixed-in semi-evergreen forests and the minimum variation in evergreen forests. This is quite in line with the accepted fact that canopy closure which is a regular feature in the evergreen forests nullify the effects of varying environmental conditions with the result that the understorey stratum is somewhat protected by the upper canopy itself. It also confirms the general statement that evergreen forests represent a self-perpetuating ecosystem compared to other ecosystems. Since canopy closure is lower in semi-evergreen forests, there are better chances for the immigration of new species into this zone.

Moist deciduous forests and plantations represent the other two forest types of which the

latter is man-made. In both these types the dominant trees stand wide apart giving ample ecological niches for new species to invade. So, plant density is the maximum in these zones. However, the mean zonal average indicates the minimum plant density in February/March in the case of plantations while in the moist deciduous forests, it is delayed to April/May. This may be due to the retention of moisture in these forest types. Surprisingly, plant density increases in plantations by April/May probably due to the sprouting of new plants like *Ichnocarpus frutescens, Chromolaena odorata,* and *Dioscorea bulbifera* from the perennating underground vegetative structures (Table 3.10).

Table 3.10 Vazhani-Vellani hill tracts: Understorey strata Regeneration studies - Quadrat size 2 m x 2m (1997 August-1998 July)

Forest types	No. of plants	No. of species	Species richness
Plantations	107.33	15.17	0.14
Moist deciduous Forests	80.17	15.26	0.19
Semi- Evergreen Forests	58.17	14.07	0.24
Evergreen Forests	37	8.92	0.24
Total	282.67	53.54	0.81
Avg	71	13	0.20

Species richness in Menhinick Index

Number of species

The number of species occurring in a quadrat is an important factor determining the species richness. There is considerable variation in the number of species in different forest types and the data collected from various localities show more or less general agreement in their distribution.

Plantations

The number of species found in the various plantations of the eight zones and their variation through seasons were almost identical and conform to the view that they are man-made forest types. Though occurrence of fire in some zones like Kalappara seems to break the continuity, the vegetation soon re-establishes on the onset of favourable season (Table 3.11).

Moist deciduous forests

In moist deciduous forests the number of species present is apparently similar to those of plantations. As is the case of plantations, a general decline in the number of species is also found in moist deciduous forests. The only area where a much lower species number has been

Table 3.11 Vazhani-Vellani hill tracts: Understorey strata Regeneration studies -Quadrat size 2 m x 2m

Total no. of species in plantations (1997 August-1998 July)

Area	97A/S	O/N	D/98 J	F/M	A/M	J/ JL
KLP	21	20	16	15	15	24
ATR	13	13	13	12	8	16
VKL	12	14	14	9	8	17
PLK	14	17	18	11	7	20
CHP	17	21	22	15	14	24
VZN	17	20	13	7	12	20
PCH	14	15	16	11	5	18
KTH	15	17	15	9	9	19
Avg	16	18	16	11	11	20

noticed is Vazhani, which was mainly due to lower moisture content in the dry season than in other zones. The vegetation type of this locality also shows considerable variations and certain taxonomists and forest officials practically treat this area as dry deciduous type (Table 3.12.).

Table 3.12 Vazhani-Vellani hill tracts: Understorey strata Regeneration studies - Quadrat size 2 m x 2m

Total no. of species in moist deciduous forests (1997 August-1998 July)

Area	97A/S	O/N	D/98 J	F/M	A/M	J/ JL
KLP	21	20	14	11	15	22
ATR	20	21	19	15	9	19
VKL	17	20	19	16	14	21
PLK	15	17	16	9	9	19
CHP	15	16	18	12	9	17
VZN	13	13	9	7	10	14
PCH	16	17	17	13	9	20
KTH	16	21	15	8	13	23
Avg	17	18	16	11	11	19

Semi-evergreen forests

Compared to plantations and moist deciduous forests, semi-evergreen forests show a general pattern in the variation of their species component. The largest fluctuation is seen in Varikulam and Kuthiran where the quadrats exhibit some features of moist deciduous forests. However, all the other six zones exhibit identical features, a fact which establishes semi-evergreen forests as a distinct and different forest type (Table 3.13).

Table 3.13 Vazhani-Vellani hill tracts: Understorey strata Regeneration studies - Quadrat size 2 m x 2m

Total no. of species in semi-evergreen forests (1997 August-1998 July)

Area	97A/S	O/N	D/98 J	F/M	A/M	J/ JL
KLP	13	15	13	11	11	12
ATR	17	17	13	13	12	16
VKL	9	17	17	16	16	20
PLK	12	15	18	17	15	18
CHP	15	15	16	14	12	18
VZN	14	14	13	12	14	15
KTH	13	13	12	8	12	14
Avg	13	15	14	13	13	16

Evergreen forests

Unlike other forest zones, evergreen forests of Vazhani-Vellani hill tracts show tremendous variation in the number of species. The species composition at Attoor remains unchanged indicating little disturbance, whatsoever, in that area. But it shows a higher number of species per quadrat. At Pullamkandam, due to canopy closure, fewer number of species occupy the quadrats and hence the occurrence of dense forests. Intermediate type occurs at Chemputhra, Kalappara and Vazhani zones. Kuthiran, however, shows the features of a much-degraded evergreen forest. Judged by the number of its plants with high fluctuations, it almost reaches the quality and physiognomy of semi-evergreen forests. Similar is the case at Varikulam, which also shows high degree of disturbance (Table 3.14).

Table 3.14 Vazhani-Vellani hill tracts: Understorey strata Regeneration studies - Quadrat size 2 m x 2m

Total no. of species in evergreen forests (1997 August-1998 July)

Area	97A/S	O/N	D/98 J	F/M	A/M	J/ JL
KLP	8	9	9	9	10	9
ATR	10	10	10	10	10	10
VKL	10	12	10	9	9	1
PLK	5	6	5	5	5	6
CHP	7	8	8	9	9	6
VZN	8	9	9	9	8	9
KTH	15	13	13	10	13	15
Avg	9	10	9	9	9	9

Number of species in forest types

The number of species in the plantations and in the moist deciduous forests is apparently

equal while the moist deciduous forests have a slightly larger number (on an average for the hill tract, moist deciduous forests have a value 15.26 species, which is negligible over that of plantations, which is 15.17). The number of species is found to be lower in semi-evergreen forests and compared to all others, is the lowest in evergreen forests. The canopy gaps in plantations and moist deciduous forests favour the growth of more species while in evergreen forests, due to canopy closure the number of species is reduced by 50 per cent. However, the mean zonal average of these quadrats shows that evergreen forests occur only as patches in the study area and that these patches cannot exhibit evergreen features due to forest fragmentation effects. The struggle for existence might be the maximum in the plantations and the moist deciduous forests where annuals and other ephemerals dominate. A higher number of species in these zones may also be due to immigration of species and competition between immigrant and resident species.

Moist deciduous forests and other forest types – Comparative studies

Locations

Vazhani-Vellani hill tracts are occupied mainly by moist deciduous forests. They are found, in general, at an elevation ranging from 200-400 m separated from the human settlements by Teak, Acacia, and Mixed Plantations. Wherever they are present, a buffer zone raised by Forest Department protects it from further biotic disturbances. At elevations higher than 400 m, semi-evergreen forests are seen inter-mingled with evergreen patches. The moist deciduous forests are distinguished easily from semi-evergreen and evergreen forests especially in October/November months. Up to July-August when many trees shed their foliage, the forest assumes an apparently withered appearance. However, during the other seasons no distinguishing features are observed.

The vegetation of moist deciduous forests is compared to other forest types like plantations, semi-evergreen, and evergreen forests both at the tree level as well as at the level of the understorey strata. Their similarity indices have been calculated considering the species content in the different types as well as the common species occurring in all the types.

Tree layer

The tree layer of moist deciduous and evergreen forests is compared using the data collected from 10m x 10m quadrats. Four such quadrats were taken in areas viz., Chemputhra, Kalappara, Pullamkandam and Vazhani and were pooled to calculate the IVI, MI, and CI in 400 sq. m area.

Importance Value Index (IVI)

The present study estimates the average IVI for moist deciduous forests at Chemputhra as 18.36 while that of Pullamkandam as 10.10. The values for Kalappara and Vazhani are 15.80 and 17.65 respectively. Higher IVI values indicate greater adaptation of the species to that particular locality. So, moist deciduous forest species at Chemputhra are more adapted than at Pullamkandm.

In Chemputhra, species like *Xylia xylocarpa,* and *Alstonia scholaris* show high IVI values. Regarding the evergreen forests of the same area the average IVI value for Chemputhra is 12.50 while the maximum value is found at Vazhani (13.63). At Pullamkandam the value is 11.54 and Kalappara it is 11.11. The species constituting evergreen forests in Vazhani are more adapted than the rest (Table 3.15).

Table 3.15 Vazhani -Vellani hill tracts: Tree layer analysis Primary analysis* of vegetation at Chemputhra area

Moist deciduous forest			
Species	**Family**	**IVI**	**CI**
Xylia xylocarpa	*Mimosaceae*	33.46	424.27
Alstonia scholaris	*Apocynaceae*	29.51	330.23
Lagerstroemia microcarpa	*Lythraceae*	22.91	199.03
Dillenia pentagyna	*Dilleniaceae*	20.88	165.32
Tectona grandis	*Verbenaceae*	20.04	152.29
Terminalia crenulata	*Combretaceae*	19.05	137.61
Terminalia paniculata	*Combretraceae*	18.79	133.78
Bombax insigne	*Bombacaceae*	18.36	127.83
Grewia tiliifolia	*Tiliaceae*	18.08	123.84
Wrightia tinctoria	*Apocynaceae*	16.52	103.49
Terminalia bellirica	*Combretaceae*	14.62	81.05
Strychnos nux-vomica	*Loganiaceae*	14.62	81.05
Helicteres isora	*Sterculiaceae*	14.01	74.43
Schleichera oleosa	*Sapindaceae*	13.14	65.47
Albizia odoratissima	*Mimosaceae*	11.06	46.38
Stereospermum chelonoides	*Bignoniaceae*	7.87	23.48
Bridelia retusa	*Euphorbiaceae*	7.09	19.06
	Evergreen forest		
Mesua ferrea	*Clusiaceae*	35.26	418.74
Dipterocarpus indicus	*Dipterocarpaceae*	31.25	328.91
Diospyros spp.	*Ebenaceae*	24.66	204.82
Walsura trifolia	*Meliaceae*	21.85	160.80
Dimocarpus longan	*Sapindaceae*	15.52	81.12
Holigarna arnottiana	*Anacardiaceae*	14.72	72.98
Cynometa travancorica	*Caesalpiniaceae*	14.47	70.52
Xanthophyllum arnottianum	*Xanthophyllaceae*	12.59	53.38
Glochidion zeylanicum	*Euphorbiaceae*	12.51	52.71
Pterospermum reticulatum	*Sterculiaceae*	11.78	46.73
Spondias indica	*Anacardiaceae*	11.24	42.55
Garcinia spicata	*Clusiaceae*	9.51	30.46

Hydnocarpus alpina	*Flacourtiaceae*	9.23	28.69
Drypetes oblongifolia	*Euphorbiaceae*	8.96	27.03
Caryota urens	*Arecaceae*	8.78	25.96
Bischofia javanica	*Euphorbiaceae*	8.12	22.20
Ixora spp.	*Rubiaceae*	7.82	20.59
Mitrephora grandiflora	*Annonaceae*	7.08	16.88
Aglaia spp.	*Meliaceae*	6.13	12.65
Agrostistachys indica	*Euphorbiaceae*	5.95	11.92
Myristica dactyloides	*Myristicaceae*	5.79	11.29
Memecylon spp.	*Melastomataceae*	5.62	10.63
Polyalthia fragrans	*Annonaceae*	5.57	10.44
Nothopegia colebrookeana	*Anacardiaceae*	5.57	10.44

* Four 10 m x 10 m quadrats pooled as 20 sq.m

The IVI value of the moist deciduous forests at Pullamkandam shows the maximum for *Vitex altissima* (45.06) followed by values for *Spondias pinnata* (31.72) and *Grewia tiliifolia* (30.93). While evergreen forests at Pullamkandam have *Lagerstroemia microcarpa* with the highest IVI value, *Hydnocarpus alpina* (26.10), and *Walsura trifolia* (23.64) occupy the second and the third positions (Table 3.16).

Table 3.16 Vazhani-Vellani hill tracts: Tree layer analysis Primary analysis* of vegetation at Pullamkandam area

Pullamkandam area			
Moist deciduous forest			
Species	**Family**	**IVI**	**CI**
Vitex altissima	*Verbenaceae*	45.06	498.50
Spondias pinnata	*Anacardiaceae*	31.71	247.03
Grewia tiliifolia	*Tiliaceae*	30.93	234.87
Wrightia tinctoria	*Apocynaceae*	24.48	147.13
Xylia xylocarpa	*Mimosaceae*	21.12	109.51
Dillenia pentagyna	*Dilleniaceae*	12.92	40.98
Mallotus philippensis	*Euphorbiaceae*	12.57	38.79
Calycopteris floribunda	*Combretaceae*	11.72	33.72
Macaranga peltata	*Euphorbiaceae*	10.89	29.11
Canthium travancoricum	*Rubiaceae*	10.10	25.04
Naringi crenulata	*Rutaceae*	10.08	24.94
Helicteres isora	*Sterculiaceae*	10.06	24.84
Tabernaemontana heyneana	*Apocynaceae*	8.68	18.49
Miliusa tomentosa	*Annonaceae*	8.44	17.48
Strychnos nux-vomica	*Loganiaceae*	7.96	15.55

Leea indica	*Leeaceae*	5.95	8.69
Terminalia bellirica	*Combretaceae*	5.58	7.64
Bridelia retusa	*Euphorbiaceae*	5.18	6.58
Cassia fistula	*Caesalpiniaceae*	4.55	5.08
Olea dioica	*Oleaceae*	4.50	4.97
Terminalia paniculata	*Combretaceae*	4.46	4.88
Sterculia urens	*Sterculiaceae*	4.37	4.68
Schleichera oleosa	*Sapindaceae*	4.33	4.60
Holarrhena pubescens	*Apocynaceae*	4.33	4.60
	Evergreen forest		
Lagerstroemia microcarpa	*Lythraceae*	28.10	338.59
Hydnocarpus alpina	*Flacourtiaceae*	26.10	292.11
Walsura trifolia	*Meliaceae*	23.64	239.64
Myristica dactyloides	*Myristicaceae*	21.97	206.98
Holigarna arnottiana	*Anacardiaceae*	18.85	152.36
Diospyros sp.	*Ebenaceae*	17.52	131.73
Zanthoxylum rhetsa	*Rutaceae*	16.61	118.30
Dipterocarpus indicus	*Dipterocarpaceae*	14.53	90.53
Spondias indica	*Anacardiaceae*	13.64	79.78
Mitrephora grandiflora	*Annonaceae*	12.97	72.13
Gomphandra sp.	*Icacinaceae*	11.27	54.46
Diospyros microphylla	*Ebenaceae*	10.98	51.69
Polyalthia fragrans	*Annonaceae*	9.44	38.21
Alseodaphne semecarpifolia	*Lauraceae*	8.97	34.50
Anodendron sp.	*Apocynaceae*	8.23	29.04
Drypetes sp.	*Euphorbiaceae*	7.89	26.62
Sapindus laurifolia	*Sapindaceae*	5.99	15.38
Knema attenulata	*Myristicaceae*	4.87	10.17
Cynometra travancorica	*Caesalpiniaceae*	4.87	10.17
Aglaia sp.	*Meliaceae*	4.85	10.08
Nothopegia sp.	*Anacardiaceae*	4.78	9.79
Pterygota alata	*Sterculiaceae*	4.78	9.79
Firmiana colorata	*Sterculiaceae*	4.78	9.79
Leea indica	*Leeaceae*	4.78	9.79
Mallotus aureo-punctatus	*Euphorbiaceae*	4.78	9.79
Lepisanthes tetraphylla	*Sapindaceae*	4.78	9.79

At Kalappara, *Strychnos nux-vomica* (36.74) is found to be having the highest IVI while *Anogeissus latifolia* (32.58) and *Pterocarpus marsupium* (30.74) are found to be in the next two positions. With regard to evergreen forests, *Terminalia bellerica* with IVI value 24.23 is closely followed by *Walsura trifolia* and *Spondias pinnata* with IVI value of 22.25 (Table 3.17).

At Vazhani, the maximum IVI is found to be that of *Xylia xylocarpa* 41.07, a characteristic pyro-resistant species of moist deciduous forests. *Dillenia pentagyna* (33.72), *Lagerstroemia microcarpa* (32.48), and *Grewia tiliifolia* (32.42) are the other important species. In the evergreen forests of that area *Vitex altissima* has the highest IVI (44.13) followed by Walsura trifolia (22.33), *Aglaia spp*., (21.06) and *Pterospermum reticulatum* (20.78) [Table 3.18].

Thus, the IVI values and the constituent species composition show that moist deciduous forests are diverse and heterogeneous. The IVI values range between 10.10 (Pullamkandam) and 18.36 (Chemputhra). However, this range is quite low when compared to those of some dominant species, which go up to 44 in certain localities. The majority of the plant species above the 15 cm girth class are not well developed and are at various stages of growth. The IVI values might have also been affected by biotic disturbances especially the felling of trees of economic value including those used for making handles of agricultural implements and to some extent, those used as fuel wood. The IVI value of evergreen forests varies between 13.63 and 11.11, the highest at Vazhani and the lowest at Kalappara. The range being narrow the evergreen patches of the whole study area may be considered identical in species composition.

Table 3.17 Vazhani -Vellani hill tracts: Tree layer analysis
Primary analysis* of vegetation at Kalappara area

	Moist deciduous forest		
Species	**Family**	**IVI**	**CI**
Strychnos nux-vomica	*Loganiaceae*	34.74	411.75
Anogeissus latifolia	*Combretaceae*	32.58	362.14
Pterocarpus marsupium	*Fabaceae*	30.74	322.39
Xylia xylocarpa	*Mimosaceae*	27.73	262.35
Terminalia crenulata	*Combretaceae*	25.87	228.33
Dillenia pentagyna	*Dilleniaceae*	24.51	204.96
Miliusa tomentosa	*Annonaceaae*	21.47	157.27
Lagerstromia microcarpa	*Lythraceae*	16.47	92.54
Tectona grandis	*Verbenaceae*	15.67	83. 77
Anthocephalus cadamba	*Rubiaceaae*	10.80	39.79
Holarrhena pubescens	*Apocynaceae*	9.69	32.03
Careya arborea	*Lecythidaceae*	7.43	18.83
Vitex altissima	*Verbenaceae*	6.99	16.67
Spondias pinnata	*Anacardiaceae*	6.85	16.00
Naringi crenulata	*Rutaceae*	6.22	13.19
Streblus asper	*Moraceae*	5.74	11.24
Pterospermum reticulatum	*Sterculiaceae*	5.57	10.58
Cassia fistula	*Caesalpiniaceae*	5.51	10.35
Terminalia paniculata	*Combretaceae*	5.43	10.05

Evergreen forest			
Terminalia bellirica	*Combretaceae*	24.23	300.91
Walsura triflora	*Meliaceae*	24.19	299.92
Spondias indica	*Anacardiaceae*	22.25	253.74
Holoptelia integrifolia	*Ulmaceae*	21.25	231.45
Ficus sp.	*Moraceae*	18.83	181.73
Nothopegia colebrookeana	*Anacardiaceae*	16.68	142.60
Atalantia racemosa	*Rutaceae*	16.19	134.34
Mitrephora grandiflora	*Annonaceae*	14.00	100.46
Calophyllum polyanthum	*Clusiaceae*	13.60	94.80
Lepisanthes tetraphylla	*Sapindaceae*	12.01	73.93
Aporusa lindleyana	*Euphorbiaceae*	11.44	69.08
Polyalthia fragrans	*Annonaceae*	11.36	66.14
Litsea sp.	*Lauraceae*	11.33	65.79
Hydnocarpus pentandra	*Flacourtiaceae*	10.44	55.86
Derris sp.	*Fabaceae*	9.47	45.96
Capparis rheedei	*Capparaceae*	7.02	25.25
Artocarpus hirsutus	*Moraceae*	6.53	21.85
Mallotus philippensis	*Euphorbiaceae*	5.64	16.30
Glochidion zeylanicum	*Euphorbiaceae*	5.64	16.30
Mallotus aureo-punctatus	*Euphorbiaceae*	4.81	11.85
Mussaeda laxa	*Rubiaceae*	4.76	11.61
Myristica dactyloides	*Myristicaceae*	4.72	11.41
Aphanamixis polystachya	*Meliaceae*	4.72	11.41
Leea indica	*Leeaceae*	4.72	11.41
Alseodaphne semecarpifolia	*Lauraceae*	4.72	11.41
Naringi crenulata	*Rutaceae*	4.72	11.41

* Four 10 m x 10 m quadrats pooled as 20 sq.m

Table 3.18 Vazhani-Vellani hill tracts: Tree layer analysis
Primary analysis* of vegetation at Vazhani area

Moist deciduous forest			
Species	**Family**	**IVI**	**CI**
Strychnos nux-vomica	*Loganiaceae*	34.74	411.75
Anogeissus latifolia	*Combretaceae*	32.58	362.14
Pterocarpus marsupium	*Fabaceae*	30.74	322.39
Xylia xylocarpa	*Mimosaceae*	27.73	262.35
Terminalia crenulata	*Combretaceae*	25.87	228.33
Dillenia pentagyna	*Dilleniaceae*	24.51	204.96
Miliusa tomentosa	*Annonaceaae*	21.47	157.27

Lagerstromia microcarpa	*Lythraceae*	16.47	92.54
Tectona grandis	*Verbenaceae*	15.67	83. 77
Anthocephalus cadamba	*Rubiaceaae*	10.80	39.79
Holarrhena pubescens	*Apocynaceae*	9.69	32.03
Careya arborea	*Lecythidaceae*	7.43	18.83
Vitex altissima	*Verbenaceae*	6.99	16.67
Spondias pinnata	*Anacardiaceae*	6.85	16.00
Naringi crenulata	*Rutaceae*	6.22	13.19
Streblus asper	*Moraceae*	5.74	11.24
Pterospermum reticulatum	*Sterculiaceae*	5.57	10.58
Cassia fistula	*Caesalpiniaceae*	5.51	10.35
Terminalia paniculata	*Combretaceae*	5.43	10.05
	Evergreen forest		
Terminalia bellirica	*Combretaceae*	24.23	300.91
Walsura triflora	*Meliaceae*	24.19	299.92
Spondias indica	*Anacardiaceae*	22.25	253.74
Holoptelia integrifolia	*Ulmaceae*	21.25	231.45
Ficus sp.	*Moraceae*	18.83	181.73
Nothopegia colebrookeana	*Anacardiaceae*	16.68	142.60
Atalantia racemosa	*Rutaceae*	16.19	134.34
Mitrephora grandiflora	*Annonaceae*	14.00	100.46
Calophyllum polyanthum	*Clusiaceae*	13.60	94.80
Lepisanthes tetraphylla	*Sapindaceae*	12.01	73.93
Aporusa lindleyana	*Euphorbiaceae*	11.44	69.08
Polyalthia fragrans	*Annonaceae*	11.36	66.14
Litsea sp.	*Lauraceae*	11.33	65.79
Hydnocarpus pentandra	*Flacourtiaceae*	10.44	55.86
Derris sp.	*Fabaceae*	9.47	45.96
Capparis rheedei	*Capparaceae*	7.02	25.25
Artocarpus hirsutus	*Moraceae*	6.53	21.85
Mallotus philippensis	*Euphorbiaceae*	5.64	16.30
Glochidion zeylanicum	*Euphorbiaceae*	5.64	16.30
Mallotus aureo-punctatus	*Euphorbiaceae*	4.81	11.85
Mussaeda laxa	*Rubiaceae*	4.76	11.61
Myristica dactyloides	*Myristicaceae*	4.72	11.41
Aphanamixis polystachya	*Meliaceae*	4.72	11.41
Leea indica	*Leeaceae*	4.72	11.41
Alseodaphne semecarpifolia	*Lauraceae*	4.72	11.41
Naringi crenulata	*Rutaceae*	4.72	11.41

The CI value for the moist deciduous forests at Kalappara is the highest (2304) while it is the lowest for Pullamkandam (1557). Intermediate figures are observed for Chemputhra (2288) and Vazhani (2053). The Continuum Index value gives the total performance of constituent species in a single stand of a particular locality. It gives due weightage to various growth parameters and is processed from the IVI and the adaptation number. The latter is calculated from the highest and the lowest IVI and their differences. Hence, a high CI value indicates better performance of constituent species in total. In this respect moist deciduous forests of Kalappara are well developed than forests in other areas and forests in Pullamkandam are the least developed. The moist deciduous forests at Pullamkandam are subjected to constant and continuous exploitation by encroachers and population in the nearby habitats for various requirements including timber, firewood, manure, and medicinal plants (bark). All these anthropogenic activities must be contributing their share to the depletion apart from climatic and edaphic variables.

