

**STUDY OF PRESSURE AND DEPENDENCY OF LOCAL PEOPLE
ON THE NATURAL RESOURCES OF MUDUMALAI WILDLIFE
SANCTUARY WITH A VIEW TO DEVISING COMPATIBLE
MANAGEMENT STRATEGIES**

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DOCTOR OF PHILOSOPHY
IN
WILDLIFE SCIENCE**

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Dedicated to my grandfather

Late Pt. Jas Ram Silori



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I have great pleasure in forwarding the thesis of Shri Chandra Shekhar Silori titled "*Study of pressure and dependency of local people on the natural resources of Mudumalai Wildlife Sanctuary with a view to devising compatible management strategies*" for acceptance for the degree of **Doctor of Philosophy in Wildlife Science**. The thesis embodies original findings and interpretation of facts. This research was carried out by Shri Silori under my supervision and has not been submitted in part or full to any other University/Institution for the award of any degree.

(B. K. Mishra)

Guiding Teacher

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(Chandra Shekhar Silori)

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CHAPTER 1

1

INTRODUCTION

1.1 Major Conservation Issues in India

Establishment of Protected Areas (PAs) as Wildlife Sanctuaries (WLS), National Parks (NP) and Biosphere Reserves is an age old practice for conserving and regulating the use of scarce wild renewable resources (Lucas, 1990; Child, 1994). Such reserves safeguard many of the outstanding areas of living richness, help to maintain the diversity of an ecosystem, protect genetic variety, are often home to communities of people with traditional culture, have significant scientific, educational, cultural, recreational and spiritual values, and provide major direct and indirect benefits to local and national communities (Rodgers and Panwar, 1988; McNeely, 1994). Nevertheless, the PA conservation issues which still remain unresolved are i) commercial pressure on them in the form of demand for timber; ii) infra-structural development in the form of roads, dams, etc. iii) biomass requirements of people residing within and on the periphery iv) religious and cultural activities; and v) political will to support conservation. The problems get accentuated because of the lack of i) popular public support, ii) a national land use policy, and iii) lack of natural resource budget. Although these are broad national issues, there are site specific problems demanding site-specific management strategies. The major consequences are seen in the form of habitat degradation both in quality and quantity, fragmentation, and thus habitat shrinkage

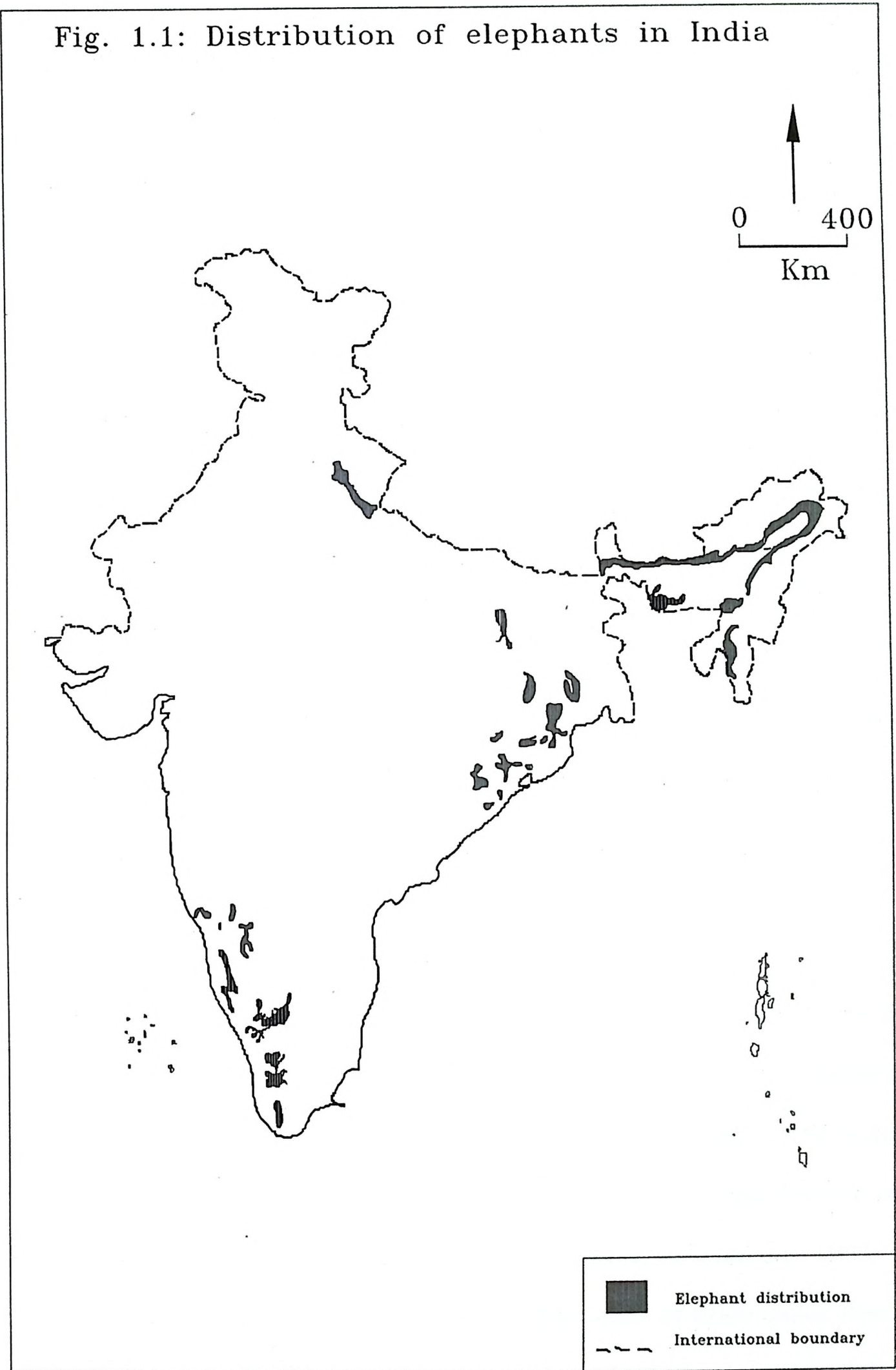
(Marcot, 1992), ultimately leading to the loss of animal and plant species. Although loss of habitat has affected most large mammals, animals like the elephant have suffered more due to large body size and home range, and thus have been restricted to small isolated habitats threatening their very survival.

1.2 Distribution of Elephants in India

The Asian Elephant (*Elephas maximus*), once distributed over a large area of the Indian sub continent (Nair and Gadgil, 1978; Olivier, 1978; Nair *et al.*, 1980; Daniel, 1980; Sukumar, 1985; Santiapillai, 1988), is now reduced to a number of discrete populations (Fig. 1.1), totalling 17,000-22,000 individuals in the wild (Sukumar, 1989; Chadwick, 1994). Of the total elephant habitat (85,250 km²), half is under National Parks and Sanctuaries. Sukumar (1989) has divided the total population into four widely separated populations : southern Indian, central Indian, north-western Indian and Nepal, and north-eastern Indian and Bhutan populations. Each of these populations are isolated because of fragmented elephant habitats.

The south Indian population totalling about 7,000 elephants is distributed in 10 sub regions covering an area of 23,000 km² in the hilly tracts of Eastern and Western Ghats of Karnataka, Tamil Nadu and Kerala (Nair and Gadgil, 1978; Olivier, 1978; Nair *et al.*, 1980; Sukumar, 1985). The Eastern Ghats have the largest population of elephants in south India with an estimated number of 1,800-2,000 elephants distributed over an area of 7,000 km². The continuous elephant tract of Bandipur-Mudumalai-South Wynaad-North and East Nilgiris which covers an area of about 2,150 km² has the second largest population in south India with an estimated number between 1,200 to 1,500 elephants. Sukumar (1985), has

Fig. 1.1: Distribution of elephants in India



Source: Sukumar, R. (1985)

estimated density of elephants in Bandipur-Mudumalai area as one of the highest in India and perhaps in Asia.

The central Indian population is distributed in the states of Orissa, Bihar and south west Bengal (Shahi, 1980; Shahi and Choudhury, 1986). In Orissa about 1,300 elephants are distributed over 12,000 km². At least 335 elephants in Bihar are distributed in three distinct populations i) 65 elephants in 1,000 km² of Palmau Tiger Reserve ii) 200 elephants in 2,250 km² of Singhbhum tract and iii) 70 elephants in 250 km² of Dalbhum tract.

The north-western population of elephant is restricted in four pockets along the foothills of the Himalaya in the Terai Forest region of Uttar Pradesh where the forest divisions of Dehradun East and West, Shivalik, Lansdowne, Bijnor, Kalagarh, Corbett NP, Ramnagar, Terai Bhabar and Haldwani have an isolated population of about 500 elephants (Singh, 1978) and another herd of 25 has been reported from Dudhwa National Park (Singh, 1978).

The north-eastern population is distributed into two sub-regions. As per the records of Arunachal Pradesh Forest Department between 2,000-4,300 elephants are distributed in 10,000 km² of the hilly tracts (Choudhury, 1980). The Assam Forest Department has estimated 1,200 elephants from Manas Tiger Reserve and 400 elephants in Darrang West and East Forest Divisions (Choudhury, 1980). A very good population of elephants is found to the South of Brahmaputra river in isolated pockets. A few other smaller populations have been recorded from Dibrugarh region totalling nearly 200 elephants. A major population of about

1,900 elephants is found in the Kaziranga NP in Assam. Another large population is recorded from Garo and Khasi hills of Meghalaya, where the number is estimated to be between 2,500-3,500 elephants. While Jaintia hills and North Cachar region harbours between 150-175 elephants, in South Cachar and Tripura the numbers estimated are 100-150 and 120-150 elephants respectively. Very low number of elephants have been reported from Manipur and Mizoram.

1.3 Causes of Decline of Elephant Population

The main problems associated with decline in elephant population in India are; i) man's direct impact such as hunting for ivory trade, and killing and wounding for crop protection, and ii) man's indirect impact such as fragmentation and degradation of elephant habitats.

1.3.1 Direct Impacts

(a) Hunting of Elephant

Elephants are mainly killed for ivory and to a lesser extent, for meat. Besides this, farmers also shoot the elephants to protect their crops and themselves. In Tamil Nadu, of the total incidence of elephant death during 1975-1987, while 45% cases were because of poaching, 11% cases were associated with crop defence. During this period in Karnataka, 54% of the total deaths were due to poaching and 4% were due to crop raiding (Sukumar, 1985).

Poaching of male tusked elephants was rampant in south India and also in Assam before 1972 for the ivory trade. However, this got reduced drastically after enforcement of Wildlife Protection Act of 1972. Even then Sukumar (1989), has

revealed that during 1980-1986, 100 male elephants got killed every year by the poachers alone in south India. Tribals of Meghalaya and Mizoram also hunt elephants for meat (Choudhury, 1980).

Selective hunting of male elephant for ivory leads to widening of the disparity in the sex ratio, which may adversely affect the fertility of the population. The presence of a few breeding males in a population can not ensure the successful mating with all the available breeding females, which results in a lower rate of conception and longer calving intervals, reducing the rate of population growth (Nair and Gadgil, 1978).

(b) Crop Depredation

Crop depredation by elephants has been reported throughout their distributional range wherever cultivation encroached upon the elephants habitat (Mishra, 1971; Choudhury, 1980; Sukumar, 1985, 1986a, 1986b, 1989b). While the adult male elephants are usually the most tenacious raiders, family herds at times cause widespread damage when they come in large groups. Herds of up to 70 elephants have been known to devastate crop fields and damage huts in which harvested grains are stored in West Bengal (Choudhury, 1980). Crop raiding is a serious problem in Tamil Nadu, Karnataka (Nair and Gadgil, 1978; Sukumar, 1989) and Kerala. Human killing by elephants is associated with elephant incursion into cultivation and majority of such cases occur within human settlements. Even some of the killings within forests may have their origin near the crop fields, where elephants may be injured by bullets and later turn into

rogues. When elephants affect humans by damaging their crops or killing them, they get killed by the people.

1.3.2 Indirect Impacts

(a) Shifting Cultivation and Spread of Agriculture

Shifting agriculture which is predominant in the north-eastern India (Mishra and Ramakrishnan, 1981; Ramakrishnan *et al.*, 1981a) has done extensive damage to elephant habitat of the region in the recent years. Short *Jhum* cycles of 4-5 years as prevalent now (Ramakrishnan, *et al.*, 1981b) alters the hydrologic and nutrition cycling (Mishra and Ramakrishnan, 1983a; 1983b, 1984), retards forest regeneration and biomass build up (Mishra and Ramakrishnan, 1983c), and proliferates exotic weeds like *Eupatorium spp*, *Imperata cylindrica*, and *Mikania spp* (Ramakrishnan and Mishra, 1981), and thus affects the availability of palatable food species and the habitat of elephants.

The rapid spread of agriculture has created the destruction and shrinkage of habitat. An important past event deserving special mention is the leasing out of land under the Grow More Food Scheme. This has drastically reduced the elephant habitat, depriving the animals of their most favourable localities which acted as store houses for food and water (Basha, 1990). This scheme which was started in 1942, and intensified in 1947 on a large scale, which posed a threat to forest conservation as these localities formed the nuclei for further encroachment in order to expand cultivation.

(b) Habitat Damage, Fragmentation and Shrinkage

The elephant's habitat undergoes serious changes because of the mounting biotic pressure and unplanned developmental activities. People may exploit the elephant's habitat for a variety of plant resources such as fruits, bark, fodder, fuel and timber. Exploitation of timber may not always be carried out according to ecologically sound prescription resulting in devastation of the natural habitat. Over-exploitation of forests resources often results in fragmentation and shrinkage of habitat.

(c) Plantation

The conversion of natural forest to commercial timber or pulp-wood plantation have had tremendous impact on space and food resources of elephant populations. Monoculture plantations of Eucalyptus (*Eucalyptus spp.*), wattle (*Acacia spp*), teak (*Tectona grandis*), and silver oak (*Grevillea robusta*) in southern India are some of the examples (Sukumar, 1989). In Kerala, between 1985-1990 about 16.25% of rich forests were cleared for raising commercial plantation like rubber, oil palm, coffee, cardamom etc. Quantitatively it might be less, but qualitatively it is a very big loss to elephants as their prime habitats were destroyed permanently (Basha, 1990).

(d) Hydro-Electric Projects and Human Settlements

Rapid proliferation of hydro-power projects have displaced elephants from hilly tracts and from the plains by agriculture. Hilly terrain is suitable for the construction of dams across the rivers to store water for generating electricity or irrigating the cultivated lands in the plains.

Dams have had a mixed impact on elephant habitat. On the one hand they have submerged the prime river valley habitats, disrupted traditional movements patterns and fragmented the habitat; on the other they have sometimes provided a perennial water source in an otherwise dry habitat for elephants (Sukumar, 1989). In the Anamalai hills of Western Ghats, a series of reservoirs and associated canals under the Parambikulam-Aliyar projects has hampered the movement of elephants and even been a direct death trap for them. A study done by Nair and Gadgil (1978) in North Kanara district of Karnataka, states that the execution of Kalinadi Hydroelectric Projects and mining for manganese have created lots of disturbances in the forest.

With the rapid developmental activities, human settlements also proliferated along such developmental sites, which has further enhanced the degree of fragmentation and denuded the habitat by exploiting the natural resources for their biomass requirements.

1.4 Population Isolation

Habitat fragmentation has been identified as one of the most critical threats to wildlife which results in the isolation of populations in small pockets. Some prominent examples are found in: i) Rajaji-Corbett NP (Johnsingh *et al.*, 1990), ii) Manas-Buxa Tiger Reserves and iii) Kaziranga-Karbi hills (Johnsingh, 1992). Fragmentation generally leads to the formation of several separate patch populations that are too small to be viable in the long run (Saunders and Hobbs, 1991). Thus the presence of a species in an isolated patch does not ensure its continued existence there in absence of gene flow, which is required to prevent

inbreeding depression from causing extinction (Harris, 1984, 1985; Simberloff *et al.*, 1992). Corridors connecting patches are needed for this gene flow.

1.5 Elephant as a Flagship Species

The elephant is an apex animal, able to influence the direction of development of its biotic environment, by its size and interaction with habitat, particularly in its quest for food, (Daniel, 1980). Elephants, being at the top of the ecosystem pyramid have been affected much as these are wide ranging animals and require habitat contiguity to move freely during all seasons in search of food, water and shelter. Therefore the conservation of such a wide ranging animal is a must as part of the conservation of the entire ecosystem. This was how the idea of project elephant (MoEF, 1993) emerged, on the line of Project Tiger.

1.6 Biological and Ecological Value of Mudumalai WLS in Bandipur-Wynaad Elephant Tract

Mudumalai WLS of Tamil Nadu is located at the tri-junction of three states (Tamil Nadu, Karnataka and Kerala) of peninsular India (Fig. 1.2). The forests of Mudumalai WLS (321 km²), and adjoining forests of Bandipur NP (874 km²), Nagarhole NP (643 km²), Wynaad WLS (344 km²) and Sigur Reserve Forest (RF) (281 km²) form the largest continuous elephant tract (Fig. 1.3), which is rich in floral and faunal diversity (Sukumar, 1985a; Desai, 1991). This forest tract has diverse flora which ranges from dry thorny scrub forest to semi-evergreen forest and that is why it provides ideal habitats to a variety of animal species, the major species being Asian elephant (*Elephas maximus*), tiger (*Panthera tigris*), dhole (*Cuon alpinus*), gaur (*Bos gaurus*), sambar (*Cervus unicolor*), cheetal (*Cervus*

Fig. 1.2: Location of Mudumalai Wildlife Sanctuary in peninsular India

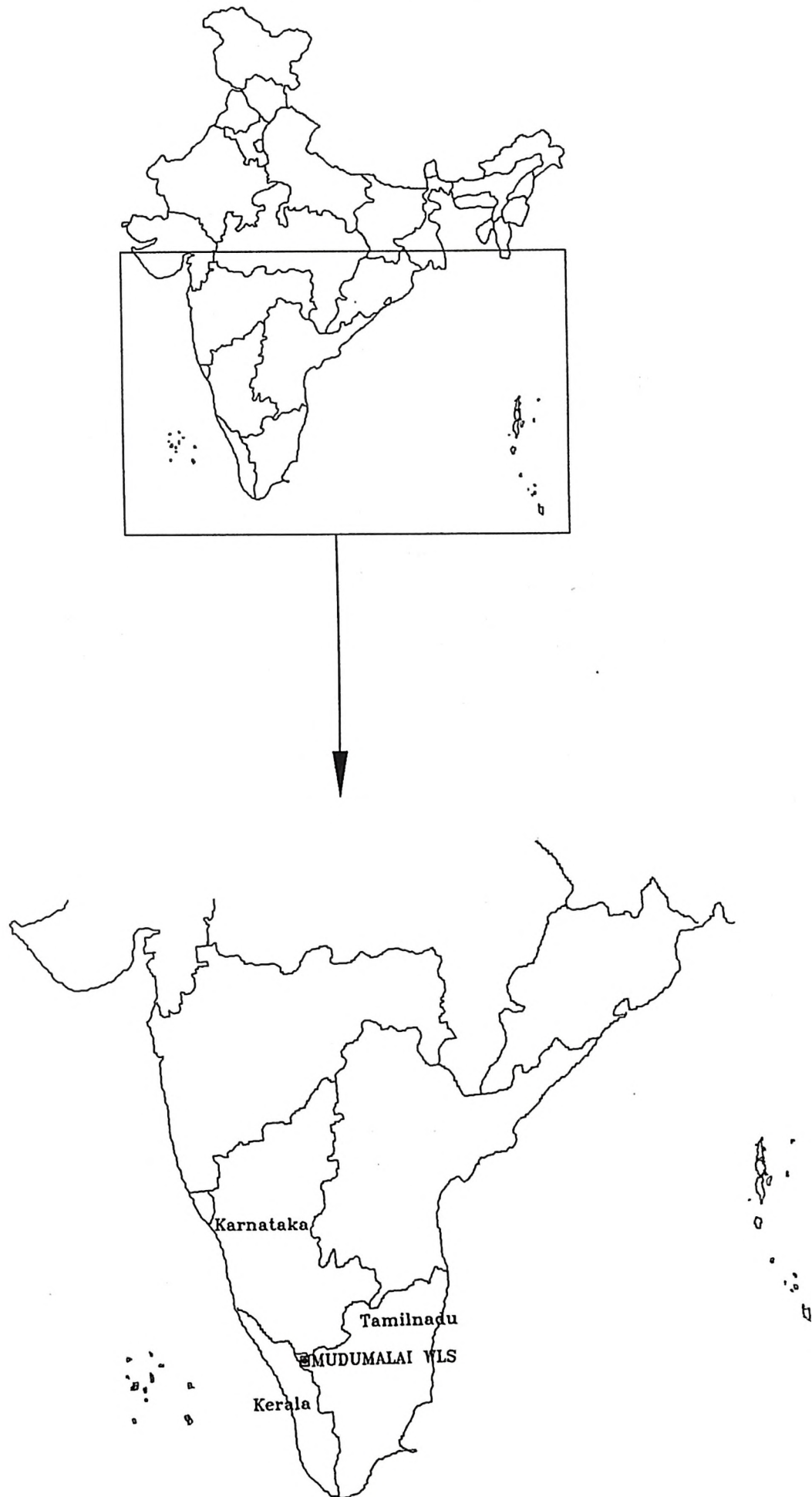
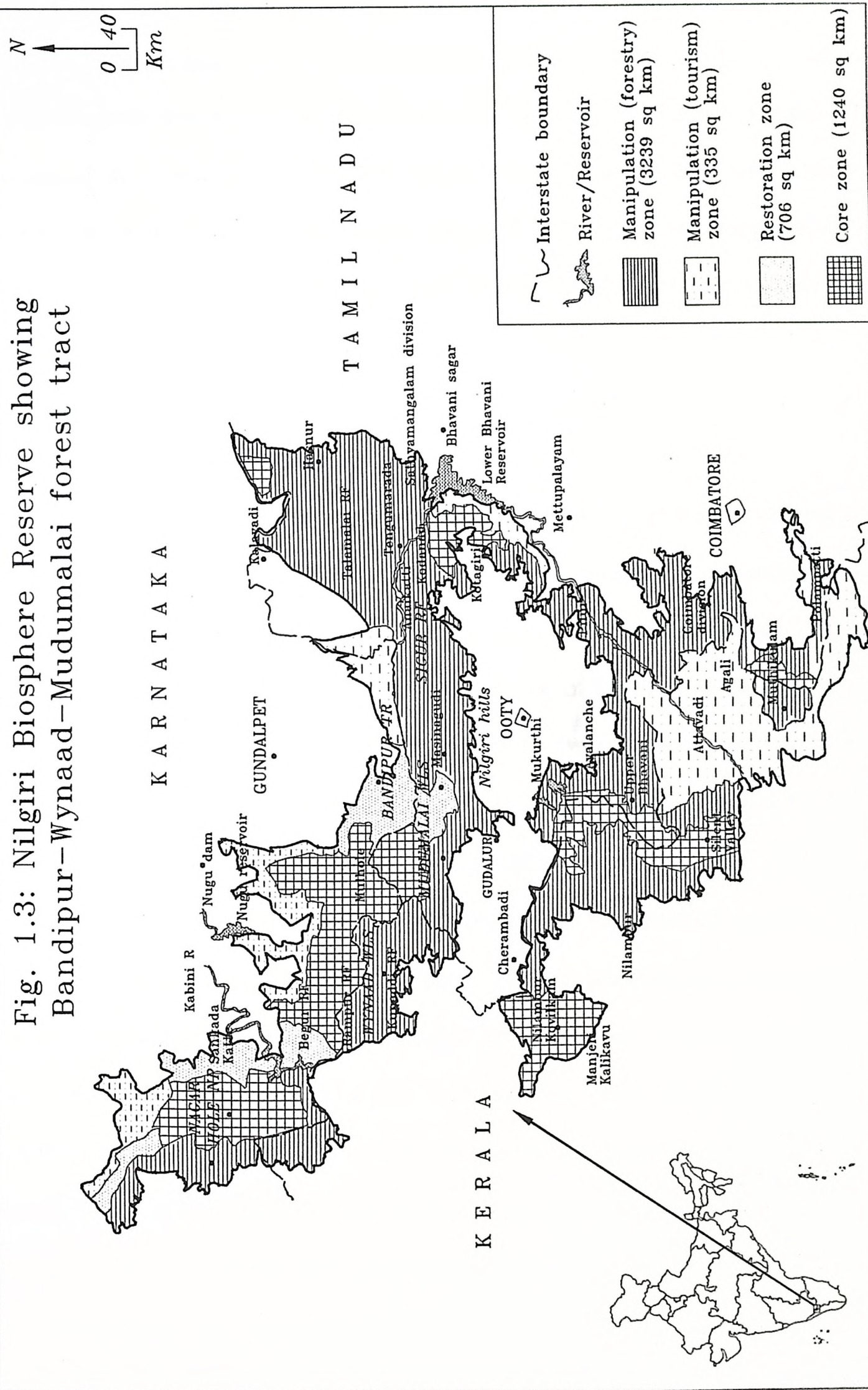


Fig. 1.3: Nilgiri Biosphere Reserve showing Bandipur–Wynaad–Mudumalai forest tract



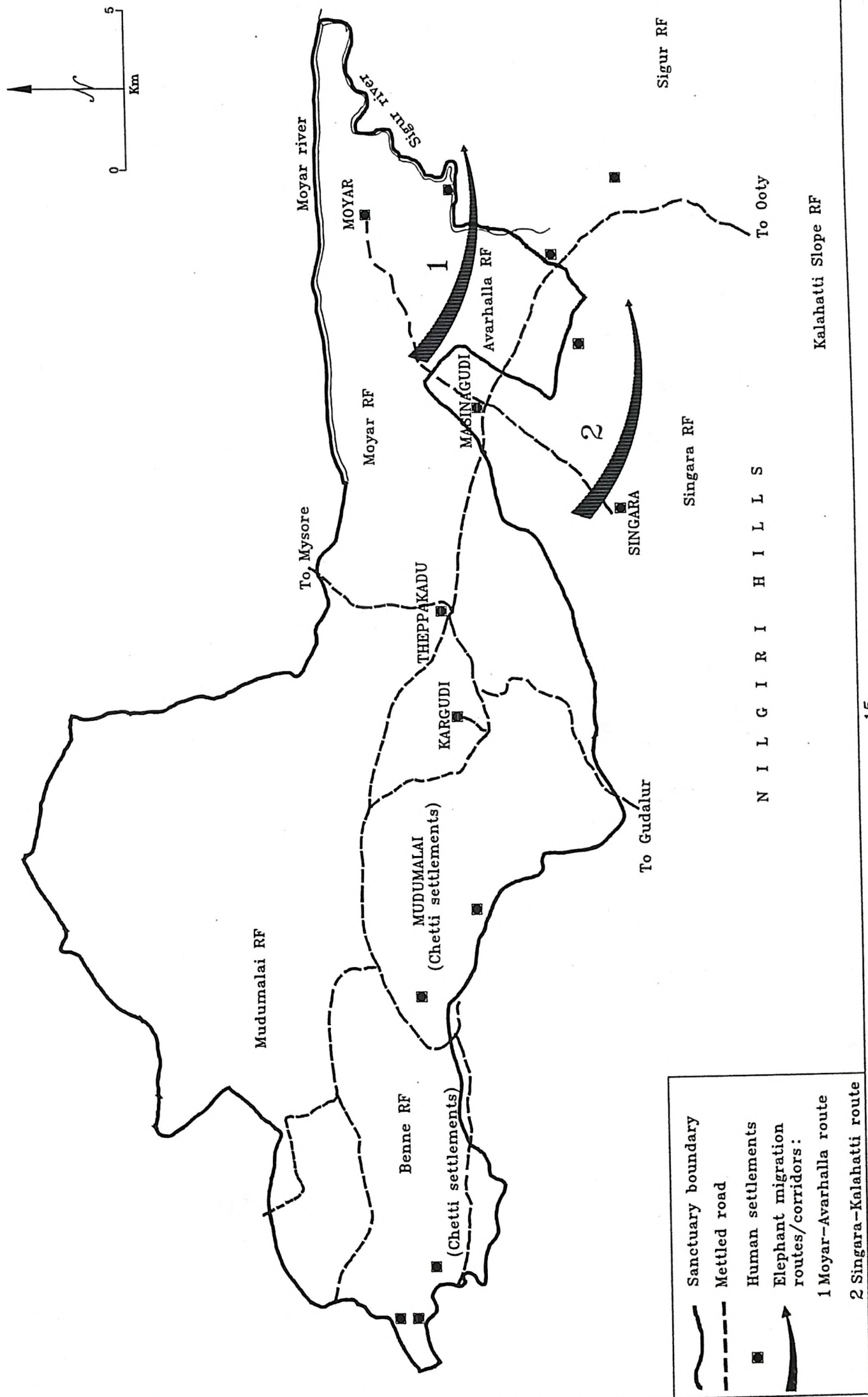
axis), sloth bear (*Melursus ursinus*) and barking deer (*Muntiacus muntjak*). Because of its location and habitat contiguity, Mudumalai WLS plays a vital role in providing the crucial habitat linkage between Western and Eastern Ghats. The Sanctuary is linked to the Eastern Ghats through forest corridors between Mudumalai and Sigur plateau which offer the seasonal migratory paths for elephants (Davidar, 1981; Sukumar, 1989; Desai, 1991). A detailed description of this area is given in Chapter 2.