The CI of the evergreen forests shows the highest value in Kalappara (2286) and the lowest in Vazhani (1387). The values for Pullamkandam and Chemputhra are 2061 and 1772 respectively. So, in the CI rating, evergreen forests are the best at Kalappara, followed by Pullamkandam, Chemputhra, and Vazhani in that order.

Maturity Index

The MI values of moist deciduous forests range between 57.35 (Vazhani) and 42.11 (Kalappara). Value for Chemputhra is found to be 45.59 and that for Pullamkandam 42.71. From these values it may be inferred that moist deciduous forests of Vazhani are in an advanced stage of succession compared to the rest. The moist deciduous forests at Chemputhra are slightly better. In Pullamkandam and Kalappara, these values are almost identical.

With regard to MI values of evergreen forests, as in the case of moist deciduous forests, Vazhani is advanced (46.74) followed by Pullamkandam (39.42), Chemputhra (35.42) and Kalappara (34.26). When the MI value is higher, the community is more mature with high frequency percentage of the dominant species and small number of the sporadic species. On this assessment, the forests of Vazhani may be considered more mature with regard to moist deciduous and evergreen forests. The moist deciduous forests at Chemputhra are more mature than those of Pullamkandam and Kalappara. Evergreen forests of Pullamkandam are more developed and more mature than forests of Chemputhra and Kalappara areas. With regard to tree layer as a whole, Vazhani is well developed and mature and Kalappara is the least developed.

The tree layers were further subjected to an assessment of overall similarity at different localities with respect to species diversity in the 10m x 10m area. The study is based on a community coefficient concept (Jacard, 1912) in which the presence/absence relationship between the number of species common to two areas and total number of species are considered. When the evergreen forests of one area were compared to the moist deciduous forest of the same or different areas, the value was found to be near four and five. However, when the moist deciduous forests of Pullamkandam were compared to evergreen forests of

Vazhani the value was 8.51; when the moist deciduous forests of Pullamkandam were compared to evergreen forests of Kalappara the value was much higher i.e., 11.76. In general, moist deciduous and evergreen forests are two distinct forest types their similarities being less than 5 per cent.

Understorey stratum

Vazhani forests are found to be well developed and more mature than Kalappara both at the level of moist deciduous and evergreen types. In order to ascertain the condition at understorey stratum, further studies were conducted at eight locations (quadrat size 2m x 2m) and also in a single locality viz. Kundukad Chelappara to exclude climatic and edaphic variables.

When the understorey strata sampled from 2m x 2m quadrats of different locations were compared with all the forest types, greater similarity was noticed between plantations and moist deciduous forests irrespective of location. When the plantations at Chemputhra were compared to moist deciduous forests at Pullamkandam, the value was found to be 24.39. Similar studies between plantations at Attoor and moist deciduous forests at Varikulam SI, the value was 16. When the plantations at Kuthiran and moist deciduous forests at Kalappara as well as plantations at Peechi were compared with the moist deciduous forests at Vazhani the value was found to be 33.33. Greater similarities were observed among semi-evergreen / evergreen forests of different locations. Similar to the tree layer data, 5 per cent similarity is found between moist deciduous and evergreen forests at the understorey level also.

However, these values do not seem consistent at the understorey level; comparison between moist deciduous forests at Kuthiran and evergreen forests at Kalappara, revealed the value as 12.50 and that of moist deciduous forests at Peechi and evergreen forests at Vazhani, as 10.52. Overall, SI values from different locations suggest that at the understorey level, the forest types like plantations, moist deciduous forests, semi-evergreen forests, and evergreen forests are more or less identical in Chemputhra, Pullamkandam, Attoor, and Varikulam whereas those of Kuthiran, Kalappara, Peechi, and Vazhani are of another class. Slopes and aspects may be having some influence on the understorey vegetation, but the data are insufficient to make any generalisation (Table 3.19).

Table 3.19 Vazhani-Vellani hill tracts: Moist deciduous and evergreen forests Comparison
Similarity Index – Understorey strata (in 2m x 2m area)

	Forest types					
Area	**PL/MD**	**PL/SEG**	**PL/EG**	**MD/SEG**	**MD/EG**	**SEG/EG**
Chp/Plk	24.39	4.34	5.00	4.34	5.00	20.00
Atr/Vkl	16.00	4.50	5.20	8.30	4.76	21.62
Kth/Klp	33.33	8.88	11.76	18.60	12.50	17.39
Pch/Vzn	33.33	15.00	12.50	22.72	10.52	——*

* Data not recorded due to biotic disturbances

Similarity Index: Tree layer (in 10m x 10m area)

Area	F- Type	Area	F-Type	Similarity Index
Chemputhra	Md	Pullamkandam	Eg	4.65
Pullamkandam	Md	Vazhani	Eg	8.51
Pullamkandam	Md	Kalappara	Eg	11.76
Pullamkandam	Md	Pullamkandam	Eg	4.00
Vazhani	Md	Kalappara	Eg	4.54
Vazhani	Md	Pullamkandam	Eg	4.65
Vazhani	Md	Vazhani	Eg	5.00
Kalappara	Md	Kalappara	Eg	4.34
Kalappara	Md	Vazhani	Eg	4.76

Ecotone studies

The composition of species in tree, shrub, and herb layers varies within amplitude in such a way that characteristic species and appearance and more correctly a sort of physiognomy, is visible among various forest types. However, such zones of vegetation are essentially separated by a transition zone, or tension zone technically called Ecotone. Such ecotones are clearly visible in the case of shola/grassland interface. Similar interface, though less common, occurs among catchment area/plantations, plantations/moist deciduous forests, moist deciduous forests/semi-evergreen forests, and semi-evergreen forests/evergreen forests owing to simultaneous effect of diverse environmental factors such as temperature, soil moisture, relative humidity, and biotic characteristics. These zones usually have a species composition different from that of the adjacent forest types, due to what is known as the 'edge effect'.

Plots selected for study

In order to monitor and analyse the ecotones and the edge effects, three sites were selected 5-6 km apart, at Peechi (Palalkkunnu), Kundukad (Chelappara), and Vazhani (Kakkinikkad). Quadrats of two types i.e., 3m x 3m and 1m x 1m were fixed at convenient distances of 5m-10m to record the number of species present including the immigrant species. There is competition between resident species and immigrant species for various requirements and this competition itself varies in the different ecotones. Data were collected monthly for a span of two years to understand the trends of colonisation and succession within a particular zone as well as within an area. Collection of such data from three locations every month for two years was quite a time-consuming task, which also required careful planning and foresight.

Kundukad-Chelappara area: Species density

This area represents a unique location where various ecological zones like encroachments, teak plantations, and evergreen forests occur in places away from small patches of moist deciduous and semi-evergreen forests. 1m x 1m quadrats were fixed at 170m and 180 m in encroachment area, at 220m and 230m in teak plantations and at 240m and 250m in the

evergreen forests. The data collected revealed a phenomenal increase in the number of species in various ecological zones for the study period August 1996-July 1998. 1m x 1m quadrats and 3m x 3m quadrats show similar peaks.

Great fluctuations were visible in the case of annuals and ephemerals found in the encroachments while the species composition showed a gradual change in the case of evergreen forests. Plantations constitute an intermediate case. When the plantation species are compared with species in the evergreen forests, fluctuation in species density becomes quite clear in the plantations against a moderate increase in the evergreen forests.

Immigration of species

In the case of the immigration of species, encroachment area represents the ecological zone with the highest number of immigrant species while the area of the evergreen forest remains at the bottom of the graph with the lowest minimum number of immigrants. The same feature was compared between plantations and evergreen species. The differences in the immigration pattern between these ecological zones are quite clear.

Vazhani-Kakkinikkad area: Species density

This area differs from the Kundukad-Chelappara area due to the presence of moist deciduous forests separating the Acacia plantations and a semi-evergreen patch. Quadrats were fixed at 160m and 170m at Acacia plantations, at 190m in semi-evergreen forests (an upper value), and 200m, 205m, and 210m at moist deciduous forests. In these cases plantations species outnumber the moist deciduous species and the former varies greatly from the semi-evergreen forests. Ecologically, plantations and moist deciduous forests being quite similar in species composition, species density and immigration of species, their understorey strata also manifest similar characteristics. This observation is further supported by close and identical lines of the corresponding zones in the locality. However, slight differences still occur in the plant communities present in the different quadrats in the plantations, and moist deciduous forests. Therefore, the ecotone studies of the area illustrate that though ecological zones behave rather in a continuum, physiognomically, they separate them into discrete zones like plantations, moist deciduous and semi-evergreen forests.

Peechi-Palakkunnu area: Species density

This area is under severe biotic disturbances. Two 1m x 1m quadrats were lost in encroachments adjacent to settlers on two occasions. So the number of 1m x 1m quadrats monitored was reduced to four. Of these four quadrats, two were in the catchment area of Peechi reservoir at 100m and 105m and one each in teak plantations (110m) and moist deciduous forests (220m). The density of plants in these areas is affected by biotic disturbances mainly due to manure collection and also forest fires. So the data from 1m x 1m quadrats were found inconsistent; nor were they comparable with data of the other two areas (Kundukad and Vazhani). Large number of species was also lost due to occurrence of forest fire in the quadrats fixed at 225m in April 1998. Identical characteristics of plantations and moist deciduous forests are, however, still noticed.

Annual variation in the number of species

The numbers of species, which have invaded in the quadrats, show significant variations among ecological zones. When the immigrant species were calculated per sq.m, the value was found to be the highest in the case of encroachment followed by the plantations and the moist deciduous forests, in that order. Semi-evergreen and evergreen forests showed the least variation. But the percentage of increase is the maximum for the moist deciduous forests and the plantations. Though the catchment area in the reservoir shows 100 per cent decrease, it is actually due to flooding. In all the other ecological zones, an annual increment is visible. The moist deciduous forests and plantations are also identical in this respect as well leading general confirmation to the observations already made in the analysis of understorey vegetation (Table 3.20).

Table3.20 Vazhani-Vellani hill tracts: Ecotone studies (1996 Aug-1998 July) No. of species in 1m x 1m quadrats*

Area	I Year	II Year	Difference	% Increase
Plantations	4	8.4	4.44	110
Semi evergreen Forest	0.5	1	0.5	100
Moist deciduous Forest	3	5.5	2.5	83
Encroachments	6	8.5	2.5	42
Evergreen Forests	0	1.5	1.5	150
Catchment area	2	0	-2	-200

* Study Areas: Kundukad-Chelappara, Peechi-Palakunnu & Vazhani-Kakkinikad

Ecotones

Annual variations in the number of species

Excluding microclimatic and edaphic variations, four 1m x 1m quadrats located between teak plantations and moist deciduous forests at altitudes ranging from 200m-220m show an average increase in the number of species to three per year. A further increase in the number of species was also found (5.5 species.). So, during the course of the study 2.5 species have increased yearly. But this average increase of 2.5 species is expressed differently in different quadrats and it differs from -.25 to 1.5 from the average value.

A similar change in the number of immigrant species is also noticed in the case of 1m x 1m quadrats in various ecotones separating encroachments - teak plantations and moist deciduous forests. The average number of species increased to four by the first year and further increased to 8.4 in the second year. So the average increase in the number of species for one year is 4.4. However, again the increase of 4.4 species was not uniform in different quadrats as it differs from -3.4 to 4.6 from the average. Data from evergreen forests show an average increase of 1.5 species per year and in encroachment area,an average increase is 2.5 per year.

Different ecotones are present in the study area as the average increase in the number of

species per year varies greatly. For the ecotones within the plantations, the annual maximum increase is (4.4); for ecotones within moist deciduous forests/encroachments it is 2.5 each and in the case of ecotones with evergreen forests/semi-evergreen forests it is only less than 1.5 species. Such values are in quite conformity with the data from the regeneration studies using 2m x 2m quadrats of the eight locations. The higher number of species in encroachments/plantations, and moist deciduous ecotones, may be ascribed to the presence of more ephemerals in these zones.

The successional trends operate significantly in moist deciduous forests/plantations while it is rather slow in semi-evergreen and evergreen forests. Though encroachments show extreme canopy opening, colonisation and competitive annuals(of limited species)result in lower species richness. Eventually,moist deciduous forests retain maximum species richness favouring new immigrant species to colonise in canopy gaps and retaining most of the resident species.

Species richness

Immigration of species changes the equilibrium between various resident species. The resident species may oppose invasion of new species and if the immigrant species are successful, may colonise new areas. Hence, the species richness in a given time is the combination of these two types of species, resident and invading arbitrarily; it may be said that these two types are in equilibrium.

Menhinick Index

Species richness (SR) may be calculated in terms of total number of species to total number of plants, a measure known as Menhinick Index.

Plant density

The average number of plants in plantations of four sq.m. is found to be 107. It is 80 in the case of moist deciduous forests. With regard to semi-evergreen and evergreen forests it is 58 and 37 respectively. When compared to the plant density during August/September months, the end of June/July plantations shows a net increase of 59 plants while in moist deciduous and semi-evergreen forests it is 6 and 8 respectively. Contrary to other forest types, the number of plants in evergreen forests is found to be lower in the understorey stratum. It shows that evergreen forests are developing, exhibiting strong signs of succession in the forward direction towards maturity of stands. In plantations, the canopy openings are so wide that it permits the introduction of annuals resulting in increase in the number of immigrant plants (Table 3.21).

The forest types at Attoor show lower levels of immigration than plantations and moist deciduous, semi-evergreen, and evergreen forests, may be,due to anthropic disturbances or canopy closure. Field studies confirm the latter view. However, the situation at Pullamkandam

shows greater immigration of plants in all the four-forest types because of canopy opening formed due to the felling of trees. Encroachments and biotic disturbances are the main factors behind higher immigration of plants. Plantations, moist deciduous and semi-evergreen forests of Chemputhra show close similarity to conditions in Pullamkandam.

Table 3.21 Vazhani-Vellani hill tracts
Regeneration Studies – Understorey strata (1997 Aug-1998 July)
Quadrat Size 2m x 2m - 8 Locations

	Forest Types			
	Plantation	**Moist deciduous forest**	**Semi-evergreen forest**	**Evergreen forest**
No. of plants	107.33	80.17	58.17	37.00
Variation	59.00	6.00	8.00	-2.5
No. of species	15.17	15.26	14.07	8.92
Variation	4.31	2.53	2.48	-0.27
Immigrant species	3.18	2.84	2.94	1.49
Variation	3.38	4.50	3.06	1.38
Species richness*	0.14	0.19	0.24	0.24

* in Menhinick Index

Number of species

The average number of species per four sq.m. in plantations and moist deciduous forests is identical i.e., 15. The average number of species is slightly lower in semi-evergreen (14) and very low in evergreen forests (9). Plantations show an annual increase of four species while in moist deciduous and semi-evergreen forests it is three and two respectively. In the case of evergreen forests there is a reduction of number of species by 0.3.

Corresponding to the high variation in the number of plants (plant density) there is also variation in the number of species. In Pullamkandam, Chemputhra, and Kuthiran also, similar variations are noticed.

According to the Menhinick Index values, high species richness was found in semi-evergreen and evergreen forests (0.24 each). The value for moist deciduous forests is found to be 0.19 and for plantations only 0.14. These values are in conformity with accepted values for forest types in general. Accordingly, evergreen and semi-evergreen forests are said to be species rich; for conservation of biodiversity, these two types of forests should be protected to the maximum extent possible.

Moist deciduous forests have more species richness than plantations. Plantations may yield economically important species like Teak and Eucalyptus in greater quantities and greater annual revenue. But with regard to species richness plantations are far lower than moist deciduous forests (Table 3.22).

Table 3.22 Vazhani-Vellani hill tracts
Regeneration studies - Understorey strata
No. of plants, No. of species and Menhinick Index in forest types (1997 Aug-1998 July) Quadrat size 2m x 2m - 8 locations

No.of plants (N)	A/S	O/N	D/J	F/M	A/M	J/Jl	Avg
Plantation	118	137	92	50	70	117	107.33
Moist deciduous Forest	92	110	82	51	48	98	80.17
Semi Evergreen Forest	61	65	60	48	45	70	58.17
Evergreen Forest	41	41	37	31	31	41	37
No of species (S)							
Plantation	15.85	17.94	15.63	10.88	10.56	20.17	15.17
Moist deciduous Forest	16.55	17.99	15.72	11.37	10.84	19.08	15.26
Semi Evergreen Forest	13.12	14.98	14.43	12.93	13.00	15.95	14.07
Evergreen Forest	8.83	9.50	9.10	8.62	9.10	8.52	8.94
S/N values*							
Plantation	0.13	0.13	0.17	0.22	0.15	0.11	0.14
Moist deciduous Forest	0.18	0.16	0.19	0.22	0.23	0.19	0.19
Semi Evergreen Forest	0.22	0.23	0.24	0.27	0.29	0.23	0.24
Evergreen Forest	0.22	0.23	0.25	0.28	0.29	0.21	0.24

* Menhinick Index

Conclusions

Floristic and phyto-sociological studies on the forest types of Vazhani-Vellani hill tracts especially of the moist deciduous forests, revealed the composition of various taxa at tree, shrub, and herb levels and their interrelationships. The species found in the tree layer together with the understorey species, plantations, semi-evergreen forests and evergreen forests have also been identified and listed and their relative density, frequency, and abundance worked out to elucidate the roles performed by various species in specific ecological niches. The species composition of different ecotones and immigration species in such zones were recorded for a span of two years. Similarity Indices calculated with regard to moist deciduous and evergreen forests showed concordant values for both in 3m x 3m and 1m x 1m quadrats.

Floristic studies

Floristic studies, though conducted exclusively to cater to the needs of phytosociological studies revealed interesting results.

Tree layer

Analysis of tree layer showed species like *Dillenia pentagyna*, *Terminalia paniculata,* and *Xylia xylocarpa* with high IVI values in moist deciduous forests; in evergreen forests *Walsura*

trifolia, Aglaia spp., and *Holigarna arnottiana* occupy high positions with regard to IVI. Families like *Combretaceae*, *Apocynaceae, Euphorbiacea, Mimosaceae*, and *Sterculiaceae* are found to be dominant in the moist deciduous forests while in evergreen forests families like *Euphorbiaceae, Anacardiaceae, Meliaceae, Annonaceae,* and *Myristicaceae* dominate.

Understorey stratum

Understorey strata of moist deciduous forests are dominated by species like *Chromolaena odorata*, *Eranthemum capense, Piper longum*, *Biophytum sensitivum*, and *Helicteres isora*. Families like *Euphorbiaceae, Fabaceae, Acanthaceae, Asteraceae,* and *Malvaceae* are found to be dominant.

In the plantations *Curculigo orchioides, Hyptis suaveolens, Ichnocarpus frutescens, Mimosa pudica, and Dioscorea bulbifera* dominate. The dominant families are found to be *Fabaceae, Acanthaceae*, *Euphorbiaceae, Rubiaceae*, and *Apocynaceae*.

In the semi-evergreen forests *Eranthemum capense, Schleichera oleosa, Stachyphrynium spicatum,* and *Piper longum*. *Bauhinia anguina* and families like *Rubiaceae, Sterculiaceae, Apocynaceae, Rutaceae*, and *Fabaceae* dominate.

Piper longum, Dimocarpus longan, Lepisanthes tetraphylla, Elatostemma acuminatum, and *Ventilago bombaiensis* are found to be dominant in the evergreen forests whereas families like *Fabaceae, Rubiaceae, Annonaceae, Sterculiaceae*, and *Caesalpiniaceae* are codominants.

The A-F ratios calculated for *Holarrhena pubescens*, *Spermacoce articularis*, *Glycosmis pentaphylla, Piper longum,* and *Desmodium triquetrum* are found to be high in plantations, while in moist deciduous forests *Spermacoce articularis*, *Murdannia japonica*, *Lantana camara*, *Cymbopogon citratus,* and *Desmodium laxiflorum* occupy the top positions. In the semi-evergreen forests *Piper longum, Glycosmis pentaphylla, Eranthemum capense, Clerodendrum infortunatum,* and *Bauhinia anguina* are found to be important and in evergreen forests the significant species are: *Elatostemma acuminatum, Capparis rheedii, Piper nigrum, Aganope thyriflora*, and *Derris sp*.

Phytosociological studies

Phytosociological studies come under six heads (i) Tree layer, (ii) Understorey stratum, (iii) Moist deciduous forests-evergreen forests comparison. (iv) Ecotone studies, (v) Immigrant species and (vi) Species richness.

Tree layer

The average IVI value for tree species of the moist deciduous forests is found to be 15.57, which shows that component species are of moderate performance. The value is as low as 12.20 in the case of evergreen forests, a fact which indicates that the evergreen forest species are also in the same condition as, or lower condition than, of moist deciduous forest species.

The Continuum Index for the entire study area is estimated to be 2051 for moist deciduous forests and 1877 for evergreen forests; these figures demonstrate moderately low attainment of the component species in the tree layer.

The Maturity Index is found to be 46.94 for moist deciduous forests and in the case of evergreen forests it is 39.04. The Maturity Index values of these forest types indicate that the plant communities are not mature and successional trends are still in operation.

Understorey stratum

Four types of understorey vegetations are met with in the study area with characteristic species composition.

The number of plants present in various types shows remarkable variations. Understories of plantations and moist deciduous forests show identical curves with regard to the number of species. The number of plants per quadrats, more particularly the immigration of species and above all variation in the number of species all elucidate similarity and structural proximity between plantations and moist deciduous forests.

On the other hand semi-evergreen and evergreen forests are two types very close to each other and totally different from the plantations and moist deciduous forests. The four forest types are found to be distinct entities; they also show similarities between plantations and moist deciduous forests on one side, and between semi-evergreen and evergreen forests on the other. It is really interesting to note that the number of plants per quadrat converges in February-March, irrespective of the forest type, from which they diverge. Moreover, moist deciduous forests show a convergence with semi-evergreen forests during April/May. This clearly shows moist deciduous forests as a transition stage or rather a degraded state, from semi-evergreen and evergreen forests.

Moist deciduous/Evergreen forests comparison

Tree layer

Moist deciduous and evergreen forests are compared using IVI, CI, and MI values.

I V I

The IVI values and the constituent species composition show that moist deciduous forests of the study area are diverse and heterogeneous. The IVI value ranges between 10.10 (Pullamkandam) and 18.36 (Chemputhra). But this range is quite low when compared to some dominant species that have values up to 44 in certain localities.