1.6.1 Conservation Problems in Mudumalai

Conservation problems in general around the Mudumalai area are not very different from other PAs of the country. History of resource exploitation of the area dates back to 1799, when the entire area including Sigur and Wynaad plateau came into possession of British after the fall of Tipu Sultan. They avoided cultivation in this area in the initial phase due to the plateau being considered highly malarial (Prabhakar and Gadgil, 1995). But in the second half of the nineteenth century, they extracted valuable timber which was used as building material in the Nilgiris. Simultaneously the Sigur Ghat was opened up and formed the main route into the Nilgiris from Mysore. Forests were cleared to expand tea and coffee plantations and many seasonal cattle penning sites appeared in the area. Along the Mysore route, a new township had come up at Masinagudi. It provided trade and services to coffee plantations and travellers (Prabhakar and Gadgil, 1995). The situation was further aggravated by major developmental changes in the area in the form of hydroelectric projects on the Sigur plateau in the 1950s with the establishment of Pykara hydroelectric system. The establishment of this system demanded more man power and the ongoing

construction activities further increased the township of Masinagudi; labourers from adjoining states came in search of jobs and later settled permanently on encroached Government land. Eradication of malaria from the area contributed much to the immigration and expansion of human habitation around the forested land. Agricultural areas decreased due to the water shortage and changes in the micro-climate (Prabhakar and Gadgil, 1995); the abandoned coffee estates of Bokkapuram and Singara villages are some of the examples of this. Cattle grazing and selling of cattle dung to the nearby coffee planters were some of the options left for the landless immigrants which resulted in increased livestock population, overgrazing and subsequent degradation of forests. Realising the biological wealth of the area, various categories of PAs were established in this area and the status of these were later upgraded to strengthen protection measures. Even though Mudumalai WLS is free from biotic interference in its northern part because of the presence of Bandipur NP and Moyar gorge, it bears the full brunt of pressure from the people and their cattle (Plate 1) in its southern and south-eastern parts. The corridor forest between Mudumalai WLS and Sigur RF, which is composed of Moyar-Avarhalla Sanctuary Forest (eastern territory of the Sanctuary) and Singara-Kalahatti RF (south-eastern territory of the Sanctuary) (Fig. 1.4) is heavily exploited by the people of Masinagudi and adjoining villages and their livestock. The villagers, who are mainly landless labourers or marginal farmers, collect fuel wood (Plate 2), fodder, timber, thatch and other building material from these forests besides grazing their cattle freely (Plate 3). Selling of cattle dung forms a major source of income for the poor villagers (Plate 4 and 5). In addition to this, the increased tourism in the area in recent years has indirectly imposed pressure upon these forests by building up the fuel wood pressure at an

Fig. 1.4: Elephant migratory routes between Mudumalai WLS and Sigur RF



alarming rate. It may be mentioned here that Masinagudi village is located on the main road linking Mysore and Ooty, and a large number of transit tourists stop here for a while to take a meal on their way, and the local hoteliers still use fuel wood for cooking.

1.6.2 The Perceived Impact

If the degradation of these crucial corridor forests between Western and Eastern Ghats continues to increase at the present rate, this habitat linkage will not be possible in the near future. Viability of these corridors is thus crucial for the long-term conservation of elephant in this area.

1.7 The Present Study

The conservation problems around Mudumalai WLS as described above and the related perceived fear prompted us to undertake the present study on "Pressure and dependency of local people on the natural resources of Mudumalai Wildlife Sanctuary with a view to devising compatible management strategies". This study was funded by the Wildlife Institute of India as one of its research projects.

1.7.1 Objectives of the Study

The present study aims at:

- (i) Investigating the socio-economic and cultural dimensions of the sustenance problem of the local people,

- (ii) Quantifying and analysing the pressure of local people and their cattle on the biomass resources of the corridor forest, and
- (iii) Designing viable alternatives for people so as to mitigate their sustenance problem, as well as reducing pressure upon the resources of the corridor forest and the surrounding elephant habitat.

1.7.2 Current Status of Knowledge and Justification of Undertaking the Work

If the elephant habitat is to be rehabilitated effectively in the eastern and south-eastern part of the Mudumalai WLS, besides improvement in the general protection of the forests, ecodevelopment measures have to be undertaken in the neighbouring areas so as to make the rural ecosystem as self reliant as possible, with a view to mitigate pressures upon the forest. Little work has been done towards achieving this goal and there is a scarcity of literature available on the subject of ecodevelopment research (Mishra *et al.*, 1984; Berkmuller, 1986, Panwar, 1992; Wells, 1992, 1993; McNeely, 1994; Pabla *et al.*, 1995; Rathore and Campbell, 1995).

Research studies undertaken in the field of wildlife science in the last few decades have mainly been centred around status surveys (Ravi Chellam *et al.*, 1994; Mishra and Johnsingh, 1994; Pandav *et al.*, 1994; Athreya and Johnsingh, 1995), breeding ecology (Gopalkrishnan and Choudhary, 1977; Choudhary, 1987), behavioural ecology (Pendharkar and Goyal 1995) and feeding ecology (Goyal, 1981; Goyal *et al.*, 1986; Chundawat, 1990). Understanding of the ecology of the human and livestock population living adjacent to the PAs and their interaction

with wildlife and their habitat had hardly begun (Mishra *et al.*, 1984; Berkmuller, 1986; Panwar, 1990; Wells, 1993). However the recent years have seen better acceptance of the role of scientific research in PA management (Clarke, 1986; Machlis, 1992). Research efforts specifically aimed at investigating the effects of management practices on wildlife and its habitats have also recently been initiated in many PAs.

One of the striking features of the Indian wilderness is the intimate interspersed of human habitations with wildlife habitats. People have traditionally and substantially depended upon the resources in the wild for their sustenance (Gadgil, 1989). With a low man-to-forest ratio until the turn of the century such resource dependence was sustainable and there was no real need for any special measures for wildlife conservation at that time (Panwar, 1990). However, this century has witnessed radical demographic changes. With the growing human population, the land-to-man ratio and forest-to-man ratio has rapidly declined. From 0.20 ha in 1951, the per capita forest has reduced to 0.11 ha in 1981 (Lal, 1989). In the meantime the lifestyles and the biomass resource needs of the forest based communities have remained relatively unchanged. The pressure on the resources in the wild have therefore increased manifold. A majority of the PAs in India are thus burdened with a variety of resource use pressure from marginalised people living in and around them. In such a scenario the resolution of the resource conflict or man-animal conflict is very important for effective management of PAs. The resource dependent people who have already been marginalised from the cumulative abuse and overuse of private as well as common property resources, face considerable problems. The inappropriate and

inadequate rural development inputs have failed to build up the degraded rural ecosystems in the forested regions (Panwar and Mathur, 1991). This situation can be mitigated only by providing viable alternatives through site-specific integrated programmes of ecodevelopment. The conservation of forest areas in general and of the PAs in particular, which is being seriously jeopardized because of irrational land use practices and increasing pressure from the resource dependent people, has to become the main plank of an area specific development strategy which also brings in sustainable land use and economic well being to such people. This however, can only be achieved with the full involvement and participation of local people in the planning and implementation of an alternative package of measures of sustainable and economically productive land use and resource utilization (Panwar, 1990). International development and aid agencies as well as developed countries through bilateral programmes have come forward to support the ecodevelopment programmes in developing countries to help in the realization of the much talked about global concerns for the environmental care and biodiversity conservation.

The pressure of human needs is over taking every sphere of life and the PAs are no exception. It can not be denied that our ability to consolidate field conservation and to expand the PA network for meeting the basic requirements of environmental concerns depends very strongly on our ability to resolve conflicts at the interface between people and PAs. The success in the field of conservation depends on adopting an ecodevelopment approach in managing and strengthening land use in the surrounds of the PAs. The strategy for ecodevelopment envisages reduction in people's dependency upon the biomass

resources of the PAs. This can be achieved partly by promoting sustainable alternative on-farm and off-farm activities which are economically more productive, and partly by providing alternative sources of energy and fodder. Some examples of supplemental measures are: improved animal husbandry practices (phased livestock population reduction and breed improvement), pasture development, rotational grazing, promotion of fisheries with sustainable fishing regimes with full participation of local people and elimination of intermediaries. Alternative cash crops, horticulture, sericulture, agro-forestry, and off-farm activities (handicrafts, cottage industry) can gainfully employ people and reduce their dependence upon forests and other wild lands, thus enabling better conservation. The conservation of biodiversity through a representative PA network very strongly depends on the success of conservation measures which are thus integrated with sustainable rural development. The PA managers need to acquire skills in involving people in the formulation and implementation of coordinate and compatible wildlife management and ecodevelopment.

While evolving compatible land-use strategies and sustainable development practices for the hill tribes of the north-eastern hill region of India, Mishra and Ramakrishnan (1981) have compared and contrasted the economic yield and energy efficiency of agro-ecosystems under slash-and-burn or *jhum* agriculture with that under two other land use systems of the area namely, valley cultivation and terrace cultivation. Jhum cultivation with a ten year jhum cycle has been recommended for the North-East region because of high monetary return and high energy efficiency. Terrace cultivation was found totally inappropriate because of less economic return, excessively high input of inorganic fertilizers, and low life-

span of the terrace inspite of the reduction in soil loss in the initial years of cultivation.

Some in-depth information is also available on dynamic inter-relationship of rural ecosystems and forest ecosystems in the North-Eastern region (Mishra and Ramakrishnan, 1982). The intricate relationship existing between production and consumption compartments of the village ecosystem have been worked out in great detail from both economic and energetic points of view.

A study conducted by Mishra *et al.*, (1984) on the functioning of village ecosystems of the North Kanara district in the Western Ghats of Karnataka has shown how rural needs are inter-related in a number of ways and that this interplay is governed by the resources of land, energy, water, livestock and the human beings themselves. This study emphasised how a thorough understanding of the rural conditions and needs of the people is essential in planning site specific sustainable rural development of an area.

Pandey and Singh (1984), studied the energy-flow relationships between agro and forest ecosystems in the central Himalaya. The study investigates the energy efficiency of agriculture and the viability of agro ecosystems at current levels of agriculture. In an another study, Mishra *et al.*, (1985) have worked out in great detail the biomass production and utilisation pattern of a prosperous agrarian community in the Western Ghats, which responded well to new methods of ecodevelopment specially when faced with the problems of resource scarcity.

Moench and Bandopadhyaya (1986), carried out a case study on rural forest management in Manglori village in the Aglar watershed situated north of Dehradun in the Uttar Pradesh Himalaya. This research was directed at the biomass flow of the village, concentrating on the fuel cycle, the fodder cycle and the yearly migration cycle. Relationship between village biomass consumption and forest productivity are demonstrated.

Monga and Lakhanpal (1988) conducted studies on the energy needs of some selected villages in different topographic zones of Himachal Pradesh.

Nishanka and Mishra (1990) studied the biomass production and consumption pattern of a village on the east coast of Orissa. The major finding of this study was that the agriculture is the major contributor of the total plant biomass to the village ecosystem. The authors suggest that the village ecosystem was in urgent need of local source of firewood which they concluded could be fulfilled by growing energy plantation, and using fuel efficient stoves. Agrawal (1990) have studied the impact of scraping, fire and heavy grazing on the floristic composition and phenology of temperate grasslands of the Western Himalaya. He found that grazing had considerable impact on the herbaceous vegetation, and accelerated soil erosion. Rajvanshi and Gautam (1990) studied the pole cutting pressures and their ecological impacts in Bastar forests in Central India. Results of the study revealed the preference of poles of a particular girth class by residents of all the villages under study. The impact of pole cutting was observed in the form of arrestation of maturation of forests due to failure in recruitment class.

Berkmuller (1988) studied the dependence of local people on the resources of the proposed Rajaji National Park. In another study, Berkmuller *et al.*, (1990) assessed the distribution of human pressure within the Ranthambore National Park.

It has been increasingly accepted that park management policies in some countries should allow for limited access to park resources by the local people to meet their subsistence and cultural needs. However, unlimited access to natural resources of a Park may simply cause people to rely on the Park resources and manage their own lands less intensively than hitherto.

The issue of illegal livestock grazing and fodder cutting in Royal Chitwan NP (RCNP) by local people has been examined by Sharma and Shaw (1993). The study area comprised 16 village units having an estimated human population of 1,48,404 in 21, 621 households. Despite the presence of a large number of armed guards, the data from interviews with farmers indicated that illegal livestock grazing and fodder-cutting in RCNP were prevalent. In the spring season, grazing intensity in the Park was higher than in other seasons, whereas cutting of fodder was intense in both winter and spring seasons. The actual monitoring of 11 patches (totalling 365 ha) of grassland or savanna for a calendar year inside the Park and near its boundary, indicated that illegal grazing averaged 4.1 head ha⁻¹ (3.0 cattle, 0.9 buffalo, and 0.2 sheep/goats). In addition, the livestock biomass was found to be increasing by 2.36% per annum the villages adjoining the Park. There is some evidence that villagers adapt their livestock practices in response

to the availability of (illegal) grazing inside the Park, and fodder removal from the Park.

The pressure for illegal access to Park resources will continue to grow and eventually will exceed the capacity of the resource to recover from harvest. The approach to resolve the illegal livestock grazing issue is neither strict protection nor widely expanded access. The Park should consistently work to induce a gradual behavioural change, on the part of the farmers, to stall-feed livestock with fodder originating from their own farms and/or from community plantations.

The Wildlife Institute of India is currently completing a study engaged in evaluation of habitat status for the elephants in the corridor forests linking Rajaji and Corbett National Parks, as well as people's dependency and resource use pattern on this forest (Badola and Mishra, 1995; Badola and Mishra, 1996).

The present study is thus significant from the point of view of evolving a more disciplined and organised use of the forest resources, which, once implemented will help in rehabilitation of the forest corridors in the study area.

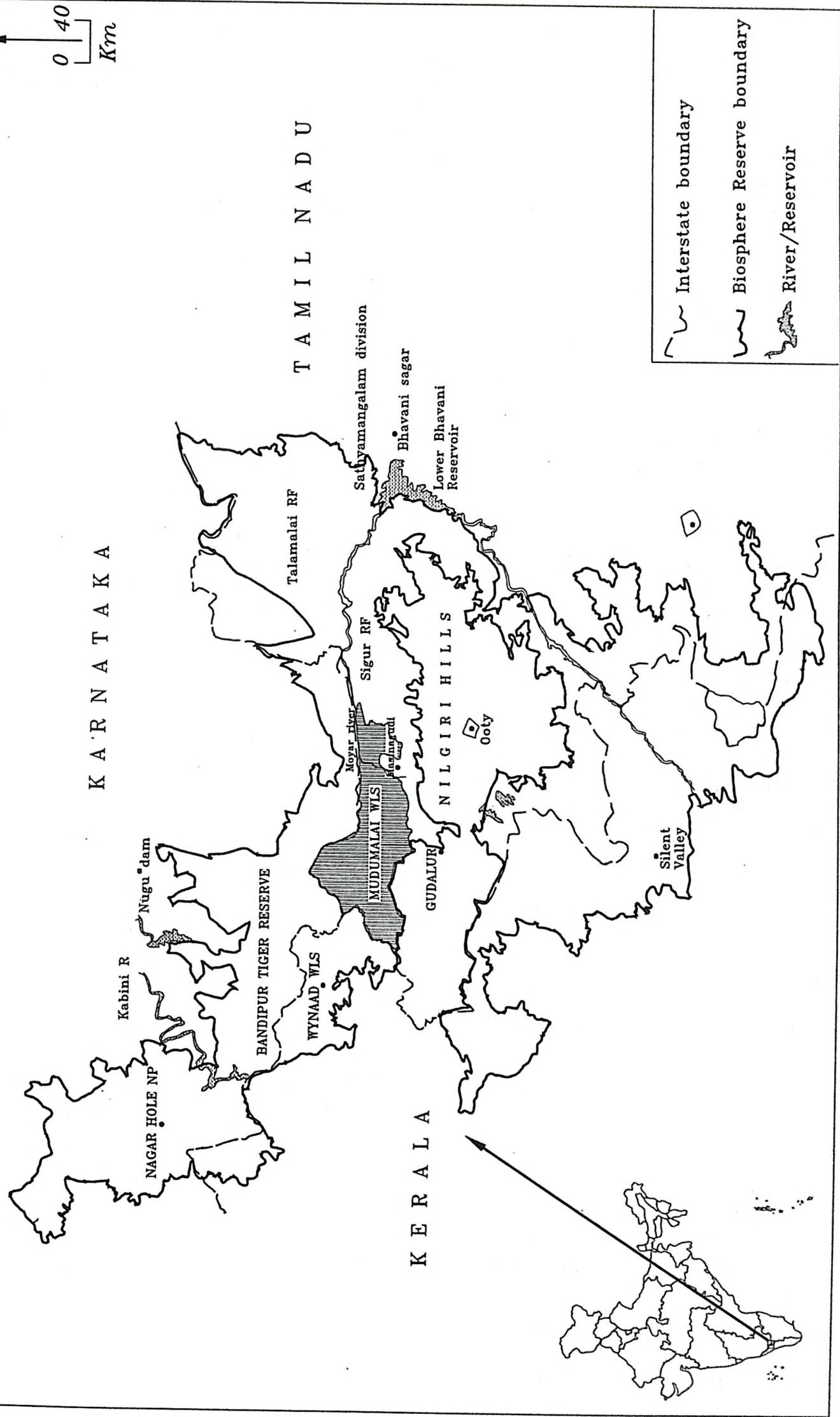
CHAPTER 2

STUDY AREA AND METHODS OF STUDY

2.1 Geographical Location and Boundaries

Mudumalai Wildlife Sanctuary is situated in the Nilgiris district of Tamil Nadu and lies between 11°32' and 11°42' N latitude and 76°21' and 76°45' E longitude. It occupies the eastern slopes of Western Ghats (Sukumar, 1986). The Sanctuary is contiguous with Bandipur Tiger Reserve and Nagarhole National Park of Karnataka in the north and Wynaad Wildlife Sanctuary of Kerala to the west (Fig. 2.1). All the four PAs constitute a continuous forest tract of about 3,300 km² including 321 km² of Mudumalai WLS (Desai, 1991; Varman, 1993). The east of the Sanctuary is linked to the Sigur plateau, is ultimately connected with the Barbitte and Biligiri Forests of the Eastern Ghats. To the immediate south, there are tea and coffee plantations owned by private owners with human settlements inside them. Further to the south are the very steep hills of the Nilgiri mountains, which can not be easily negotiated by the elephant herds. The hills are under Singara and Kalamalai Reserve Forests. To the south-east the Sanctuary is contiguous with the Bokkapuram and Kalahatti Reserve Forests (Fig. 2.1).

Fig. 2.1: Location map of Mudumalai WLS and its surrounding PAS



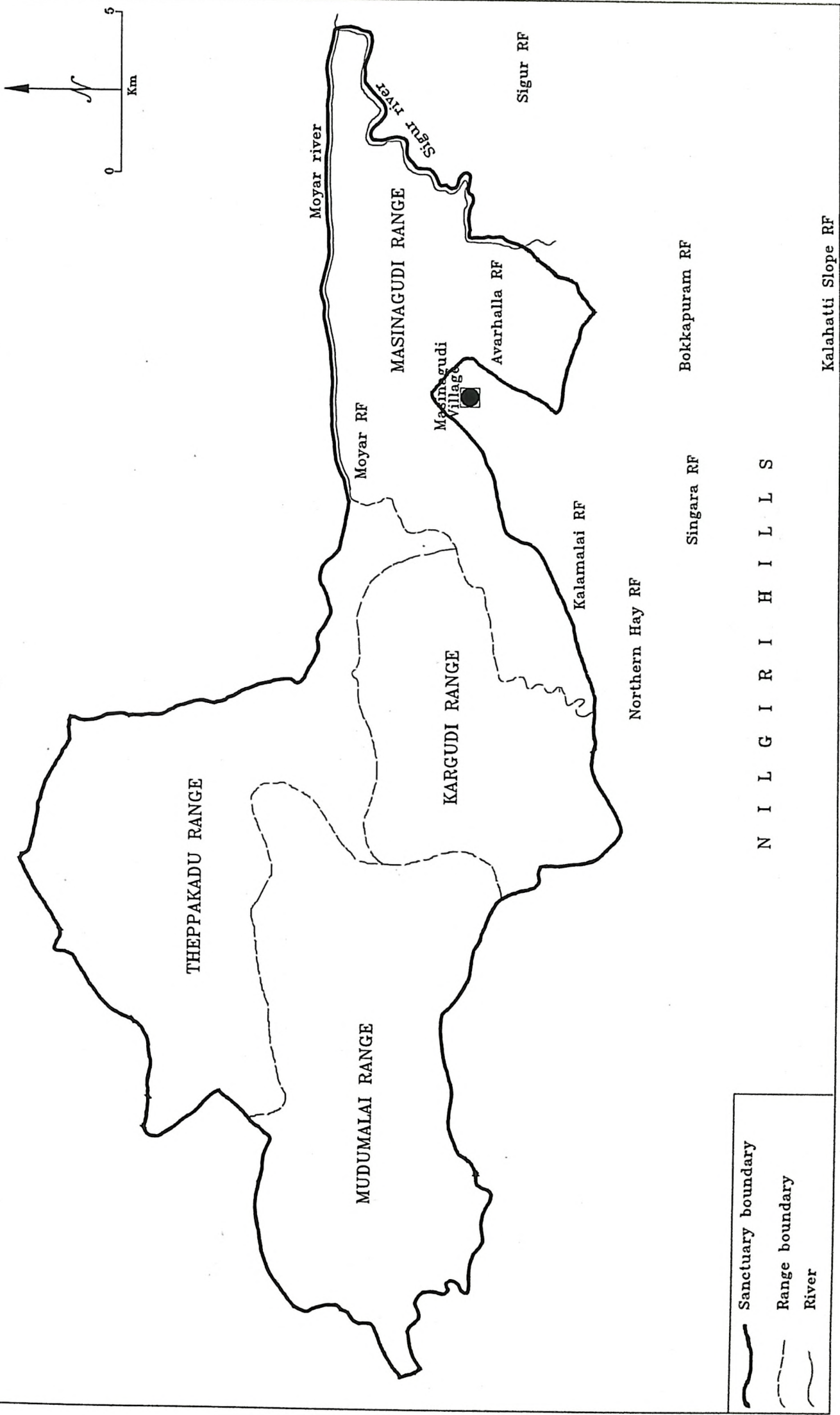
2.2 Zonation and Total Area

The Sanctuary has been divided into four ranges (Fig. 2.2) viz. Mudumalai range (96.6 km²), Kargudi range (54.6 km²), Theppakadu range (89.5 km²), and Masinagudi range (80.4 km²). Each range has further been divided into blocks and these blocks into compartments. Altogether there are 39 compartments. Theppakadu block (71.9 km²) and Mudumalai block (80.2 km²) have 14 compartments each, while Benne block (46.1 km²) has been divided into 11 compartments. Dodagatty block (63.9 km²) has not been sub divided into compartments. In addition, 26 km² of Avarhalla RF and 32.9 km² of Moyar RF were added to the Theppakadu block without any further sub divisions into compartments. The total area of the Sanctuary is again divided into different zones for scientific and intensive management activities (Neelakantan, 1988). These are Wilderness Zone, Optimum Forestry Zone, Tourism Zone, Administrative Zone, Buffer Zone or Multiple Use Zone, and Experimental Zone.

2.3 Topography

The terrain throughout the Sanctuary is more or less undulating, with an average elevation of 1,000 m above msl. The altitude decreases from west to north and north east. The highest peak in the Sanctuary is known as Morgan Betta and is located in the central part with an elevation of 1,258 m above msl. The altitude in the central part decreases towards east and south. The major peaks in the Sanctuary, besides Morgan Betta are Doda Betta and Karadi Gudda, all of them situated in the central part. The eastern most part of the Sanctuary linked with Sigur RF, is more undulating, forming valleys and micro habitats for elephant feeding (Sivaganesan, 1991).