The majority of the plant species above the 15 cm girth class are not well developed and are at various stages of growth. The IVI might have also been affected by biotic disturbances especially the felling of trees of economic value including those for making handles of agri-cultural implements and to some extent for fuel wood. The IVI values of evergreen forests

also vary between 13.63 and 11.11, the highest at Vazhani and the lowest at Kalappara. The range being narrow, the evergreen patches of the whole area can be considered identical in species composition.

Continuum Index

The CI value of the evergreen forests is seen to be the highest in Kalappara (2286) and the lowest in Vazhani (1387), the values for Pullamkandam and Chemputhra being 2061 and 1772 respectively. In the CI rating, evergreen forests are found to be the best at Kalappara; next in the order are Pullamkandam, Chemputhra, and Vazhani.

Maturity Index

As the Maturity Index value increases, maturity of the community rises with higher frequency of the dominant species and smaller number of the sporadic species. The forests of Vazhani may be considered more mature than moist deciduous and evergreen forests; moist deciduous forests at Chemputhra are more mature than those of Pullamkandam and Kalappara; and evergreen forests of Pullamkandam are more developed and more mature than their counterparts in Chemputhra and Kalappara areas. With regard to tree layer as a whole, Vazhani is well developed and mature and Kalappara is found the lowest in the ladder.

Understorey stratum

The analysis of the 2m x 2m quadrats at the eight different locations is summarised below.

Overall SI values from different locations suggest that the forest types like plantations, moist deciduous, semi-evergreen, and evergreen forests are almost identical in Chemputhra, Pullamkandam, Attoor, and Varikulam at the understorey level; those of Kuthiran, Kalappara, and Peechi-Vazhani show another class. Slopes and aspects may be having some influence on the understorey vegetation, but the data are not sufficient to make any generalisation. When quadrats of the same locality (Kundukad-Chelappara) were analysed, the results showed consistency to a great extent.

The present study illustrates that similarity is the highest between plantations and moist deciduous forests (44) and the lowest between plantations and evergreen forests (7). When moist deciduous forests were compared to evergreen forests, similarity was found to be of the value of 13.

Ecotone studies

Ecotone studies conducted at Kundukad-Chelappara area, Vazhani-Kakkinikkad area revealed the variations in plant communities at different intervals starting from the boundary of the forests to the interior. Peechi-Palakkunnu area was subjected to tremendous biotic and anthropogenic disturbances. The species density was found to vary among the various ecologi-

cal zones. Similarly the immigration of new species also showed considerable variation among localities. These two species density and immigration seem to be identical in plantations/ moist deciduous forest interfaces. However, substantial differences are observed among encroachments/plantations, plantations/semi-evergreen forests, and plantations/evergreen forest interfaces. Fluctuation in species density is the maximum in encroachments and the minimum in evergreen forests. The moist deciduous forests/ plantations come in-between.

Immigration of new species is found to be higher in encroachments and lower in evergreen forests. The annual increment in the number of species per one sq. km is found to be the highest for encroachments followed by plantations and the lowest for semi-evergreen and evergreen forests.

Immigration of species

In Vazhani-Vellani hill tracts immigration in four sq.m. in two months time is found to be 2.61 species. The number of immigrant species is quite high in plantations (3.18) followed by moist deciduous (2.84) and semi-evergreen forests (2.94). However, in evergreen forests it is very low, only 1.49. The competition for light and other requirements of the annuals seems to be the main reason for the number of immigrant species being the highest in the plantations. The situation seems to be the same in moist deciduous and semi-evergreen forests as well with regard to immigrant species. But, in evergreen forests, due to canopy closure, immigrant species are low. It is also because evergreen forests have attained more maturity with regard to succession, the variety of seeds produced, and the dormancy factors operating in that zone.

The immigrant species also produce their impact on the number of species. The whole study area is estimated to have 13.35 species per four sq.m. in two months period. The number of species present is high in the case of moist deciduous forests (15.26) followed by plantations (15.17), and semi-evergreen forests (14.07). Like in the case of immigrant species, the number of species per sq.m. is the lowest in the evergreen forests, 8.92(Table 3.23)

Species richness

Tree layer

Species richness of trees > 15 cm gbh. in moist deciduous forests was estimated to be 0.0036 and that of evergreen forests 0.0054, in four sq.m.

Understorey stratum

Plant density and species density are found to be factors in the determination of species richness is found to vary with seasons. Analysis of average species composition shows species richness of the value of 0.20 in Menhinick's Index. However, the average species richness is found to be very low in plantations (0.14) and nearer to the average in moist deciduous forests (0.19). The species richness values are high with regard to semi-evergreen and evergreen forests, viz. 0.24. (Table 3.23)

Table 3.23 Vazhani-Vellani hill tracts

Regeneration studies - Understorey strata

(1997 Aug-1998 July) Quadrat Size 2m x 2m - 8 locations in Menhinick Index

Rest types	No. of plants	No. of species	Species richness*
Plantations	107.33	15.17	0.14
Moist deciduous Forests	80.17	15.26	0.19
Semi Evergreen Forests	58.17	14.07	0.24
Evergreen forests	37	8.92	0.24
Average	71	13	0.20

The species richness values suggest that, in order to preserve biodiversity, it is imperative to preserve the semi-evergreen and evergreen forests. Conversion of moist deciduous forests to plantations will decrease the species richness greatly i.e., from 0.19 to 0.14. Hence clearing of moist deciduous forests for raising plantations would be detrimental to the interests of preservation of forests; clearing of semi-evergreen and evergreen forests would be disastrous (Jayanarayanan, 1999).

Grazing

Grazing influences plant density as well as species richness profoundly. Continuous and constant grazing would reduce the growth and development of shrubs and tree seedlings, in fine, the development of all vegetation. Areas of grazing would be suitable only for fast-growing, light-demanding annuals and similar shrubs and the competition from the fast growing species would be critical for the comparatively slow growing seedlings of shrubs and trees.

As a result, the forest area once invaded and colonised by fast growing annuals, especially of the members of the family *Asteraceae* would become unsuitable for the growth and development of tree species constituting moist deciduous, semi-evergreen, and evergreen forests. Grazing generally increases species density particularly due to higher colonisation of annuals and similar herbaceous plants and also certain shrubby forms like *Chromolaena odorata, Lantana camara*, etc. It certainly would decrease species richness to a great extent.

Grazing also affects forest development. The regeneration potential that perpetuates the existence of forests in a particular area would be affected adversely by grazing as seedlings, the trees of future years are lost at the juvenile stage itself. Though forests are regarded as a self-sufficient, self-preserving, and self-perpetuating ecosystem, their natural balance would be upset by continuous and constant grazing. Though trees are not much affected by grazing, the new generation seedlings get lost in this process. As and when tall trees are lost by indiscriminate cutting or by natural calamities, the top canopy is removed and the understorey, which is subjected to heavy grazing, is left with nothing else than seedlings of light-demanding annuals/shrubs. It would be another type of forest denudation since the types of

forests, which were in existence, would not re-emerge due to lack of seedlings of tall species and competition from fast-growing annuals/shrubs to seedlings of the tree species. A forest once so thick and dense eventually gets reduced to a more or less savannah type with medium- sized trees at distances apart and the interspaces filled with fast-growing annuals and thorny shrubs of no economic value.

4. Biotic Pressure

The human and livestock population of the *panchayat* wards adjoining the sanctuary exerts biotic pressure on the sanctuary. A section of the people depends on forests for their livelihood. They earn income from the collection of firewood, manure, medicinal plants, MFP, etc. Grazing is another form of economic exploitation of the forests.

Forest dependent communities

The term 'forest-dependent communities' denotes all sections of the population in the study area who, in one way or the other, earn a livelihood at the expense of the resources of forest origin like, firewood, charcoal, manure, minor forest produce (MFP viz. honey, *cheenika*, wax, bark, etc.), and game. Such exploitation has no direct relationship to any community or religion. The role of forest-dependent communities in activities related to forest degradation is examined here to place the socio-economic conditions of a particular group in their proper social perspective. The forest-dependent communities belong to a particular sector of working class similar to agricultural workers but earn their incomes to a large extent from forest resources. This group partakes of the characteristics of grazers and collectors of MPF.

In order to ascertain the socio-economic conditions of various forest-dependent communities in and around the study area, two wards adjacent to the sanctuary viz.: Ward 10 of Madakkathara *panchayat* (Pullamkandam) and ward 13 of Pazhayannur *panchayat* (Thrikkanaya) were selected. One ward i.e. ward 2 of Madakkathara *panchayat* (West Vellanikkara) situated away from the sanctuary area was also included in the detailed study. Students of Sri Vyasa NSS College were trained to collect socio-economic data and were divided into convenient batches of four and were assigned different *ayalkkoottams* (blocks of around 50 households) under the supervision of field assistants. The data were collected based on a pre-tested questionnaire.

Religion and caste

Out of 559 houses surveyed in ward 10 of (Pullamkandam) Madakkathara *panchayat*, 337 were of Christians, 125 of Hindus, and one of Muslim. Seventy-two houses belonged to OBCs. SC and ST houses numbered 22 and 2 respectively. In ward 2 (Vellanikkara) of Madakkathara *panchayat* 313 out 549 belonged to Hindus; there were only 47 Christian and 5 Muslim houses. OBCs houses were found to be 132 while SCs and STs houses were only 21 and 4 respectively (Table 4.1).

Table 4.1 Socio-economic survey in wards adjoining Peechi-Vazhani Wildlife Sanctuary - Religion and caste

	Hindu	**Xian**	**Muslim**	**S.C.**	**S.T.**	**O.B.C.**
Ward 10 – Madakkathra *Panchayat*	125	337	1	22	2	72
Ward 2 - Madakkathra *Panchayat*	313	47	5	21	4	132
Ward 13- Pazhayannur *Panchayat*	319	109	88	58	32	91

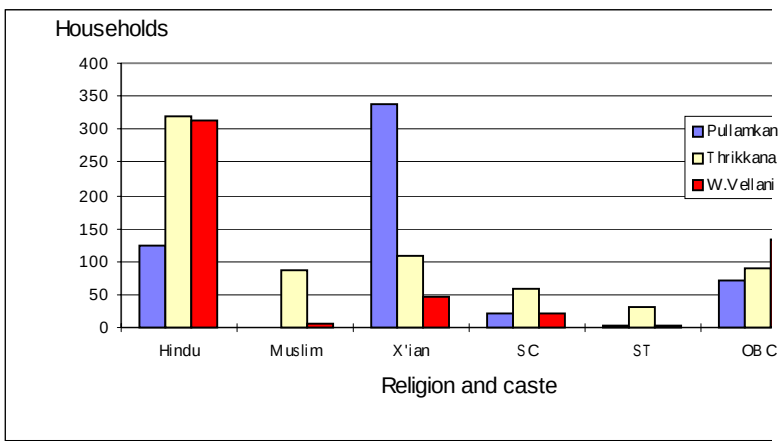
In ward 13 (Thrikkarnaya) of Pazhayannur *panchayat*, the number of Hindu household has 319 out of a total of 697 followed by 109 Christian households and 88 Muslim households. Other Backward Castes (OBCs) had 91 houses followed by 58 households of SCs and 32 of STs.

Christian families in Pullamkandam are inmigrants or their descendants from erstwhile Travancore (Chundamannil; 1993).

Year of settlements

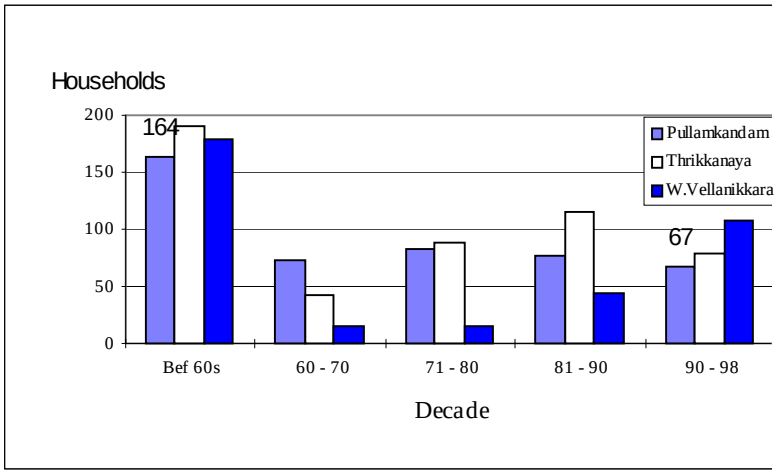
Inmigrants from Travancore came to this area during the 1950s and the 1960s, mostly to Pullamkandam. Inmigration of Christian community is not observed in the wards situated away from the forest area (Figure 4.1). Availability of forestland must have been a major attraction for inmigration particularly since encroachments were not considered a serous punishable offence during that period. The Grow More Food Scheme introduced by the then Governments in a way came in handy for the encroachers; their settlements on enervated lands were later regularised by the government on remittance of a nominal penalty (Chundamannil; 1993).

Figure 4.1 Religion and caste: No. of households



New encroachments and settlements have declined steeply from 164 during the 1950s to 67 during the 1990-'98 period (Figure 4.2). Several reasons may be attributed to this trend. Issue of *Pattayams* was rendered difficult due to Central Government interventions. Encroachments became increasingly risky over time. However, the trend of new encroachments continued at Thrikkanaya during the 1980s, but on a lower scale. The situation in Vellanikkara was the reverse: Here new settlements have continued to appear even during the 1990s may be due to the proximity of the area to the national highway and the Agricultural University and to the fact that the area is on an urban-rural fringe. However, the tendency cannot be attributed to any sort of forest-related activities (encroachments and exploitations) as is seen at Pullamkandam or Thrikkanaya.

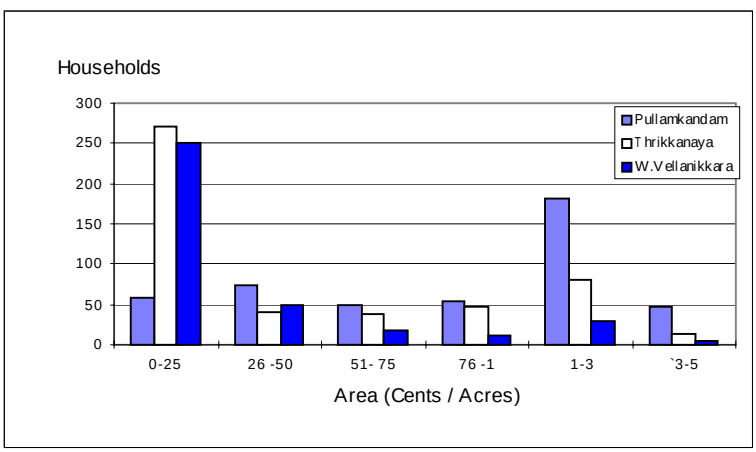
Figure 4.2 Year of settlement



Land holdings

The land holding pattern is found to differ among the three study sites. Land holdings up to 25 cents are found to be a significant category both at Thrikkanaya as well as Vellanikkara, while land holdings of 1 to 3 acres constitute a significant proportion at Pullamkandam. The larger landholders in Pullamkandam are likely to have depended upon the nearby forests for their agricultural and other related requirements than the smaller landholders found in the other two areas (Figure 4.3).

Figure 4.3 Land holding pattern

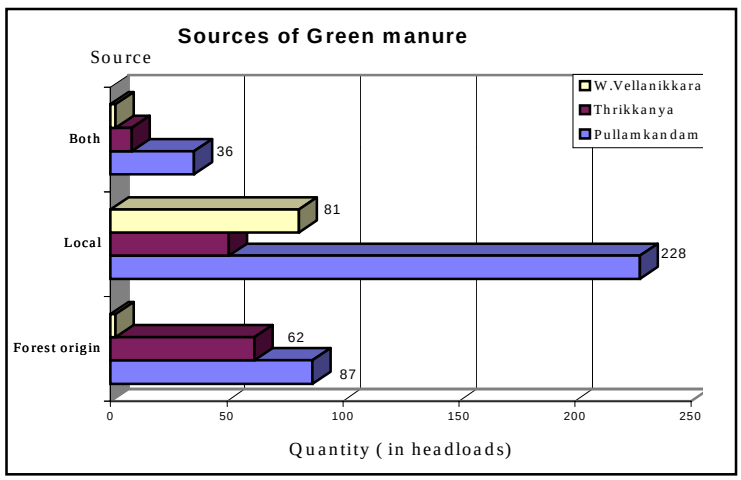


In both Pullamkandam and Thrikkanaya, the self-employed category of workers outnumbers persons engaged in government and the private sector. This shows that considerable number of households is forest-dependent in the former two areas and that their main source of income is agriculture-dependant or forest-related sources (Figure 4.6).

Forest dependency

Farmers depend heavily on the forests for their green manure supply and rearing of livestock. Both these factors reduce the greenery, the former by way of fertiliser and the latter as grazing pressure on the forest area. Hence, the quantity of green manure used and the extent of grazing practised are significant in the present study. It is observed that 25 per cent of the households of Pullamkandam use green manure of forest origin while in Thrikkanaya it is 51 per cent. These figures are significantly higher than the corresponding figure for Vellanikkara where it is only 2 per cent. Ninety-six households of Vellanikkara use green manure of local origin and exert little pressure on the nearby forests. About 65 per cent of the households in Pullamkandam as well as 42 per cent of the households of Thrikkanaya also use non-forest-dependent manures. Thirty-six households at Pullamkandam (10 per cent) and nine households in Thrikkanaya (7 per cent) use both types of manure i.e., of forests and local origin.

Figure 4.4 Sources of manure

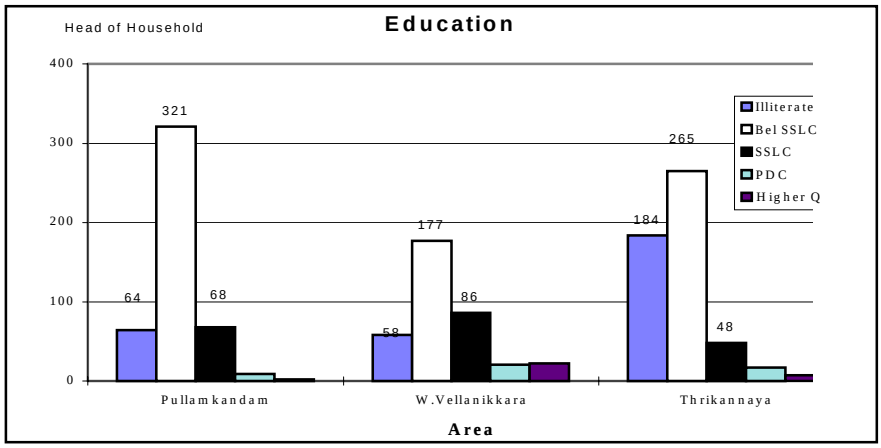


A shift in the source of procurement of manure from forest to non-forest is clearly visible in Pullamkandam and Vellanikkara. The farmers of these areas now find it easy to cultivate and thereby generate green manure for their requirement rather than depending on forests. This is a positive sign whereby a forest- dependent community shifts to non-forest-dependant and non-exploitative practices. Farmers of Thrikkanaya have not reached this stage as the majority of them (51 per cent) use green manure of forest origin and only 42 per cent use locally produced green manure. This may be attributed to the easy availability of green manure from the nearby forests.

Educational qualifications

The educational qualifications of the heads of households show comparable features in Pullamkandam and Thrikkanaya. As Vellanikkara is situated in an urban-village fringe, educational qualification is in general higher than in the other two areas, especially in respect of graduates and post-graduates.

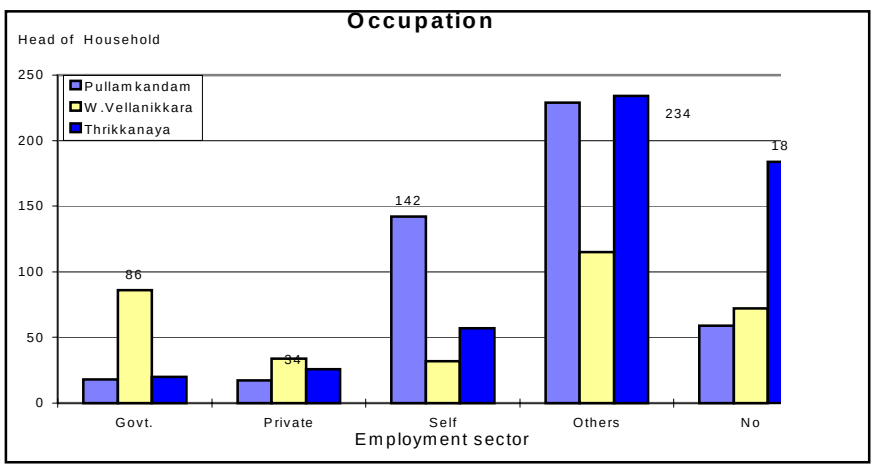
Figure 4.5 Educational status of heads of the households



Occupation

The occupational distribution of the heads of households shows remarkable differences among the three sites. Government employees (25 per cent) constitute a significant group at Vellanikkara while this category is very small in the other two areas (Pullamkandam 4 per cent, Thrikkanaya 4 per cent). The higher proportion in the new settlement of Vellanikkara may be ascribed to the higher educational levels of the settlers of the recent period (since the 1970s); a large proportion of the urban population has opted for government jobs and prefers urban conditions and high living standards. The opposite trend is observed at Pullamkandam where the self-employed category is significant (31 per cent). In Thrikkanaya also, the self-employed category exceeds the category of government employees. The number of persons working in private institutions does not vary much across the study sites. The number of self-employed persons is higher in these sites due mainly to their location in the vicinity of forests.

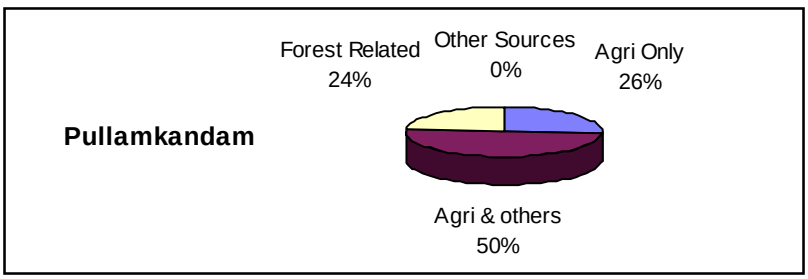
Figure 4.6 Occupation of heads of households

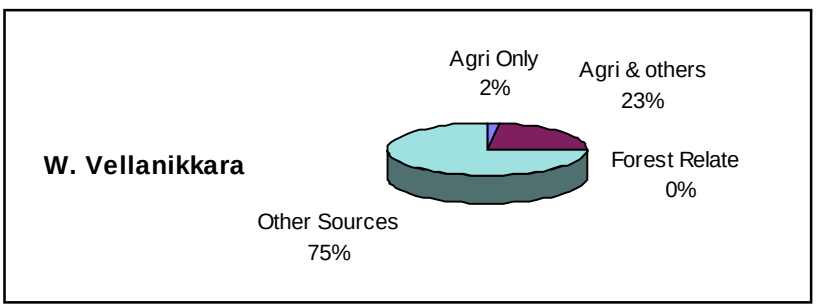


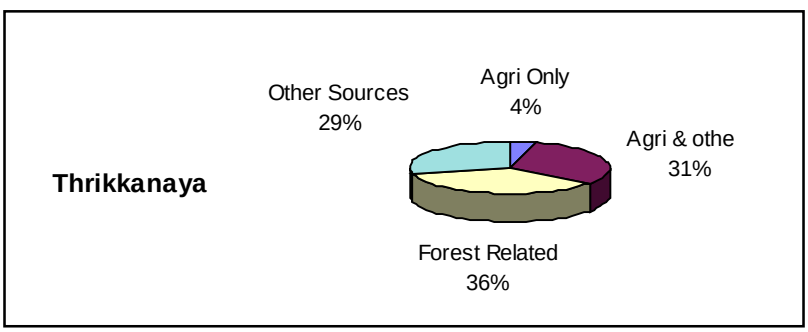
Main source of income

An effort was made also to ascertain the main source of income and to identify the forest-dependent communities. It was found that 26 per cent of the families of Pullamkandam and 4 per cent of the families of Thrikkanaya have agriculture as the sole source of income. However, in Vellanikkara only 2 per cent families are under this category. But, for 50 per cent families of Pullamkandam, 31 per cent families of Thrikkanaya, and 23 per cent families of Vellanikkara, agriculture constitutes an important source of income. Quite significantly, 24 per cent families of Pullamkandam and 36 per cent families of Thrikkanaya have incomes from products of forest origin (Figure 4.7). These families contribute, therefore, to degradation of forest areas. These families were studied further in order to ascertain the reasons for their forest-dependence and explore ways and means to shift them to other areas to reduce forest degradation to the extent possible.

Figure 4.7 Main sources of income

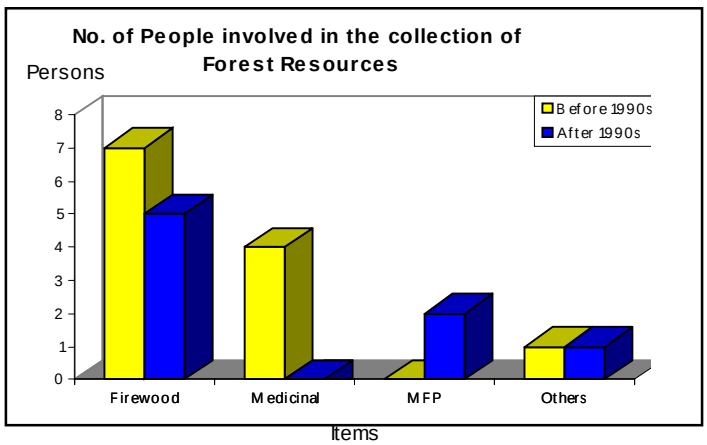






At Pullamkandam, the number of families living exclusively on income derived from firewood collection from forests has come down from 7 to 5, and those dependent on medicinal plants from 4 to zero. However, there are chances that a few families might have shifted to MFP collection (Figure 4.8).

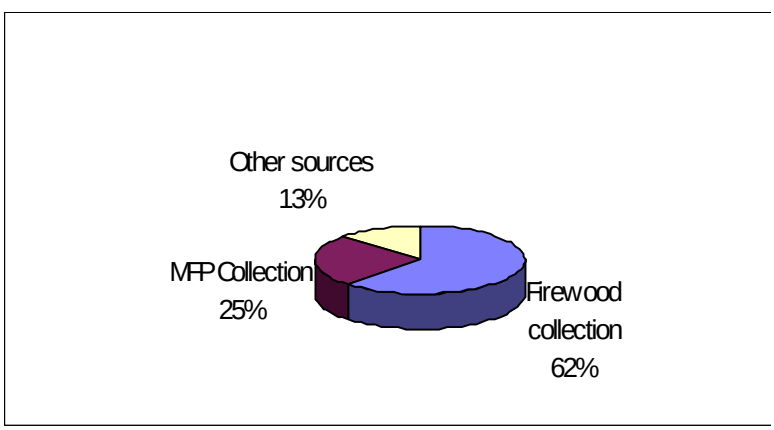
Figure 4.8 Exploitation of forest resources: Trends



The number of families at Thrikkanaya dependent on firewood collection from forests, the chief source of income, has increased from 3 to 4. Similar figures are also reported from Vellanikkara.

At Pullamkandam 62 per cent of the forest-dependent communities earn a living by firewood collection, 25 per cent from MFP collection, and 13 per cent on other forest-related activities (Figure 4.9). The number of families engaged in collection of medicinal plants is relatively small may be due mainly to inability of the present generation to identify them and the incapability of the older generation to reach the interior of forests.

Figure 4.9 Forest-dependent communities

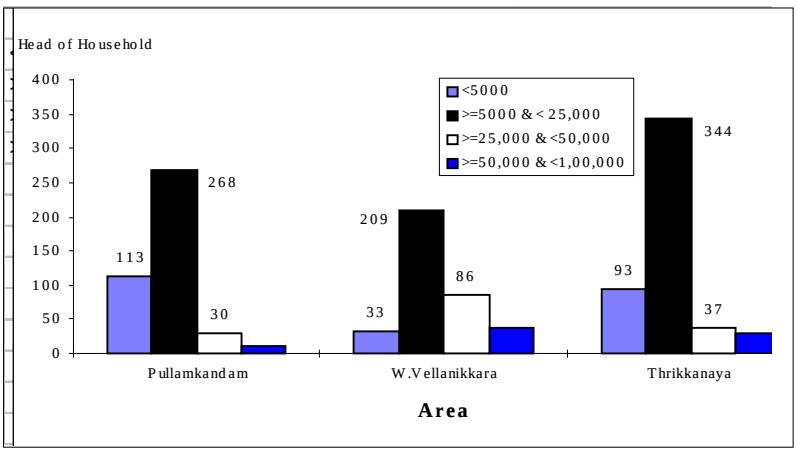


Income class

About 27 per cent of households of Pullamkandam are having an annual income of only less than Rs 5000 while at Thrikkanaya the corresponding figure is 18 per cent. Vellanikkara seems to be better off where this category is only 9 per cent. The predominant income class in all the three study sites is found in the range of Rs 5000 and Rs 25000.

In Pullamkandam, 64 per cent of the families come under this category while at Thrikkanaya it is 68 per cent. In Vellanikkara 57 per cent of the families represent this category. It is seen that 91 per cent of the households at Pullamkandam and 86 per cent at Thrikkanaya belong to the category with an annual income not exceeding Rs 50, 000. However, this class represents only 66 per cent of Vellanikkara.

Figure 4.10 Income class



Households with an annual income of less than Rs 5000 and those whose incomes are in the range of Rs 5000-Rs 25,000 are significantly high at Pullamkandam and Thrikkanaya. It is these categories, which are highly dependent on forests for their livelihood. People with higher educational qualifications and higher annual incomes tend to migrate to urban areas, a process which decreases forest dependency.

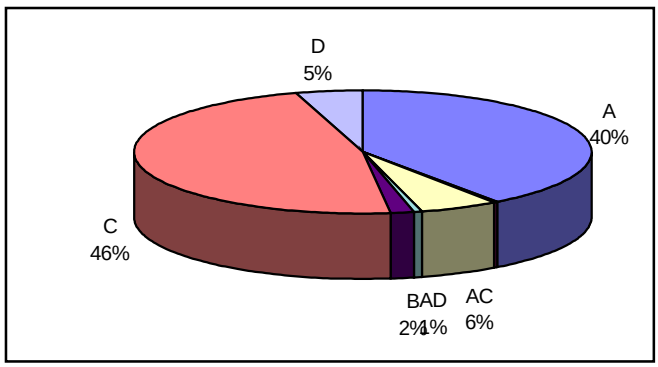
Fuel

Cooking fuel is a commodity for which the degree of forest dependency is found to be great. In the study area, there are families depending solely on LPG and Kerosene on the one hand and entirely on firewood extracted from forests on the other. The availability of other fuel sources like gobar gas, agricultural waste, saw mill waste (sawdust, firewood etc.) would reduce the dependency on forest sources. It is observed that 79 per cent of households of Pullamkandam, 92 per cent at Thrikkanaya, and 45 per cent of Vellanikkara use firewood as the main cooking fuel. Of these, 40 per cent of households at Pullamkandam use firewood of forest origin, while 46 per cent obtain it from agro-waste; at Thrikkanaya 72 per cent of the

households extract firewood from forests and 16 per cent from their own lands. The households of Vellanikkara do not make use of firewood of forest origin, as this area is 4-6 km away from the forest boundary. They purchase sawdust and other saw mill wastes and firewood of plantation origin for their firewood requirements. About 20 per cent of the households of Vellanikkara use to some extent, firewood extracted from their own farmlands. Thus 92 per cent households of Thrikkanaya use firewood as the source of cooking fuel of which 72 per cent comes from firewood collected from forests. This is the biggest sector of the forest-dependent community.

Hence, forest dependency with regard to firewood is the highest at Thrikkanaya, moderate at Pullamkandam, and the lowest at Vellanikkara.

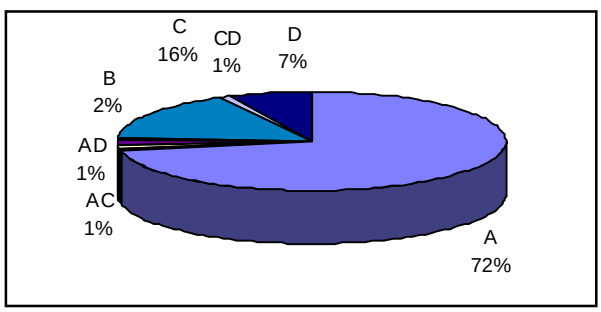
Figure 4.11 Sources of firewood: Pullamkandam



Source of Fuel

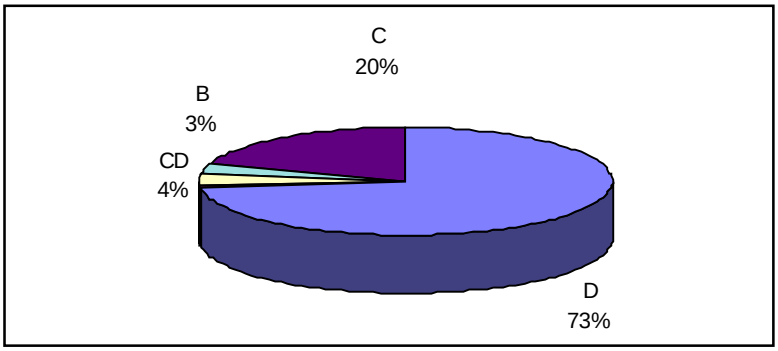
Detailed analysis of these households of Pullamkandam shows that about 40 per cent (183) households of this area use firewood exclusively of forest origin (Figure 4.12). The corresponding figure for Thrikkanaya is almost double (Figure 4.12).

Figure 4.12 Sources of firewood: Thrikkanaya



Vellanikkara being situated away from the forest areas, households in this site purchase fuel wood from timber depots and saw mills and also purchase kerosene or gas (Figure 4.13).

Figure 4.13 Sources of firewood: West Vellanikkara



Firewood source in the form of agro-waste is getting importance because it is a sector showing lesser dependency on forests (Figure 4.14). However, in order to raise plantation crops such as coconut, households depend on green manure of forest origin but only to a limited extent.

Figure 4.14 Main cooking fuels: Pullamkandam

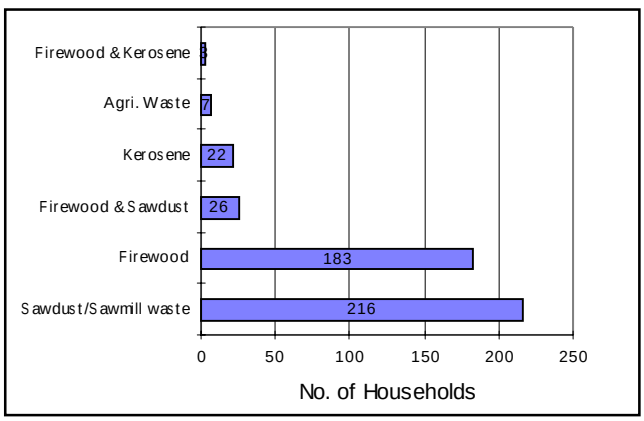
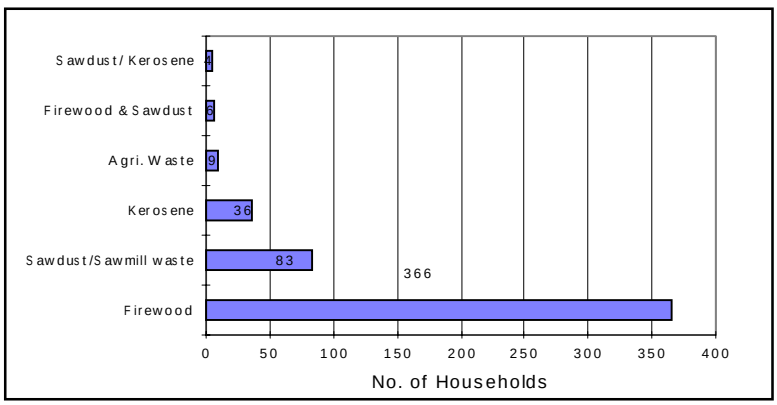


Figure 4.15 Main cooking fuels: Thrikkanaya



The increase in the number of households that utilises agro-waste as firewood is certainly a positive sign since it indicates a fall in the degree of dependence on forests. It is seen that 46 per cent of households at Pullamkandam and 16 per cent of the households at Thrikkanaya have some agro-waste for use as firewood.

Nearly 46 per cent households of Pullamkandom, 16 per cent of Thrikkanaya, and 20 per cent of Vellanikkara are not dependent on forests with regard to firewood, since they have lease holdings of more than one acre.

However, the picture is significantly different at Vellanikkara where people make larger use of alternative sources of fuel such as kerosene, gobar gas or LPG. The households exclusively dependent on firewood comes to only 45 per cent while, those using alternate sources is 55 per cent. Though the latter also use firewood to varying extents, about five per cent exclusively use agro waste one per cent kerosene, and one per cent on LPG giving a total of 8 per cent dependent on sources of fuel other than of forest origin. Though Vellanikkara shows no direct fuel extraction from forests as firewood, actually 45 per cent of the families use firewood purchased from timber depots, saw mills waste, etc., which are indirectly related to fuel of forest or plantation origin.

Green manure

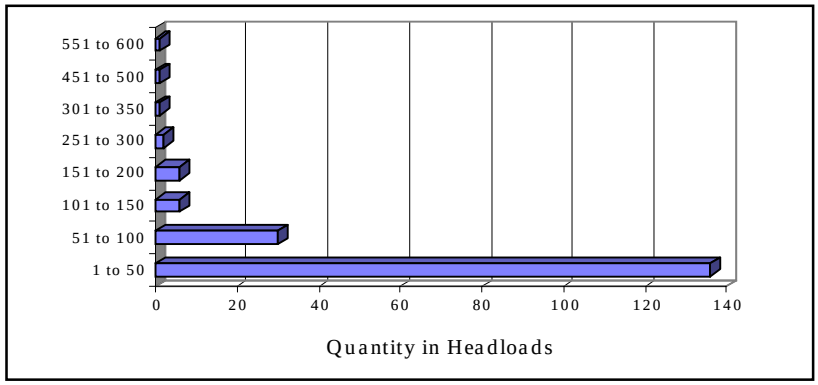
Green manure used by households as fertiliser either in raw form or as compost mixed and processed with dung. Like cooking fuel, green manure is also collected from forest source as well as from own land holdings or households. So, the number of headloads of manure used would not by itself gives the extent of forest dependency. Hence, the study was extended to quantify the manure used from both the sources and to estimate the impact of the agricultural practices on the forest flora.

Traditionally green manure was considered a good organic soil fertiliser in cultivation of rice, coconut, arecanut, and plantains. With the advent of chemical fertilisers like urea, the importance and preference of green manure got reduced; it seems, however, to be the main fertiliser used by traditional farmers along with dung and ash. The availability of green manure from forest sources got restricted during the past decade and farmers supplemented it with own green manure from cultivation of *Glyricidia* (*Seema Konna*) in their holdings along hedges and farm boundaries and by sowing certain *Papilionaceous* varieties like *Pueraria tuberosa* in rubber and other plantations.

However, large quantities of green manure are being extracted from forest sources even today.

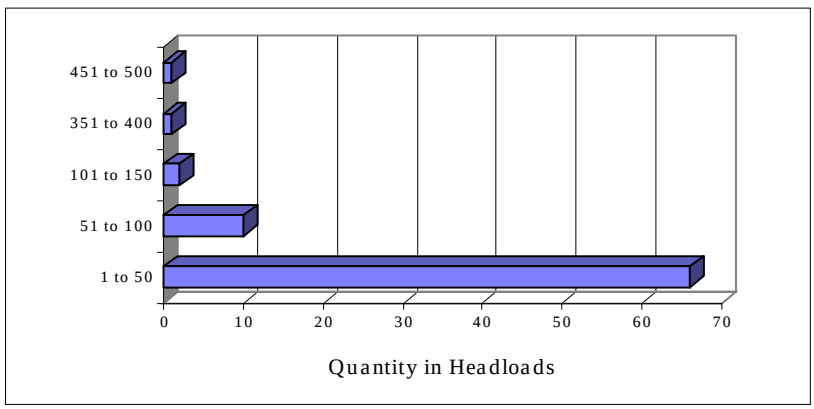
The present study reveals that 74 per cent of the families of Pullamkandam, 82 per cent families of Thrikkanaya, and 92 per cent families of Vellanikkara use up to 50 head loads of green manure annually. Households using 51-100 loads a year were estimated to be 16 per cent at Pullamkandam and 13 per cent at Thrikkanaya. Nearly 3 per cent of households at families of Pullamkandam, 3 per cent of the households of Thrikkanaya, and 4 per cent of Vellanikkara use quantities between 101-150 headloads. At Pullamkandam area there is a

Figure 4.16 Extraction of green manure at Pullamkandam



proportion of households, which use more than 250 headloads of green manure. The proportions of households using large quantities are the highest in Vellanikkara.

Figure 4.17 Extraction of green manure at Thrikkanya



Livestock

Livestock exert pressure on vegetation of the vicinity unless they are completely stall-fed. Though possible, complete stall-feeding is not practised in the rural areas due to several economic reasons: cost of construction of cattle sheds and cost of fodder, on the one hand and availability of grazing lands, vicinity of forests, and laxity shown by forest officials to control grazing in reserved forests and plantations, on the other. The biotic effect of grazing on the flora of a particular locality seems to be more damaging than firewood collection as the former removes almost completely the seedlings/saplings of a locality thus inhibiting the development of new generations of understorey stratum. On the other hand, firewood collection removes a portion of a tree or even some trees altogether, but does not hamper development of new seedlings in the area. Moreover, even if a tree had been removed by way of firewood collection, a gap will be produced in the canopy, which will favour the growth of new species as in the case of naturally fallen trees.

Cows

Cows constitute an important component of the livestock population. The majority of the cows in Kerala of the period 1960-1980 were non-crossbred and hence low milk-yielding. However, these varieties showed high disease resistance and yielded large quantities of dung. Cow dung was the major form of fertiliser used during that period. During 1960-1990, a progressive increase in the number of households with up to four cows is observed in the study area.

Figure 4.18 Cow population in Pullamkandam area

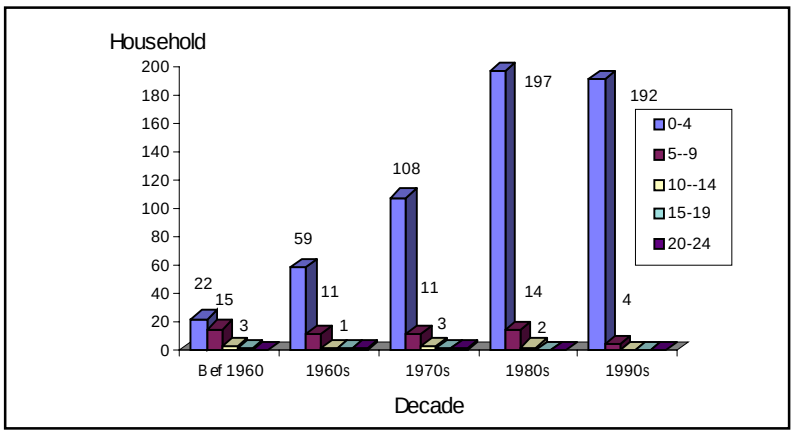
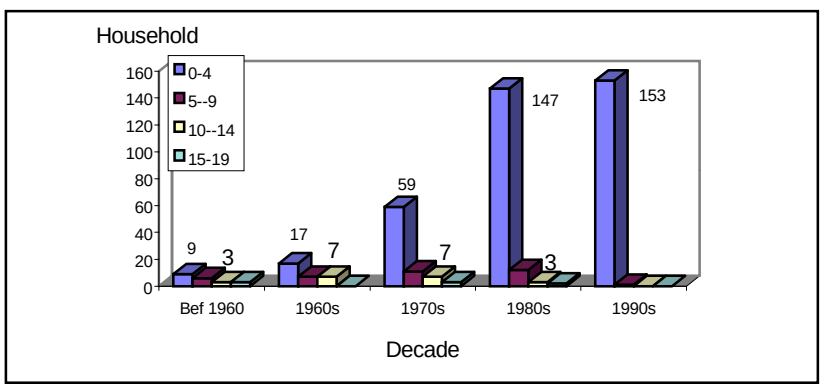


Figure 4.19 Cow population in Thrikkanaya area



The number of cows kept on increasing up to 1990, since then, the number began to fall. But the decline was confined to Pullamkandam and Vellanikkara.

In Pullamkandam area 34 (81 per cent) of cows used to be managed by grazing as against 19 per cent by stall-feeding during the period 1950-‘60. The grazing practice decreased during the period 1960-1970 from 81 per cent to 62 per cent.

During the 1970s, the number of stall-fed cows outnumbered those reared by grazing. This trend has continued ever since. During 1990-1998, the proportion of stall-fed cows had rose to 77 per cent.

The trends in the feeding practices in Thrikkanaya are almost similar to those in Pullamkandam. Here also the number of cows maintained by grazing decreased from 71 per cent to 23 per cent during 1960-1990 to 15 per cent by 1990 to 1998.

In general, there has taken place a reduction in the grazing practices and an upward trend towards stall-feeding. This change was mainly due to non-availability of grazing lands, much of the pastures having been already encroached upon. Moreover, several areas adjacent to forests were converted into rubber plantations where a practice of periodical removal of undergrowth is followed. The rubber plantations are maintained with great care and the owners do not permit any sort of grazing in them. The introduction of crossbred cattle also had its share in the reduction of the grazing practice in forest and plantation (Teak, Eucalyptus, Acacia, etc.) lands. Further, the new varieties of cattle introduced are not sturdy enough to graze on hilly terrain unlike the indigenous varieties.

Buffaloes

Buffaloes are the other important category of livestock showing tremendous decline in their number after 1990. The number of buffaloes had kept increasing in all the study sites up to 1980. Since then their number began declining reaching the lowest ebb during the 1990s. The decrease in the number of buffaloes corresponds to the reduction in the extent of rice cultivation and the increase in other crops like plantains and coconut. During 1990-'98, rice cultivation dwindled which resulted in the fall in the production of hay and other fodder. Moreover, the introduction of ploughing machines caused displacement of buffaloes from draught activities. Families keeping large number of buffaloes decreased drastically during 1990 – 1998. At present the highest number of buffaloes per household seems to be only 2, while in the earlier period there were large number of households, which had more than 3 buffaloes; some even had up to 10 buffaloes.

The number of buffaloes maintained by grazing practices increased up to 1980. From 1980, a decline in the number is observed and the lowest levels were reached during the period 1990-1998.