Fig. 2.2: Range map of Mudumalai WLS

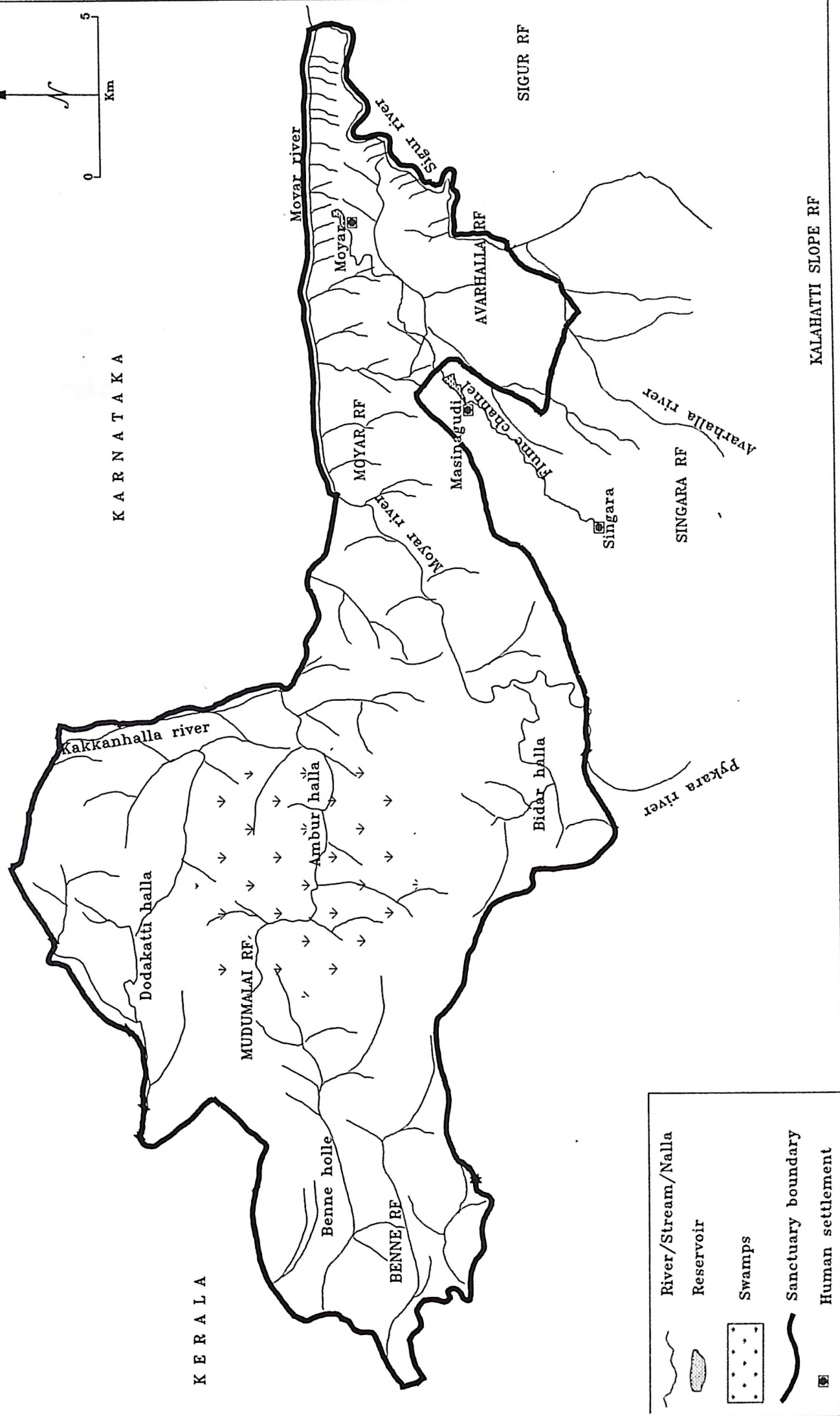


2.4 Hydrology

Due to undulating terrain and valley formations, the Sanctuary is drained by several seasonal and perennial streams and rivers. The major are Moyar river, Benne Hole, Bider Halla, Kakanhalla, Dodakatti Kumbar Halla, Sigur Pallam and Avarhalla river (Fig. 2.3).

Moyar river, the chief source of water is one of the most important perennial drainage systems of the Sanctuary. It flows through the centre of Mudumalai Sanctuary up to Theppakadu and then to the east. Thereafter it changes its course towards north-east, flowing through a deep gorge of average depth of 260 m. This gorge is known as Moyar gorge with steep rocky faces on either bank, which act as natural barriers against the free movement of wild animals. Sigur river is the main tributary of Moyar river which flows in the north-east direction and forms the eastern boundary of the Sanctuary. It joins the Moyar river and forms the Moyar waterfall. The lowest altitude within the Sanctuary is 851 m above msl at the foot of Moyar waterfall. While the western part of the Sanctuary is drained by Benne Hole, the southern part is drained by the river Bidder Halla which joins the Moyar river. Kakanhalla and Moyar rivers are the frontier between Mudumalai Sanctuary and Bandipur Tiger Reserve. Dodakatti and Imberhalla drain the northern part while the eastern part of the Sanctuary is drained by Avarhalla river which joins the Sigur river. Several other semi-perennial and seasonal streams form the drainage network of the Sanctuary.

Fig. 2.3: Drainage map of Mudumalai WLS



Besides these natural drainage systems, there flows a flume channel from south towards north-east. This channel carries water from Singara to Moyar via Masinagudi to generate electricity. The channel is fed by the Glenmorgan reservoir at the top of Singara at a height of 2,000 m above msl. Water from this reservoir flows through huge penstocks down to Singara which is ultimately released into Moyar river at the base of the Moyar gorge through an open mud banked channel after power generation at Singara, Masinagudi and Moyar. These penstocks with large diameter are laid across the parallel contours of the Singara RF, and act as barriers to the free movement of wild animals.

The entire Sanctuary is a part of the Wynaad plateau. The meaning of Wynaad is "the land of swamps". The western part of the Sanctuary has several swampy patches due to undulating terrain and improper and poor drainage system. These swamps have bamboo thickets on their banks which provided ideal wallowing grounds for herbivores. Ombatta swamp is one of the largest where one can see elephants, gaur, sambar and cheetal frequently. These swamps provide ideal habitat for fresh water turtles also.

2.5 Climate

The climate in the Sanctuary is moderate. All three seasons, summer, winter and rainy are markedly noticed. The area experiences summer from March to mid May, and winter lasts from November to February. The rainy season consists of the south-west and north-east monsoons, beginning in the later half of May and extending up to October.

The temperature rises to the maximum during summer months reaching up to 33°-35°C, while it comes down to 12°-14°C during December-January, the peak winter months. The temperature in the eastern part of the Sanctuary remains higher than in the western part.

A great variation in the rainfall is observed as one moves from west to east of the Sanctuary. The pre-monsoon showers start at the end of summer, lasting from late April to May. The south-west monsoon starts in June and lasts upto September. In October and early November, the Sanctuary receives light showers from the north-east monsoon. The western part of the Sanctuary that is, the Benne RF receives the heaviest rainfall. The rainfall gradient decreases very sharply from west to east, and the eastern-most part, which is linked to the Sigur plateau, receives very little rainfall as it lies in the rain shadow zone. The gradient of annual rainfall is from 250 cm in the western part to 40 cm in the eastern part. On an average, the Sanctuary receives 100 cm rainfall annually. The major part of the Sanctuary receives between 80-200 cm annually. The distribution of rainfall is so drastic that its variation could easily be marked out by the range of vegetation types within a distance of few kilometres.

2.6 Geology of Soil and Rocks

The fundamental rocks of Nilgiri and Wynaad are typical biolite and hornblende gneiss, with intensive bands of charnockite and much younger biolite, granite, pegmatites and basic doleric dykes (George *et al.*, 1988).

Soils are broadly of two kinds viz. i) black sandy loam containing over 50% sand and gravel, and ii) red heavy loam soil. The latter type is generally confined to the western and southern parts of the Sanctuary, allowing good vegetation growth alongwith the heavy rainfall of the area (George *et al.*, 1988). The northern part of the Sanctuary has black soils with dry deciduous forests of poor and stunted growth. The eastern part has rocky and gravelly dark brown soil with least rainfall and soil moisture.

2.7 Flora

The vegetation types vary in the entire Sanctuary along with the gradient of variations of rainfall. Therefore, the Sanctuary represents one of the best examples of floristic diversity. It has forest types ranging from open thorny scrub to semi evergreen forests (Champion and Seth, 1968).

The western part of the Sanctuary, with highest annual rainfall consists of southern tropical semi-evergreen forest (2A/C2). The presence of swampy patches in this part of the Sanctuary help in maintaining adequate moisture to support the semi-evergreen forests. The forest type is represented by *Artocarpus hirsuta*, *Schleichera trijuga*, *S. oleosa*, *Cullenia excelsa*, *Terminalia tomentosa*, *Tectona grandis*, *Pterocarpus marsupium*, *Dalbergia latifolia*, *Lagerstroemia microcarpa*, and *Lonicera malabarica*. Average height of trees varies from 14 to 18 m. *Bambusa arundinacea* is common along the fringes of the swampy patches. The lower storey is made up of shrubs, with herbs, stragglers, and saplings of tree species and shrubs forming a dense undergrowth. *Lantana*

camara and *Eupatorium glandulosum* are very common shrubs covering most of the lower storey.

The southern part of the Sanctuary, which receives high rainfall is characterised by southern mixed deciduous forest and falls under 3B/C2 category of Champion and Seth's classification (1968). Rainfall in this area varies from 120 to 160 cm annually. This type of forest has a dense canopy with tall trees ranging from 25 to 30 m. There are mostly deciduous species in this region, but also some evergreen species. The terrain in this part is very undulating, with high hills. The highest peak of the Sanctuary is present in this area. The top canopy is dominated by good quality of teak (*Tectona grandis*), with average girth at breast height (GBH) being 1.5 m. *T. grandis* is associated with *Terminalia tomentosa*, *Pterocarpus marsupium* and *Lagerstroemia lanceolata*. Scattered shorter individuals of the same species form the understorey. *Adina cordifolia*, *Dalbergia latifolia*, *Ougeinia dalbergiodes*, *Kydia calycina*, *Bombax malabaricum*, *Albizzia odoratissima*, *Emblica officinale*, *Terminalia chebula*, *T. belerica* and *Anogeissus latifolia* form the understorey. The ground vegetation is typically herbaceous and consists of *Helecterus isora*, *Clerodendron* spp, *Lantana camara*, *Solanum* spp, *Eupatorium* spp and *Seratum* spp. The top storey, being very dense, does not permit enough radiation to reach to the ground level, and therefore does not allow growth of a good ground flora.

The central part of the Sanctuary is dominated by tropical dry deciduous forest (5A/C1B) with poor quality of tree growth. The upper canopy is very uneven and relatively open. This area receives comparatively less rainfall. The

area is dominated by a mixture of species practically most of which shed their leaves during the dry season giving them characteristics of dry deciduous vegetation type. Generally the tree height ranges between 10-15 m. The vegetation is dominated by *Tectona grandis*, *Anogeissus latifolia*, *Terminalia tomentosa*, *T. chebula*, *Albizzia odoratissima*, *Emblica officinalis*, *Grewia tilaeifolia*, *Shorea roxburghii*, *Syzygium cumini* and *Acacia* spp. The incidence of fire are common in this part of the Sanctuary. The ground vegetation is mostly covered by *Lantana camara* and other thorny shrubs. Leaf litter of *L. camara* and of the top storeyed species helps in incidences of fire occurrence. *Bambusa arundinacea* is confined to the rivers and streams beds. Grasses are found amidst shrubs, but wherever the canopy is open, it is found in abundance.

The eastern-most part, which is linked with the Sigur RF, has thorny scrub forest (6A/C) with very short canopy. The upper canopy is very stunted and scattered. The annual rainfall in this area is only 40-60 cm as it is in the rain shadow zone. Numerous species of dry deciduous forests are found here but the growth and the distribution of these tree species is very poor. The important species in this area are *Acacia catechu*, *A. chundra*, *Chloroxylon swietenia*, *Canthium dicoccum*, *Sapindus emarginatum*, *Maytenus emarginata*, *Premna tomentosa*, *Erythroxylon monogynum*, *Zizyphus jujuba*, *Z. xylopyra*, *Z. oenoplea*, *Z. mauritiana*, *Cassia fistula*, *Capparis* spp, and *Randia dumetorum*. There is very little ground vegetation in this area. *Euphorbia* spp is found in abundance but in patches. The incidence of fires is very high. The area is very undulating with rocky terrain. The dominant appearance of *Acacia chundra* indicates the transition from dry deciduous forest to thorn forest.

The vast network of streams and rivers of the Sanctuary harbours moist bamboo brakes and riparian forest. Moist bamboo brakes are found throughout the semi-evergreen and moist-deciduous forest, all along the streams and shady slopes. The continuous forest of tall clumps of *Bambusa arundinacea* is found with intermittent *Terminalia arjuna*. Riparian forest (4E/RS1) is found along the banks of perennial rivers and streams like Moyar, Bider Halla, Kakkan Halla, Ombatta and Kurumber Pallam. The dominant tree species of this type of forest are *Ficus* spp, *Pongamia* spp, *Mangifera indica*, *Syzygium cumini*, *Terminalia arjuna*, *Schleichera oleosa* and *Dalbergia latifolia*. The average height of the tree ranges from 15 to 18 m.

2.8 Fauna

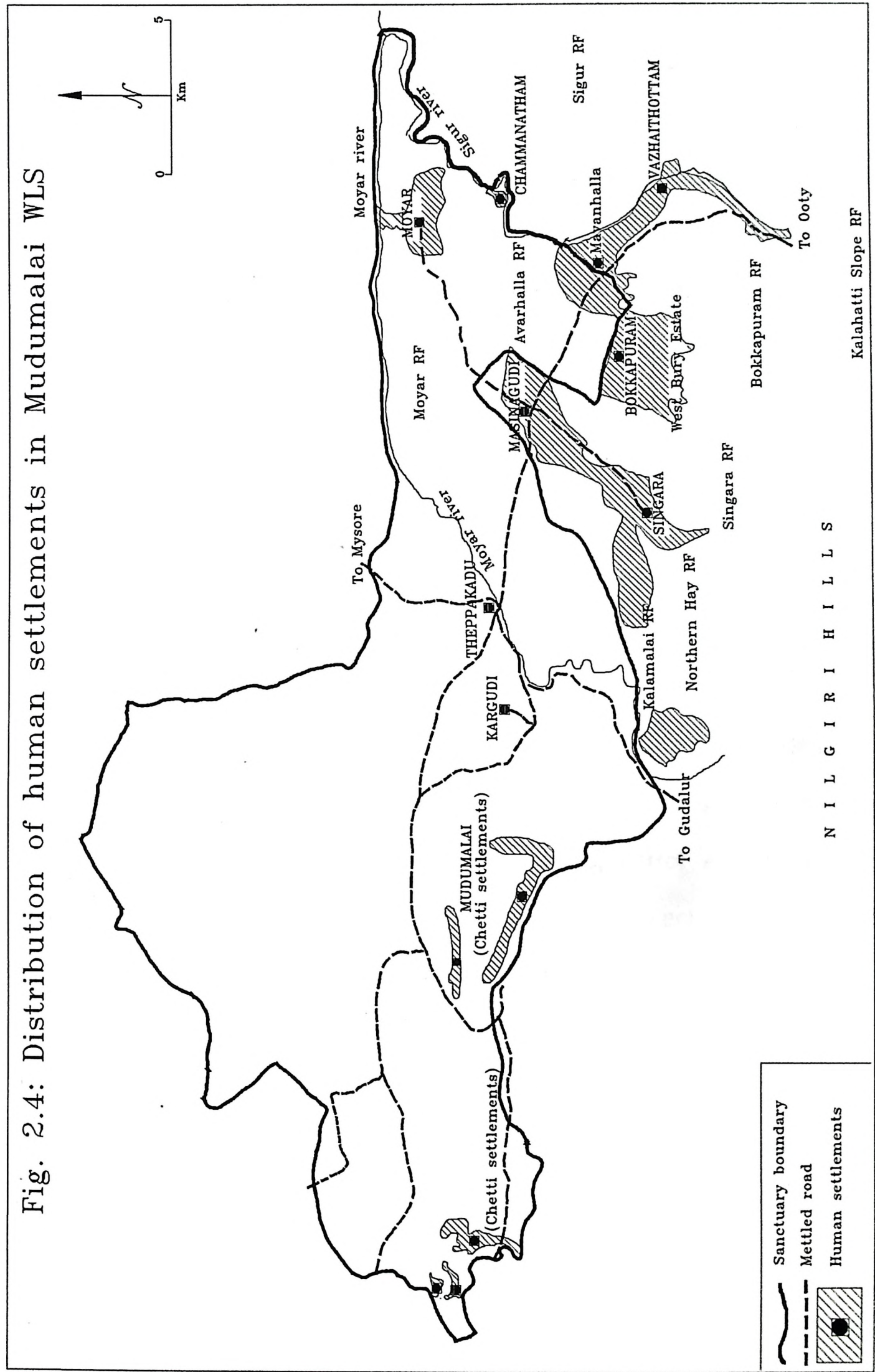
The diverse habitat types of the Sanctuary described in the preceding paragraphs provides the best grounds for an equally diverse fauna. The Sanctuary is well known for a variety of herbivores, carnivores, avi-fauna, reptilian and aquatic fauna. Mudumalai Sanctuary along and the adjoining three PAs harbour one of the largest population of Asian elephants (*Elephas maximus*) (Sukumar, 1989; Desai, 1991). The total elephant population in this area is about 2500-3000 (Tamil Nadu Forest Department records). The elephants are seen solitary or in small herds. They move seasonally in search of forage and water (Desai, 1991), within and between the PAs and RFs adjoining the Sanctuary. A variety of deer can be seen throughout the Sanctuary. The cheetal (*Cervus axis*) is seen in herds of 100-200 in the Masinagudi range in Jaydev Avenue and Mandradiar Avenue. Sambar (*Cervus unicolor*) are seen in small herds. Barking deer (*Muntiacus muntjak*), Mouse deer (*Tragulus meminna*) and four-horned

antelope (*Tetraceros quadricornis*) are distributed in different parts of the Sanctuary. The gaur or Indian bison (*Bos gaurus*), a very graceful animal, is found in herds of 35 to 50 in the western part and also in the central part of the Sanctuary. After the rinderpest epidemic of 1968, the population of gaurs in the Sanctuary is slowly recouping. The Indian wild pig (*Sus scrofa*) is very commonly distributed throughout the Sanctuary. Porcupine (*Hystrix indica*), black naped hare (*Lepus nigricollis*), common langur (*Presbytis entellus*) bonnet macaque (*Macaca radiata*), and other herbivores are commonly found. Among predators, tiger (*Panthera tigris*), leopard (*Panthera pardus*), wild dog (*Cuon alpinus*) and jungle cat (*Felis chaus*) are common in the Sanctuary. Striped hyena (*Hyaena hyaena*), Bengal vulture (*Gype bengalensis*) and King vulture (*Sacrogyaps calvus*) are the common scavengers. The sloth bear (*Melursus ursinus*), Indian giant squirrel (*Ratufa indica*), flying squirrel (*Petaurista petaurista*), small Indian civet (*Viverricula indica*), common mongoose (*Herpestes edwardsi*) and striped necked mongoose (*Herpestes vitticollis*) are other common wild animals. The common otter (*Lutra lutra*) and fresh water crocodiles (*Crocodylus palustris*), a variety of fishes and tortoise are common aquatic animals found in the Sanctuary. A variety of snakes like King cobra, Python, Krait, Rat snakes, the green whip snakes etc. are commonly sighted in the Sanctuary forest. A variety of avi-fauna is also found in the Sanctuary.

2.9 The Local People and Land Use Pattern in General

The south-eastern boundary of the Sanctuary is inhabited by a resource-dependent population of seven villages (Fig. 2.4), of which Masinagudi is the largest village situated on the southern boundary. The other six villages are

Fig. 2.4: Distribution of human settlements in Mudumalai WLS

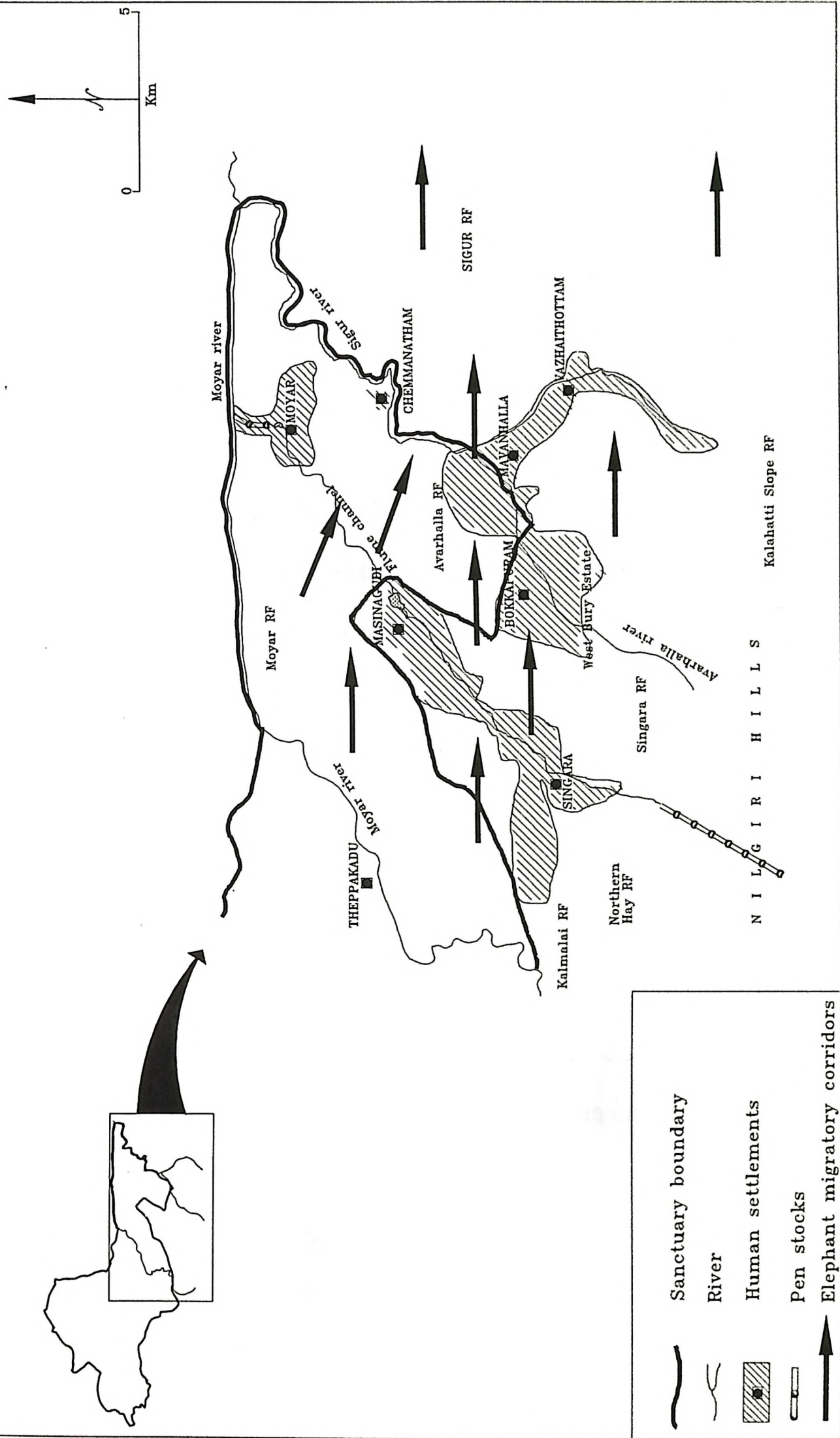


Moyar, Singara, Bokkapuram, Mavanhalla, Chemmanatham, and Vazhaithottam. Moyar, the second largest village and Chemmanatham, the smallest village, are inside the Sanctuary. There are numerous human settlements of the Chetti community in the western part of the Sanctuary and all these are inside the Sanctuary. People of this area are mostly migrants from neighbouring states, and from other parts of Tamil Nadu. The hydroelectric projects of Masinagudi, Singara and Moyar and have largely been responsible for the immigration of people from other states in search of jobs, which resulted in the sudden increase in the human and cattle population of the area. Most of these people are labourers, who after termination of hydroelectric projects, were jobless, and started encroaching the revenue and forested lands, exerting tremendous biotic pressure. There are several tribal families living in this area. They are mostly Kurubas, Irulas and a few of Naikans. They use the biomass resources of the Sanctuary and surrounding RFs for their daily need as well as for selling in the local market. The local villagers cultivate the patta lands and revenue lands and grow mainly ragi, maize, beans and vegetables like potato, cabbage, carrot and some leafy vegetables. Very few farmers grow paddy. Local tribals collect a variety of Non-Timber Forest Products (NTFPs) from the Sanctuary forest and surrounding RFs.

2.10 Intensive Study Area and Approach of Study

The present study was undertaken in the eastern and south-eastern part of the Sanctuary which is linked to the Sigur RF through forest corridors. While the northern corridor comprised the Moyar-Avarhalla Sanctuary Forest and is present between Masinagudi and Moyar village, the southern corridor comprised Singara-Kalahatti RFs and present is between Masinagudi and Singara (Fig. 2.5).

Fig. 2.5: Intensive study area with elephant corridors



Both these corridors are situated between two natural barriers, the deep Moyar gorge on the north and the steep Nilgiri mountains on the south, unnegotiable by the elephants for their movements. Thus the two corridor forests are the only means of passage routes for the elephants to migrate from the Sanctuary to the Sigur RF. A cluster of seven villages described in the previous paragraph is situated at the fringes of Theppakadu and Masinagudi Forest Blocks. All the seven villages on the south-eastern boundary of the Sanctuary to be referred to henceforth as the Masinagudi group of villages, were selected for the socio-economic study. Dependency of local people of the Masinagudi group of villages upon the Sanctuary and corridor forests and the resultant biotic pressure of the local people and their cattle was quantified.

The base camp for the study was set up at Masinagudi, because this is a centre place besides having other infra-structural facilities. To achieve the stated objectives, the study was conducted in two major phases. In the first phase the socio-economic survey and dependency pattern of the local people living around the corridor forest was completed and in the second phase analysis of vegetation structure and quantification of biotic pressure upon the corridor forest were done. For the socio-economic study, Masinagudi was selected as sample village and a reconnaissance was carried out. Based on the information collected during the reconnaissance, computer compatible questionnaires were designed for conducting a detailed socio-economic survey in all the villages. All the entry and exit points leading into and out of the corridor forest, of all the villages, were monitored on a regular basis, to quantify the removal of biomass from the corridor forest as well as for studying the patterns of cattle grazing. Selected households

were sampled to study the actual per capita consumption of fuelwood and fodder. Radial belt transects were laid inside the corridor forest and other parts of the Sanctuary Forest, to analyze the vegetation structure and composition, grass production, and biotic pressure in the form of wood cutting and livestock grazing. Habitat use by elephants was studied using the information collected on these transects. Information such as land ownership pattern, land utilisation pattern, incidence of man-animal conflict in the form of crop raiding, loss of human lives and cattle lifting were collected, based on the interviews and the official records of various Government departments. Data were analyzed using different computer programmes. While FOXBASE was used for data entry, SPSS/PC+Statistics 4.0 (Statistical Package for Social Sciences) (Marijia, 1990), and TWINSpan (Hill, 1979) were used to analyze socio-economic, vegetation and biotic pressure quantification data. Detailed methods have been dealt with in the concerned chapters.

CHAPTER 3

3

SOCIO-ECONOMIC BACKGROUND OF PEOPLE

3.1 INTRODUCTION

Social science has made significant inroads as an applied discipline relevant to conservation biology in recent years (Gadgil and Thapar, 1990; Machlis, 1992). This is because, biologists, ecologists and conservationists have increasingly realised that the solution to many biological problems lie in tracing and analysing social, cultural, and economic systems. The approach of understanding the resource sharing equation has been applied to studies of PAs (Machlis & Tichnell, 1985; Machlis, 1989, Lele, 1993), and involves the study of social forces, economic status and environmental quality that is being affected due to human activities. Therefore, the functioning of such natural and socio-economic systems has to be studied from the angle of material inputs and outputs of all production and consumption processes. In this context, new sub-disciplines such as human ecology and environmental economics have come to the fore, making serious attempts to ensure a merger between economics and ecology (Costanza and Daley, 1987; Archibugi *et al.*, 1989; Costanza, 1989; Maxwell and Costanza, 1989). These studies are increasingly being recognised by environmentalists and conservationists as the foundation step towards the most critical environmental problems currently being faced all over the world, especially

in the Third World countries. The approach includes: i) studying and analysing the socio-economic indicators which serve as measures for key social variables, such as population explosion among humans and livestock, land use, occupation and income generation; ii) assessing the impact of these variables upon biological variables in the form of human dependence on biomass resources; and iii) measuring biodiversity loss due to biotic pressures in terms of species composition, population structures and overall biodiversity. This information would help managers and planners in taking appropriate decisions with respect to natural resource management. The study on the socio-economic background of the Masinagudi group of villages is one such attempt, and was undertaken with the aim of yielding information of value for better management of the resources of the study area which would eventually help in rehabilitation of the elephant corridors, described earlier.

3.2 METHODOLOGY

Socio-economic information was collected from various sources. Three major steps were followed:

- i) a reconnaissance survey;
- ii) examination of records of Government and non-Government departments/organisations (secondary sources); and
- iii) conducting structured and semi-structured interviews.

3.2.1 Reconnaissance Survey

Reconnaissance of the study area involved a rapid survey of all the seven villages to get acquainted with the village and villagers and to identify their problems of sustenance and parameters that need detailed investigation. It included interaction with various Government and non-Government individuals and organisations. This survey was conducted with the help of the local staff of the Forest Department, who helped in the identification of tracks, paths and areas of the forest used by the local villagers. Simultaneously, different government institutions and the resource persons were identified and approached for help during the course of the reconnaissance survey. The village headman from each study village was informally interviewed (semi-structured and unstructured interviews) (Burgess, 1982) about the profile of the village, people, their income sources, major occupation types, land use, cropping patterns and biomass production and consumption pattern. Based on these basic information, detailed

structured questionnaires (Clarke, 1986) were designed for a door-to-door socio-economic survey of all the villages (Appendix I and II).

3.2.2 Questionnaires Interviews

Questionnaire survey is a well established method in socio-economic studies (Clarke, 1986). Structured questionnaires involved asking the same question in the same order to different individuals so that response may be comparable. Structured questionnaires included two types of questions namely, open-ended and close-ended questions. Open-ended questions provided an opportunity to the respondent to express his/her views freely. These questionnaires are appropriate where there is a small range of information, but the disadvantage is the coding process of the response (Clarke, 1986). Close-ended structured questionnaires have a small range of response, and may not elicit what a respondent really thinks, but it is easy to code and analyze the data gathered. In this study the questionnaires were designed with a limited number of questions, and it turned out to be a useful approach in getting easy and co-operative response from various respondents. Supplementary questions were added to the major questions, which enabled them to be fully answered. Major parameters covered during the questionnaire interview were demographic structures, cattle rearing pattern, land use pattern, types of biomass used and income-expenditure pattern.

To collect information on the demographic set-up and other socio-economic profiles of the study area, the head of each family was interviewed. Information on caste, family size, main occupations, literacy rate, land holdings, cropping

pattern, manuring pattern, housing pattern, income-expenditure pattern, and involvement in different rural development activities were recorded in computer-compatible formats. Even though the head of family became the main respondent, care was taken to involve others in the family to arrive at a consensus. Female members participated significantly, helping to answer some of the questions. The morning time was usually avoided for questionnaire survey since most of the family members were busy in different routine works. Therefore, the interview was conducted individually as well as in groups in the evening time when most members of the family were at home. It was interesting to note a mixed response from the different respondents. At some places the response of the people was overwhelming and very positive, while at other places it was very rude and negative.

Information on livestock rearing patterns was collected during questionnaire interviews and by personal observations at various households and cattle camps. Information on the number of livestock, their composition, average quantity and duration of milk yield, its marketing, and number of grazing and/or stall-fed livestock was collected during household surveys.

3.2.3 Collection of Information From Secondary Sources

During reconnaissance, various individuals, Government and non-Government institutions and organisations were identified and approached for the relevant information for the study, which they owned in the form of official records. The Tamil Nadu Forest Department provided information on: i) the number of truck-loads of cattle dung that go out of the area through their Forest check post,

and ii) the number of cases of human deaths or injuries by wild elephants, and compensation paid by the Department to the victims. Amount of milk (litre/day) sold by each member of the Milk Co-operative Society was computed from their records. Information regarding number of cattle vaccinated or artificially inseminated to improve the existing local breed, and facilities of loans and other financial help that the villagers received was collected from the local veterinary hospital, district veterinary hospital and banks. From the Census Hand-book and other records of the District Revenue Department situated at Udhagamandalam (Ooty), information regarding the human population, land holding and the legal status of land were collected. Information on the marketing of a variety of NTFPs were collected from "Lamp Society" at Masinagudi village which is a local co-operative society established for tribals.

3.2.4 Data Analysis

Socio-economic data collected either from the secondary sources or by structured and semi-structured interviews were stored in a specially designed data-base using the computer programme, FOXBASE. Analyses of these data was done using the statistical package, SPSS/PC+4.0. Data was analyzed for each individual village. Human and livestock population was compared, and trends in the population growth were worked out. To calculate the literacy rate, children below 4 years of age were not considered in the final calculation, as the usual practice in these villages is to send their children to school only after 4 years of age. This rate was worked out for the male and female populations separately also. The land use pattern was analyzed and mapped separately for each village.

3.4 RESULTS

3.4.1 General Information

All the seven study villages are revenue villages and are under the administration of two Village Panchyats namely, Masinagudi and Sholur. Masinagudi Panchayat has six villages, namely, Masinagudi, Moyar, Singara, Mavanhalla, Chemmanatham and Vazhaithottam under its administration, while Bokkapuram was under the administration of Sholur Panchayat. Moyar and Chemmanatham villages are situated inside the Sanctuary while the remaining 5 villages are located on the south-eastern boundary at varying distances (Table 3.1). Masinagudi and Mavanhalla village have a common boundary with the Sanctuary. Masinagudi village, which is growing very rapidly into a township, is one of the heavily populated village, while in terms of area, Singara is the largest of the seven villages. Most of the people living in these villages are migrants from other parts of state and from the neighbouring states. While Chemmanatham is totally a tribal village, Bokkapuram is a tribal-dominated village.

3.4.2 Human Population

The total human population of all the seven villages was calculated to be 7,401. Of the total population, 30% are children (below 13 years), 5% old (> 58 years) while the rest 65% are between 13 and 58 years (Table 3.2). The male:female ratio is calculated to be 100:89. Masinagudi village alone harboured about 53% of the total population of all the seven villages. Chemmanatham is the smallest village with only 42 people living in 12 families. The average family size

is calculated to be 5 consisting of 2-3 adults and 2 children. Average human population density in the study area is calculated to be 122 people km⁻².

Table 3.1: General information of study villages

Village	Location (outside/inside Sanctuary)	Distance from Sanctuary boundary (km)	Distance from motorable road (km)	School (P/A)	Bank (P/A)	Post office (P/A)	Hospital (P/A)
Masinagudi Panchayat:							
Masinagudi	Outside	0.0	0.0	P	P	P	P
Moyar	Inside	0.0	0.0	P	A	P	P
Singara	Outside	5.0	0.0	P	A	P	P
Mavanhalla	Outside	0.0	0.0	P	A	P	A
Chemmanatham	Inside	0.0	3.0	A	A	A	A
Vazhathottam	Outside	1.5	0.0	P	A	A	A
Sholur Panchayat:							
Bokkapuram	Outside	3.5	0.0	P	A	A	A

P = Present; A = Absent

Table 3.2: Human population

Village	No. of Families	Age groups (years)						Total
		<13		13-58		>58		
		M	F	M	F	M	F	
Masinagudi	768	657	562	1322	1204	100	79	3924
Moyar	207	147	124	421	363	27	30	1112
Singara	115	50	73	241	184	9	10	567
Bokkapuram	193	152	154	265	259	34	12	876
Mavanhalla	101	98	80	150	143	18	9	498
Chemmanatham	12	8	8	10	11	3	2	42
Vazhathottam	79	47	76	122	116	14	7	382
Total	1475	1159	1077	2531	2280	205	149	7401

M = Male; F = Female

3.4.3 Human Population Trend

Table 3.3 shows the trends in the growth of human population of the study villages for the last 3 decades, from 1961 to 1991. The increase in the human population has been 2.5 times during the last 30 years. On an average, increase in population for the above duration was found 4.8% per annum.

Table 3.3: Human population trends

Year	Male	Female	Total	% Increase
1961	1871	1594	3465	-
1971	2576	2227	4803	38.6
1981	3069	2824	5893	22.7
1991	4363	4044	8407	42.7

Source: District Revenue Department, Ooty.

3.4.4 Caste Composition

Backward Class dominated in the community followed by the Scheduled Caste and Scheduled Tribes (Table 3.4). Caste composition of Masinagudi, Moyar, Singara and Vazhaithottam followed a similar pattern while in case of Bokkapuram and Mavanhalla village, the Scheduled Tribe dominated and in case of Chemmanatham all the residents are of Scheduled Tribe. The Scheduled Tribes are represented by Irula and Kuruba communities with few families of Panniyar. Forward Class forms only 13% of total families. While most of the Backward Class and Scheduled Caste families migrated into this area in search of job prospects, the Scheduled Tribe families are believed to be the original residents of this area. They are distributed throughout the Nilgiri Plateau of South India.

Table 3.4: Caste composition

Village	Number of families			Total
	BC	SC	ST*	
Masinagudi	374 (49)	242 (31)	60 (8)	768
Moyar	101 (49)	49 (23)	22 (11)	207
Singara	46 (40)	30 (26)	14 (12)	115
Bokkapuram	24 (12)	10 (5)	147 (77)	193
Mavanhalla	16 (16)	22 (22)	47 (46)	101
Chemmanatham	0	0	12(100)	12
Vazhaithottam	29 (37)	16 (20)	23 (29)	79
Total	590 (40)	369 (25)	325 (22)	1475

BC = Backward Class; SC = Scheduled Class; ST = Scheduled Tribe; FC = Forward Class

Values in parentheses refer to the percentage of total

* Represented by Irula and Kuruba

3.4.5 Housing Pattern

Of the total, while 63% families possess *pakka* houses with cement and concrete used as construction material, 37% possess *kachcha* houses with mud, thatch, stones and wooden poles as the construction material (Table 3.5). Moyar, Singara and Masinagudi villages has the maximum percent of *pakka* houses with 88%, 81% and 65% respectively. Of the total 1475 families, 54% have electrified houses. The proportion of electrified houses is also higher Masinagudi, Moyar and Singara villages. While in Bokkapuram village only 7% houses are electrified, in the Chemmanatham village not a single house is with electric connection (Table 3.5).

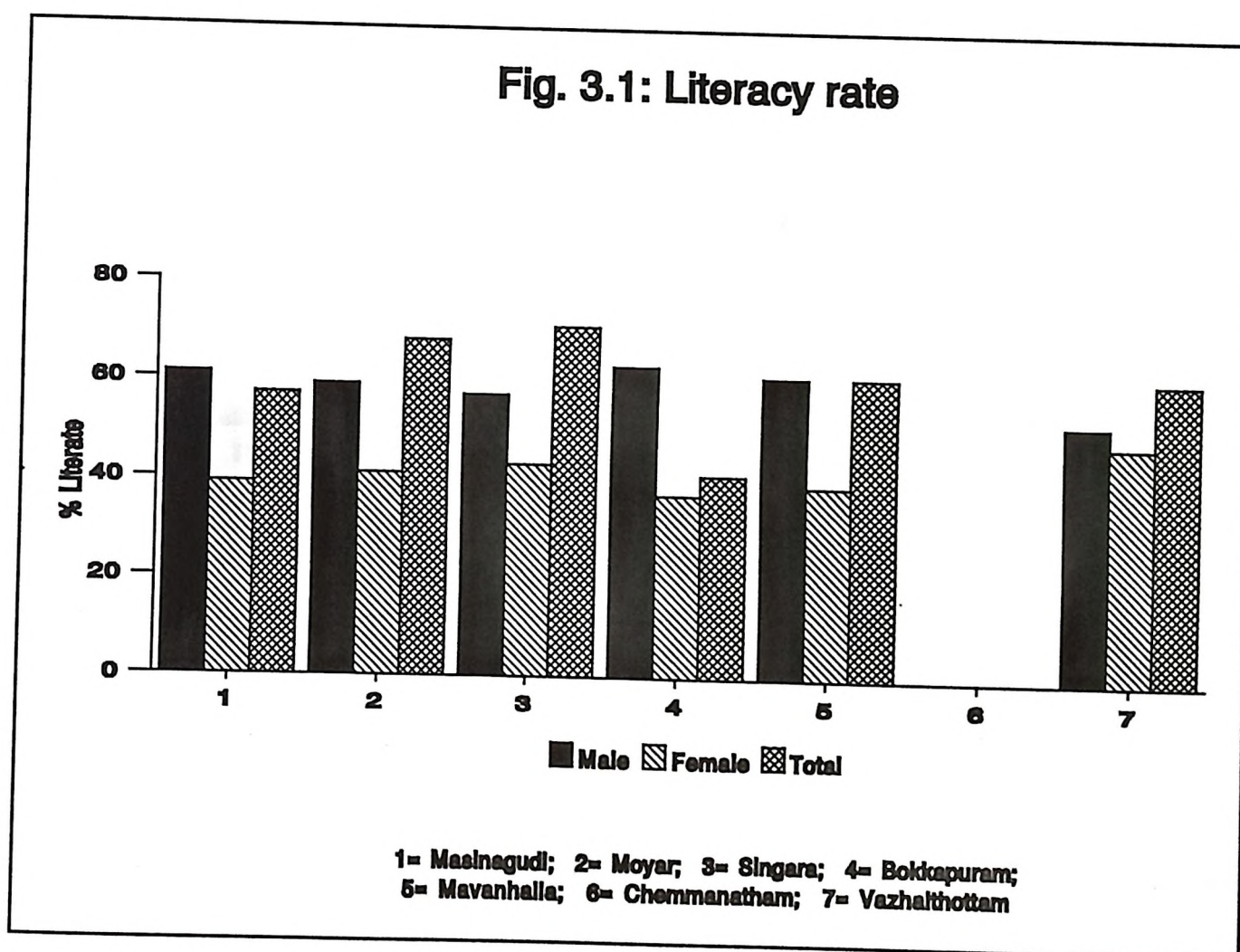
Table 3.5: Types of houses

Villages	Number of houses		
	Pakka	Kachcha	Electrified houses
Masinagudi	500	268	484
Moyar	183	24	150
Singara	93	22	96
Bokkapuram	73	120	14
Mavanhalla	37	64	24
Chemmanatham	0	12	0
Vazhaithottam	44	35	28
Total	930 (63)	545 (37)	796 (54)

Values in parentheses refer to the percentage of total families

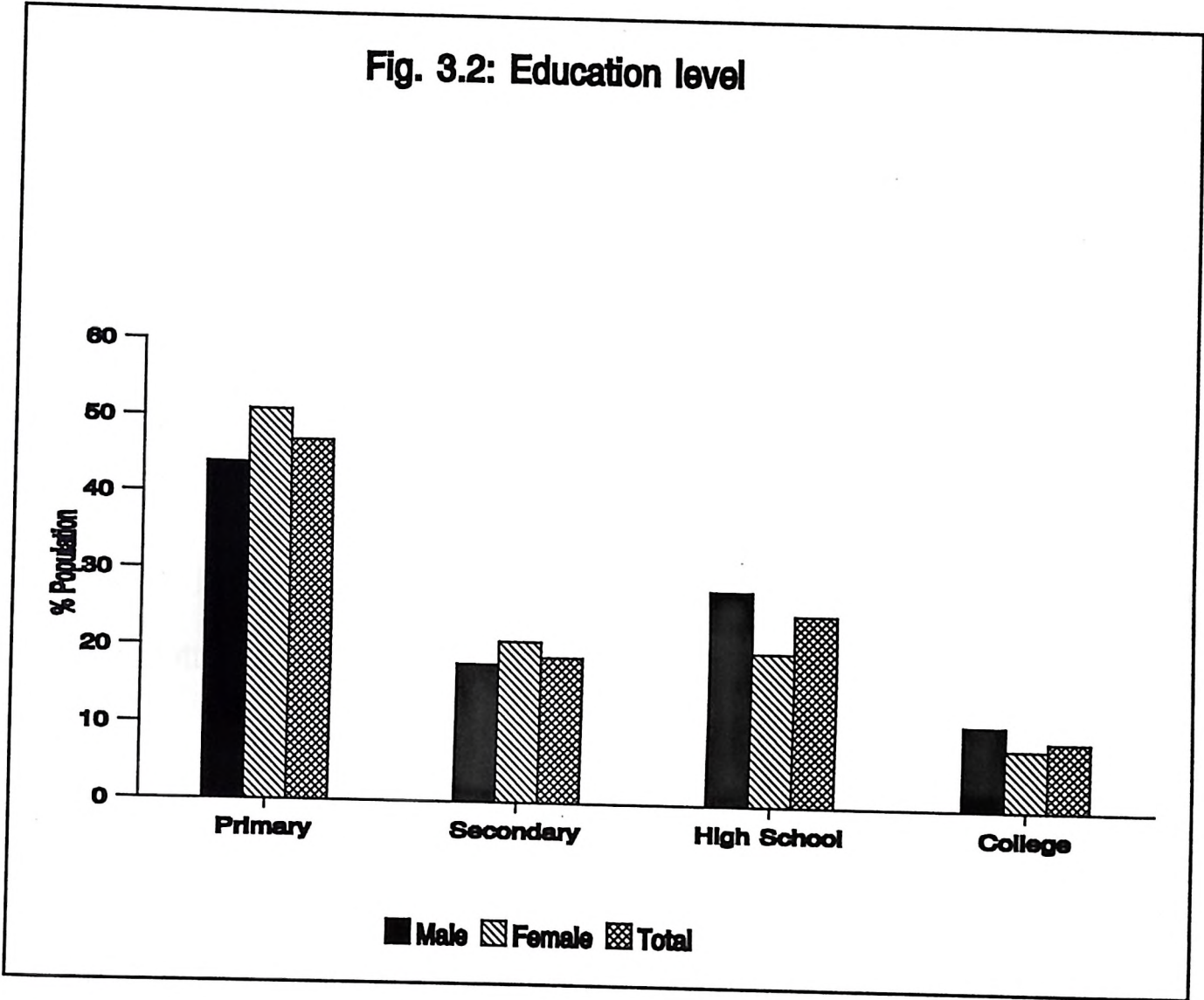
3.4.6 Literacy

Average literacy rate for the study area was 64%. Singara village has highest literate population (73%) followed by Moyar (71%) (Fig. 3.1). It may be mentioned that both these villages are dominated by employees of the State Electricity Board. All the villagers in Chemmanatham village were illiterate. In Bokkapuram village, literacy percent was as low as 45%. On an average, literacy rate among males was 1.5 times that of females.



Of the total literate population, 47% is educated upto primary level, 25% upto high school, and 19% to be secondary level (Fig 3.2). The remaining 9% has got college level education. A higher proportion of females is educated upto

secondary level. But this trend is reverse at the high school and college level education.



3.4.7 Occupation Pattern

Table 3.6 shows the occupation patterns of the people in the study area. Five major occupation categories were identified. These are agriculture, labour, self employment, Government employment and collection of NTFPs. The population is dominated by labour class people which accounted for 44% of the total families. They are mainly involved in building construction activities of the State Electricity Board besides road repair work, quarrying and some agriculture, mostly on encroached land. The second major occupation was Government

service (23%). Thus 67% of the total families gets regular employment throughout the year either from Government service or from construction activities of the hydroelectric projects. Only 3% families were occupied in the collection and sale of NTFPs.

Mavanhalla and Bokkapuram villages had maximum percent of agriculturist family representing 53% and 52% of the total respectively. The labour class dominated in Chemmanatham and Masinagudi village. Singara and Moyar villages had the maximum percent (68 and 43% respectively) of Government employees, the majority of whom were employed in the State Electricity Board. It is interesting to note here that cattle owners of Ooty and other adjacent areas bring their cattle to Chemmanatham to be looked after by the villagers. For this work, villagers of Chemmanatham get a small amount of money, ranging from Rs. 300 to 400 per month. The rest of the earnings from milk and cattle dung, go to the owners of these cattle every 15-20 days.

Table 3.6: Occupation pattern

Village	No. of families and occupation categories				Total
	Agriculture	Labour	Self employment	Government employment	NTFP collection
Masinagudi	46	425	129	135	33
Moyar	42	58	17	90	0
Singara	0	28	9	78	0
Bokkapuram	101	68	6	16	2
Mavanhalla	55	24	6	15	1
Chemmanatham	0	10	0	0	2
Vazhathottam	20	39	8	11	1
Total	264 (18)	652 (44)	175 (12)	345 (23)	39 (3)
NTFP = Non-Timber Forest Produce					1475

Values in parentheses refer to the percentage of total

3.4.8 Land Distribution and Land Use Pattern

The land distribution pattern in the study villages has been shown in Table 3.7. Patta land is owned by private owners and the Tamil Nadu Electricity Board (TNEB) while the revenue land belongs to the Revenue Department, and has been either leased out to the villagers and different Government institutions by charging nominal rates, or encroached by villagers. Singara is the largest village in terms of area followed by Bokkapuram and Masinagudi. Chemmanatham is the smallest village. Of the total land, 70% is owned by private parties and the TNEB, while the rest 30% is revenue land. Of the total patta land, 8% is owned by the State Electricity Board, and lies in three villages viz, Masinagudi, Singara and Moyar. The remaining 92% is owned by private parties. Of the total revenue land, almost 30% is in Masinagudi village, and 17% in Bokkapuram. Chemmanatham village has only 4% revenue land, which is lying as a scrub jungle without encroachment.

Records of the Revenue Department and household surveys were analyzed to derive the land use pattern of the study area (Table 3.8). Of the total area, about 92% was under the agricultural sector, 6.8% under settlements. Interestingly, of the total land available for agriculture, only 37% is cultivated for different types of crops and the majority of it, i.e., 63% is lying as cultivable waste land (Table 3.8). It may be mentioned here that Masinagudi village works as a hinterland/central village and all the other village are satellite hamlets. Therefore, all the residents of the area use the common burial ground at Masinagudi. The distribution and utilisation of total geographical area of each village has also been mapped (Fig. 3.3 to 3.8).