The situation is similar both in Pullamkandam and Thrikkanaya with regard to feeding practice of buffaloes. The phenomenal decline in buffalo population is significant in the sense that it shows the shift in the agriculture sector from rice to non-rice cultivation such as of plantains, coconut, and even rubber. It also indicates a fall in grazing pressure, a positive change from the forest degradation point of view. Decline in the number of buffaloes maintained exclusively on grazing coupled with increase in the number of stall-fed buffaloes implies decrease in the grazing pressure to a considerable extent. Here, one sees a marked reduction in forest dependency and a ray of hope for forest conservation. It now appears that our forests can be preserved with minimum damage with sustainable use of forest produce and planning of the agricultural sector with crops suitable to natural conditions.

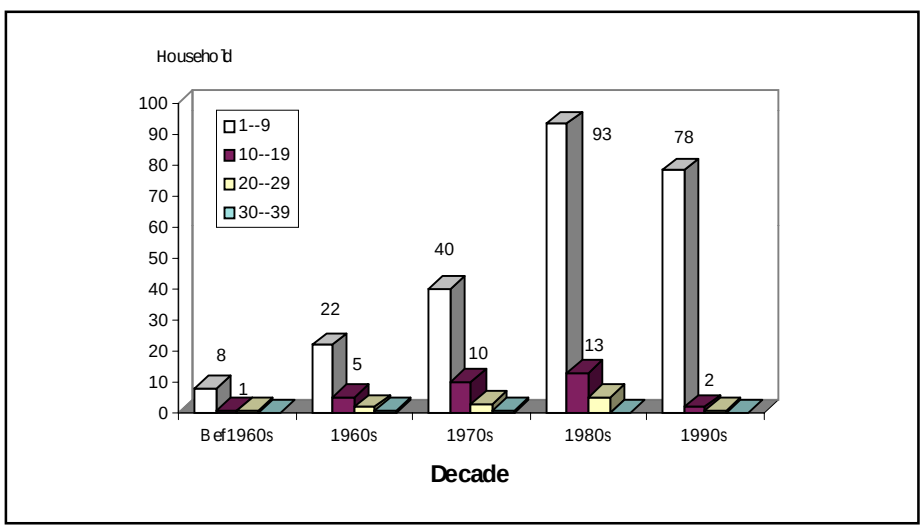
Production of green manure other than of forest origin is thus an important step towards forest conservation. It promotes self-sufficiency and enables farmers to plan crop calendars. Sustainable use of resources in and around the village has not yet been fully explored. The People's Planning Programme would, it is hoped, create a congenial atmosphere to such efforts. Programmes should be envisaged with the basic understanding that forest and agriculture are not two independent entities but are closely related and that one cannot be improved at the expense of the other. So, protection of nature and natural resources should not in any way affect the agricultural pattern prevalent in a particular period nor should agriculture become totally dependent on natural resources viz. forests. In the yesteryears agriculture and maintenance of livestock were done mainly at the expense of forest resources. Gone are these days and the present generation should attempt at sustainable development of these obviously interdependent sectors – forest and agriculture. Only such an approach would fulfil the demands of the emerging era, without causing damage either to forests or to agriculture.

Goats

Goats, despite their being smaller animals than cows and buffaloes, exert more grazing pressure. The feeding habits of goats are totally different from those of higher animals as they consume larger number of species as fodder resulting in greater grazing pressure and more loss of biodiversity. During the past three decades, villages in Kerala witnessed a sharp decline in the number of the larger-sized livestock such as cows and buffaloes and a corresponding increase in the goat population. The study made in three sites provides the clue for this change and its implications.

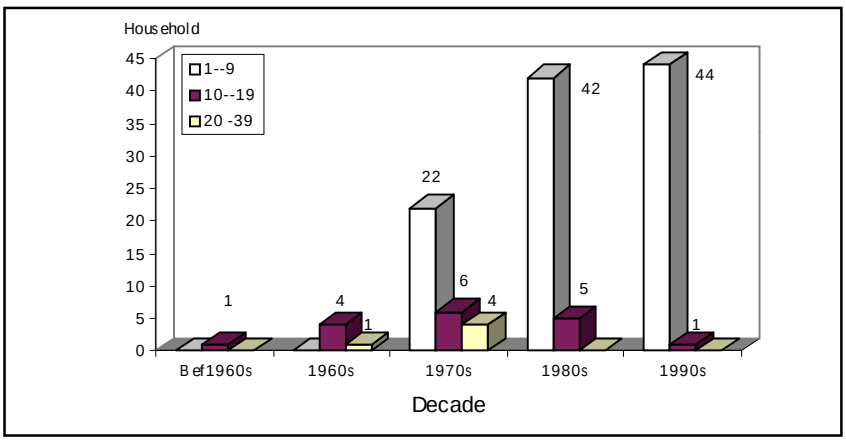
The livestock population shows a decline in the number of large animals (cows and buffaloes) and a progressive increase in the case of smaller ones like, goats, rabbits, etc.

Figure 4.20 Goat population in Pullamkandam area



The goat population in the study area kept on increasing till 1990, after which it has steadily fallen. In Pullamkandam, households having 1 to 9 goats, with 10-19 goats and also with 20-29 goats increased steadily till 1990. However, a drop in the goat population is noticeable during the period 1990-1998 (Figure 4.21).

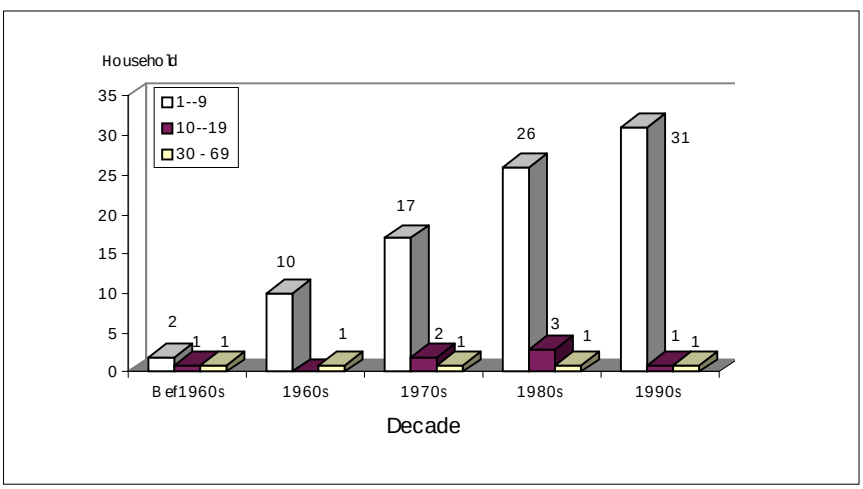
Figure 4.21 Goat population in Thrikkanaya area



The situation at Thrikkanaya is almost similar to that of Pullamkandam. However, the average number of goats per household seems to have been steadily falling (Figure 4.22)

Goat population at Vellanikkara also shows similar trends. Here also the number of goats increased with decrease in the number of bigger livestock. As this trend is uniform in all the areas, it may be presumed that this change in livestock size and composition is due mainly to changes in the cropping pattern. Grazing by goats produces more grazing pressure and reduces the biodiversity more than grazing by larger animals like cows and buffaloes.

Figure 4.22 Goat population in West Vellanikkara area



At Pullamkandam the mode of feeding of goats during the 1950s was 80 per cent grazing and 20 per cent stall-feeding. The proportion of goats kept under grazing practices was more or less the same during the 1960s; it declined to 56 per cent during the 1970s and further to 49 per cent during the 1980s. However, in absolute numbers, it was going up. The proportion reached a level of 25 per cent during the 1990s.

At Thrikkanaya, almost the same trend is visible; there is a marginal decrease in the number of goats kept under grazing management and increase in the number of stall-fed goats.

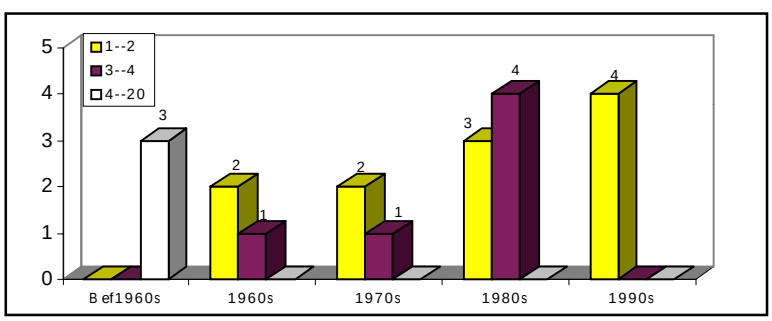
The decrease in the goat population during the 1990s is also a positive sign with regard to grazing pressure. Stall-fed goats exert less grazing pressure than those kept fully on grazing. So, both the reduction in the number of the goat population as well as the increase in the number of stall-fed goats reduces pressure. Thus, the forests in the vicinity of the study area are subjected to lesser grazing or biotic pressure during 1991-'98 than during the earlier decades. Viewed from the point of biodiversity conservation and ecological parameters, reduction in biotic pressure is an extremely desirable trend with regard to the conservation of the forest ecosystem. Attempts should be made to continue the present trend so as to decrease the biotic pressure to the maximum extent possible.

However, decrease in the goat population, and the livestock population at large, would have adverse socio-economic impacts especially with regard to income levels of the households in the area. In these circumstances, it is imperative to identify the factors, which determine the optimum livestock population of an area that could be sustained without causing excessive biotic pressure on reserved forests and plantations. Possibilities of maintenance of livestock practically independent of the forest ecosystem have also to be explored.

Pigs

Pigs constitute a minor component of the livestock of the study area. Being a voracious feeder, keeping pigs in household background is a heavy task. Pigs maintained at forest boundaries consume lots of waste derived from tapioca cultivation if other forms of biological waste are not sufficient. In such situations pigs might exert a biotic pressure quite different from those of other livestock.

Figure 4.23 Pig population at Pullamkandam area



At Pullamkandam the pig population doubled from 3 to 7 during 1981-'90 and currently their number has come down. So, the decline in the number of pigs is in quite conformity with the decrease in the number of the other bigger livestock. Some rearing of pigs existed in Thrikkanaya during 1981-'90; no cases are now reported from that area. Thus, it may be seen that grazing pressure from pigs is negligible in the study area. The few pigs that are reared are occasionally let out to wander outside the piggets but only for muscular movements and development, to places immediately around the dwelling places and seldom to forests. So, rearing of pigs may prove to be a better substitute to rearing of other categories of livestock as they cause minimum damage to forests, for effective clearing of biological waste, and for providing a supplementary source of income to farmers belonging to the low and middle economic categories.

5. Impacts of Biotic Pressure

Forest degradation takes place due mainly to dependence of people on forests for their lives. It is the poor people who depend on forest resources the most. To them, forests give sustenance; they collect firewood, green manure, medicinal plants, and MFP from forests. They graze their cattle in forestlands. The biotic pressure, due to exploitation by human population, on forests has been on the increase in recent decades.

While the impact of the pressure created directly by human population is immediate, that from the pressure exercised indirectly by people through their livestock is far reaching. The impact would be determined also by socio-economic conditions of the forest-dependent communities. In the present study, families were classified according to forest-dependency by giving relative scores (30 per cent for firewood dependency, 30 per cent for grazing, 20 per cent for manure collection, and 20 per cent for MFP collection).

Forest-dependency is assessed based on the relative contribution towards forest degradation. In this context, firewood collection and grazing are the major contributions to destruction of forests. Collecting fallen trees may be apparently harmless, but the practice of burning living trees for charcoal and cutting and removal of trees like *Xylia xylocarpa* and other species would cause serious imbalance in the ecosystem. Hence their effect on degradation is given a weightage of 30 per cent. The same score is given to grazing also as it contributes to ecological imbalance leading to the removal of understorey vegetation and destruction of regeneration potential. Collection of manure and MFP are seasonal, hence they are given low scores of 20 per cent each.

The regional distribution of forest-dependent families, of Pullamkandam and Thrikkanaya areas, is shown in Table 5.1.

Table 5.1 Forest dependency of selected areas

Area	No. of families	Percentage	Forest dependency (%)
Pullamkandam	266	50	up to 20
	162	30	21 - 40
	93	17	41 - 60
	14	3	61 - 80
	2	< 1	80 and above
Thrikkanaya	432	82	up to 20
	85	16	21 - 40
	9	2	41 - 60
	2	< 1	61 - 80

In Pullamkandam area, 367 families depend on forests for grazing purposes and 87 families earn an income from manure collection. Five families are exclusively dependent on firewood collection as the main source of income while 2 families are engaged in MFP collection. In Thrikkanaya, 56 families earn an income from grazing cattle and 61 families from manure collection. Four families are exclusively dependent on firewood collection as the principal source of their income.

It was found that 50 per cent of the total 537 families of Pullamkandam had forest-dependency only of less than 20 per cent. Thirty per cent (162 families) showed forest dependency between 21 to 40 per cent; in the case of 17 per cent (93 families) it was between 41 to 60 per cent; only 14 families (constituting 3 per cent) had dependency between 61 to 80 per cent; and 2 families showed dependency of more than 80 per cent. At Thrikkanaya 82 per cent of the families surveyed showed forest dependency of less than 20 per cent. Those having 21 to 40 per cent dependency came to 16 per cent; dependency ranged between 41 to 60 per cent in the case of 2 per cent; and only less than 1 per cent of the families was dependent on forests to the tune of 61–80 per cent.

Cooking fuel

Households in the vicinity of forests collect forest firewood mainly for own cooking purposes. In areas where other sources of cooking fuels are available, the pressure on the forest for firewood is seen to be lower.While nearly four-fifths of the families in Pullamakandam and 92 per cent of the families in Thrikkanaya depended on forests for firewood, the corresponding proportion was only 45 per cent in Vellanikkara due to the availability of alternative fuels such as agro-waste, saw dust, kerosene and LPG in the latter. Households in Vellanikkara were economically better off too (Figure. 5.1, 5.2, and 5.3).

Direct firewood dependency is noted in households situated immediately near the sanctuaries; families with higher living standards, and having their own lands, meet their requirements from their own farms, timber depots, kerosene, LPG or gober gas. The use of LPG is low in villages and settlements, which are not accessible to vehicular traffic.

Figure 5.1 Cooking fuels: Pullamkandam area

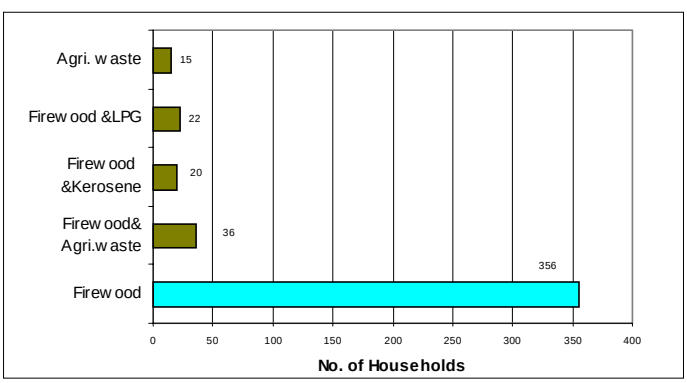


Figure 5.2 Cooking fuels: Thrikkanaya area

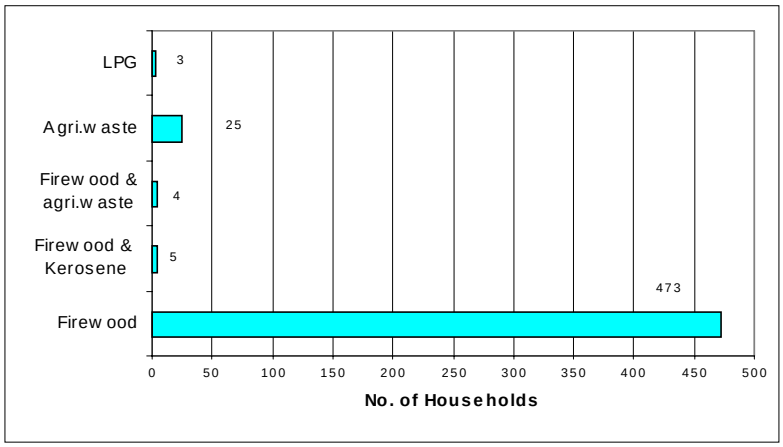


Figure 5.3 Cooking fuels: Vellanikkara area

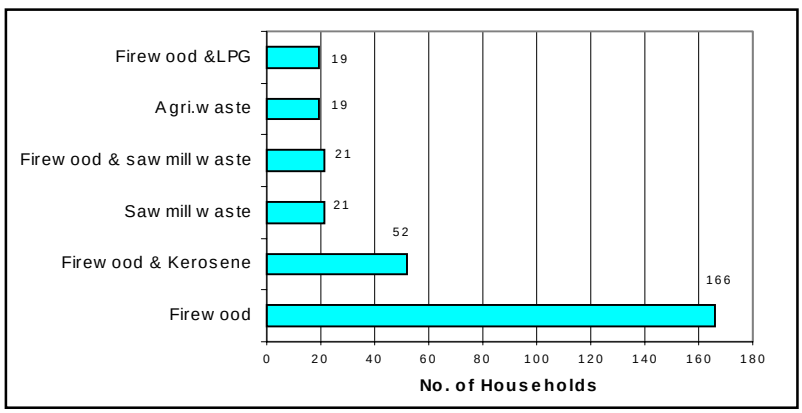


Figure 5.4 Sources of firewood: Pullamkandam area

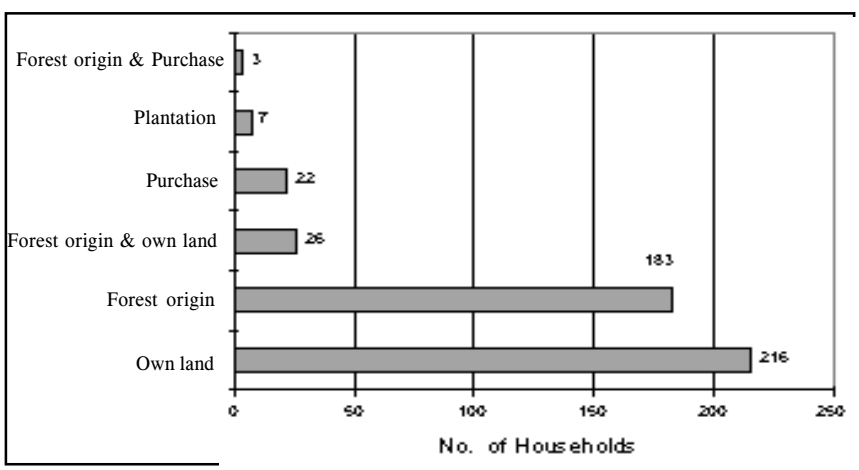


Figure 5.5 Sources of firewood: Thrikkanaya area

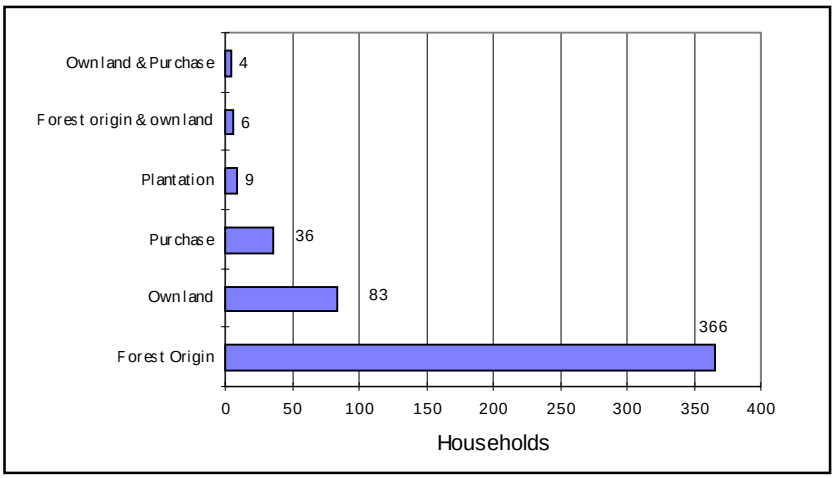
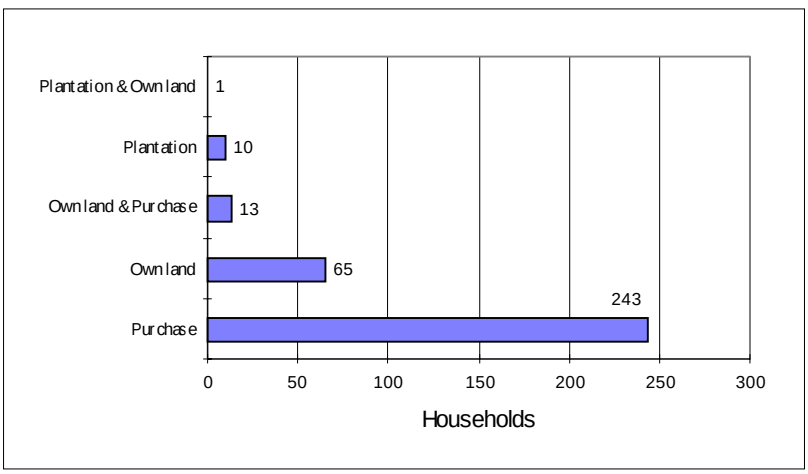


Figure 5.6 Sources of firewood: Vellanikkara area



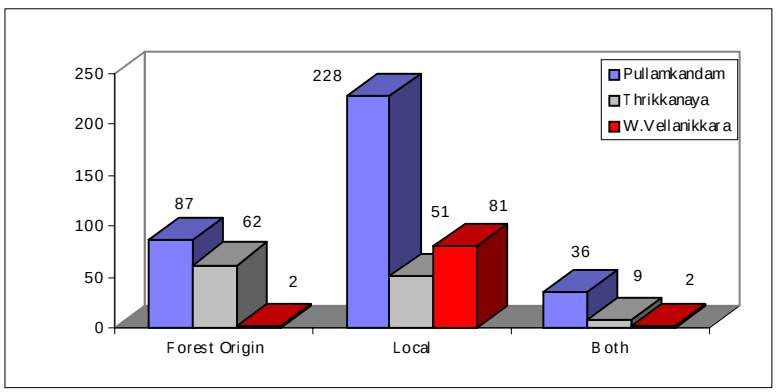
The use of alternate fuels like kerosene, gobar gas, and LPG is not widespread at Pullamkandam and Thrikkanaya due mainly to lack of transportation facilities as well as to poor economic conditions. Access to forests makes firewood an ideal source of cheap fuel (Table 5.2.1, 5.2.2, and 5.2.3).

Manure

The rural farmer depended for ages on biological fertilisers or manure till the advent of nitrogen-rich chemical fertilisers about four decades ago. Even now organic manure requirement is very high in our study area. The bulk of the green manure requirement is met from the forests. Only a low percentage is obtained from cultivation of leguminous plants or from bushes on canal boundaries.

The annual requirement of manure is estimated to be 9,400 headloads (for 183 families) at Pullamkandam, 3500 head loads (80 families) at Thrikkanaya, and 1000 headloads (27 families) at Vellanikkara. The average manure requirement per family is quite high at Pullamkandam, where it is 51 headloads compared to 43 headloads at Thrikkanaya, and 37 headloads at Vellanikkara. The requirement is met mainly from forest sources and to some extent from other local sources. Eighty-seven families of Pullamkandam and 62 families of Thrikkanaya exclusively use manure of forest origin. On the other hand, 228 families of Pullamkandam and 51 families of Thrikkanaya, and 81 families of Vellanikkara use manure of non-forest origin. Thirty-six families of Pullamkandam and 9 families of Thrikkanaya use both types of manure (Figure 5.7).

Figure 5.7 Sources of green manure



Madakkathara *panchayat* authorities have recently come up with a programme for production of green manure by the farmers themselves. They supplied stumps of *Seemakonna* (*Glyricidia spp*.) and encouraged the cultivation of *Chanampu*, *Dinga*, Wild cowpea, etc., for increasing production of green manure.