Table 3.7: Land distribution pattern

Villages	Land categories (area in acres)			
	Patta land		Revenue land	Total land
	TNEB	Private		
Masinagudi	38.60	667.88	535.85	1242.33
Moyar	112.00	39.38	249.35	400.73
Singara	177.56	1551.22	190.67	1919.45
Bokkapuram	0	1174.82	309.55	1484.54
Mavanhalla	0	261.82	267.55	529.37
Chemmanatham	0	44.31	76.60	120.91
Vazhaithottam	0	275.91	165.31	441.22
Total	328.16	4015.34	1794.88	6138.55

TNEB = Tamil Nadu Electricity Board

Table 3.8: Land use pattern

Land Occupation Categories	Area of village (in acres)							Total
	1	2	3	4	5	6	7	
A. Settlements								
1. Private	12.64	3.85	0.26	1.89	1.68	0.10	1.08	21.50
2. TNEB	38.60	132.36	177.56	0	0	0	0	348.52
3. Govt. Institutions	34.27	0.15	0	1.00	1.56	0	0.50	37.48
4. Religious sites	3.18	4.17	0.18	1.27	0.15	0	0.04	8.99
B. Agriculture								
1. Cultivated	290.25	127.00	1010.88	417.75	144.00	0	90.50	2080.38
2. Cultivable waste	850.31	133.20	730.57	1023.77	364.40	120.31	337.33	3559.89
C. Others								
1. Streams	10.30	0	0	37.76	7.73	0	11.77	67.56
2. Reservoirs	0	0	0	0	0	0.50	0	0.50
3. Road	2.48	-	-	1.10	9.85	-	-	13.43
4. Burial ground	0.30	0	0	0	0	0	0	0.30
Total	1242.33	400.73	1919.45	1484.54	529.37	120.91	441.22	6138.55

1 = Masinagudi; 2 = Moyar; 3 = Singara; 4 = Bokkapuram; 5 = Mavanhalla; 6 = Chemmanatham; 7 = Vazhaithottam

Source: Village Administrative Office, Masinagudi

- Indicates the non-availability of records

Fig. 3.3: Land use map of Masinagudi village

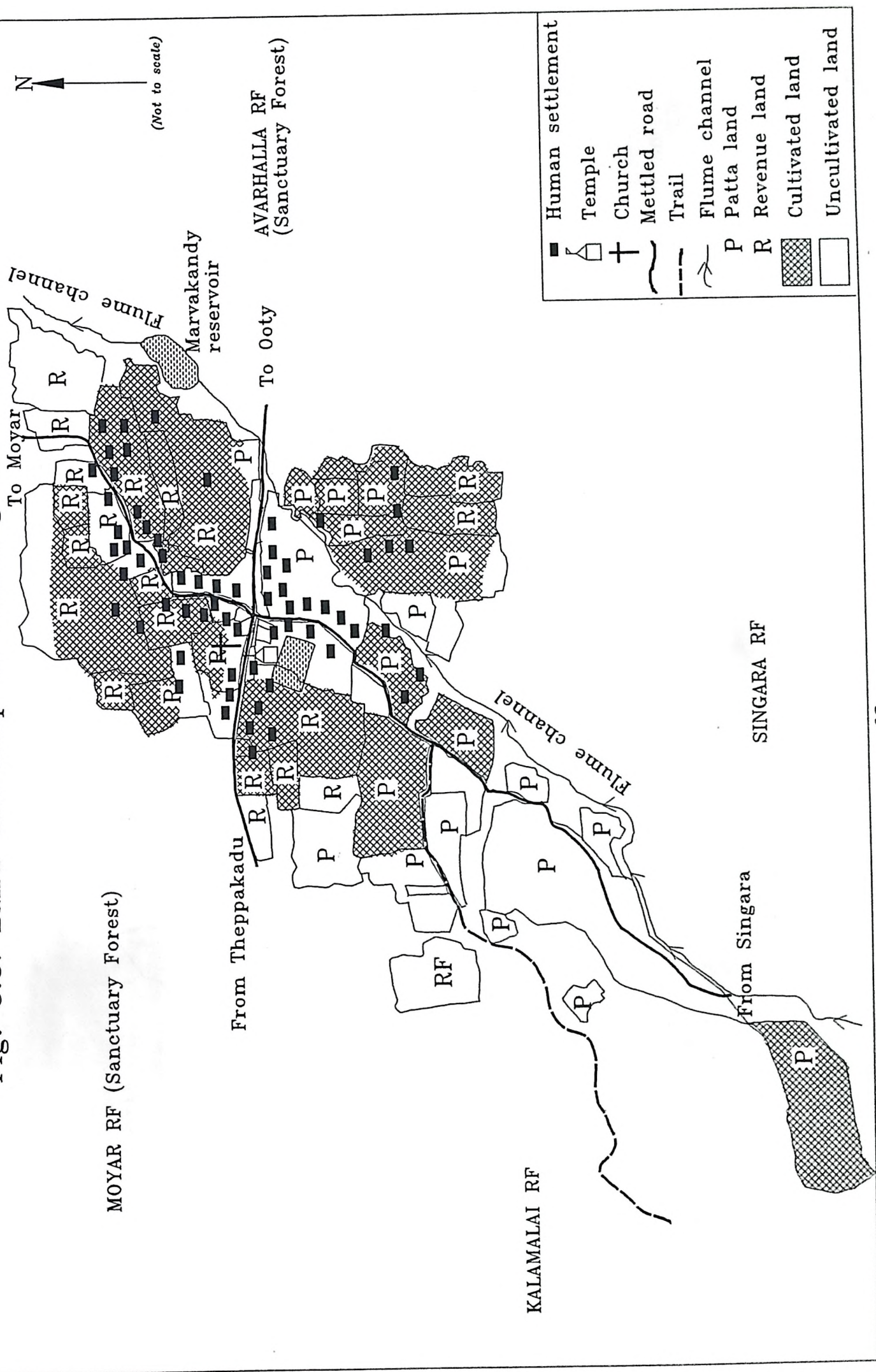


Fig. 3.4: Land use map of Moyar village

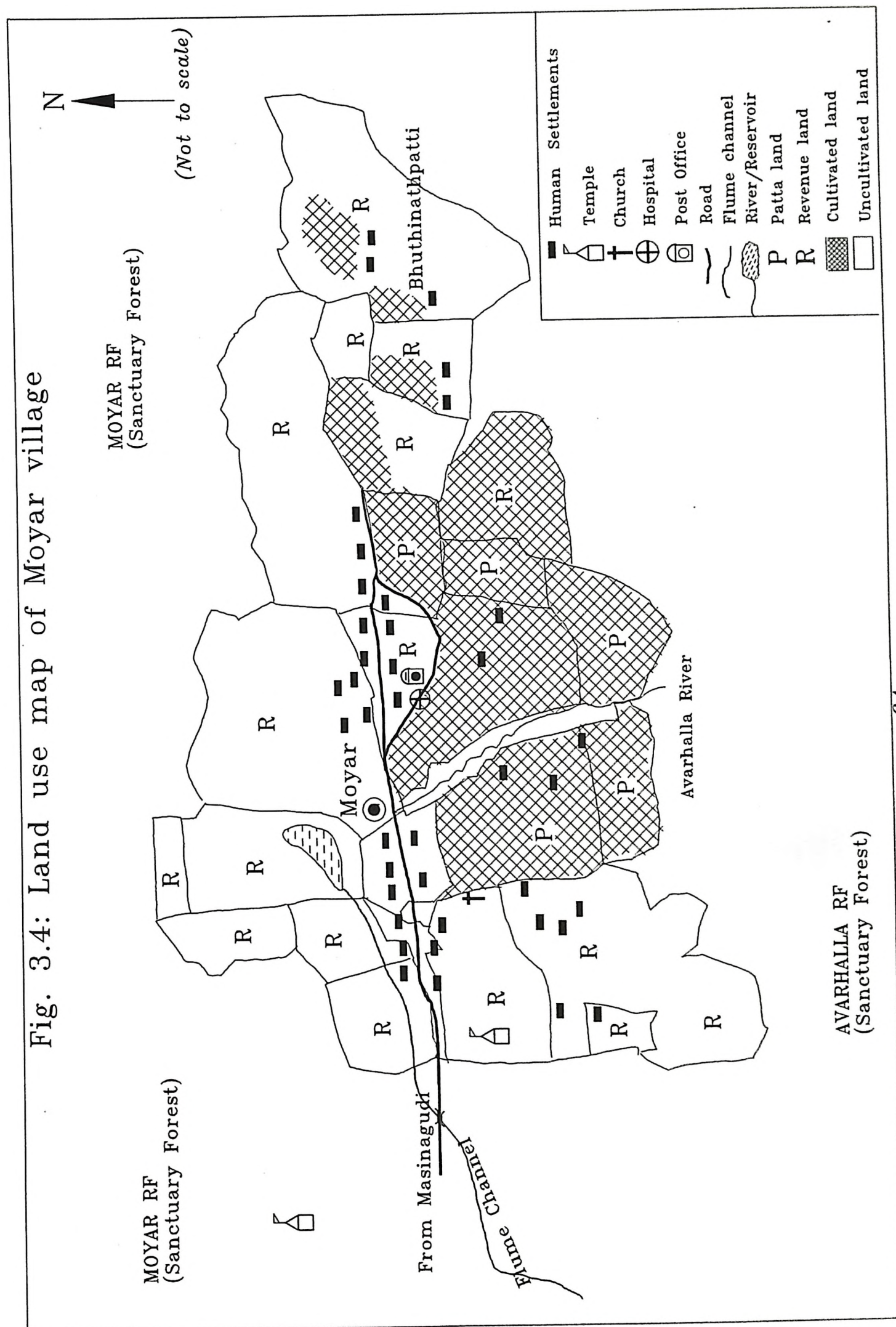


Fig. 3.5: Land use map of Bokkapuram village

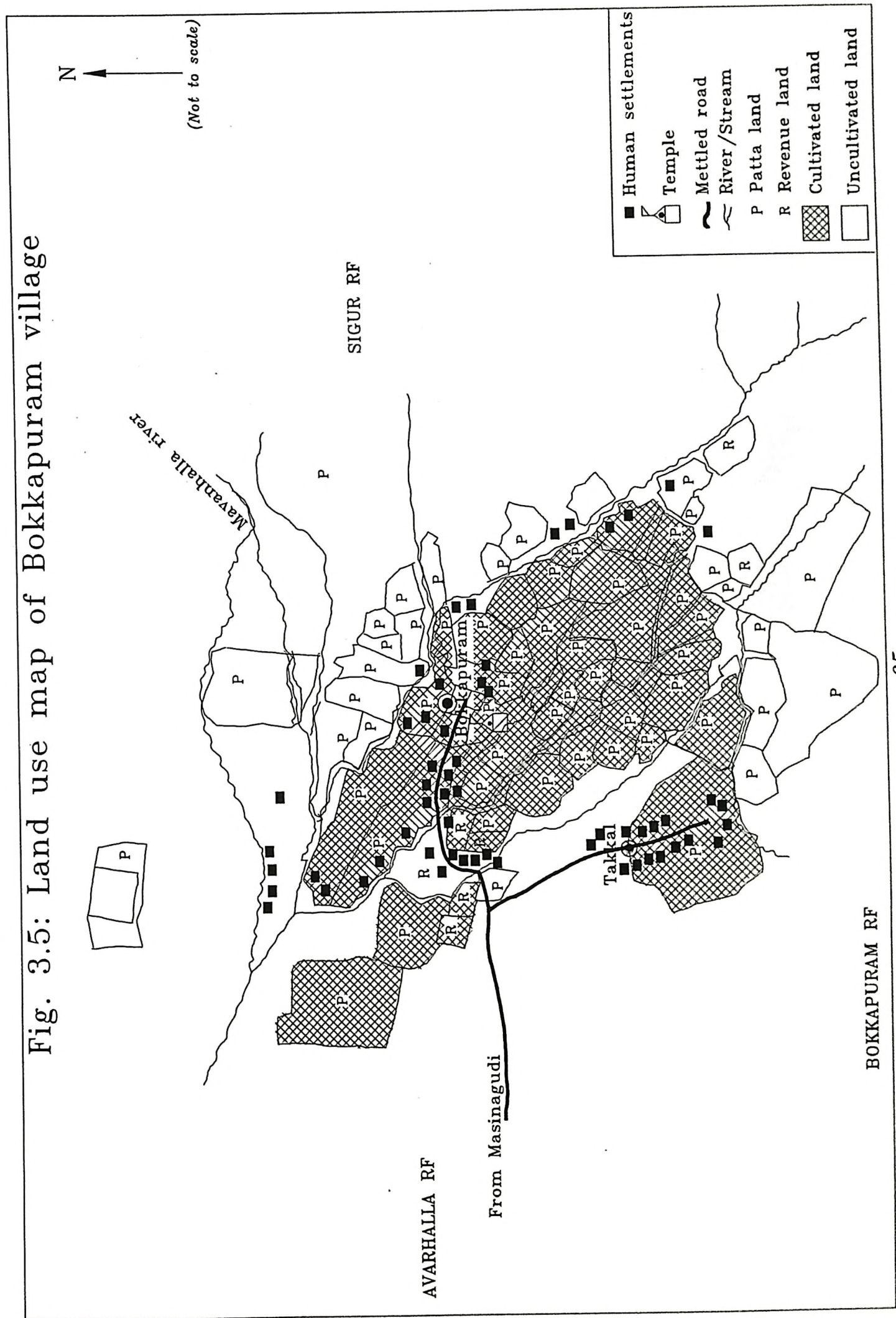


Fig. 3.6: Land use map of Mavanhalla village

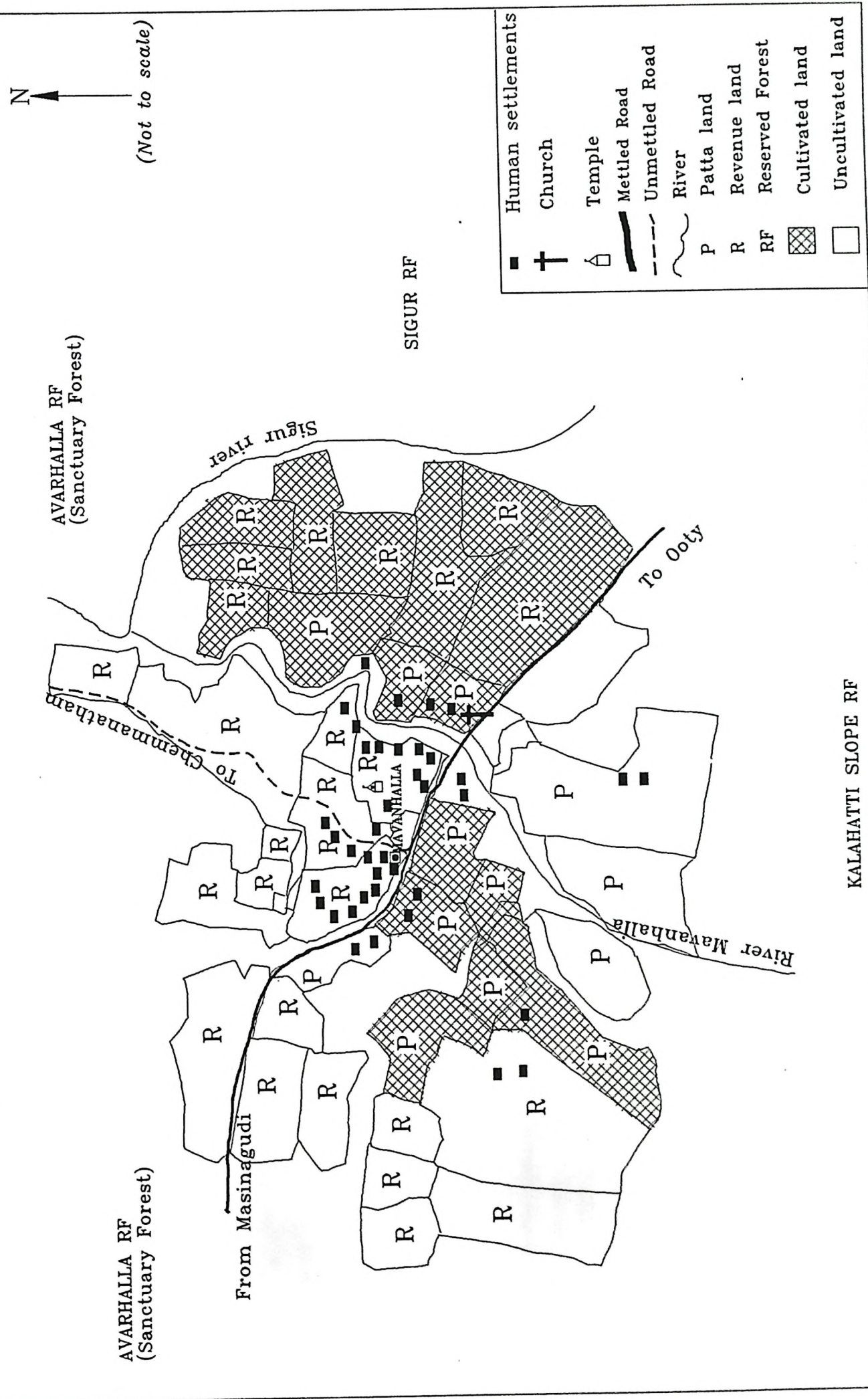


Fig. 3.7: Land use map of Chemmanatham village

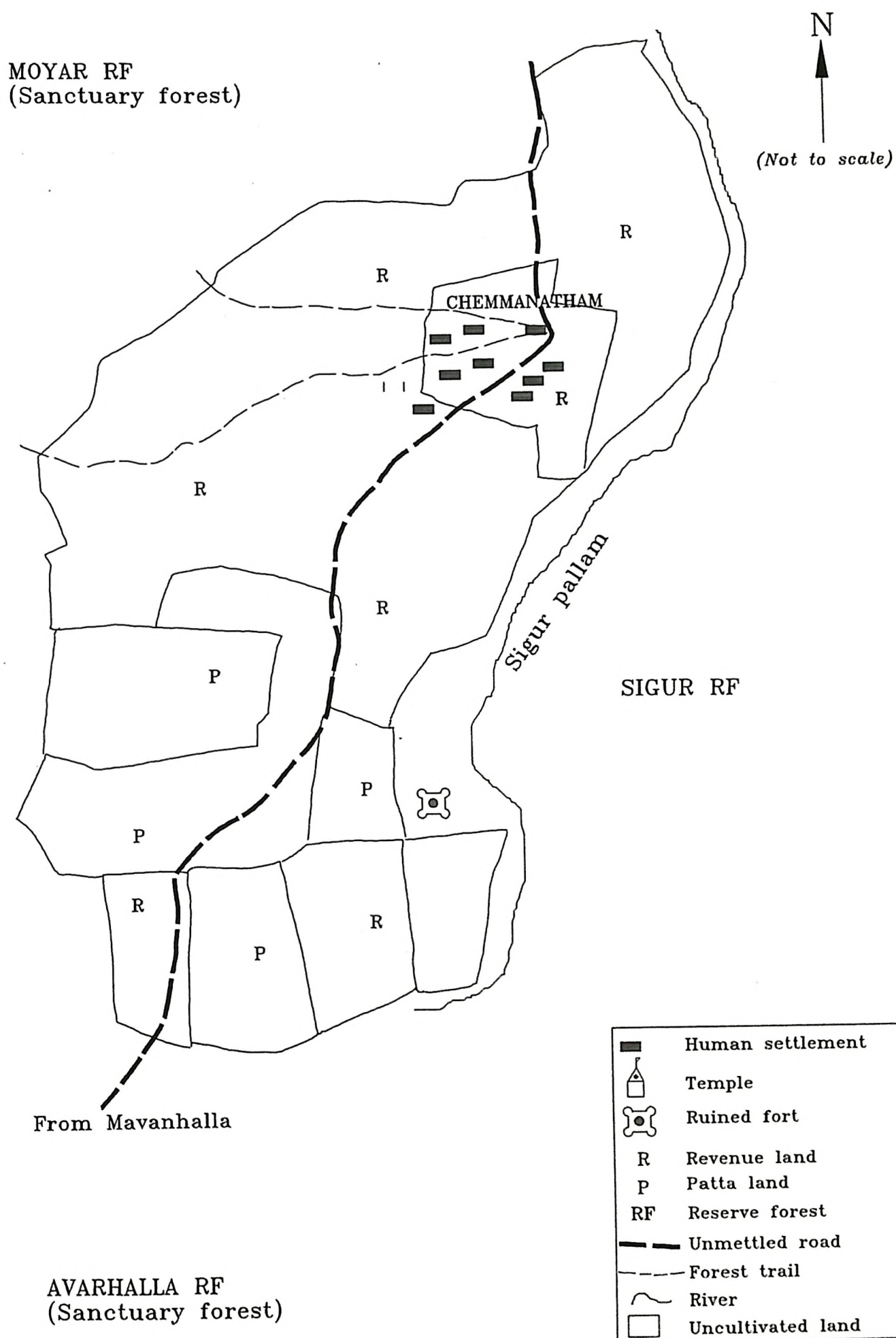
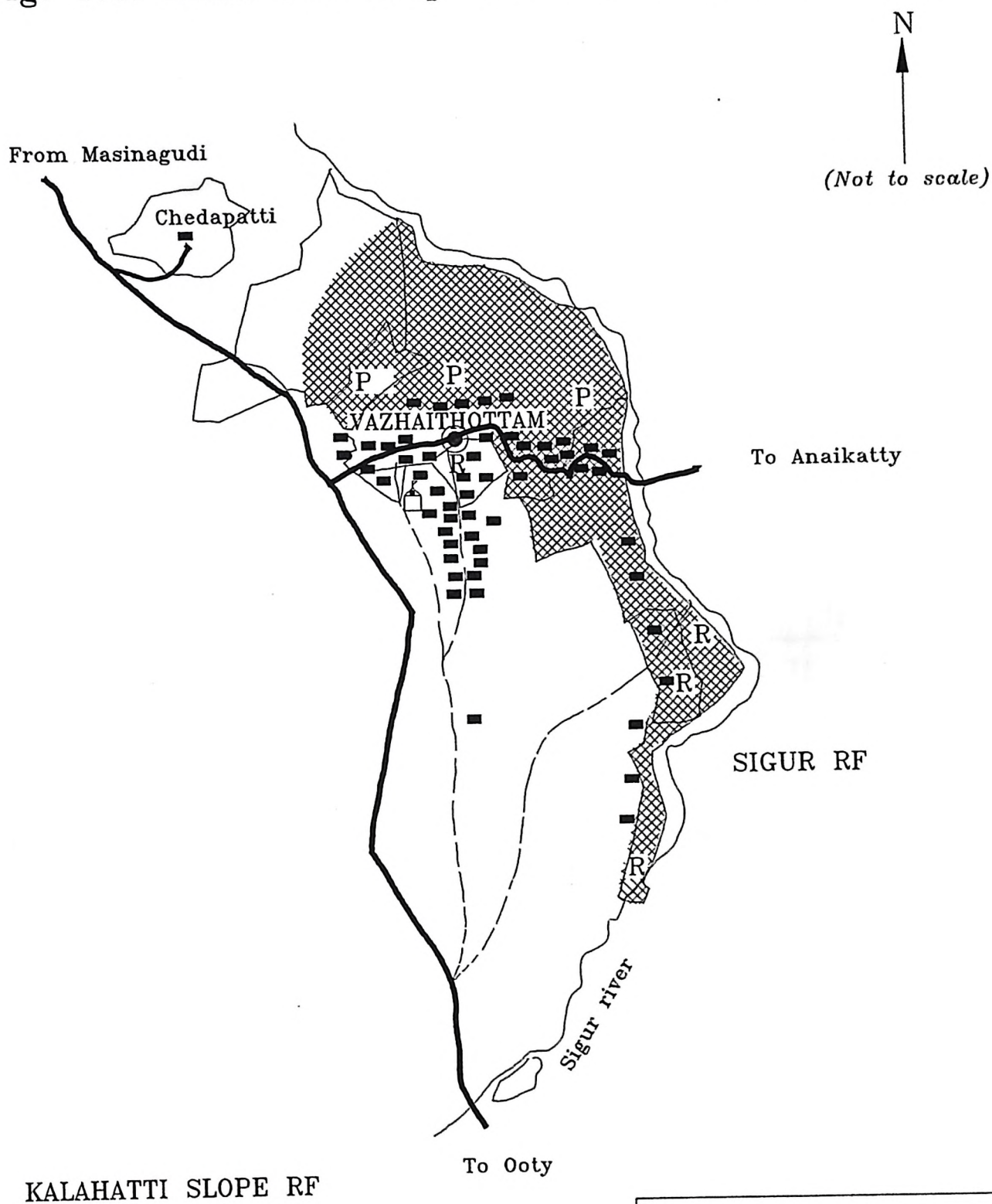


Fig. 3.8: Land use map of Vazhaithottam village



-  Human settlement
-  Temple
-  Mettled road
-  Unmettled road
-  River
-  P Patta land
-  R Revenue land
-  Cultivated land
-  Uncultivated land

3.4.9 Land Holding Pattern

Table 3.9 shows the proportion of landless people and land owners in all the seven villages of study area. While the majority of families (75%) are landless, only 25% families possess land. It is very interesting to note here that while the permanent residents of Singara and Chemmanatham village do not own cultivated land at all, some people who reside outside these villages own the entire cultivated land of these villages.

Table 3.9: Proportion of land-owning families

Village	No. of land-owning families	Total families
Masinagudi	110 (14)	768
Moyar	44 (21)	207
Singara	7 (7)*	115
Bokkapuram	115 (60)	193
Mavanhalla	54 (53)	101
Chemmanatham	4 (33)*	12
Vazhaithottam	37 (47)	79
Total	371 (25)	1475

Values in parentheses refer to the percentage of total

* All the land belongs to land owners residing outside the village

The land holding per village is given in Table 3.10. While 71% of the total land is owned by large landholders (who account for only 3.7% of the total families), only 18.5% of the land is distributed among the largest chunk of the population who are small and marginal farmers (87% of families). Medium and semi-medium type of landholders form only 9.5% of the total land-owning families and possess only 10.5% of the land of the area under consideration.

Table 3.10: Land holdings of the study villages

Village	No. of families and category of farmers *											
	Marginal farmer		Small farmer		Semi-medium farmer		Medium farmer		Large farmer		Total	
	No. of families	Total area (acres)	No. of families	Total area (acres)	No. of families	Total area (acres)	No. of families	Total area (acres)	No. of families	Total area (acres)	Total area (acres)	
Masinagudi	77	139.8	26	97.0	3	20.5	0	0	4	574.7	110	832.0
Moyar	25	48.8	15	51.0	3	19.0	1	20.0	0	0	44	138.8
Singara	0	0	1	4.6	0	0	0	0	6	1544.7	**7	1549.3
Bokkapuram	93	149.0	13	40.3	4	35.0	3	50.0	2	350.0	115	624.3
Mavanhalla	42	71.3	6	21.0	2	14.0	2	35.0	2	98.0	54	239.3
Chemmanatham	0	0	1	3.2	1	5.3	2	35.8	0	0	**4	44.3
Vazhaithottam	16	25.0	6	22.3	7	48.7	8	97.3	0	0	37	193.3
Total	253	433.9	68	239.4	20	142.5	16	238.1	14	2567.4	371	3621.3

* Farmers were categorised as marginal, small, semi-medium, medium and large farmers based on their land holdings as suggested by Shyam (1989). These are: Marginal farmers = <2.5 acres; Small farmers = 2.5-5 acres; Semi-medium farmers = 5-10 acres; Medium farmers = 10-25 acres and Large farmers = >25 acres.

** Represent those families who are living outside the study area

3.4.10 Irrigation

Of the total land of 3621.3 acre, only 391 acre (11%) is irrigated while the remaining cultivated land is rain fed (Table 3.11). Means of irrigation in the study villages are restricted to the natural streams and private wells. Of the total 380 agriculturist families of all the 7 villages, only 40 families (11%) have irrigation facility on their agricultural land. Of the total, 85% families whose land was irrigated, depended on wells, while the rest depended on the natural streams for irrigating their agricultural land. Only in Vazhaithottam, Mavanhalla and Bokkapuram farmers depended on streams for irrigation. Even though a flume channel flows for the generation of electricity throughout the year between Singara and Moyar, passing through Masinagudi the local farmers were not allowed to use the water for irrigation!

Table 3.11: Irrigation facility of the study villages

Villages	No. of Families whose land is			Acreage of land which is		
	Unirri-gated	Irrigated		Unirri-gated	Irrigated	
		Well	Stream		Well	Stream
Masinagudi	107	3	0	747.0	85	0
Moyar	34	10	0	83.8	55	0
Singara	7	0	0	1549.3	0	0
Bokkapuram	106	8	1	531.3	91	2
Mavanhalla	49	3	2	162.3	63	14
Chemmanatham	4	0	0	44.3	0	0
Vazhaithottam	24	10	3	112.3	72	9
Total	331	34	6	3230.3	366	25

3.4.11 Manuring and Land Development Pattern

Analysis of the manure used in the farm land of all the 7 villages revealed that, of total 353 families, only 146 families (41%) did not use manure at all despite easy availability of dung manure in the area (Table 3.12). This is because livestock dung is preferred to be sold by the poor marginal farmers to the nearby tea and coffee planters for fetching easy money. The remaining 207 families used two types of manure viz., organic and inorganic. Organic manure included mainly livestock dung and decomposed waste from the cow shed, while inorganic manure included chemical fertilizers like phosphate, urea, and Di-Amino Phosphate (DAP). Of the total families using manure or fertilizers, 68% used livestock dung 4% used several chemical fertilizers, while the remaining 8% families used both types of fertilizers. Chemical fertilizers are mainly used by those families who have semi-medium to large land holdings, and grow mainly cash crops.

Table 3.12: Manure use pattern

Village	Number of families who are				Total
	Not using manure	Using manure			
		Inorganic	Organic	Both	
Masinagudi	19	1	75	15	110
Moyar	12	0	22	10	44
Singara	0	0	0	0	0
Bokkapuram	81	0	28	6	115
Mavanhalla	25	7	15	7	54
Chemmanatham	0	0	0	0	0
Vazhaithottam	9	0	0	21	30
Total	146	8	140	59	353

Results of the questionnaire survey related to the land improvement methods known to the farmers revealed that 71% did not know of any land improvement methods. The farmers who answered positively regarding the knowledge of land improvements (29%), did mainly terracing and bunding of their land, to check erosion of the top soil. Some of them use pesticides and other chemicals to protect the crop plants from pests and diseases. Some of the farmers answered positively regarding the knowledge of bank loans and other subsidies offered by Government departments, but none of them ever used those facilities, as they are afraid of the complicated procedures related with this, and the high rates of interest. Most of the farmers plough their fields with bullocks or buffaloes, while very few use tractors. Most of the farmers did all the agricultural works by themselves, except for a few of semi-medium to medium farmers and all the large farmers who hired labourers.

3.4.12 Agriculture and Cropping Pattern

Of the total cultivated area of the 7 villages under consideration, 49%, 20% and 10% land is in Singara, Bokkapuram and Masinagudi village respectively (Table 3.13). The rest of 21% is distributed in Moyar and Vazhaithottam village. The entire cultivable land in Chemmanatham, which belongs to 4 families, is uncultivated because the owners reside in Ooty and other area outside the village. In Singara, 93% of the total 1011 acres of cultivated land is used for coffee plantation, 7% is used for oranges. No other crops are grown in this village. It may be worth mentioning here, that the entire cultivated land is owned by 7 families, all residing outside the village.

The cropping pattern in the study area is, to a large extent dependent on the availability of irrigation water. The farmers who have irrigation facility in one

form or the other, grow a variety of cash crops, while the others cultivate only traditional crops like ragi, maize, paddy and jowar. Of the total cultivated area, 55% is under a 30 year old coffee plantation in Singara and Bokkapuram. This was followed by cereals and millets like ragi, maize, paddy and jowar covering 23% of the total cultivated land. Vegetable crops are grown on 6.7% of total cultivated area, followed by oil seeds like sunflower, groundnut and coconut (5.4% area) and fruits like orange, lime, mango, banana, and papaya (4.7% area). Spices like garlic, pepper and chilly are grown on only 1.6% of total area. Other crops included cotton, silver oak and some pulses like black gram, horse gram and pigeon peas. All these crops are cultivated and harvested at different times of the year. Coffee, which is replanted every 70-75 years is harvested every year from December through March, after the plantation is 7-8 years old. Two species of coffee viz., *Coffea arabica* and *C. robusta* are grown here. *C. arabica* which is favoured because of its early maturation period, is harvested in December and January, while *C. robusta* is harvested in February and March.

Table 3.13: Cropping pattern in the study village

Name of crop	Village wise area under cultivation (in acres)							Total
	1	2	3	4	5	6	7	
A. Cereals & Millet								
1. Ragi (<i>Eleusine coracana</i>)	185.50	58.00	0	109.75	42.00	0	6.50	401.75
2. Maize (<i>Zea mays</i>)	4.50	20.00	0	33.00	6.00	0	5.00	68.50
3. Paddy (<i>Oryza sativa</i>)	0	0	0	0.50	8.00	0	0.75	9.25
4. Jowar (<i>Sorghum vulgare</i>)	0	0	0	0	1.50	0	0	1.50
B. Pulses								
1. Pigeon peas (<i>Cajanus cajan</i>)	1.50	0	0	0	0	0	5.85	7.35
2. Horse gram (<i>Dolichus uniflorus</i>)	2.50	6.00	0	0	0	0	0	8.50
3. Black gram (<i>Phaseolus mungo</i>)	0	0	0	0	2.50	0	5.25	7.75
C. Vegetables								
1. Cabbage (<i>Brassica oleracea</i>)	7.00	6.00	0	1.00	4.00	0	12.50	30.50
2. Potato (<i>Solanum tuberosum</i>)	1.00	4.00	0	3.50	1.50	0	25.50	35.50
3. Beans (<i>Phaseolus vulgaris</i>)	9.50	9.50	0	25.75	22.25	0	4.50	71.50
4. Onion (<i>Allium cepa</i>)	0	0	0	0	1.00	0	2.00	3.00
5. Brinjal (<i>Solanum melongena</i>)	0	0	0	0	0.50	0	0	0.50

D. Fruits

1. Mango (<i>Mangifera indica</i>)	0	0	0	0	0	0	0	0	4.50	4.50
2. Orange (<i>Citrus sinensis</i>)	0	0	0	75.00	0	0	0	0	0	75.00
3. Lime (<i>Citrus aurantiifolia</i>)	0	0	0	0	0	0	13.00	0	0	13.00
4. Papaya (<i>Carica pappaya</i>)	0	0	0	0	0	0	0.50	0	0	0.50
5. Banana (<i>Musa paradisica</i>)	0	0	0	0	0	0	2.00	0	2.15	4.15

E. Oil Seeds

1. Sunflower (<i>Helianthus annus</i>)	4.00	6.00	0	0	1.50	14.00	0	0	0	25.50
2. Groundnut (<i>Arachis hypogaea</i>)	46.75	0	0	0	10.50	0	0	0	0	57.25
3. Coconut (<i>Cocos nucifera</i>)	20.00	9.00	0	0	0	0	0	0	0	29.00

F. Spices

1. Garlic (<i>Allium sativum</i>)	2.00	8.00	0	0	0.50	0	0	0	6.50	17.00
2. Pepper (<i>Piper nigrum</i>)	0	0	0	0	2.00	0	0	0	3.00	5.00
3. Chilly (<i>Capsicum frutescens</i>)	1.00	0.50	0	0	2.25	3.50	0	0	3.50	10.75

G. Others

1. Coffee (<i>Coffee spp</i>)	0	0	0	935.88	201.50	0	0	0	0	1137.38
2. Cotton (<i>Gossypium herbaceum</i>)	0	0	0	0	1.50	10.00	0	0	0	11.50
3. Mulberry (<i>Morus alba</i>)	5.00	0	0	0	8.50	11.25	0	0	0	24.75
4. Silver oak (<i>Grevilla robusta</i>)	0	0	0	0	17.00	0	0	0	3.00	20.00

Total Area

	290.25	127.00	1010.88	418.25	143.50	0	90.50	2080.38		
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1= Masinagudi; 2= Moyar; 3= Singara; 4= Bokkapuram; 5= Mavanhalla; 6= Chemmanatham; 7= Vazhathottam

3.4.13 Crop Raiding

Since all the 7 villages are located adjacent to the forest land there are frequent incidences of crop raiding by wild animals throughout the cropping season. Of the total farmers interviewed, 91% reported loss of crops due to crop raiding by wild animals. Extent of damage was very high in case of crop raided by wild boars and elephants, often leaving nothing to be harvested. Wild boar mainly damaged groundnut and potato crops, while elephants very frequently raided ragi, maize, and pulses. Vegetable crops suffered due to raiding by common langur and nilgiri langur, while birds damaged the sunflower crop. Crops were raided at different stages of their life cycles. For example, ragi was raided by cheetal at the early stage, soon after germination. The same crop was damaged by elephants when seeds matured and it was ready for harvesting. Sloth bear raided maize when the corn was mature, and wild boar damaged groundnuts and potatoes when the nuts and tubers were mature. Even though 3% of the total farmers used electric fence to protect their agricultural fields from wild elephants, these were not very effective because of the poor maintenance.

3.4.14 Livestock Rearing

Rearing of livestock in the study area played a major role in the economy of the local population. The huge demand of livestock dung manure by the owners of the nearby tea and coffee estates, has been the major cause of the rising livestock population. Information regarding the trends in the livestock population over the past 5 years was collected from the various offices of Nilgiri District Co-Operative Milk Producer's Union (NDCMPU), and it was found that there was an increase of almost 31% in the total livestock population in the five years from 1987-88 to

1991-1992 averaging a 6% increase per year (Table 3.14). Cattle population increased by 26% in 5 years of time which is equal to a 5.3% increase per annum. While goat population decreased a little, sheep population increased 3.3 times during this period. Horse and donkey did not increase significantly.

Table 3.14: Increase of livestock population during 1987-92

Livestock category	1987-88	1988-89	1989-90	1990-91	1991-92
Bull	266	221	336	514	558
Cow	4453	4950	5749	5974	5708
Cow calf	2257	2158	2364	3129	2982
Buffalos	720	617	854	528	540
Buffalo calf	344	386	366	377	368
Goat	1423	885	1042	1241	1013
Sheep	592	937	1562	1342	1967
Horse	4	3	16	4	4
Donkey	60	60	60	78	73
Total	10119	10217	12349	13187	13213

Source: Nilgiri District Co-operative Milk Producers Union, Ooty

3.4.15 Livestock Ownership Pattern

Results of the household survey regarding livestock population have been given in Table 3.15. Of the total 1475 families from all the seven villages, 630 families (43% of total families) possessed 8665 livestock, including cattle, sheep, goat and donkeys. Of the total livestock owning families, 520 owned only cattle, 21 owned only sheep and goat, while the other 89 families owned both cattle, and sheep and goats. Of the total livestock owning families, Masinagudi village had the largest

percent with 49% families owning 38% of the total livestock population. Individually, Chemmanatham village had largest percent of livestock holders with 7 of 12 families (58%) possessing livestock, followed by the Moyar village (104 of 207 families - 50%). It may be mentioned here that the cattle holders of Chemmanatham village were not actual owners because the cattle population was owned by the people residing outside the village. In Singara, only 33% of the families owned livestock.

Table 3.15: Livestock population of study villages

Village	Number of livestock			
	Cattle	Sheep & goat	Donkey	Total
Masinagudi	2656	601	0	3257 (309)
Moyar	1525	142	0	1667 (104)
Singara	164	12	0	176 (38)
Bokkapuram	1063	256	0	1319 (98)
Mavanhalla	689	119	80	888 (40)
Chemmanatham	365	0	0	365 (7)
Vazhaithottam	961	32	0	993 (34)
Total	7423	1162	80	8665 (630)

Values in parentheses refer to the number of family having livestock.

Most of the cattle population in the study area was of local or non-descript breed, and yielded not more than half a litre of milk per day. The average milking cattle remains dry for more than six months in a year. Therefore, selling of milk contributed much less compared to selling of dung which is produced throughout the year and by all categories of cattle. The milk was sold to the milk co-operative society established at each village. The rate of milk was fixed by the society based

on the fat quantity of milk. On an average it ranged between Rs. 3.00 and Rs. 3.50 per litre.

Cattle owners were divided into 10 categories, based on the cattle holdings. Village-wise cattle holding and sheep and goat holding have been given in Table 3.16 and 3.17 respectively. Of the total 609 cattle owning families, 433 i.e., 71% owned 27% of the total cattle population having a maximum of 10 numbers. The remaining 73% population (5423) was owned by only 29% of the families, with >10 cattle, of which 48% were owned by just 36 families, each having >45 cattle. The 36 families account for 6% of the total cattle owners, and 20% of the 176 families that owned more than 10 cattle each (Table 3.16). Similarly of the total 103 sheep and goat owning families only 29 families (28%) possess >10 sheep and goats each and they together hold 806 sheep and goats (Table 3.17). Of the total 176 families with more than 10 cattle, 16 families had more than 5 acres of agricultural land, 27 were small farmers with 2.5 to 5 acres of agricultural land, 53 were marginal farmers with 1 to 2.5 acres of agricultural land, and 80 were landless, with no other economic support other than livestock rearing. In case of the 29 families having more than 10 sheep and goats, 8 are landless, 3 have more than 5 acres and rest 18 are marginal and small farmers.

Table 3.16: Cattle holdings of the study villages

Cattle holding categories	Number of families and cattle owned by them													
	1		2		3		4		5		6		7	
	NF	NC	NF	NC	NF	NC	NF	NC	NF	NC	NF	NC	NF	NC
1-5	159	474	35	107	28	81	36	101	15	42	0	0	13	40
6-10	78	605	26	212	8	60	24	196	9	68	0	0	2	19
11-15	27	337	13	170	2	23	9	116	3	43	0	0	1	11
16-20	8	139	9	162	0	0	11	205	4	70	0	0	1	17
21-25	9	209	5	114	0	0	2	47	0	0	0	0	1	24
26-30	3	88	7	193	0	0	0	0	2	53	0	0	2	56
31-35	3	98	2	66	0	0	1	32	1	33	2	56	2	66
36-40	2	76	1	37	0	0	0	0	0	0	1	35	1	40
41-45	1	45	1	45	0	0	2	87	0	0	0	0	1	42
>45	7	585	5	419	0	0	5	279	6	380	4	274	9	646
Total	297	2656	104	1525	38	164	90	1063	40	689	7	365	33	961
													609	7423

1 = Masinagudi; 2 = Moyar; 3 = Singara; 4 = Bokkapuram; 5 = Mavanhalla; 6 = Chemmanatham; 7 = Vazhaithottam

NF = No. of families; NC = No. of cattle

Table 3.17: Sheep and goat holding of the study villages

Sheep and goat holding categories	Number of families and sheep and goat population owned by them															
	1		2		3		4		5		6		7		Total	
	NF	NSG	NF	NSG	NF	NSG	NF	NSG	NF	NSG	NF	NSG	NF	NSG		
1-5	22	62	3	13	1	3	11	36	2	2	0	0	7	17	46	133
6-10	13	103	3	29	1	9	8	54	2	13	0	0	1	15	28	223
11-15	3	38	0	0	0	0	1	12	2	24	0	0	0	0	6	74
16-20	5	98	2	40	0	0	2	37	1	20	0	0	0	0	10	195
21-25	2	50	0	0	0	0	2	47	0	0	0	0	0	0	4	97
26-30	1	30	0	0	0	0	1	30	0	0	0	0	0	0	2	60
31-35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36-40	0	0	0	0	0	0	1	40	0	0	0	0	0	0	1	40
41-45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>45	4	220	1	60	0	0	0	0	1	60	0	0	0	0	6	340
Total	50	601	9	142	2	12	26	256	8	119	0	0	8	32	103	1162

1 = Masinagudi; 2 = Moyar; 3 = Singara; 4 = Bokkapuram; 5 = Mavanhalla; 6 = Chemmanatham; 7 = Vazhaithottam

NF = No. of families; NSG = No. of sheep and goats

3.4.16 Vaccination and Artificial Insemination

Most of the livestock owners did not take much care of the health of their livestock, as they were merely treated as dung-producing machines. The Animal Husbandry Department was also not very enthusiastic regarding the health care and other aspects of cattle farming and breed improvement programmes. Information regarding the vaccination and artificial insemination of cattle was collected from local milk co-operative unions. It was found that there were no systematic programmes of vaccination for the domestic livestock to check any outbreak of diseases in the wild animals. Although there was cattle trade still going on between Karnataka and Tamil Nadu through various routes, most of which were through the Moyar gorge, there were no veterinary check posts at the border area except at Theppakadu where extensive vaccination of emigrating and immigrating livestock was done. The information collected for nine months, from April to December 1992 showed that of the total 7453 migratory cattle (Table 3.18), 7253 (97%) were vaccinated. For further information, NDCMPU at Ooty was approached regarding the Foot and Mouth Disease (FMD) outbreak in Masinagudi and Thengumarada, a village to the north east of the Sanctuary and on the migrating route of elephants. The outbreak occurred in July 1991 in Thengumarada and in October 1991 in Masinagudi village, due to the immigrating cattle from Puliambatty, a village near Thengumarada. Of the 142 diseased animals in Thengumarada only 17% has been vaccinated while in Masinagudi, of the 39 diseased animals, only 39% had been vaccinated for FMD, and the reasons for not vaccinating the total population were unknown. Data regarding artificial insemination of the local breed to improve the milk yielding capacity were collected from Masinagudi milk co-operative society for the year 1988-89, after which there were no records of artificial insemination. Of the 112 animals artificially

inseminated during the year, only 48% gave birth to calves. The reason for not continuing the insemination programme to improve the local breed was, however, unknown to the staff of the Veterinary Department then posted in the veterinary centres.

Table 3.18: Number of migratory livestock

Months	Immigrating		Emigrating		Total	
	Cattle	Sheep & goats	Cattle	Sheep & goats	Cattle	Sheep & goats
April	84	122	291	0	375	122
May	328	205	386	8	714	213
June	249	76	133	20	382	96
July	523	336	56	40	579	376
August	186	125	583	84	769	209
September	0	115	560	12	560	127
October	0	481	287	254	287	735
November	101	307	324	0	425	307
December	0	611	569	0	569	611
Total	1471	2378	3189	418	4660	2796

No. of vaccinated animals: 7253

Source: Veterinary hospital, Theppakadu Checkpost

3.4.18 Man-Animal Conflict

Secondary information on human attacks by wild elephants and sloth bear were collected for 1987-1992. During these five years, of the 8 cases reported, 6 cases were of death due to elephant attack, while the other 2 cases were due to bear attack, in which the victims were injured seriously (Table 3.19). Of these

8 cases, 4 cases were reported near Masinagudi village while remaining 4 cases were reported from the western part of the Sanctuary around Gudalur.

Table 3.19: Incidence of man-animal conflict

Year	Animal	Place of incidence	No. of cases	Death/ Injured
1987	Elephant	Benne*	One	Death
1988	Elephant	Benne*	One	Death
1989	Elephant	Masinagudi	One	Death
1990	Elephant	Kariashola	One	Death
1991	Sloth bear	Mudumalai	One	Injured
1991	Sloth bear	Mudumalai	One	Injured
1992	Elephant	Bokkapuram	One	Death
1992	Elephant	Gudalur	One	Death

* Near Gudalur

Source: Tamil Nadu Forest Department, Ooty

3.5 DISCUSSION

3.5.1 Expansion of Human Settlements

Masinagudi and its surrounding area has undergone drastic changes in the past few decades, after the establishment of the first power generation station at Singara in 1936. When the construction work of the hydro-electric project began at Singara in the early 1930s, people from the adjoining areas started pouring into the area for job opportunities. A large chunk of the immigrant population belonged to the labour class. During the construction phase, much of the wilderness area of the region was replaced by concrete structures, and some land was converted into secondary forest because of the growing demands of fuel and fodder of the immigrants and their cattle. On completion of the construction work, the immigrants settled permanently in the area on encroached revenue land. In the absence of their own agricultured land, they became more and more dependent on the forest resources of the area, and cattle rearing and selling of the cattle dung became their main sources of income. Because of the potential of the area for hydro-electric power generation, more and more small projects were undertaken in a phased manner in the subsequent years. This resulted in the expansion of settlements on the encroached revenue land and one such example is Masinagudi village, which is very soon going to be a township. The annual growth rate of human population (4.8%) for the last three decades in this area is more than double the national average of 2.2% (Govt of India Census, 1991), and is mainly because of the continuing flow of labourers into the area. This is not the end of the problem, as the trend of immigration of labourers is still going on because of two new power projects which are under construction. These are the Marvakandy project, and the Pykara Ultimate

Stage Hydroelectric Power Project (PUSHEP) at Masinagudi. Further, the unplanned developmental activities and lack of inter-departmental co-operation, enhances the problem. The construction of new tribal settlements by Nilgiri District Development Authorities under tribal development scheme is one such example. There are about 30 concrete houses constructed by clearing a 1 ha patch of scrub forest on the boundary of Moyar-Avarhalla corridor forest near Mavanhalla village. The human and livestock populations of this new settlement enjoy easy access to the northern corridor, which is definitely going to increase the problem.

3.5.2 Impact of Land Use

The lack of irrigation facility and frequent incidences of crop raiding by elephants have left the people with no other option than to leave the encroached land uncultivated. As a result 63% of the total agricultural land is lying as cultivable waste, and is only being used as cattle camping grounds. Everyday almost 9000 livestock of all the 7 villages trample these grounds, thereby accelerating the erosion of top soil. On these lands, the ground flora is seen in the form of scattered individuals of *Euphorbia* and scanty vegetation of some other species, which is slowly being encroached by *Lantana* and *Parthenium*. Agricultural produce from the cultivated land is not enough to meet the annual requirements of the villagers. However, because of irrigation facility all farmers of Vazhaithottam and a few of Mavanhalla village were able to produce good crops. In this situation the local people, especially the labour class, are forced to be dependent on forest resources, in the form of firewood, cattle dung and NTFPs to meet their daily requirements. Although cattle dung in the villages was available in plenty, it was not popular for use as manure in their own agriculture fields, and a large proportion was seen to be sold to owners

of coffee and tea estates of the adjoining areas; people were seen collecting cattle dung even from their agricultural fields just to earn few rupees! Of course this practice might have evolved as a strategy to overcome the situation arising due to the lack of irrigation in the area. The introduction of sericulture in some villages of the study area was not successful, primarily due to the absence of irrigation facility and also due to the lack of proper extension programmes.

The rise in the human and livestock population was parallel in the study area. Increasing demand of cattle dung manure from the nearby tea and coffee planters, gave the locals the scope of rearing more cattle. The migrant labourers who were jobless on completion of the power generation projects, or had more than 2-3 working members in the family raised more cattle. The dung manure demand was so high that these people even found it profitable to gather dung from the surrounding forest floor. Keeping of more number of cattle in an area than it could support is not a healthy practice from the point of view of the ecosystem health (Bock *et al.*, 1996; Shankar and Singh, 1996). Excessive grazing depletes the forests and arrests regeneration. Removal of cattle dung from the forest floor further aggravates the forest depletion process, because the dung which should enrich the forest floor, is not recycled into the soil (Shaltout *et al.*, 1996). To add to the above problems, migratory cattle also visit the area from Karnataka every year between July to November. Further, the artificial insemination programmes which were undertaken by the Animal Husbandry Department, were not very successful, for which reason not known, provided an opportunity of proliferation of more scrub livestock. Since the human habitation and the agriculture fields are rapidly encroaching upon the corridor forest, the elephants are now left with no option than to raid crops and damage

the human settlements during their seasonal migration. In extreme cases, it leads to loss of human life as well.

CHAPTER 4

4

RESOURCE DEPENDENCY

4.1 INTRODUCTION

The dependence of man on the natural resources is as old as himself. In the early stage of development of human society, forest was simply a part of the environment: a place to find food, energy and shelter. Man made his appearance in the biosphere around 3,000 BC and in the early Bronze Age (2200-1000 BC), he started cattle rearing and farming (Andersson, 1991). Since then, the environment, its components, and their physical and biological inter-dependence have undergone dramatic changes by the activities of man. Most of these changes that occurred on the face of the earth, were human induced and got accelerated due to the uninterrupted increase in the number of people and their livestock. The dependency of man on forests, may be for basic need or commercial greed, has increased at the same pace of its population growth. What causes concern today, is the speed at which the change in relationship between man and environment occurs, in the form of climate change, pollution, over exploitation and extinction of species and varieties.

Fuelwood, timber, fodder, grass, thatch, NTFPs, and other forest produces are major items that are extracted by man from forests to fulfil his basic requirements.

On creation of the PAs, people loose access to the resources of the forest. Dependency however, persists and therefore people get involved in the illegal means to fulfil their basic needs (Panwar and Mishra, 1994). It has been realised that until and unless alternatives are provided, any attempt to conserve the resources of the so declared PA will be futile. It is therefore, essential to quantify the resource dependency of the people on the forest as the first step, if the conservation of natural resources of the PAs are to be effective.

In this chapter, an attempt has been made to study the resource dependency patterns of the Masinagudi group of villages.

4.2 METHODOLOGY

4.2.1 Biomass Extraction

Information on biomass extraction by local people were collected by actual observations and measurements in the field as well as by the questionnaire survey. To begin with however, as per the methods suggested by Sale and Berkmuller (1988), statements of the local Forest Staff were systematically recorded, with respect to the usual routes used by the people of the study villages, to go inside the forest for collection of different biomass items or even for grazing their livestock, and also the place of the collection/grazing. These information were very useful to begin the work, and as the work progressed, data collected by questionnaire survey and also by actual observation and measurements in the field, were cross checked.

Based on the staff statements, information given by the villagers, and personal observations, a total of 28 entry points leading to different forests were identified for various types of observation and measurements on the boundary of all the seven villages (Table 4.1). This study was done for one complete year to know the seasonal differences.

4.2.1.1 Firewood and Grass Collection

To quantify the firewood and grass collection from the corridor forests and surrounding forest, regular monitoring of entry/exit points was done. The parameters recorded at each of these entry/exit points were: i) the number of the people visiting, ii) time of entry and exit into and from the forest, iii) distance travelled, and iv) species cut/lopped for firewood, timber and fodder. Quantification of extracted biomass

was also done systematically on these entry/exit points. Monitoring of entry/exit points in each village was conducted at least 4 times in every month. Number of males, females and children visiting forest, was also recorded. Head loads of wood and grass were weighed randomly using spring balance at each entry point to find out the average weight of a male, female, and a child headload. To estimate the timber wood extraction, individual piece of timber wood carried by the headloaders was weighed. Based on this, the annual extraction of firewood, timber and grass was calculated for each village.

Table 4.1: Village wise details of entry points

Village	No. of entry points	Entry points leading to
Masinagudi	6	Moyar RF, Singara RF, Kalmalai RF, Avarhalla RF
Moyar	5	Moyar RF, Avarhalla RF, Sigur RF
Singara	2	Northern Hay RF, Kalamalai RF, Singara RF
Bokkapuram	4	Kalahatti Slope RF, Avarhalla RF, Singara RF
Mavanhalla	4	Kalahatti Slope RF, Avarhalla RF, Singara RF
Chemmanatham	3	Avarhalla RF, Moyar RF, Sigur RF
Vazhaithottam	4	Sigur RF, Kalahatti Slope RF, Avarhalla RF

4.2.1.2 Cattle Dung Collection

Monitoring of entry/exit points was carried out, in the similar manner as described above, to quantify the seasonal removal of cattle dung from the forest floor. Amount of dung collected by individual collector was weighed in the field. Simultaneously, the cattle pans were also visited randomly in each village, to quantify

the dung production per day. Dung from each cattle pan was removed completely after the cattle were sent into the forest. Dung produced inside cattle pan from evening of the first day to the morning of the second day was weighed and averaged for 10 days in different seasons. Information regarding the number of truck loads of dung, being sold out of the study area, was collected based on the records at Masinagudi Forest Check Post. The marketing of collected dung is done through middlemen who were also interviewed regarding the peak season of dung collection and selling, market value, and the places where the dung is sold.