Pressure is exerted by the local communities on the sanctuary with regard to manure requirements is heavy. However, this state of affairs is not alarming since there is evidence of growing dependence on manure produced from non-forest sources. *Panchayat* authorities, as part of People's Planning Programme, have begun encouraging production and use of green manure of non-forest origin.

Grazing

Grazing cattle on forestlands causes considerable biotic pressure with far-reaching effects. It affects the growth and development of new generations of plants at the seedling, herb, and shrub stages. In other words, greater the intensity of grazing, lesser would be the regeneration potential of forests.

Needless to say, not only increase in the livestock population but the mode of its management contributes much to the biotic pressure. An increase in livestock population with stall-feed-

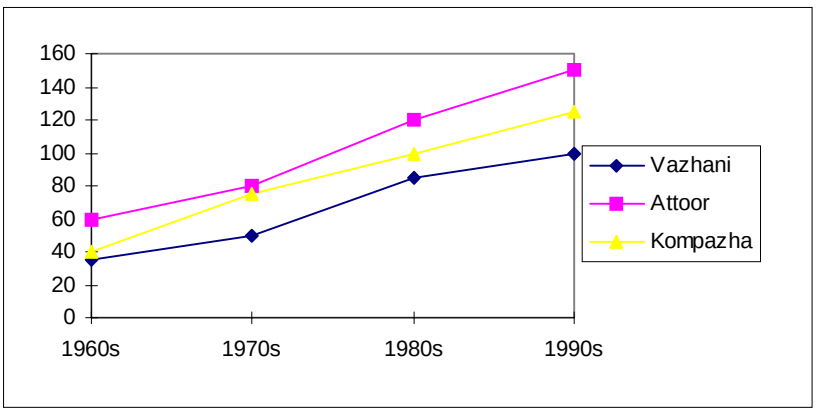
ing as the mode of its management, would not lead to increase in biotic pressure; villages situated near the sanctuary areas inhabited by people in low socio-economic conditions cannot afford stall-feeding. They would resort to open grazing of cattle in forestlands thus leading to progressive and irreversible deterioration and degradation of forestlands.

Goat farming

A study on goat farming conducted at selected areas of Vazhani, Attoor, and Kompazha shows that the goat population is increasing in all the three areas. The increase in the price of mutton attracted certain sections of the population adjoining the sanctuary to small-scale goat farming. In consequence, the grazing pressure by goats has been steadily on the increase.

There are also instances of people who earn a living by collecting monthly grazing charges based on the number of goats, from goat owners. This practice has resulted in partial lopping and removal of certain selected tree species like *Naringi crenulata* and *Pterocarpus marsupium,* etc., which are specially palatable to goats (Plate 2). This trend indicates a new type of mounting grazing pressure (Figure 5.8).

Figure 5.8 Goat farming at Vazhani, Attoor, and Kompazha areas



In general, grazing pressure has been on the increase up to 1990; at present the pressure is coming down. The phenomenal decline in the number of buffaloes and the reduction in the number of cows together with the increase in the practice of stall-feeding are the major factors contributing to the reduction in the grazing pressure (Figure 5.4).

Though the number of goats is also coming down at Pullamkandam, their number is rapidly increasing in certain other areas such as Vazhani, Attoor, and Kompazha. The overall grazing pressure is, however, diminishing.

Grazing pressure

Changes in grazing pressure of Pullamkandam, Vellanikkara, and Thrikkanaya areas are

estimated for the past four decades using census method as well as PRA techniques. The daily fodder requirement is fixed as 5 kg per goat, 40 kg per cow, and 50 kg per buffalo (Figure 5.9).

Grazing pressure at all the three areas shows a gradual increase during the 1950s and the 1960s and a rapid increase by the 1970s and the 1980s. It shows sharp decline at both Pullamkandam and Thrikkanaya areas while in Vellanikkara it is gradual during the 1990s. The grazing pressure was the highest during the1980s at 26,740 kg/day at Pullamkandam followed by 20,830 kg/day at Thrikkanaya. However, it is only 9,540 kg/day at Vellanikkara. During the 1990s the rates have come down to 19,305 kg/day at Pullamkandam and 13,845 kg/day at Thrikkanaya. The fodder requirement/day is estimated to be only 6,695 kg at Vellanikkara.

Species richness

Preliminary studies on graze lands show that their species richness is only 0.06 compared to 0.20 calculated for the whole Vazhani-Vellani hill tracts (Species richness values are found to be 0.14 for plantations, 0.19 for moist deciduous forests and 0.24 for semi-evergreen and evergreen forests). Studies over wider areas are required to draw any conclusion with regard to graze lands. Graze lands are found to be dominated by herbaceous annuals like *Mitracarpus sp*. and *Spermacoce articularis*. These species are not common in moist deciduous, semi-evergreen and evergreen forests. Moreover, taxa like *Chromolaena odorata, Cassia tora, Mimosa pudica, Phyllanthus urinaria, Desmodium triflorum, Sida rhombifolia, Hyptis suaveolens, Teramnus labialis*, and *Alicicarpus sp*. are fairly common in graze lands compared to types like moist deciduous, semi- evergreen, and evergreen forests. Increase in the number of herbaceous annuals would alter the ecological balance. The development of seedlings of various tree species may be affected as they are exposed to grazing animals particularly during the dry seasons when the herbaceous annuals perish. This in a way may also lead to the destruction of palatable seedlings of tree species and eventually result in the almost complete loss of the regeneration potential of that area. The only survivors might be thorny species and their ilk.

MFP collection

Collection of minor forest produce (MFP) would degrade forests considerably; compared to manure collection and grazing the damage is, however, of lesser magnitude. A good number of seeds of forest species are collected for their medicinal and other economic value; such collection certainly affects the regeneration potential of these species. Bark collection is a potential threat to certain invaluable species like, *Dipterocarpus*. It s practised on such a wide scale that certain landscapes even appear as if fully burnt or dried up.

Enquiries made at Thirumani, Kalappara, Kakkinikkad, and Olakara reveal that over a hundred species/items were being collected during the period 1960-1990. However, owing to fall in market demand, only about 50 species/items are at present collected from Thirumani and Kalappra areas. There is local demand for about 70 species/items at Olakara. The tribesfolk residing inside the sanctuary in this area have ample opportunities for collection of a wide

variety of MFP items, particularly since they work under tribal welfare societies (Table 5.2). Hence, the quantity of MFP collected is quite high at Olakara compared to collection in the other three areas. The biotic pressure by way of collection of MFP may decrease in the coming years due to possible decrease in the number of persons involved in MFP collection. It may be seen that though there is an increase in the number of tribal families, the number of persons engaged in MFP collection is decreasing. However, the current rise in demand for

Table 5.2 Tribesfolk and collection of MFP and medicinal plants

Area	Men involved in collection			No. of Families			No. of items		Quantity. (Kg) 1998
	1960s	1990	1998	1960s	1990	1998	1990	1998	
Thirumani	30	30	20	14	20	33	106	48	7540
Kalappara	38	25	18	11	9	18	110	55	4321
Olakara	28	35	24	13	16	32	108	68	10819
Kakkinikad	22	8	2	15	15	7*	102	7	105

* Other families migrated to Poovanchira

the Ayurvedic system of treatment and Ayurvedic medicines may increase MFP collection, though the tribesfolk may not carry out the collection. The middlemen in the business of Ayurvedic medicines and their raw materials may enter in the field as is already happening in certain areas. Intensive collection of MFP and medicinal plants may even within a short period of less than five years cause serious quick degradation of forests (Vide Appendix I).

Poaching

Apart from the extent of the forest area and its flora, forest degradation also affects its fauna. Forest areas with their floristic wealth provide the appropriate ecological habitat for several interacting fauna. There are characteristic fauna particular to each forest type. Moreover, the various fauna present in a forest ecosystem have their unique ecological niches as well. Conversion of evergreen and moist deciduous forests affects sustenance and breeding of fauna characteristic to these areas.

Poachers also contribute to forest degradation particularly of its fauna. It is found that poaching affected the populations of deer, *veruku*, wild pig, rabbits, etc. The number of poachers and the intensity of their poaching activities are shown in (Table 5.3).

Table 5.3 Number of poachers and poaching

Area	1960s	1970s	1980s	1990s
Malakka	2 poachers (weekly)	5 poachers (fortnightly)	5 poachers (monthly)	Nil
Pullamkandam	4 poachers (weekly)	8 poachers (fortnightly)	4 poachers (monthly)	Nil

The number of poachers seems to have been gradually decreasing from 1980; at present there are only very few instances of poaching in these areas. However, the easy availability of wild animal meat at bars and restaurants compels us to believe that poaching still continues unabated in the sanctuary area. Recent newspaper reports disclose that poachers with unlicensed guns are getting apprehended from the adjoining Chimmnoy Wildlife Sanctuary. All these indicate that poaching is exerting some biotic pressure on the fauna of the study area.

Rock-mining

Rock-mining imparts considerable pressure on the forests directly by decreasing the forest area and indirectly by polluting the area with rock waste and leftovers of explosives. Noise pollution is caused by the bursting of explosives. Vehicular transport in and around the forests is also a serious threat to forests. Rock-mining was started at the Pullamkandam beat of Pattikkad range in 1967. The demand for rock as bollard, metal etc., for house and road construction and for sea walls is so high that the number of quarries has risen from one in the 1960s to eight in 1998.

The number of quarry workers has also increased phenomenally from six in 1967 to 90 in 1990. Rock- mining is a seasonal work, which has its peak during October-May. There are large numbers of workers including women employed in occupations related to quarrying such as preparing 11/2" to 6" metal for road work and reinforced concreting. All these workers usually reside in the vicinity of quarry areas and exert some sort of biotic pressure on the plantations and the nearby reserved forests. There are chances that many quarry workers have later turned encroachers into forest areas. Their demand for fuel and other forest produce exert various types of biotic pressures.

For rock-mining the Forest Department collected Rs 90 per lorry load by way of charge for issuance of pass during the 1990s. Such passes actually heralded new vistas to encroachers and intruders. Political affiliations of workers' unions are so powerful that rules and regulations on conservation of forests remain largely ineffective. At present about 45 loads of rock are being transported almost everyday during October-May. Currently, Forest Department has increased the pass rate almost doubling it to Rs 170. Rock-mining would continue to attract potential encroachers to the vicinity of quarries. Vote bank politics and the brutal power of the working class unions make the forest staff helpless in their discharge of duties. Only ray of hope is the reduction in the number of quarry workers from 90 to 64 the others having moved to urban areas for loading work where the rates are higher (Table 5.4).

Evaluation of forest degradation

The biotic pressure exerted on the fauna and flora of forests is not easy to assess and quantify with any degree of accuracy. An attempt was made in this direction by giving appropriate scores to different types of disturbances that are noticeable in the forests visually. The visual grading system, though not fault-proof, gives some idea regarding the presence/absence of various types of disturbances and their relative magnitude. It essentially would give a comparative picture of biotic disturbances and would help in the planning of programmes for long-term conservation.

Table 5.4 Quarries and quarry workers

Particulars	1967	1970s	1980s	1990	1998
Number of quarries	1	1	2	5	8
Number of workers	6	15	32	90	64*
Rubble (loads)	2	6	14	30	45
Gate pass	-	Rs. 10/-	Rs. 30/-	Rs. 90/-	Rs. 170/-
Daily wage	Rs. 9/-	Rs. 15/-	Rs. 40/-	Rs. 60/-	Rs. 130/-

*Others migrated to local towns

Visual grading system

Grazing, firewood collection, disturbances caused in the collection of fodder by wild pig, MFP collection, manure collection, and fire occurrences are included in the visual grading system. Fire occurrence may be due to natural reasons or action by encroachers or inhabitants in the vicinity. Four sites viz. Kuthiran, Attoor, Peechi, and Varikkulam were selected for visual grading; 10 quadrats of 2m X 2m were laid out and observed bimonthly, for a span of one year. Scores were given to each incidence of the types mentioned above and a cumulative total calculated for each plot.

The overall disturbance pattern of each area is given in the pie charts 5.6.1, to 5.6.4. They clearly indicate that degradation due to grazing is the highest at Attoor (45 per cent) and the lowest at Varikkulam (20 per cent). This is due to intensified goat-farming now prevalent at Attoor and the high prevalence of stall - feeding at Varikkulam. The situation at Kuthiran is almost similar to that of Attoor while that at Peechi lies in-between.

Like the case of grazing, firewood collection is also reported more from Attoor (35 per cent) followed by Kuthiran (28 per cent), Peechi (26 per cent) and Varikkulam (20 per cent) in that order. Disturbances caused by wild pigs seem to be of the same level (8 to 11 per cent) at Kuthiran, Attoor, and Peechi. However, it is a major type of disturbance at Varikkulam. The establishment of a forest station at Kurichikkara, and the vigilance watchers posted at these areas might have had a deterrent effect on the use by poachers of licensed \ unlicensed guns in this area. The number of poachers and the frequency of poaching have also come down considerably after the 1990's. It is evident that wild pig population is increasing particularly at Pullamkandam.

Fire occurrences have been reported only from Peechi and Kuthiran areas. These areas are more prone to encroachment and chances are that the fires are set off by encroachers.

MFP is found to be collected from Varikkulam in greater magnitude (10 per cent). It is 7 per cent from Kuthiran and 4 per cent each from Attoor and Peechi. Larger number of instances of manure collection have been reported from Peechi (17 per cent); instances are lower in Varikkulam (10 per cent) and Attoor (8 per cent) (Figures 5.9 to 5.12).

Figure 5.9 Forest degradation at Kuthiran: Visual grading system

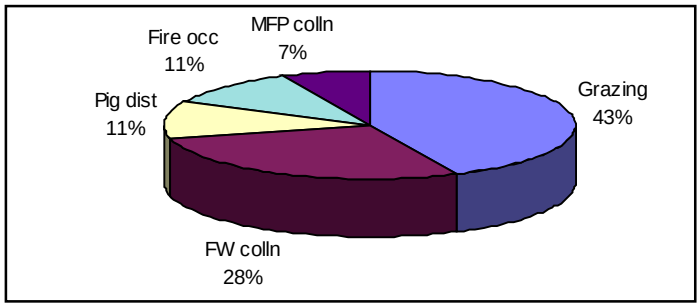


Figure 5.10 Forest degradation at Attoor: Visual grading system

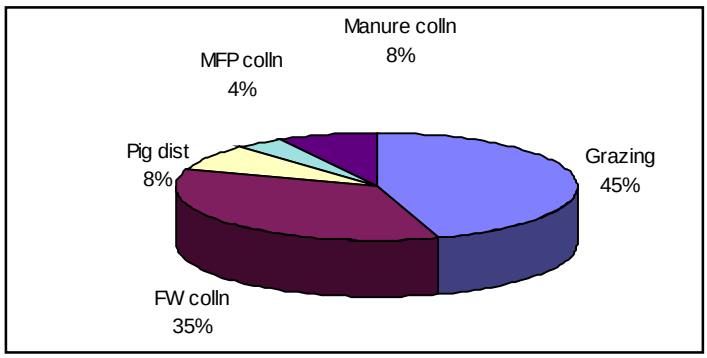


Figure 5.11 Forest degradation at Peechi: Visual grading system

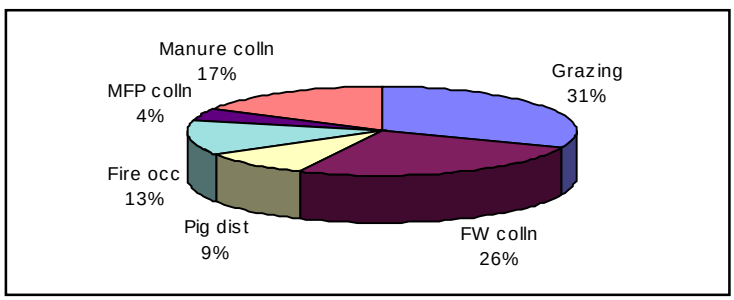
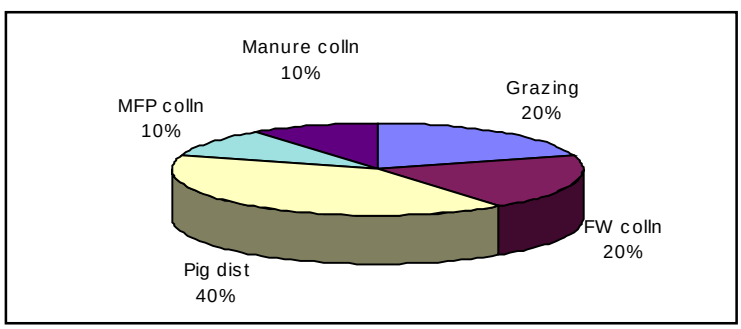


Figure 5.12 Forest degradation at Varikkulam: Visual grading system



Grazing constitutes an important factor for forest degradation in Attoor, Kuthiran and Peechi. Firewood collection also seems to be important in the above areas. Manure collection is noticed at Peechi and Varikkulam in greater quantities. Grazing and firewood and manure collection should be controlled if the degradation processes of these areas have to be brought under check. Fire occurrences are more frequent in Kuthiran and Peechi and MFP collection in Varikkulam. Hence, steps should be taken to regulate these activities on a long-term basis to control forest degradation.

Tribesfolk

Tribesfolk, a section of the population traditionally involved in collection of MFP and medicinal plants constitute a significant sector of the forest-dependent community. PRA conducted at Thirumani, Kalappara, Kakkinikkad, and Olakara gave valuable data regarding this category. The first three sites are situated adjacent to the sanctuary boundary while Olakara is a tribal colony located deep inside reserved forest. Tribesfolk naturally prefer livelihood from forest-related produce as they are not familiar with or rather not accustomed to ordinary agricultural practices and related semi-skilled jobs.

The number of tribal households is gradually increasing except at Kakkinikkad where it got reduced to 7 (the number decreased from 15 during the 1960s to 7 during the 1990s; the decrease was due to out-migration of a few households to Poovanchira). At present, there are 18 tribal houses at Kalappara, 33 at Thirumani, and 32 at Olakara (Table 5.5). Their literacy rate is 11 at Kalappara, 9 at Thirumani, and 6 at Olakara. A higher literacy rate is observed at Kakkinikkad (57). Average landholdings of those at Kalappara are 45 cents; at Thirumani it is 10 cents, at Olakara 20 cents, and at Kakkinikkad 75 cents.

Table 5.5 Tribal houses selected for studies from Peechi-Vazhani Wildlife Sanctuary area

	Tribal Houses			
	1960s	**1990s**	**Literacy per cent**	**Land Holdings**
Olakara	13	32	6	20 cents
Kalappara	11	18	11	45 cents
Kakkinikkad	15	7	57	75 cents
Thirumamni	14	33	9	10 cents

However, this increase in tribal houses does not imply increase in the number of persons involved in MFP collection; on the contrary, the number is coming down. The number of persons involved in collection of MFP and medicinal plants got reduced from 30 to 20 at Thirumani, from 38 to 18 at Kalappara, and from 22 to 1 at Kakkinikkad during the period 1960-1990. However, at Olakara only a marginal reduction in their number is seen i.e. from 28 to 24. Therefore, a sizeable sector of Olakara Tribal colony is still dependent on MFP collection as the chief source of income (Table 5.6).

Table 5.6 Tribal men involved in MFP/medicinal plant collection

Area	1960–'70	1971- '80	1981- '90	1991-'99
Olakara	28	60	50	24
Kalappara	38	45	30	18
Kakkinikad	22	20	12	1
Thirumamni	30	50	40	20

The quantity of MFP collected during 1997-'98 also shows this variation. It has been estimated that about 10,820 kg of MFP have been collected at Olakara against 105 kg at Kakkinikkad. At Thirumani and Kalappra it is 7540kg and 4320 kg respectively (Table 5.2).

The data collected from persons involved in collection of MFP and medicinal plants during the past three decades clearly show that there has taken place a decrease in their number. This decline in the extent of forest-dependency must have had a positive influence in the biotic pressure on forests. However, recently, in response to rising demand, local wholesale dealers employed non-tribesfolk for MFP and medicinal plant collection. Their activities, especially the intensified collection of particular materials like *Asoka* bark (*Derris sp.*), have resulted in large-scale destruction to certain sought-after species. Fluctuations in local demand for MFP and plant species are also similar at Thirumani, Kalappara, and Olakara. Formerly, during the period 1960–1990, about 100 species/items of MFP had local demand (Table 5.7). But at present only 48 items/plants are being collected from the Thirumani area. Their number is 55 at Kalappara and 68 at Olakara. At Kakkinikkad, only 2 persons are at present involved in MFP/medicinal plants collection and they collect only up to 8 species /items (Table 5.7).

Table 5.7 Medicinal plant collection by tribesfolk* - No. of species collected

Period	Thirumani	Kalappara	Kakkinikad	Olakara
1960s	105	101	109	98
1990s	48	55	8	68

Vide Appendix I

MFP/Medicinal plant collection by tribesfolk and by non-tribesfolk should be evaluated in different perspectives. From experience, it is evident that tribesfolk and the weaker sections usually do not exploit the resources completely from any particular area. This is because they expect the same resources in future years as well.

The regeneration potential of the forests is strong enough to see that marginal exploitation of MFP/medicinal plants by tribesfolk makes little impact on the quality of the forest. But, greedy and destructive collection by the other, non-tribal sectors (employed by local wholesale dealers) exploits the forest so ruthlessly that all the produce is forced away in a short period, i.e., in less than two years. The regeneration potential of forests will not be sufficient to nullify or overcome the damage caused by such wanton exploitation. This practice has already resulted in total disappearance of certain common species. Though these species are not altogether extinct, their over-exploitation if continued on the present scale may result in

complete extinction of *Diospyros ebony, Derris eolata*, etc., in the near future. Collection of bark from certain *Derris spp.*, locally known as *Asoka* bark has resulted in the drying up of several tall trees of the species at Pullamkandam (plate 1). Of late, the Forest Department has taken stringent measures in this direction that culminated in the seizure of state transport buses in response to strong public protest.

The tribal population rearing livestock exclusively depends upon forests for grazing. Table 5.8 shows the present livestock population owned by tribesfolk and their mode of feeding.

As all these livestock are totally dependent on forest for grazing, they exert tremendous biotic pressure. Total dependency on forests is possible because of the tribesfolk's proximity to forests; non-availability of other sources of fodder to them is due to their practically low socio-economic situation.

Table 5.8 Tribal households and livestock

Area	Houses	Houses possessing livestock			Mode of feeding
		Houses	Cows	Goats	
Olakara	32	3	1	0	Grazing
		6	0	4	Grazing
		1	0	11	Grazing
Kalappara	18	1	2	0	Grazing
		5	0	15	Grazing
		1	0	12	Grazing
Kakkinikad	7	1	1	0	Grazing
		1	0	12	Grazing
		1	0	18	Grazing
Thirumani	33	1	2	0	Grazing
		3	0	3	Grazing
		1	0	13	Grazing

Source: Socio-economic survey

6. Forest Degradation in the Past Four Decades, 1950-1990

Forest degradation is a continuous process taking place on varying scales except in the inaccessible parts of the forest. No forest area is free from exploitation though its degree varies from place to place as well as from time to time. However, monitoring and quantifying of forest degradation even in a small area is a Herculean task.

Forest degradation is quite visible in the case of clear felling. Teak, eucalyptus, and other plantations raised in such clear-felled areas have eventually reduced the species richness at the understorey level. Moreover, monocultures face, in the long run, threats of infection, chronic diseases, and reversals in microclimatic variations. This type of degradation affects the quantity of natural forests, as every plantation, apart from the revenue it may yield, is a loss in terms of species richness, biodiversity, and other ecological parameters.