4.2.1.3 Non-Timber Forest Produce (NTFPs) Collection

Information on the types of NTFPs collected from the forest were recorded during questionnaire survey and also based on the actual observation in the field. Tribals do not use the NTFPs so collected from the forest but sell it through a tribal co-operative society (Lamp Society) based at Masinagudi. Lamp Society records were examined for the amount collected, and marketing of these products.

4.2.1.4 Livestock Grazing Pattern

Primary information on the number of grazing livestock was collected during questionnaire interview. This was followed by, monitoring of grazing cattle on each entry point for one complete year. Cattle paths were monitored in order to know the herd composition. Cattle herds were followed, to know the time spent, distance travelled and the forest area visited as per the methods suggested by Rodgers (1990).

4.2.2 Fodder Production

Since cattle of these villages are mainly dependent on grazing of the grass biomass of the corridor forest, an attempt has been made to estimate the annual grass production. Lopping of fodder species to feed the livestock is completely absent in these villages.

The annual grass production (standing biomass) of the corridor forests was estimated by using harvesting technique (NewBould, 1967; Sundriyal *et al.*, 1988). The above ground biomass was measured in the month of March as well as in July, which is peak growing season, after harvesting from 30 quadrats of 50x50 cm in three sites (northern corridor; southern corridor and Sigur RF). The clipped biomass was collected in polythene bags and brought to the base camp, where it was oven dried at 80°C for 24 hours, and the dry weight thus obtained was extrapolated to calculate the grass production ha^{-1} of the study sites. The total grass production of the study area was calculated by multiplying values and the total geographical area of the different study sites.

4.2.3 Fodder Requirement

The theoretical annual requirement of fodder for the entire livestock population of the area was calculated based on the standard requirement suggested by the veterinary scientists (Ranjhan, 1977) for different categories of animal. For this calculation, the average live weight of each animal category, their state of life history (immature, mature, pregnant) and the type of work they carry out for man (drought animal etc.).

4.2.4 Firewood Consumption Pattern

For estimating the per capita annual consumption of firewood, Masinagudi was selected as representative village. Ten representative families were selected in this villages for the study, based on stratified random sampling. The representative families belonged to 5 major occupation categories *i.e.*, labourer, self employment, government employment, agriculture and NTFPs collection. Each of the selected families was, monitored regularly for three days in a month for one complete year. The selected families were provided pre-weighed quantity of firewood for consumption in a day for cooking all the three meals. Same family was visited again on the following day to quantify the left over fuelwood. The number of family member for whom food was cooked, for each monitoring day in each representative family, was also recorded. Thus the per capita actual consumption was calculated by subtracting the left over quantity from the initial given quantity and dividing it by the number of family member for whom food was cooked, and finally averaged.

To find out the fuelwood consumption in hotels, 3 representative hotels of Masinagudi village were monitored in the similar manner for 3 days in a month for a period of one year.

4.3 RESULTS

4.3.1 Fuel Use Pattern

4.3.1.1 Fuel Use Pattern in Households

Results of questionnaire survey with respect to fuel use pattern has been presented in the Table 4.2. Of the total 1475 families, 85% were found totally dependent on firewood for cooking. While all families of Chemmanatham village were found using firewood, 94% use firewood in Mavanhalla and in Bokkapuram village each. In Singara village, however, 70% families were found dependent on firewood. Other fuel used in the villages were gobar gas, LPG, kerosene and electricity for stoves and heaters. Next to wood stoves, electric heaters were preferred by people for cooking in Masinagudi, Singara and Moyar village where electricity is free or very cheap for the employees of the State Electricity Department. While kerosene was used by only 66 families which is 4.5% of the total families, biogas and LPG were used by only 2.3% and 1.5% families respectively. LPG was mostly owned by the employee State Electricity Board and other government employees.

4.3.1.2 Fuel Use Pattern in Hotels

Firewood was not only used for household purposes, but was also consumed by the hotels who entertain the local population as well as the transit tourists passing through Masinagudi on the Ooty-Mysore-Bangalore highway. It was estimated that on an average about 60 vehicles pass through Masinagudi village daily carrying about 700 tourists (Table 4.3). About 249000 transit tourists pass through this route annually, of which 60% tourists stopover at Masinagudi for light refreshment or even a meal. On an average, 0.4 kg of fuel wood is required to cook one meal for one person.

Table 4.2: Types of fuel used

Village	Number of families using different types of fuel					Total no. of family
	Wood	LPG	Biogas	Kerosene	Electricity for heater	
Masinagudi	668 (87)	7 (1)	18 (3)	35 (4)	40 (5)	768
Moyar	150 (72)	3 (2)	11 (5)	4 (2)	39 (19)	207
Singara	81 (76)	1 (1)	0	20(17)	13 (11)	115
Bokkapuram	182 (94)	8 (4)	1(0.5)	2 (1)	0	193
Mavanhalla	95 (94)	3 (3)	2 (2)	1 (1)	0	101
Chemmanatham	12(100)	0	0	0	0	12
Vazhaithottam	73 (92)	0	2 (3)	4 (5)	0	79
Total	1261 (85)	22 (2)	34 (2)	66 (5)	92 (6)	1475

Values in parentheses show the percentage of total

Table 4.3: Number of transit vehicles and tourists passing through Masinagudi village

Month	Av. no. of vehicles/day	Av. no. of tourists/day	Total monthly tourists
January	13	156	4836
February	52	624	17472
March	67	804	24924
April	94	1128	33840
May	163	1959	60729
June	106	1272	38160
July	78	936	29016
August	34	408	12648
September	39	468	14040
October	13	156	4836
November	13	156	4680
December	10	120	3720
			248901

Of the total 29 medium and small hotels surveyed in Masinagudi village, 23 of them (79%) used exclusively firewood while the remaining 21% used kerosene. Supply of firewood to these hotels was done by local people who collect the firewood from nearby forests and sell it to the hotel owners at a cost of Rs. 18-22 for one bundle of firewood weighing about 40 kg. However, none of the hotels was found using LPG or gohar gas.

4.3.2 Firewood Collection

Results of monitoring of entry/exit points revealed that the collection of firewood and timber was done round the year from the corridor forest and surrounding RFs. Local people had to walk about 2-4 km into the forest and spent about 4-5 hours

for collection of one head load. Many times the same person was seen going into the forest twice in a day to bring firewood. While the staff statement regarding the average number of people visited the forest in a day gave a figure of around 85 individuals, on the basis of field work, we found that on an average 191 individuals visited the Sanctuary Forest and RF for firewood collection in a day from all the seven villages. Of these, 55 were male, 107 female and 29 were children. The male, female and children head loads were weighed at entry/exit points and the average weight was calculated to be 42.3 kg, 37.9 kg and 14.0 kg respectively. Based on this the annual collection of firewood was calculated. Annually about 2803 t of firewood was removed from the Sanctuary and Reserved Forests (Table 4.4). However, there were variation in the quantity of extracted firewood as per the season. During rainy season from May to August the collection was affected by rains and quantity came down. On an average per month collection was 211 t for rainy season while for the rest of the months it was 245 t per month. Of the total removed firewood, 33% was extracted by Masinagudi village alone. The major tree species that were cut by the villagers for firewood, were *Anogeissus latifolia*, *Acacia catechu*, *Maytenus emerginata*, *Premna tomentosa*, *Randia dumetorum*, and *Erythroxylon monogynum*.

4.3.3 Grass Collection

Grass collection was done round the year (Table 4.5) to be used as fodder. However, there was difference in quantity of grass collected in different seasons. Grass collection in Singara and Chemmanatham villages was not found at all. In Masinagudi, Moyar, Bokkapuram, Mavanhalla and Vazhaithottam villages, the grass collection was either nil or too meagre during the monsoon. The maximum collection

was done from September till the end of February. The young cattle are fed at home during the dry months of January-April. At the end of April or first week of May with the onset of monsoon, the new shoots of grasses are available to the grazing livestock. Villagers had to walk about 4-5 km inside the forest to collect the grass and spent about 7-8 hours. However, collection of lopped fodder was found totally absent during monitoring of entry/exit points at village boundary. Table 4.5 gives the details of amount of extracted grass from the study area for one complete year. Average weight for one head load of grass was calculated to be 41.2 kg for male and 38.9 kg for female head loaders. Since the head loaders had to walk a long distance for grass collection, the children were usually not sent to the forest for this purpose. The annual extraction of grasses from the study area was estimated to be 324 tonnes of which almost 60% was collected by Masinagudi village alone followed by 18% by Moyar village. Of the total grass collected, 88% was collected during September through April, while the remaining 12% was collected during the rest of the months of the study period.

4.3.4 Non-Timber Forest Produces (NTFPs) Collection

Of the total families, about 3% earn their income through collection and selling of a variety of NTFPs. The major produces collected, their season of collection and uses have been shown in Fig. 4.1 and Table 4.6. Tree moss which was scrapped from the bark of trees, was collected round the year. Other major produces were honey, gallnut and gooseberry. The tribals were followed and their routine work in the forest was monitored to understand the methods of collection of various NTFP items. It was found that, in case of most of the produces, the method of exploitation was destructive. For example, in case of gooseberry collection, villagers mostly

Table 4.4: Quantification of firewood

Months	Village wise firewood collection (in tonnes)							Total collection (in tonnes)
	1	2	3	4	5	6	7	
April	89.83	44.33	8.53	43.16	45.42	9.48	25.89	266.64
May	75.98	30.74	5.32	42.99	32.17	6.01	28.95	222.16
June	73.36	29.88	4.84	36.80	35.52	8.91	25.48	214.71
July	69.37	27.08	4.55	21.65	31.29	6.31	20.48	180.73
August	81.15	29.87	8.63	39.92	39.92	8.35	18.73	226.57
September	79.32	39.09	8.23	34.19	43.42	7.37	17.12	228.74
October	87.19	46.54	10.21	36.84	38.62	9.97	29.98	259.35
November	77.20	44.18	8.32	38.63	33.83	9.94	32.97	245.17
December	69.82	54.56	9.54	45.45	48.18	6.87	35.83	270.15
January	78.29	54.26	12.63	35.95	34.65	8.79	28.24	252.83
February	64.39	45.04	10.44	36.77	31.72	7.11	19.69	215.16
March	71.99	39.82	8.06	36.51	33.78	7.62	22.95	220.73
Total	917.89	485.39	99.30	448.86	448.52	96.73	306.31	2803.02

1 = Masinagudi; 2 = Moyar; 3 = Singara; 4 = Bokkapuram; 5 = Mavanhalla; 6 = Chemmanatham; 7 = Vazhaithottam

Table 4.5: Quantification of extracted grass

Months	Village wise grass collection (in tonnes)							Total collection (in tonnes)
	1	2	3	4	5	6	7	
April	14.21	1.28	0	0	1.28	0	0	16.77
May	6.14	0	0	0	0	0	1.20	7.34
June	7.18	1.16	0	0	1.16	0	0	9.50
July	6.22	0	0	0	0	0	0	6.22
August	7.34	3.67	0	1.28	1.16	0	2.47	15.92
September	18.15	5.95	0	4.71	1.28	0	0	30.09
October	23.14	8.62	0	7.34	7.42	0	3.67	50.19
November	18.92	13.13	0	5.80	4.43	0	3.67	46.15
December	23.30	17.16	0	2.39	3.67	0	6.22	52.74
January	25.78	4.79	0	1.28	1.28	0	2.47	35.60
February	16.50	3.32	0	3.32	3.32	0	0	24.46
March	25.93	0	0	0	0	0	1.20	27.13
Total	192.81	59.08	0	26.12	25.20	0	20.90	324.11

1 = Masinagudi; 2 = Moyar; 3 = Singara; 4 = Bokkapuram; 5 = Mavanhalla; 6 = Chemmanatham; 7 = Vazhaithottam

either break or cut entire fruit bearing branch which retards the tree growth. Occurrence of forest fires has also been seen in areas of honey collection. The produces such collected from the forest, are cleaned, processed and sold through the Lamp Society in the open market. Table 4.7 shows the annual collection and earning from selling of NTFPs. On an average, the net annual earning per tribal family from selling of NTFPs comes to Rs. 7238.

Table 4.6: Various uses of different NTFPs

Items	Uses
Tree moss	Food and Medicine
Tamarind (<i>Tamarindus indica</i>): Fruit	Food
Gooseberry (<i>Emblica officinalis</i>): Fruit	Pickle, Murabba and Medicine
Cotton Silk (<i>Bombax ceiba</i>): Pod	Thread
Honey	Food, Medicine
Soapnut (<i>Sapindus emerginata</i>): Fruit	Soap Making
Gallnut (<i>Terminalia chebula</i>): Fruit	Medicine
Sikakai (<i>Acacia concinna</i>): Bark and Fruit	Dying and Medicine and Soap

Fig. 4.1: Collection season for different NTFP items

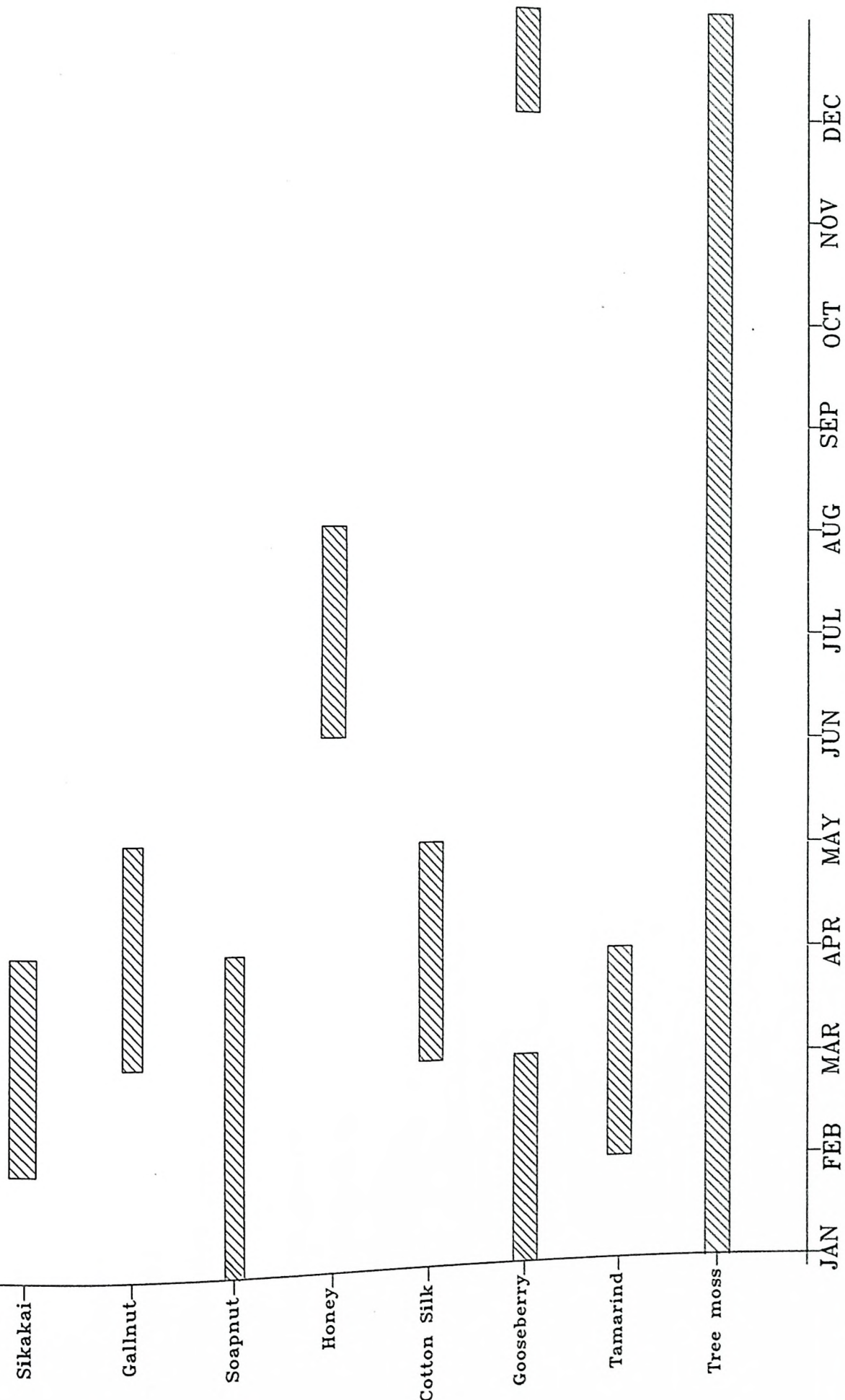


Table 4.7: Average annual collection and earning from selling of NTFPs

Item	Amount/Yr kg/Lt/No.	Cost in Rs. (per kg/Lt/No.)	Total cost (Rs.)
Tree Moss	20747	8.00	1,65,976.00
Tamarind (<i>Tamarindus indica</i>)	12559	4.00	50,236.00
Gooseberry (<i>Emblica officinalis</i>)	25578	1.00	25,578.00
Cotton Silk (<i>Bombax ceiba</i>)	18585	0.80	14,868.00
Honey	569	15.00	8,535.00
Soapnut (<i>Sapindus emarginata</i>)	7544	1.00	7,544.00
Gallnut (<i>Terminalia chebula</i>)	6674	1.00	6,674.00
Sikakai (<i>Acacia concinna</i>)	2298	1.25	2,872.50
Grand total (Rs):			2,82,283.50

4.3.5 Cattle Dung Collection

Information collected during reconnaissance survey revealed that a large number of villagers are involved in cattle dung collection from the forest floor, which is mostly marketed to the nearby tea and coffee estates as dung manure. Gathering of dung from the forest floor was seen throughout the year, except during the monsoon season from May to July, when scattered dung is either washed away from the forest floor or decomposed very rapidly. Villagers follow the cattle herds for collection of dung and walk along with them till they return from the forest in the evening. Dung gatherers had to walk about 2 to 3 km inside the forest and spend about 4 to 5 hours every day for this purpose. Annually about 495 mt of dry dung is gathered from the forest floor by the villagers of which about 22% was collected by people of the Masinagudi village alone (Table 4.8). Monitoring of truck loads of dung sold out of the study area was done at the Forest Check Post at Masinagudi village and the details are shown in Table 4.9. On an average 1620 truck loads of dry dung weighing about 2100 t were supplied annually from the study area. Information collected from middlemen of this business, revealed that most of the dung loads are supplied to the tea and coffee estates located around Ooty and Gudalur in Tamil Nadu and Sultan Battery in Kerala state. The average cost of a truck load of dung was found to be equal to Rs. 1200. About 75% of total families (1100 families) of all the seven villages of the study area, remain busy throughout the year in this business. Thus, from this business the villagers earn a total of about Rs. 20,00,000 annually which comes to about Rs. 1800 per family. Of the total sold out dung, about 24% was gathered from the forest floor while the remaining 76% was collected from the village common grounds and cattle sheds/pans.

Table 4.8: Quantification of dung collection from the forest floor

Months	Village wise amount of dung collected (in tonnes)							Total Amount (in tonnes)
	1	2	3	4	5	6	7	
April	7.2	3.3	1.3	5.3	6.6	2.6	1.3	39.4
May	0.7	0	0	0	0	0	0	0.7
June	0	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0	0
August	2.7	2.1	2.1	2.7	9.5	2.7	7.5	29.2
September	9.2	5.9	3.3	2.6	9.9	3.9	5.3	40.1
October	12.9	9.5	4.8	6.1	7.5	3.4	10.2	54.3
November	19.1	16.3	4.6	7.2	10.5	5.9	11.2	74.8
December	16.3	12.2	6.1	10.9	14.3	4.1	6.1	69.9
January	16.3	14.3	6.1	12.9	10.9	4.8	7.5	72.6
February	14.6	13.3	6.4	12.1	12.1	3.2	6.9	68.6
March	11.5	10.8	3.4	14.9	8.2	3.4	5.9	58.2
Total	110.5 (22)	87.8 (18)	37.9 (8)	74.7 (18)	89.3 (18)	33.8 (7)	60.9 (12)	494.6

Values in parentheses refer the percentage of total.

1 = Masinagudi; 2 = Moyar; 3 = Singara; 4 = Bokkapuram; 5 = Mavanhalla; 6 = Chemmanatham; 7 = Vazhaithottam

Table 4.9: Dung truck loads sold out of the study area

Months	No. of Truck loads	Cost (Rs.)
January	141	1,69,200
February	181	2,17,200
March	343	4,11,600
April	226	2,71,200
May	121	1,45,200
June	140	1,68,000
July	69	82,800
August	67	80,400
September	73	87,600
October	72	86,400
November	61	73,200
December	126	1,51,200
Total	*1620	19,44,000

* Weighing about 2100 t (dry weight)

4.3.6 Cattle Grazing

Primary information regarding cattle grazing was collected during the questionnaire survey. The results of survey revealed that, of the total cattle population, 98% is left free to graze inside the corridor forest while the remaining 2% is stall-fed which constitutes the young ones and few milk yielding breeds such as Fresian and Jersey. On an average each cattle herd walks about 5 to 6 km inside the forest and spends about 7 to 8 hours in a day. Cattle herds graze in all the areas of corridor forest and surrounding RFs. However, the Singara-Kalahatti RFs of the elephant corridor were most grazed areas as cattle herds from Masinagudi, Singara, Mavanhalla, and Bokkapuram visited these forests regularly.

4.3.7 Grass Production

The grass production of northern corridor forest was found to be the highest (9600 t yr⁻¹), while this was 5670 t yr⁻¹ and 5467 t yr⁻¹ respectively for the Sigur RF and southern corridor (Table 4.10). The annual grass production of the study villages was estimated to be as 20,737 t yr⁻¹. The theoretical fodder requirements of the total livestock population of the study area was worked out to be 52, 700 t yr⁻¹ which is almost 2.5 times more than the annual grass production of the study area. This means, the annual productivity of grass can sustain only one third of the total livestock population, and the remaining population must be putting extra pressure on the corridor forest. It is important to note here that 98% of the total livestock population is freely grazing in these forests round the year, and the agricultural byproducts contribute only a fraction of the fodder requirement of the livestock.

Table 4.10: Grass production

Site	Av. Productivity (t ha ⁻¹ yr ⁻¹)	Total area (ha)	Total Production (t yr ⁻¹)
Northern corridor	1.92	5000	9600
Southern corridor	3.16	1730	5467
Sigur RF	2.70	2100	5670
Total		8830	20737

4.3.8 Firewood Consumption Pattern

On an average, the per capita firewood consumption in the households was 1.21 kg day⁻¹. The seasonal variation in the consumption pattern was not

significant, as the fluctuation in the temperature did not incur the extra consumption of firewood in the form of room heating during winter months. Also, there was no significant difference in the firewood consumption pattern between and within the various families selected for the study.

As has been described earlier, of the total 29 hotels surveyed in Masinagudi, 23 used exclusively firewood as a source of fuel. Of the total extraction of 2803 t of firewood, 2745 t are used by the local villagers while remaining 58 t are used in local hotels to feed the transit tourists, who stopover at Masinagudi to take a refreshment or even a meal.

4.4 DISCUSSION

4.4.1 Firewood Collection and Consumption Pattern

Cutting of forest for fuel and timber, and grazing by domestic livestock have been identified as the most significant causes of forest decline in many developing countries (Osei, 1993), including ours. In India, fuelwood is mainstay of rural population for cooking and other household and non-agricultural works (Chakravarti, 1985), as it is the cheapest and most easily accessible source of fuel for the majority of the rural population, and so was the case in the present study. In the study area, the easy accessibility of natural resources have led the 85% families of the Masinagudi group of villages to be dependent on the resources of corridor forest and surrounding RFs for firewood and timber. That is why the local hotel owners who can afford to use LPG, do not ever try for this, because one bundle of 40 kg firewood costs them only for Rs 18-20. This may be the single biggest reason why people have not ever tried for any other alternatives of available fuels.

The low rate of per capita firewood consumption (1.21 kg) as compared to that of other studies (Chandola, 1985; Sagar *et al.*, 1985; Mishra *et al.*, 1988; Allen *et al.*, 1988; Tata Research Institute (TERI), 1991; Oesi, 1993; and Saksena *et al.*, 1995) can be attributed to the dietary composition of the people. Generally, the villagers do not cook many dishes, and moreover the labour class families, which constitute the largest percentage of the population, take only two meals a day. Looking at the rapid proliferation of new settlements and various hotels in the study area, one would be very sure that the demand of fuelwood will shoot up

very high in the near future, which would put an extra pressure on the degraded forest of the study area. Therefore, it is necessary to think some of the alternatives that would help in reducing the consumption of firewood and minimise the dependency of local people and livestock on the biomass resources of the area.

The annual consumption of firewood for the 85% families was calculated to be 2745 t against the annual extraction of 2803 t. The remaining 58 tonnes is being used in the local hotels. Surprisingly dung cakes were not used by the villagers despite commodity is available in plenty in the study area. Other substitutes of cooking fuels, such as *gobar* gas and Liquid Petroleum Gas (LPG) were also not popular among the villagers resulting into the constant exploitation of the only resource (firewood) to meet their fuel demands. As long as the supply of firewood to the hotel owners is easily available, they would never try for other alternatives such as LPG, and *gobar* gas even if they can easily afford to purchase these items.

4.4.2 Livestock Grazing and Cattle Economy

Almost the total livestock population of the villages of the study area graze in the corridor forest and surrounding reserved forests throughout the year. Sanctuary staff was helpless in regularising the number of grazing livestock because of less man power and the large geographical area they are suppose to protect. It may be mentioned here that, in Mudumalai WLS on an average, one

forest guard has to patrol 6-8 km² area like most of the other PAs of the country (Kothari *et al.*, 1989), which is next to impossible in the present scenario of mounting pressure on the staff from the villagers, besides other job responsibilities. This has therefore, resulted into free grazing in almost all parts of the study area. The stall-fed practice was totally absent primarily due to the attitude of local people towards the livestock for whom they are just dung producing machines, which do not require care and attention and can be left free to graze in the Sanctuary jungle. To meet out the fodder demands of livestock population, fodder farm was established at Bokkapuram village by NDCMPU, Ooty, but was not popular among the villagers. The fodder species grown were Maize (*Zea mays*), Oats (*Hordeum vulgare*), Jowar (*Sorghum vulgare*) and some grasses. Most of these fodder species are stored by silage method and even sold as air dried fodder. While, most of the fodder sold was purchased by the cattle owners of Ooty and the surrounding areas, only a small quantity of it was purchased by the cattle owners of the study villages. The main reason behind this was the easy accessibility of grazing lands and the majority of human population belonging to the labour class who are either landless or marginal farmers as described in chapter 3 and are not economically in a position to buy the fodder from fodder farm. People did not ever thought of spending some amount of money to feed their livestock because they were mostly raised for dung and not for milk!. The cultivation of grasses or fodder species was also not popular among the villagers, primarily because their objective of rearing cattle was earning money through selling dung which require practically no efforts, and not milk which require comparatively more efforts. Further, the cost of milk, the cattle owners are paid by the milk co-operative unions, do not give much returns in the

form of cash. In the absence of organised extension for improved dairying practice and without giving good price for milk to the villagers it is feared that no body in these villages will be attracted for the milk business. Rather, they will prefer to go for the dung selling business which will yield them some cash returns with practically no efforts, which will eventually lead to forest denudation in the large scale.