Forest degradation in terms of quality is difficult to estimate. Though qualitative degradation of forests is difficult to measure, its impact is not insignificant.

Population density of Kerala, which rose from 435/sq. km in 1961 to 749/sq. km in 1991 has been a factor for reduction of per capita forest area. The reduction in the total area under forest has reduced per capita forest area further. Exploitation of forests by the ever-increasing population together with the grazing pressure exerted by livestock has degraded the forest wealth.

Attempts to estimate degradation are constrained by several factors: non-availability ity of reliable records for earlier decades, changes in the administrative boundaries (e.g: formation of new *panchayats*), etc.

Participatory Rural Appraisal

In the above context, data were collected using PRA techniques. Direct observations (land use changes) semi-structured interviews, key informants (individual interviews), group interviews, mapping, timeline and ranking were utilised to gather data from people involved in collection of firewood, manure, MFP, medicinal plants, etc. Encroachers and settlers in and around the sanctuary area, poachers, and administrative staff (Forest Department, *panchayats*, etc.) were also interviewed for the same purpose (Plates 3 & 4).

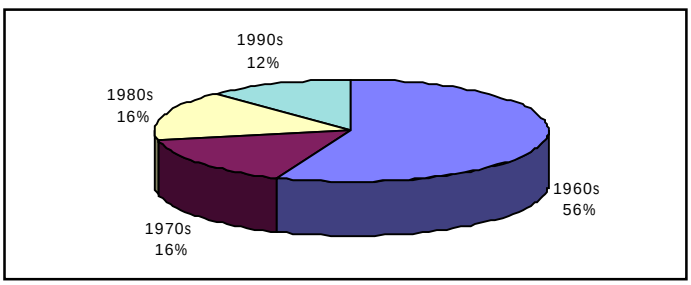
Encroachers/ settlers

The majority of the encroachers and settlers are inmigrants of the early 1950s. Inmigration continued up to the latter half of the 1960s. Philip Paulose (75 years) and U.P. Yohannan (72 years) of Kundukad had migrated during the 1940s, in 1946 and 1948 respectively. M.P. Varghese (70 years) of Elanad migrated in 1952 and Thankamma (62 years) of Kundukad in 1954. According to Puthiyaveettil John (72 years) of Kundukad, encroachers were mainly from the Travancore area and their migration was rendered easy by unification of the erstwhile Kochi and Travancore states in July 1949.

The Grow More Food Scheme of the post-Second World War years and the hill paddy scheme of the government, comparatively lower land value in Kochi and Malabar areas than in Travancore, the taciturn attitude of the Forest staff towards encroachers, etc., made conditions ideal for in-migration of people from Travancore. The early encroachers felled trees from the forest for house construction as well as for firewood. At the time of their settlement, the area was thick forest with plenty of wildlife including tiger, elephant, sambar, spotted deer, and wild boar.

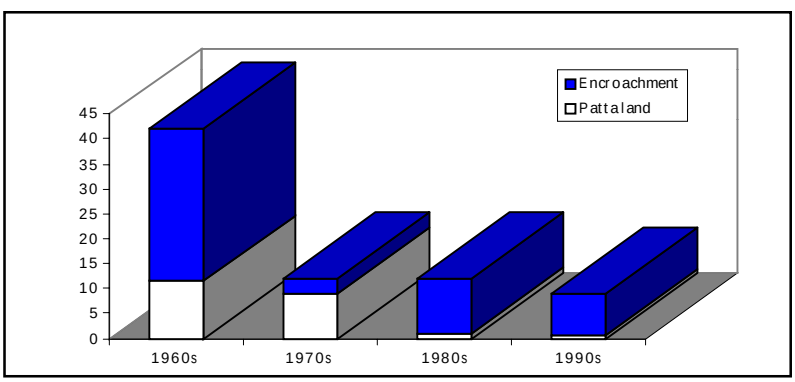
Several influential landlords of Thrissur had farmlands near the forest boundaries. They also encroached forest areas with the connivance of forest officials and sent their *kudiyans* to settle down in their forest encroachments to ward off wild animals from destroying crops. The *kudiyans* began, in turn, to make their encroachments in forest areas. Thankamma (62) encroached nearly 24 acres of forest area with the connivance of some forest officials related to her. The government leased forestlands earmarked for raising teak plantations to people for rice and tapioca cultivation. This also helped the encroachment process (Figure 6.1).

Figure 6.1 Encroachments and new settlements at Pullamkandam



Further investigation showed that of the 25 households of Pullamkandam area 56 per cent settled during the 1960s 16 per cent each during the 1970s and the 1980s and 12 per cent during the 1990s. It is seen that 27 per cent of the encroached lands of the1960s were made legal by issuing *pattayams* to the occupants. Large tracts of forestlands are still in the possession of encroachers without any valid records for occupation (Figure 6.2).

Figure 6.2 Patta lands and unauthorised occupations at Pullamkandam



The situation in the 1960s was quite different from that of the 1990s. New encroachments are not allowed now; but some do take place with the tacit support of forest staff and politicians. All sections of people agree that the forest boundary has moved one to five km towards the forest interior during the past four decades.

Agriculture

The early settlers made ample use of the fertile black soil of that period for rice cultivation. *Kattamodon, Karuthamodon, Cheera, Thavalakkannan,* and *Malabar kutty* were some of the varieties cultivated. *Chama*, horsegram, redgram, sesamum, yams, and colocasia were also cultivated. They had their own cattle for ploughing and green manure was used as organic fertiliser. The frequent forest fires also provided ash. Abundant rains after the forest fires enriched the fertility of the soil when the flooding rainwater washed off substantial quantities of forest fire-ash to the plains lower down. These conditions were quite congenial for rice cultivation. The family size was so large that when some members were busy with agriculture, others took care of the livestock. Moreover, labour was also available in the agriculture sector at low wage rate. The availability of sufficient water facilitated rice cultivation.

Verghese (70 years) of Elanad and Yohannan (72 years) of Kundukad opined that decrease in rice cultivation set in after the 1970s. Repeated rice and tapioca cultivation, by turns, in the same lands, turned the black soil in to a non-fertile, reddish type. Use of chemical fertilisers instead of green manure, non-availability of seasoned and skilled agriculture labourers, rising cost of maintaining cattle for ploughing, rise of wage rates, all these turned agriculture, particularly rice cultivation, uneconomical. Cultivation of plantation crops began to attract farmers and large tracts of rice fields got converted to coconut or arecanut plantations. This was followed by increase of rubber plantations in water scarce areas. Of late, intensive cultivation of plantains has also begun.

Livestock

In the early 1950s and 1960s livestock-rearing was considered an integral part of the agricultural system. Rice cultivation depended heavily on livestock for ploughing and for supply of dung for manure. The hay, a byproduct, became, in turn, the main fodder for livestock supplemented by bran, etc. At Thrikkanaya some households used to maintain up to 60 buffaloes each. In those days, grass was also available in plenty. Rice being a seasonal crop, there were a few months between two crop seasons when rice lands could be used for grazing of cattle. Workers were available for cattle grazing at extremely low wages. Moreover, there were no restrictions to grazing of cattle in the forest area.

Decline of rice cultivation toppled the balance of this highly efficient system. Agricultural labourers were siphoned off to the construction sector, the area of rice cultivation dwindled and the maintenance of livestock for ploughing and other agricultural operations became uneconomic. The number of buffaloes and oxen drastically declined during the 1980s. Reduction in the extent of grazing pastures and difficulties in pursuing the conventional grazing practice in the forestlands further diminished the livestock population. The number of ani-

mals maintained on grazing got reduced and those on stall-feeding increased. People who earned a living partly from rearing cattle and partly from agriculture had to shift to other non-conventional areas of occupation.

Goat-farming

With the sharp decrease in the number of cows and buffaloes during the 1980s, the number of goats progressively increased. The decrease in the extent of rice cultivation resulted in a proportional decrease in the local availability of hay, the main fodder for cows, buffaloes, and oxen. As a result, attention shifted to goats and goat-farming has been on the rise.

Some households in the area had up to 40 goats each during the 1940s. The average size has now come down to less than 20. Goats are reared predominantly by grazing them on forestlands.

Firewood/charcoal collection

During the 1960s, large numbers of people were involved in firewood collection. Hundreds of workers especially women earned a living from this occupation. Poverty of the weaker sections and the *laissez-faire* attitude of the forest officials were also some of the main reasons for the widespread increase in firewood collection during this period. Certain weaker sections like *Kumbarans* (potters) were actively involved in firewood collection when they had leisure time from their traditional work of pot-making. At present, they have to track for about 8 km into the forests to collect a headload of firewood, whereas it was about only one km a couple of decades ago. Firewood collection has turned out to be uneconomical in recent years. Firewood is collected from trees such as *Maruthi, Irumullu, Chadachi, Punna, Kaini*, and *Venthekku*. The price of firewood per headload has risen from about Rs 7 during the 1960s to Rs 80 during 1995.

Charcoal preparation was quite common during the 1950-1960 period. Many workers earned a living by converting Irimul and other suitable timber to charcoal. Charcoal was in wide demand especially in teashops where suitable boilers were used. Charcoal collection was widespread in Vazhani - Chelakkara Enkakkad areas. However, charcoal preparation as a profession, decreased since the latter half of the 1980s and has virtually disappeared during the 1990s. Forest officials were very vigilant in the prevention of charcoal preparation in forests.

MFP collection

MFP collection is a source of living for the weaker sections in general and the tribesfolk in particular. Forest officials usually do not intervene in the collection of MFP. However, collection of honey, wax, etc., is only seasonal and tribesfolk who are engaged in collecting such MFP traditionally, are entitled to get a pass for such collection from the Forest Department. They give, as a practice, MFP to societies, which purchase MFP. MFP include *Mukola, Edampiri, Nagadanthi, Chethiveru, Kurunthotti, Kallorila, Moovila, Orila, Cheruthekku, Kattuthippali, Palmuthakku, Shathavari kizhangu, Naruneendi, Padakizhangu, Koduthoova, Chembravalli, Amalpori, Moovila, Cheenikka, Marottikka, Urulinji*, and *Edana*.

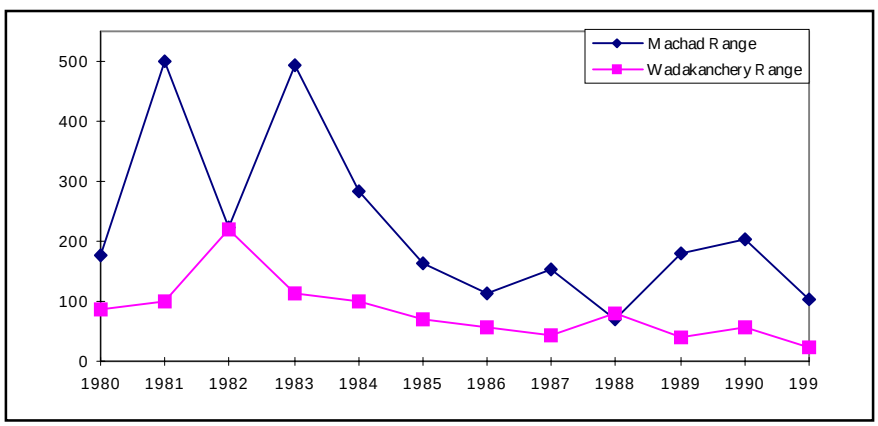
MFP collection has reached new dimensions recently. Certain local men employ 5-8 persons for wider collection of plant/products of local demand. Such intensive collection of MFP may cause complete extinction of certain species in that area and constitute a threat to people traditionally involved in MFP collection.

There are also some weaker sections involved in the collection of bamboo, reed, cane, etc. for mat-weaving and basket-making. Their number is fast dwindling. Some sections collect manure, but this activity is seasonal.

Forest management

Forest protection staff of the government was meagre in number during the 1950s compared to the demand for services. Protection of nature and natural resources was not a policy of the then governments. It became a matter of great concern only in recent decades. Food scarcity of the post-World War II years compelled the governments to implement the Grow More Food scheme and lease out virgin forests to farmers to produce food. The implementation of the Hill Paddy Scheme paved way for more encroachments. The Forest staff connived with these encroachments under the pretext of promoting the Grow More Food scheme. If the government had implemented forest conservation measures in the early 1960s and the 1970s, forest degradation could have been prevented to a large extent.

Figure 6.3 Cases booked in Machad and Wadakanchery Ranges (1980s)



The registers maintained at Peechi, Pattikkad, Machad, and Wadakanchery range offices were examined to find out the major forest offences against which action was taken. It is found that the number of cases booked at Pattikkad and Peechi ranges have been falling steadily since 1980. A corresponding decline in the loss sustained is also observed, except during 1997 in the Peechi range.

Social forestry

Some of the Social Forestry programmes were particularly aimed at the production of fuel wood. Schemes such as Rural Fuelwood and Rural Level Employment Generation Pro-

Figure 6.4 Cases booked in Peechi and Pattikkad Ranges (1981-1997)

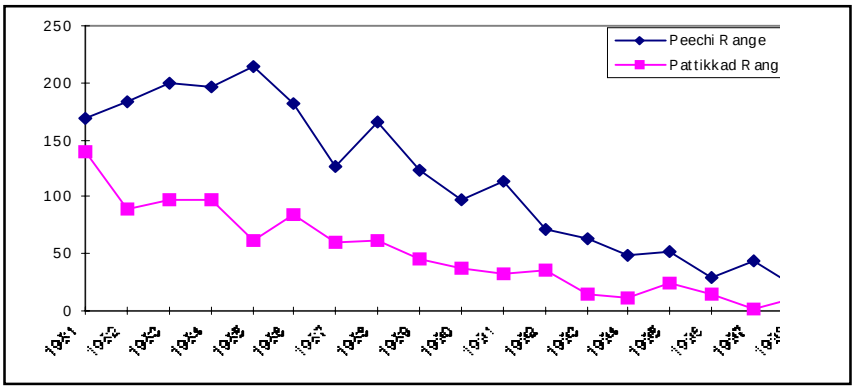
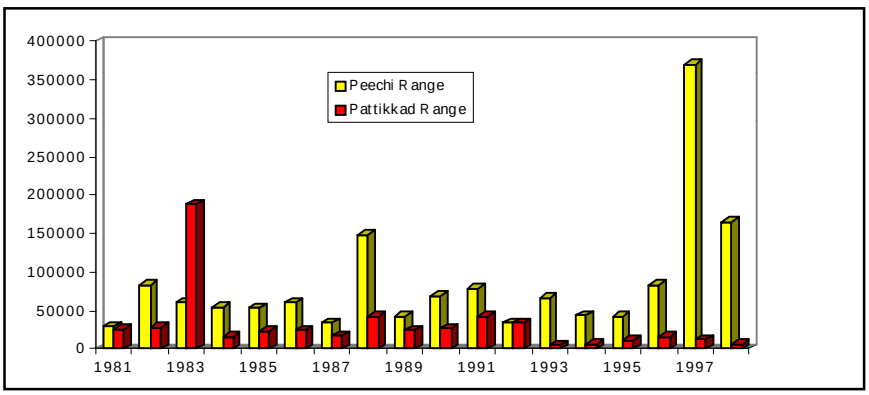


Figure 6.5 Loss sustained in Peechi and Pattikkad ranges (1980-1997)



-gramme (RLEGP) were implemented in the Peechi Range in the latter half of the 1980s. The important species selected for planting included *Ailanthus triphysa (Matti), Acacia spp., Eucalyptus spp.*, and *Artocarpus hirsutus* (*Anjili*). Such belt plantations, quite successful in the control of encroachments, extend up to 75 hectares. However, the fuelwood extracted from such belt plantations were not available to the rural public unless exploited by them stealthily. During the period 1998-1999, 434 metric tons of Eucalyptus worth Rs 2,13,698 was auctioned to private companies.

Though the belt plantations were effective in controlling encroachment in places adjacent to the sanctuary area, they were not found to reduce the degree of forest-dependency particularly with regard to firewood and manure. The above schemes were actually envisaged for the benefit of the rural poor, but these benefits did not reach them directly. Social Forestry programmes are therefore in urgent need of review and revamping so as to reduce the degree of forest-dependency of the villagers. People's Planning would be an ideal alternative to the existing strategy.

7. Joint Forest Management, People's Planning Programme, and Beyond

Forests are now used by a wider variety of people than ever before. It is quite natural that conflicts arise between the different types of users and the forest rules, making their implementation increasingly complex with the passage of time. There was a time when forests were so abundant that marginal exploitations could be ignored. It is only in recent decades that awareness to the threat of over-exploitation of forests has become widespread. In the past few decades, the demand on forest resources has increased several-fold due to population pressures and indifference to exploitation on the part of the government. There also prevailed a few fallacies in vogue about forest protection such as the following:

(i) Forest protection can be ensured by the Forest Department if they are given wider powers and weapons and more staff.
(ii) Sustainable forestry can be achieved without ensuring sustainability of forest-dependent communities.
(iii) Forests and agriculture are two independent and mutually exclusive Land Uses.
(iv) Wildlife can be managed in isolation.
(v) Man-made forests can be developed without ensuring sustainability of forest-dependent communities.

In these circumstances, "Tropical Forest Management has to be reinvented; it has to be Tropicalized, Indigenized, and Humanised." (Shah; 1998)

Traditionally, forests in India were being managed through scientifically prepared working plans, prepared on the assumption that sustainable yield and silvicultural requirement of prominent species of a forest tract are the prime considerations. Though the working plans were based on sound silvicultural principles, they did not keep pace with changing perceptions and conditions in the forestry sector to the extent desired.

Despite the fact that forests have been managed for the welfare of the society, the importance of involvement of people in forest-management was categorically emphasised only recently (National Forest Policy; 1988)). Finally it is being realised that afforestation of degraded forest on a watershed basis with total participation of people would be more effective for ecological restoration than raising of plantations by the Forest Department.

Exotic species: Monocultures and environmental costs

Production of industrial wood occupied the central stage and the Forest Development Corporations were created in all the States accordingly. This paved the way for clear-felling and the practice of monocultures in the form of plantations. Introduction of exotic species like Eucalyptus and Acacia were not palatable to environmental groups/ NGOs and marked the beginning of conflicts between Forest Department on the one side and ecologists and environmentalists on the other. Shah (1998) openly admits, "The Department (Forest) could not provide any convincing scientific data to support their claim. This resulted in a considerable loss of credibility of Forest Department over the country."

Social forestry

Social forestry projects of World Bank, USAID, CIDA, and SIDA, and ODA-aided massive tree planning programmes should be evaluated in this background. When social forestry was conceptualised and implemented it was anticipated that the tree lands so created on waste-lands would ultimately provide the basic needs for the rural people and thus reduce the existing pressure on forests. Unfortunately, this failed to materialise (Shah: 1988; Jarnail Singh: 1955; and Sreedharan and Sarkar: 1998).

Forest policies in India revolved around certain catchwords viz., 'Follow the Nature', 'Change the Nature', 'Conservative Intervention' and then to 'Aggressive Intervention'.

Joint Forest Management

Joint Forest Management is actually an offshoot developed from the widely perceived limitations of the conventional 'Scientific Forest Management System'. The conventional system was not able to cope with the ever-increasing human and livestock population pressures, industrialisation, urbanisation, and overall economic development. It essentially failed to understand and satisfy the forest-dependent rural communities whose activities were causing degradation of forests on an ever-increasing scale. It is now understood that the long-pending problems of forest degradation and deforestation can be tackled effectively only with effective and meaningful involvement of local communities. Hence, the need to evolve a sustainable Forest Management System.

Monocultures and even mixed plantations are only futile attempts in this direction. Sreedharan and Sarcar (1998) view that "Plantations could not provide much of essential intangible benefits like fertile soil, pure water, fresh air, etc. which forests otherwise provide to the neighbouring local people. Even the direct benefits like small timber, fuel wood, fodder, green manure and MFP were also not immediately available to the local population for their use. It has been realised that afforestation of degraded forests on a watershed basis with total participation of locals would be the best way for ecological restoration rather than raising plantations by the Department". The stress has now shifted from plantations to afforestation by participatory forest management.

Participatory management

Duinker (1998) defines public participation as a situation wherein people other than resource managers are invited to give opinions on matters pertaining to forest use and management. He further observes that public participation is still maturing in practice in Canada. However, finding the right mix of benefits to satisfy all forest users and the general public is impossible without direct involvement of people in the planning process. Such an approach was lacking in our country for long.

Social forestry being a rural development programme will not be successful without the participation of people. Conflicts in this area are mainly due to the non-involvement of the local people, as they were not taken into confidence. As noticed in a Ugandan case study

(Obua, et al. 1998), the attitude of the local people living adjacent to forest reserves reflects suspicion and mistrust of forest management policies. Lack of communication between forest officials and local people creates resentment and negative attitudes among the public towards forest management.

Singh (1996) had observed that "The Bible of participatory management cannot be written, rather it should be unwritten. Continuous understanding between people and Government machinery is required for harmonious, sentimental, emotional, and social relations for the cause of environment and people themselves". He further warns that care has to be taken at each and every stage as the rural people are still poor and illiterate and their decision can be influenced by pressure groups of vested interests.

Degradation of forests and other natural resources was not due to dearth of laws. For example, Government of India has banned diversion of forestland for non-forestry purposes since 1980. Clear-felling of natural forests has been completely banned since 1981, though there were selection-fellings till 1987. Selection-felling was also stopped in 1987. Further, salvage-felling of trees standing even in the encroached forests were stopped in 1988; the Kerala Preservation of Trees Act (enacted in 1986) curtailed the over-exploitation of certain important timber species standing in private holdings as well. The above Act also checked the wanton destruction of ecologically sensitive forest areas notified under the Act.

The Indian Forest Act (1927) recognised grazing in the reserve and protected forests as an offence. According to Section 70 of the Act, a Forest Officer has the same powers of a police officer for the purpose of seizing and impounding the offending cattle that might have trespassed into the reserved forest. He can follow the offending cattle up to any distance, and not merely a reasonable distance, from the area into which the trespass might have been committed by the cattle in order to seize them and take the cattle for impounding them. And in doing so, if he is forcibly opposed, the person who does so becomes liable to be punished under Section 24 of the Cattle Trespass Act (1871). Section 70 of the Indian Forest act (1927) Section 11 and 12 of Cattle Trespass Act (1871) states that cattle trespassing in reserved forests or any portion of protected forests and even the cattle damaging public roads, canals, and embankments shall be, or cause them to be, sent to the nearest pound. Besides, under Section 12 of this Act there is a provision for penalising the forcible opposition of seizure of trespassing cattle or rescuing it by force.

What was lacking is the will to implement the laws and planning on the part of administration. The alienation of the rural public, who ought to be the main beneficiary in any developmental process, from the decision-making bodies at all levels, served only to defeat the purpose of the legislation. The officials underestimated their role in development. Their niche has to be redefined, particularly in a situation where "Foresters are fighting a losing battle to save whatever still survives as forests". Large-scale encroachments still take place, encouraged and abated by vested political interest; large-scale illicit fallings are on due to the prevailing poverty; there is poaching of endangered animals because people are not actively associated, empowered, and made partners in the development process. There is widespread inertia and mistrust among the participating agencies.

Role of *panchayats*

During the second half of the 1990s, it is acclaimed that planning has been shifted from high-placed bureaucrats to rural *panchayats* in Kerala. This change should cater to the demands of the rural population as the programme is titled People's Planning Programme. High literacy rate, particularly among women, imparts an atmosphere favourable for the success of such a programme in Kerala. Identification of areas demanding immediate intervention, resource mapping to estimate the potentialities of the *panchayat*, implementation of the projects under the actual supervision of people's representatives, eliminating the *binami*/contractor system - all these are considered to be the merits of the new programme and people have shown genuine interest, zeal, and enthusiasm towards it. However, over-exploitation of projects by the political activists, suppression of facts, lack of a suitable monitoring system to verify and audit expenditure, and the absence of a vigilance machinery to control and prevent possible instances of corruption are cited as some of its deficiencies. However, as this programme is only in a formative stage, suitable rules and regulations may come up in due course of time. The role of *panchayats* in solving the problems of deforestation and degradation of forests has to be redefined in this background.

***Panchayat* forests**

As early as 1923, the government had handed over large areas of scrub forests for meeting the requirements of villagers in the form of fuel, small timber, and grazing. One of the main conditions of the agreement entered into between the Government and the *panchayats* was that the latter would carefully manage the forests and increase their capital value year by year (Nair: 1948). These Forest *Panchayats* were brought under the control of the Revenue Department. A scheme was envisaged to form the forest *panchayats* with the District Forest Officers of the respective districts as presidents and the Collectors as the ex-officio presidents. Further, a regular and comprehensive scheme of planting was drawn up under the direction of the District Forest Officers and the *Panchayats* were entrusted with the working of the scheme.

In course of time these forest *Panchayats* disappeared, either by conversion into plantations or succumbing to encroachments. The pasture lands earmarked entirely for that purpose were also encroached upon. Even the boundaries of supposedly 'well-marked' plantations were not free from encroachments. In that background the cairns constructed of boulders in the margins of reserved forest were avoided. The condition of the presently well-constructed cairns using cement and rock are not free from destruction and / or displacement either. The Forest Department is now contemplating of establishing forest boundaries using satellites; currently it is presently attempted in the Machad Range of Thrissur Forest Division. Several cases of encroachments were not defended successfully in the concerned courts of law due to lack of irrefutable evidence in the records of the Forest Department on forest boundary. There were instances of forest officials even conniving with, or otherwise facilitating, the plunder.

Shahbaz Ahmad (1988) complains that the prevalent concept (of participatory management) "envisages a host of activities of forest areas with the local groups and organisations strug-

gling with the government organisations as if there is a liberation movement." He stresses the need for a government that makes decisions for social well-being and does not absolve itself of its responsibilities to the different sections of the society.

Panchayats should take an active part in bringing the government and the people together. They should mitigate the defects of the beaurocratic approach and red tapism inherent in the centralised administrative system on the one hand and tone up the practically less controlled and under-accounted public participatory system of yester years, on the other. *Panchayats*, must, through the People's Planning Programme, ensure that the funds allotted reach the actual beneficiaries and are properly utilised by them.

Panchayat Forestry Programme

A new *Panchayat* Forestry Programme (PFP) would be desirable in this context. The barren areas in the *panchayats* might have been estimated in the resource-mapping exercises undertaken under the People's Planning Campaign. *Ayalkkoottams* should be selected particularly from the wards adjacent to forest lands and beneficiaries identified for distribution of products. Benefit-sharing in terms of firewood, fodder, and green manure, grazing and collection of MFP should form the ingredients of a suitably formulated social service programme. The selection of species for planting should be done in accordance with the requirements of the local people as well as on ecological and environmental considerations. Training should be given to the beneficiaries in the *Ayalkkoottams* for planting and other plantation procedures. A *Panchayat* Forest Council (PFC) should be formed in line with the Village Forest Council (VFC) functioning in Tamil Nadu.

The land area required for such PFC to function may not be extensive. A notable and successful attempt in this direction is noticed in the Puthur *panchayat* of Thrissur district.

In areas where sites suitable for planting are not easily available, attempts may be made in liaison with the Forest Department for leasing out abandoned plantations (areas which the Forest Department found uneconomic due to poor growth and development and hence abandoned). These abandoned plantation areas could then be successfully utilised for the activities of PFC under the People's Planning Programme.

Considerable funds have been found to be allocated to *panchayats* for Social Forestry especially for raising plantations. In a discussion with Madakkathara *Panchayat* authorities, it was found that about Rs 1 lakh is currently available for this purpose. It will be ideal to raise nurseries in wards adjoining forests/ plantation boundaries. Such locations will be suitable for the forest-dependent communities and they could be, though only seasonally, employed in such nurseries. They could be employed also in the afforestation programmes of the Forest Department. The programmes and the related activities would reduce the extent of forest dependency of these communities significantly.

The products of PFC viz., firewood, fodder, green manure, and areas earmarked for grazing will reduce forest-dependency of other sectors too. What is required is a holistic approach involving the identification of forest dependent communities, suitable employment to them in nurseries, fodder cultivation, production of green manure and MFP, afforestation pro-

grammes of *panchayats* and the Forest Department, job opportunities in other areas selected for PFP and usufructs-sharing of the PFP programme.

A *Panchayat* Forest Council may be constituted from senior citizens, NGOs, teachers of nearby colleges and schools interested in such projects, representatives of *ayalkkooottams* selected for PFP, ward members of *panchayats* and appropriate persons from *panchayat* administration. Sreedharan (1988) claims that in Tamil Nadu "Interface Forestry Programme implemented with the participation of the people have brought about sea-change in tackling the problems associated with degradation and protection of forests. The destructive causes that were responsible for degradation of forests like goat browsing, excessive cattle grazing, illicit felling and head load removal of firewood, setting off forest fire, etc., have been considerably reduced in those areas".

It is heartening to note that there is a move to set up People's Vigilance Committees with local MLA as Chairman, the Forest Range Officer concerned as Secretary, and local people and activists as members. The Assembly Committee on Environment even recommended to the Government to legislate for making the punishment for destruction of forests "as severe as for murder". Quite in line with the state policy, a similar committee, *Panchayat* Vigilance Committee (PVC), would be desirable at the *panchayat* level especially to register and monitor cases of encroachments, clear-felling, and removal of trees from reserves and plantations, poaching, etc. These activities are increasing both covertly and overtly. Encroachments taking place even a few km near to Forest Range Offices and removal of teak from plantations quite near to Forest Stations are cases in point. The PVC would offer a solution at the *panchayat* level like Ombudsman or Consumer Court at higher levels. Statutory powers should be extended to PVC for its smooth functioning without interference from Government Departments.

The PFP and beyond

The *Panchayat* Forest Council (PFC), the supposed forerunner for *Panchayat* Forestry Programme (PFP), has certain limitations. Sreedharan *et al* (1998) admits that the programme implemented in Tamil Nadu lacked transparency. Further, watersheds were not treated holistically without regard to the ownership patterns of the lands concerned.

Duinker (1998) mentions while discussing the progresses in forest-decision making in Canada, certain principles, which though not guaranteeing success, are certainly necessary for it. They include (i) openness, fairness, and inclusiveness in selection of participants, (ii) clear mandate and purpose, (iii) professional design and facilitation, (iv) informal but structural process, (v) design for positive outlook for problem solving, (vi)variety of techniques, (vii) clear influence on decision-making, (viii) sufficient time and supporting technical resources, (ix) keeping decision-makers informed throughout, and (x) reasonable and realistic expectations.

He is quite emphatic that "nothing can sour a public participation process faster than participants' suspicion that decisions are predetermined and their input will not be considered. Participants deserve to see exactly how their contributions will be used in formulating decisions."

Limitations of *panchayats* and creation of HRMS

Measures to reduce forest dependency in a particular *panchayat* will not produce the desired effect on deforestation and degradation of forests of the Sanctuary area since it comprises several *panchayats*. Moreover, it has been opined in certain quarters that "The track record of *Grama panchayats* has indicated that this institution has somehow failed to provide equal opportunities to villagers and communities which are socially, culturally, and economically diverse. *Grama panchayats* are institutions in which Government control persists in terms of finance and resource management powers such that the legitimacy of the local leadership and traditions of collective decision-making are not in place." *Grama panchayats* are state-sponsored village level bodies for self-governance and hence there is need to develop a people's institution other than *grama panchayat*. The Hill Resource Management Society (HRMS) created in Haryana is such a people's institution. HRMS is constituted of adults of both the sexes recruited from all the households in a hamlet, a village or a group of villages (which may or may not coincide with a revenue village or a *grama panchayat*) and which are located within or near forest areas.

An HRMS of the above nature will be ideal for complete protection and management of the sanctuary area. The *panchayat* administration being partially, or even totally, politically controlled, there are chances of reversals in policies and priorities. A committee that had shown adequate importance to environmental problems may not be succeeded by another with the same outlook and farsightedness. Hence, an apex body other than *panchayat* administration would be desirable to chalk out programmes and their implementation over a longer period, 10 years or more. However, this society should contain representatives from every *panchayat*; only then would it reflect the will and the discretion of the people thereby ensuring its smooth functioning.

The study thus suggests the following for the control of deforestation and degradation of the forests of the Peechi-Vazhani Wildlife Sanctuary.

Deforestation

(i) Formation of PFC (*Panchayat* Forest Council): A committee should be constituted and empowered to register cases of encroachments, tree-felling, poaching, grazing, and offences of similar nature and to see that appropriate action is taken against encroachers \ trespassers at the initial stage itself thereby avoiding problems of eviction \ management. This committee should contain officials from Forest \ Police and Revenue Departments of the area concerned.

(ii) Formation of PVC (Public Vigilance Committee): For smooth and fair working of the PFC, a PVC should also be constituted of senior citizens, school and college teachers interested in such areas, NGOs, political activists, etc., in order to report cases of encroachments and other offences to the Government officials concerned (through PFC) and to see that proper action is taken against the offences in time.

Formation and functioning of PFC and PVC would be quite in line with the activities of the

People's Planning Programme. Both the committees may work in tandem to monitor forest offences with people's support; and it will be easier to tackle forest offences this way than was the case earlier.

Degradation

Compared to deforestation, degradation is a silent killer of forests and if allowed to operate unchecked might eventually result in total deforestation. Hence, measures have to be taken at different levels to curb deforestation.

Identification of Forest-dependent Communities (FDC)

The main reason for forest degradation is evidently poverty of the forest-dependent communities (FDC). Immediate steps are necessary to identify FDCs particularly in areas adjacent to forest reserve and plantations.

Shifting of FDCs to other sectors

From the experience of the past 50 years, it is clear that degradation will not be checked or controlled exclusively by rules and regulations. Suitable provisions should be made in *panchayat* planning to give job opportunities to FDC and utilise their potential in afforestation programmes. FDC may be effectively employed in forest nurseries and in other planting programmes. Considerable funds are now earmarked for nurseries and social forestry and this programme is currently managed by the *panchayats* themselves.

Leasing out of abandoned plantations and other forest/revenue lands

Several land areas in the state remain barren in the form of wastelands, abandoned plantations and common lands (Revenue *Purampokes*). These areas may be successfully utilised to generate resources that are at present extracted from forests.

Firewood/fodder/manure/MFP production

The chief source of cooking fuel in rural areas is still firewood and people depend upon forests and plantations for firewood. Dependency on forests for this requirement is quite high in terms of quantity; it can be averted by cultivating fast-growing fuel-wood species. *Cassia siamea* and *Cassia spectabilis* have been found to be successful in China for use as fuel-wood (Zhang Jianhou, Min Cao:1995). Attempts should be made to identify species suitable to our conditions. Planting in smaller areas like canal banks and roadsides may also be considered.

About 20 years ago, there were schemes to popularise green manure production in farmlands by planting stems of *Glyricidia* (*Seemakonna* in Malayalam). Such schemes should be rejuvenated and cultivation of manure-yielding and fodder plants extended to abandoned areas. Barren areas may also be used for production of MFP.

Identification of beneficiaries in the initial stages themselves would help in sharing the re-

sponsibility of development of fuel wood, manure/fodder-yielding plants, etc. The administrative agency needs only to monitor the programme at convenient levels.

Production of firewood, manure, fodder, MFP, etc. in areas other than forests would reduce the amount of biotic pressure on forests. The job opportunities generated, if given to FDCs, would produce a double benefit i.e., prevention of the FDCs from entering the reserved forest and production of alternative resources.

The government of Tamil Nadu handed over several plantations to *panchayats* in 1987 and the revenue generated by the sale of plantations raised under the Community Wasteland Development Programmes was shared between the Forest Department and the *panchayats* in the ratio 40: 60. In Kerala, this pattern may be adopted with suitable modifications, i.e., 40:10:50 between Forest Department, *panchayats,* and villagers (beneficiaries).

Rearing of pigs and rabbits

Rearing of pigs/rabbits by FDCs would cater to their need for meat, which used to be met by poaching. It might reduce poaching to a certain extent. Verification of licensed guns by Forest/ Police officials on a quarterly or half-yearly basis would prevent misuse of licensed guns. Further, through PVC, poaching may be brought under control effectively by the people themselves reporting the use of unlicensed guns thus helping their seizure.

Creation of HRMS

A Hill Resource Management Society (HRMS) should be created constituting the representatives from every sector of the FDC and representatives of the *panchayat*. Specialists from the College of Forestry and ecologists from research institutes, universities and colleges may be co-opted to the administration of such societies as technical experts/consultants. The society may take up projects of medium duration (i.e., 5 years or more) and manage the development of landscapes. Ten per cent of the funds generated through PFP may be contributed to HRMS for their functioning and further funds may be made available through State and Central assistance. HRMS should also create own funds for implementing rolling plans.

8. Conclusions

Forest degradation is a cankerous killer, which proceeds gradually and stealthily so that during any short period of time (viz. a few weeks or months) it would appear insignificant. However, activities like collection of firewood, manure, timber, MFP, etc. would in the long run become detrimental to forests. The impact of forest encroachments that reduce forest area is more visible and measurable in quantitative terms.

The present study conducted in wards 2 and 10 of Madakkathara *panchayat* and in ward 13 of Pazhayannur *panchayat* has revealed the root causes of the problem. Scarcity of food after the Second World War period, Grow More Food Schemes implemented by the then Governments, lethargic attitude of the then forest officials towards encroachments, connivance by the government officials with the encroachers and poachers and indiscriminate issue of *pattayams* to encroachers and settlers at regular intervals are some of the links in the chain of the process of forest degradation.

The local administrators remain rather oblivious of the various demands of the people living adjacent to forest areas. In consequence, the level of forest dependency of such communities steadily increased. Forest and *panchayat* officials report that no effective steps have been taken to reduce their forest dependency till date. However, in certain cases the farmers themselves have focused alternative sources for firewood and manure.

Forest degradation can cause far-reaching changes in the eco-system. Unless it is controlled by short term and long-term measures, it would become a formidable problem threatening the ecology and the lives of people. Introduction of exotic species for plantations, ignorance of or indifference towards the requirements of the population living along forest boundaries and implementation of plans and programmes lacking concern for the needs of the common man are some of the drawbacks of the Social Forestry Programmes. These problems can be effectively tackled through people's active participation. People's planning launched in the state holds promise for such participation. The major factors for forest degradation and the various short-term and long-term measures suggested for its control are given in Table 8.1.

The implementation of these measures at the local level, particularly at the level of *grama panchayat,* would effectively solve the problem of forest degradation.

Table 8.1 Forest Degradation: Major causes and short-term/long-term measures for control

Forest degradation		
I - Degradation in quantity	**Causes**	**Consequences**
i. Forest areas to plantations	Political decisions, Five Year Plans & Policies	1. Decrease in biodiversity & Species richness
ii. Forest areas under encroachments	Political support and connivance by the Forest Department - Regular issue of *pattyams*	2. Monocultures unsuitable in dynamic weather conditions. Forest fragmentation effects (a continuous strip of forest is better than more broken patches covering greater areas, in the conservation of species and hence biodiversity)
II - Degradation in quality		
i. Grazing	1. Socio-economic conditions of forest dependent communities (FDC)	Decrease in regeneration potential (Development of new generation of plants) leading to decrease in biodiversity and species richness. Such areas may be converted to savannah type forests in the near future.
	2. Non- implementation of laws checking grazing in public and private properties	
	3. Non- implementation of cattle pound system.	
ii. Firewood Collection	1. Socio-economic conditions of FDC.	Firewood collection may not affect regeneration potential but it will promote other activities like bark collection, charcoal preparation, and poaching.
	2. Non-availability of alternate fuels.	
	3. Unrestricted forest trespass and collection of firewood.	
	4. Lethargic attitude of the forest officials.	
iii. Manure collection	1. Lack of alternate sources	Decrease in regeneration potential
	2. Non-implementation of forest trespass laws.	

iv. MFP collection	Socio-- economic conditions of FDC.	Decrease in regeneration potential and biodiversity. Over exploitation may lead to complete extinction of certain species.
v. Poaching	1. Non- implementation of forest trespass laws in the strict sense.	Decrease in the population of fauna
	2. Connivance by the Forest Staff.	
vi. Rock mining	1. Socio-economic conditions of FDC.	1. Pollution problems
	2. Lack of alternative job opportunities.	2. Promotion of encroachments and other forest exploitations.
	3. Connivance by the forest officials	
	4. Political support to workers unions.	
Deforestation	**Control measures**	
	1. Formation of *Panchayat* Forest Council (PFC). A council may be constituted of *Panchayat* administration with Forest, Police and Revenue officials to control forest offences viz. encroachments in a participatory manner with the help of government officials.	
	2. Formation of Public Vigilance Committee (PVC) to report and monitor the action taken by the officials. The functioning of PFC in tandem with PVC can check deforestation effectively.	
Degradation	1. Identification and shifting FDC to other non- forestry sectors.	
	2. *Panchayat* Forestry Programme for the production of fuel wood, fodder, manure, MFP, utilisation of wastelands/abandoned plantations, etc., can reduce forest dependency significantly.	
	3. Creation of HRMS. The sanctuary area being encircled by a number of *panchayat*s, an Apex Society may be constituted for the implementation of projects requiring five years or more.	

Appendix-I

Forest Exploitations by Tribesfolk

No	Botanical Name	Malayalam Name	Thirumani			Kalappra		
			b	p	q	b	p	q
1	*Abrus precatorius*	Kunnikuru	*	-		*	-	
2	*Acasia instia*	Incha	*	*	33	*	*	150
3	*Acampe praemorsa*	Maravazha	*	-		*	-	
4	*Achyranthes aspera*	Kadaladi	*	-		*	*	40
5	*Aerva lanata*	Cherula	*	-		*	*	15
6	*Adhatoda zeylanica*	Adalodakam	*	-		*	*	15
7	*Aegle marmelos*	Kuvalam	*	-		*	-	
8	*Ageratum conyzoides*	Appa	*	-		*	-	
9	*Alstonia scholaris*	Ezhilampala	*	-		*	*	80
10	*Aristolochia indica*	Garudakodi	*	-		*	*	20
11	*Artocarpus hirsuta*	Anjily	*	-		*	-	
12	*Asparagus racemosus*	Sathavari	*	*	44	*	*	20
13	*Atylosia goensis*	Kattuzhunnu	*	*	44	*	*	30
14	*Baliospermum montanum*	Nagadanthi	*	*	33	*	*	60
15	*Biophytum sensitivum*	Mukkutti	*	-		*	-	
16	*Bischofia javanica*	Cholavenga	*	-		*	-	
17	*Boerhaavia diffusa*	Thazhuthama	*	*	33	*	-	
18	*Bombax ceiba*	Mullilavu	*	-		*	-	
19	*Butea monosperma*	Plasu	*	-		*	*	20
20	*Calotropis gigantea*	Erucku	*	-		*	-	
21	*Calycopteris floribunda*	Pullani	*	-		*	-	
22	*Casia fistula*	Kanikkonna	*	*	22	*	-	
23	*Casia tora*	Thakara	*	*	154	*	*	160
24	*Centella asiatica*	Muthil	*	*	11	*	-	
25	*Clerodendrum serratum*	Cheruthecku	*	*	44	*	*	40
26	*Clitoria ternatea*	Sankupushpam	*	-		*	-	
27	*Cordia wallichii*	Virimaram	*	-		*	*	20
28	*Cocsinium fenestratum*	Maramanjal	*	*	11	*	*	10
29	*Costus speciosus*	Channakoova	*	*	22	*	-	
30	*Cryptolepis duchananii*	Vallippala	*	*	22	*	*	60
31	*Curculigo orchioides*	Nilappana	*	*	44	*	*	40
32	*Curcuma aromatica*	Kasthuri Manjal	*	-		*	*	10
33	*Curcuma ecalcarata*	Manjakoova	*	*	44	*	-	
34	*Cyclea peltata*	Padakizhangu	-	*	22	*	*	240
35	*Dendrophthoe falcata*	Ithikanni	*	-		*	*	40
36	*Desmodium gangeticum*	Orila	*	*	990	*	-	
37	*Desmodium triflorum*	Nilambaranda	*	*	4	*	*	100
38	*Desmodium triquetrum*	Orila	*	*	100	*	*	20
39	*Dillenia pentagyna*	Punna	*	-		*	*	100

57	*Justicia simplex*	Odichukuthi	*	-		-	-		
58	*Leucas aspera*	Thumba	*	-		*	-		
59	*Malaxis rheedi*	Jeevakam	*	*	22	*	*	20	
60	*Memecylon umbellatum*	Kashavu	*	-		*	-		
61	*Momordica charantia*	Kattupaval	*	*	22	*	-		
62	*Murraya paniculata*	Kattuvepu	*	-		*	*	40	
63	*Mussaenda laxa*	Vellilam	*	-		*	-		
64	*Myxopyrum smilacifolium*	Chathuramulla	*	-		-	-		
65	*Naregamia alata*	Nilanarakam	*	-		*	*	5	
66	*Naringi crenulata*	Kattunarakam	*	-		*	*	4	
67	*Nervilia aragoana*	Orilathamara	*	*	2	*	*	10	
68	*Olea dioica*	Edana	*	-		-	-		
69	*Oroxylum indicum*	Palakapayyani	*	-		-	-		
70	*Ocimum sanctum*	Katuthulasi	*	-		*	-		
71	*Oosbeckia aspera*	Kalampatta	*	-		*	-		
72	*Pavetta indica*	Manjapavatta	*	-		*	-		
73	*Percea macrantha*	Kulamavu	*	-		*	*	40	
74	*Phyllanthus emblica*	Kattunelli	*	*	352	*	*	80	
75	*Piper longum*	Thippalli	*	*	264	*	*	240	
76	*Piper sp.*	Kattukurumulaku	*	*	1	*	*	10	
77	*Plumbago zeylanica*	Koduveli	*	*	176	*	*	40	
78	*Pongamia pinnata*	Ungu	*	-		*	*	40	
79	*Pothos scandens*	Paruvakodi	*	-		-	-		
80	*Pseudarthria viscida*	Moovila	*	*	660	*	*	300	
81	*Pterocarpus marsupium*	Venga	*	-		-	-		
82	*Padermachera xylocarpa*	Vedamkorana	*	-		-	-		
83	*Rauwolfia serpentina*	Sarpagandhi	*	*	220	*	*	50	
84	*Ricinus communis*	Avanakku	*	-		-	-		
85	*Sapindus laurifolia*	Urulinchi	*	*	44	-	-		
86	*Schleichera oleosa*	Poovam	*	-		-	-		
87	*Scoparia dulcis*	Kallurucki	*	*	22	-	-		
88	*Sida acuta*	Kurunthotti	*	*	88	*	*	600	
89	*Sida rhombifolia*	Kurunthotti	*	*	880	*	*	600	
90	*Smilax zeylanica*	Valiyakanni	*	-		-	-		
91	*Solanum indicum*	Chunda	*	*	10	*	*	20	
92	*Spondias pinnata*	Kattampazham	*	-		-	-		
93	*Sterculia guttata*	Kavalam	*	-		-	-		
94	*Strobilanthes sp.*	Karinkurunji	*	*	176	*	*	60	
95	*Strichnos nux-vomica*	Kanjiram	*	*	2	*	*	15	
96	*Tamarindus indica*	Puli	*	*	88	*	*	80	

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