Based on the production capacity of the forest, and fodder requirement of total livestock population of the study area, one major conclusion which may be drawn is, that the forest can support only 40% of the total livestock population. The additional 60% livestock population must be severely exerting grazing pressure upon the corridor forests, and is underfed. Since the number of livestock grazing in these forests is much more than the carrying capacity, the forests are degrading very fast and graziers are entering deeper and deeper into the Sanctuary Forest. The impact of excessive grazing may be seen everywhere in the form of trampling of ground flora which are slowly disappearing. Because of this, the dry sandy soil get pulverised, while the moist soil is compacted (Srivastav *et al.*, 1996) as may be seen at several places in the Avarhalla and Sigur RF. In this situation therefore, the only option left for the development planners is to remove the 60% of the total livestock population from the study villages. But the major question is, which 60% population should be removed and how ?, which is discussed in details in the Chapter 7.

CHAPTER 5

5

VEGETATION CHARACTERISTICS

5.1 INTRODUCTION

Vegetation forms a major component of the wildlife habitats because it provides food, forage and hide. It is made up of a number of plant communities, which can be distinct entities or more diffuse, merging slowly into each other. The value of the habitat for wildlife species is directly linked to the type and variety of plant communities and their condition. Often, as a result of biotic pressure, vegetation becomes degraded, losing diversity and productivity. PA managers must be able to assess and monitor vegetation as a basis for manipulating it in tune with management objectives (Berkmuller and Sale, 1988). And this involves quantitative process such as floristic inventory, community description as well as quantification of vegetation cover.

As it has been described earlier, the long term survival of elephants of the study area depends on the effective restoration of the degraded habitats of the corridor forests and for such a manipulation of the habitat, the PA managers must understand the vegetation characteristics of these forests, the present chapter makes an attempt to study this.

5.2 METHODOLOGY

5.2.1 Tree Layer Measurements

The entire study area was divided into three sites *viz.*, i) northern corridor comprised of Moyar and Avarhalla Sanctuary Forests; ii) southern corridor comprised of Singara, Kalahatti Slopes, Bokkapuram and Kalmalai RFs and iii) Sigur RF. Size of the sample plot (quadrat) for studying vegetation characteristics was standardised based on the Nested Plot technique (Muller-Domboise & Ellenberg, 1974) by initially lining out an area of 5x5 m and recording all the species. The sample area or size of quadrat was then enlarged until the new species ceased to occur and 20x20 m (400 m²) plot size was selected to sample woody vegetation.

Density, frequency and basal cover of the different tree species (>20 cm GBH) in different sites were thus measured using 400 m² quadrat. Important Value Index (IVI), which is an integrated measure of the relative frequency (rF), relative density (rD) and relative basal area (rd) of the species, was calculated based on observation in 115, 110 and 57 quadrats respectively for northern corridor, southern corridor and Sigur RF and laid along transect lines (Misra, 1968; Kershew, 1973). Species diversity was calculated using the formula given by Shannon and Weaver (1963) and Margalef (1968) as:

$$H = -\sum_{i=1}^s (ni/n) \log_e(ni/n)$$

Where H = Shannon index of general diversity;

ni = the total number of individuals of species i and

n = the total number of individuals of all species in a site.

Dominance was calculated as the total basal cover/area of all the species (Simpson, 1949).

Parameters such as tree height, canopy cover and canopy height were estimated and stratification of the tree layer was done by classifying the heights into 3 categories (height upto 10 m as category 1, 11-15 m as category 2, and >15 as category 3) as per the method suggested by Curtis and McIntosh (1950) and Curtis (1959). Measurements of tree height and canopy height was done using clinometer while for canopy cover (crown cover) measurement a grided mirror was used (Misra, 1968; Hays *et al.*, 1981). The number of regeneration (≤ 10 cm GBH) and recruitment (10-20 cm GBH) were also counted for each species in all the quadrats/samples plots.

5.2.2 Vegetation Classification

Classification of vegetation types in the study area involved two steps: i) IVI calculation; and ii) Two Way Indicator Species Analysis *i.e.*, TWINSpan (Hill, 1979). Based on the data collected from each sampled plot regarding terrain, slope angle, soil types, riverine areas and other physical and natural features, the input parameters in TWINSpan were changed from defaults to get the best results.

5.3 RESULTS

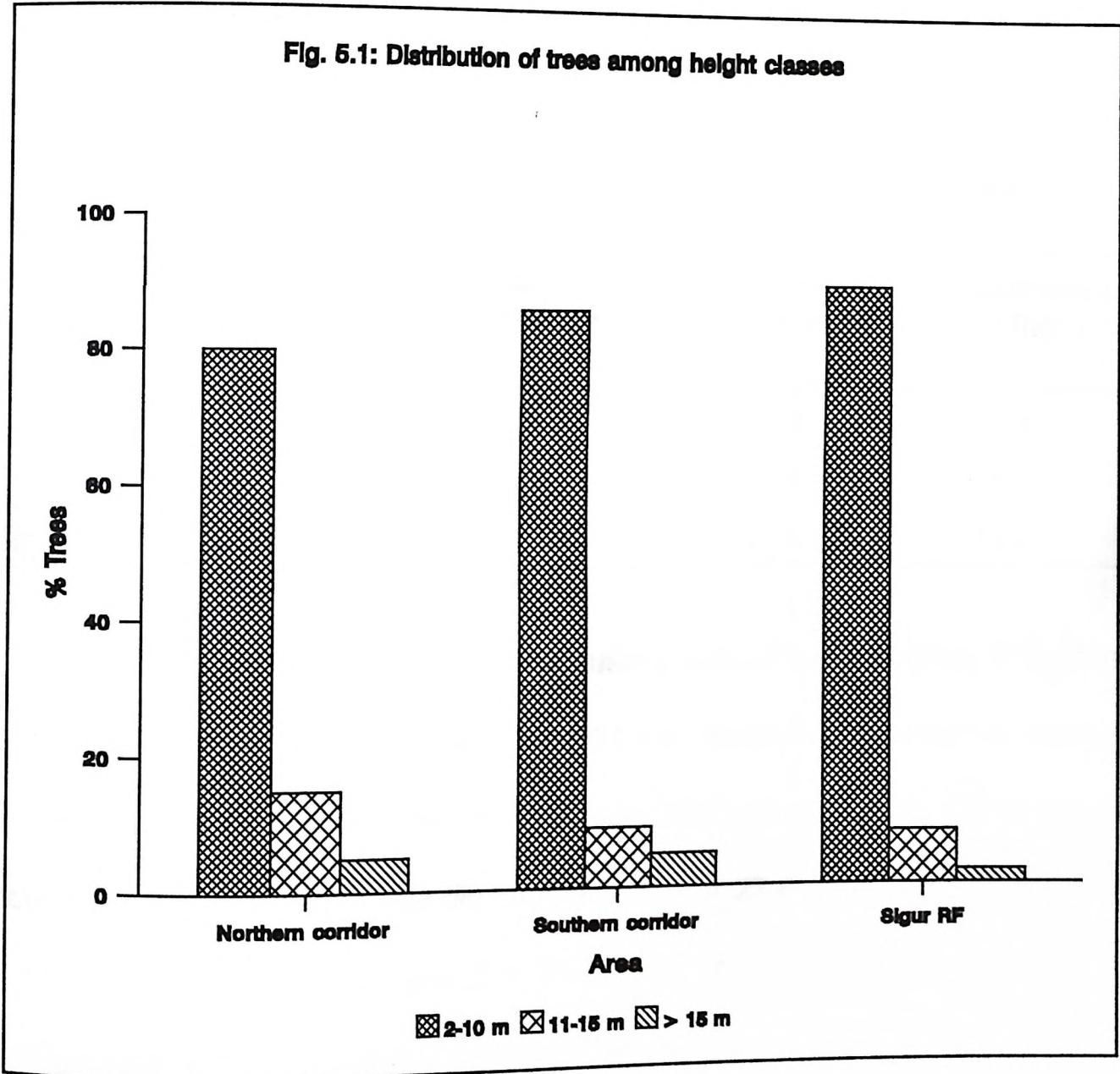
5.3.1 Vegetation Structure and Composition

5.3.1.1 Vertical Stratification

Distribution of trees in different height classes has been shown in Fig. 5.1 for all the 3 sites. In the northern corridor, of total 1, 191 trees enumerated, while 80% were upto 10 m height, 15% and 5% were respectively of 11-15 m and >15m height class. Compared to this, of the total 1, 377 trees enumerated in the southern corridor, 86% were upto 10 m height, 9% were between 10-15 m height. Remaining 5% trees had more than 15 m height. In Sigur RF average tree height did not reach beyond 12 m. Of the total 480 trees enumerated, only 2% were categorised under upper canopy layer. About 89% trees were upto 10 m height while remaining 8% were between 10-15 m.

The major tree species of upper most canopy in northern and southern corridor were *Tectona grandis*, *Terminalia arjuna*, *T. bellerica*, *Lagerstroemia parviflora*, *Shorea roxburghii*, *Dalbergia latifolia*, *Albizia odoratissima*, *Schleichera oleosa*, *Pterocarpus marsupium*, *Bombax ceiba*, and some of the fruiting tree species like *Mangifera indica* and *Syzygium cuminii* which occurred mainly along the banks of flume channel. The average height was about 20 m with dense canopy in the south-western part of the southern corridor in Kalamalai RF and along the banks of flume channel. The height of some of the individuals reached up to 25 m, while in the northern corridor, on an average it did not reach beyond 16 m. *Tectona grandis*, *Anogeissus latifolia*, *Terminalia tomentosa* and *T. bellerica* attained maximum girth class in the southern corridor (up to 2.5 m). In

Sigur RF the upper most canopy was formed by *Anogeissus latifolia*, *Emblica officinalis* and *Grewia tiliaefolia* while middle canopy had sparse trees of *Cassia fistula*, *Butea monosperma*, *Acacia catechu*, *Premna tomentosa*, *Erythroxylon monogynum* and *Kydia calycina*. The lower canopy had trees of *Acacia leucophloea*, *Emblica officinalis*, *Maytenus emerginata*, *Zizyphus xylopyra* and *Randia dumetorum*.



5.3.1.2 Dominant Species

While in northern corridor, highest number of tree species (50 species) representing 21 families were recorded, in the southern corridor 43 species belonging to same number of families were recorded. Sigur RF has 37 species representing 16 families. When values for the tree density and dominance were compared and contrasted for the 3 sites, it was found that both density and dominance was highest ($p < 0.05$) for the southern corridor followed by that in the northern corridor and the Sigur RF.

Table 5.1: Tree density and dominance in the study sites

Site	No. of species recorded	No. of families	Density (tree ha ⁻¹)	Dominance (m ² ha ⁻¹)
Northern corridor	50	21	258.9	13.6
Southern corridor	43	21	312.9	15.9
Sigur RF	37	16	210.5	11.0

Anogeissus latifolia was most frequently encountered species in northern corridor and Sigur RF (F= 57.4% and 54.4% respectively) while in southern corridor *Randia dumetorum* had the maximum frequency i e, 49%. Other species occurring frequently were *Randia dumetorum* (F= 27.8%), *Acacia chundra* (F= 26.1%) and *Zizyphus xylopyra* (F= 25.2%) in northern corridor; *Erythroxylon monogynum* (F= 42.7%) and *Anogeissus latifolia* (F= 37.3%) in southern corridor; and *Randia dumetorum* (F= 31.6%) and *Erythroxylon monogynum* (28.1%) in Sigur RF respectively. Examination of the IVI values for major tree species of all the three study sites revealed that *Anogeissus latifolia* and *Erythroxylon monogynum*, which are mainly used as firewood species by the local people

dominated in all the sites followed by elephant food species such as *Tectona grandis*, *Acacia chundra* and *Zizyphus xylopyra* (Table 5.2).

Table 5.2: Importance Value Indices (IVI) of major tree species

Tree species	Importance Value Indices (IVI)		
	Northern corridor	Southern corridor	Sigur RF
<i>Acacia catechu</i>	9.65	13.95	16.07
<i>Acacia chundra</i>	16.53	8.72	12.40
<i>Acacia feruginea</i>	0.67	0.96	2.44
<i>Acacia leucophloea</i>	0.67	1.32	11.78
<i>Adina cordifolia</i>	-	2.01	4.77
<i>Albizzia amara</i>	2.02	0.71	0.75
<i>Albizzia lebbek</i>	1.25	0.81	-
<i>Albizzia odoratissima</i>	3.83	0.76	3.57
<i>Anogeissus latifolia</i>	66.31	42.89	75.05
<i>Bauhinia racemosa</i>	4.63	8.52	8.14
<i>Bridella retusa</i>	0.43	0.49	2.84
<i>Butea monosperma</i>	-	0.47	2.10
<i>Canthium dicoccum</i>	11.29	11.12	11.79
<i>Cassia fistula</i>	6.72	4.36	1.97
<i>Citrus spp</i>	0.59	5.35	4.14
<i>Cordia mixa</i>	3.31	8.59	3.59
<i>Dalbergia latifolia</i>	8.22	2.34	3.06
<i>Dichrostachys cinerea</i>	0.99	1.76	-
<i>Diospyros montana</i>	3.39	5.30	7.60
<i>Erythroxylon monogynum</i>	26.05	45.03	33.77
<i>Ficus benghalensis</i>	-	3.88	4.46
<i>Ficus officinalis</i>	0.59	2.82	-
<i>Garuga pinnata</i>	1.02	-	-
<i>Givotia rottleriformis</i>	12.06	-	-
<i>Gmelina arborea</i>	0.36	-	2.09

<i>Grewia tiliaefolia</i>	2.98	2.33	0.72
<i>Ixora parviflora</i>	2.71	5.41	13.16
<i>Keydia calycina</i>	1.41	1.62	-
<i>Lagerstroemia parviflora</i>	8.30	2.95	7.79
<i>Lannea coromandalica</i>	0.45	0.43	-
<i>Maytenus emerginata</i>	7.50	4.69	6.75
<i>Emblica officinalis</i>	4.89	7.38	5.80
<i>Premna tomentosa</i>	9.94	1.96	3.61
<i>Pterocarpus marsupium</i>	4.88	1.96	3.61
<i>Randia dumetorum</i>	17.89	29.03	16.91
<i>Santalum album</i>	-	-	4.64
<i>Schlechera oleosa</i>	5.42	1.36	-
<i>Schrebera swietenoides</i>	1.41	-	-
<i>Shorea talura</i>	1.54	-	-
<i>Tectona grandis</i>	29.74	34.91	13.32
<i>Terminalia arjuna</i>	0.69	5.23	2.20
<i>Zizyphus oenoplea</i>	0.42	1.02	0.75
<i>Zizyphus xylopyra</i>	12.89	14.60	7.85

- Indicates the absence of species

5.3.1.3 Species Diversity

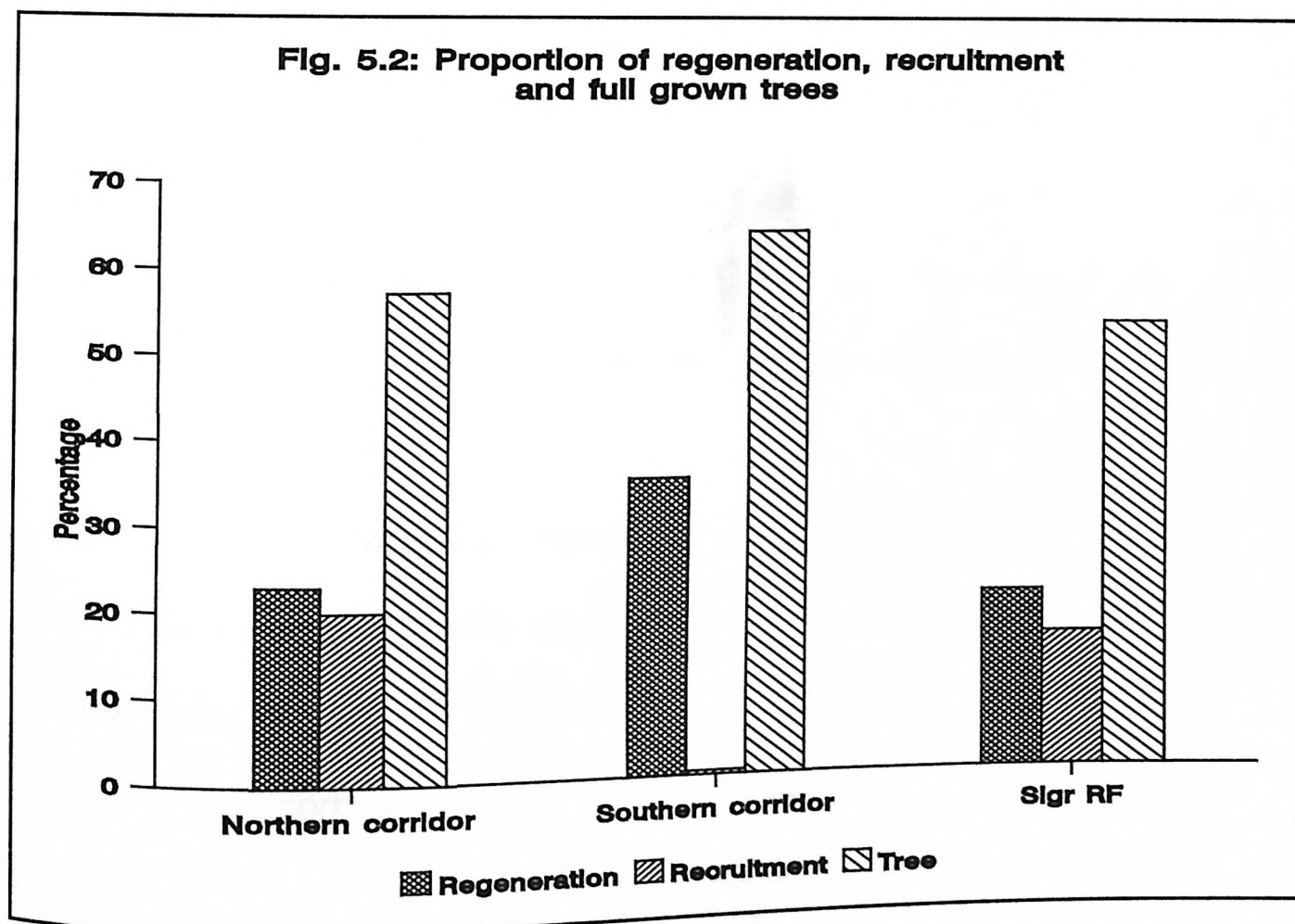
Species diversity of the southern corridor is slightly higher ($p < 0.05$) compared to that of the northern corridor (Table 5.3).

Table 5.3: Comparison of species diversity of study sites

Site	Species diversity $\pm$ SE
Northern corridor	1.0152 $\pm$ 0.0457
Southern corridor	1.0310 $\pm$ 0.0427
Sigur RF	1.0343 $\pm$ 0.0604

5.3.1.4 Species Regeneration and Recruitment

In all the three study sites, the percentage of full grown trees (GBH >20cm) was the highest compared to the percentage of regeneration (GBH <10 cm) and recruitment (GBH 10-20 cm). Surprisingly the percentage of recruitment in the southern corridor was least (0.5%) among all the three sites (Fig. 5.2).



5.3.2 Vegetation Classification

Based on TWINSpan results, the following 14 types of vegetation associations were identified in the study area:

1. *Ixora parviflora* (Ip)
2. *Canthium dicoccum* - *Ixora parviflora* (CI)
3. *Cordia mixa* (Cm)
4. *Randia dumetorum* - *Cordia mixa* (RC)
5. *Randia dumetorum* - *Zizyphus xylopyra* (RZ)
6. *Randia dumetorum* (Rd)
7. Mixed Forest (MF)
8. *Erythroxylon monogynum* - Mixed Forest (EM)
9. *Acacia catechu* - *Zizyphus xylopyra* (AZ)
10. *Acacia catechu* - *Randia dumetorum* (AR)
11. *Dalbergia latifolia* (DI)
12. *Anogeissus latifolia* (AI)
13. *Tectona grandis* - *Anogeissus latifolia* (TA)
14. *Tectona grandis* - *Anogeissus latifolia* - *Emblica officinalis* (TAE)

5.3.2.1 *Ixora parviflora* Association (Ip)

This association mainly occurred on the rocky and bouldery soil with less moisture content. Sigur RF and adjacent Sanctuary Forest, which constituted part of the northern corridor represented this association. Other associated species are *Acacia catechu*, *Butea monosperma* and *Vernonia arborea*. The total tree density for this association is recorded as 75 ha⁻¹ (n=4). Mean diversity is 0.50±0.29. The IVI is recorded highest (146.91) for *Ixora parviflora* followed by

Butea monosperma (65.85) (Table 5.4). The understorey of this association is formed by scattered shrubs of *Zizyphus xylopyra* and *Lantana spp.* with climbers of *Acacia chundra*.

Table 5.4: IVI of tree species in *Ixora parviflora* association

Tree species	rD	rF	rd	IVI
<i>Acacia chundra</i>	16.67	12.50	7.71	36.88
<i>Butea monosperma</i>	25.00	12.50	28.35	65.85
<i>Garuga pinnata</i>	8.33	12.50	4.18	25.02
<i>Ixora parviflora</i>	41.67	50.00	55.24	146.91
<i>Vernonica arborea</i>	8.33	12.50	4.51	25.35

5.3.2.2 *Canthium dicoccum*-*Ixora parviflora* Association (CI)

This association occurred towards the eastern most part of the study area in the Avarhalla Sanctuary Forest and Sigur Reserved Forests of the study area. The colour of soil is dark brown to reddish brown with top layer eroded due to lack of ground cover as the understorey is formed by scattered shrubs of *Acacia leucophloea*, *Zizyphus xylopyra* and *Z. oenoplea*. The dominating tree is *Canthium dicoccum* (Table 5.5) and other associated species are *Ixora parviflora*, *Ficus religiosa*, *Diospyros montana* and *Maytenus emerginata*. The tree density is 203.6 ha⁻¹ (n=7). Mean tree diversity is 0.92±0.18.

5.3.2.3 *Cordia mixa* Association (Cm)

This association occurred on moderate to slightly undulating terrain with dark brown to greyish black soil. A total of five species formed this association (Table 5.5). Major associates are *Randia dumetorum*, *Erythroxylon monogynum* and *Acacia chundra* which formed the lower strata. *Cordia mixa* had 100%

frequency with more than 66% abundance. The tree density is recorded 162.5 ha⁻¹ (n=4) (Table 5.6). Mean tree diversity is 0.67±0.11.

Table 5.5: IVI of tree species in *Canthium dicoccum-Ixora parviflora* association

Tree species	rD	rF	rd	IVI
<i>Acacia chundra</i>	1.75	4.00	0.04	5.80
<i>Canthium dicoccum</i>	63.91	32.00	92.29	190.96
<i>Cordia mixa</i>	1.75	4.00	0.13	5.88
<i>Diospyros montana</i>	3.51	8.00	0.23	11.74
<i>Ficus</i> spp	1.75	4.00	0.22	6.39
<i>Ixora parviflora</i>	8.77	16.00	5.71	30.48
<i>Erythroxylon monogynum</i>	3.51	4.00	0.22	6.39
<i>Maytenus emerginata</i>	3.51	8.00	0.16	11.67
<i>Randia dumetorum</i>	5.26	12.0	0.40	17.66
<i>Schlechera oleosa</i>	1.75	4.00	0.06	5.82
<i>Zizyphus xylopyra</i>	3.51	4.00	0.13	7.64

Table 5.6: IVI of tree species *Cordia mixa* association

Tree species	rD	rF	rd	IVI
<i>Acacia chundra</i>	7.69	20.00	1.93	29.62
<i>Albizzia lebbek</i>	3.85	10.00	1.31	15.16
<i>Cordia mixa</i>	73.08	40.00	93.71	206.79
<i>Erythroxylon monogynum</i>	3.85	10.00	0.22	14.07
<i>Randia dumetorum</i>	11.54	20.00	2.82	34.36

5.3.2.4 *Randia dumetorum-Cordia mixa* Association (RC)

This association occurred in degraded areas formed because of severe grazing pressure in Avarhalla Sanctuary Forest and adjacent Sigur and Kalahatti Slope RF. *Randia dumetorum* had >66% abundance. Other associates are *Aegle*

marmelos, *Canthium dicoccum* and *Diospyros montana*. Abundance of all these associates ranged between 25 to 35%. Undergrowth was heavily infested with thick cover of *Lantana camara* alongwith scattered shrubs of *Acacia nilotica*. The tree density is 191.7 ha⁻¹ (n=6). Mean tree diversity is 0.99±0.11. Relative dominance as well as IVI is recorded for *Randia dumetorum* followed by *Cordia mixa* (Table 5.7).

Table 5.7: IVI of tree species *Randia dumetorum*-*Cordia mixa* association

Tree species	rD	rF	rd	IVI
<i>Aegle marmelos</i>	2.17	5.26	0.65	8.08
<i>Albizzia amara</i>	2.17	5.26	0.17	7.61
<i>Canthium dicoccum</i>	10.87	10.53	8.31	29.71
<i>Citrus</i> spp	34.78	31.58	37.51	103.87
<i>Cordia mixa</i>	4.35	5.26	1.31	10.92
<i>Diospyros montana</i>	2.17	5.26	0.14	7.58
<i>Premna tomentosa</i>	8.70	5.26	3.20	17.15
<i>Randia dumetorum</i>	34.78	31.58	48.70	115.07

5.3.2.5 *Randia dumetorum*-*Zizyphus xylopyra* Association (RZ)

Singara-Kalahatti Slope RF, which constitute the southern corridor is represented by this association. A total of 16 species formed this association. The terrain is undulating with seasonal streams breaking the continuity of flat land. The proportion of exposed ground is relatively high due to heavy grazing by livestock from Mavanhalla and Bokkapuram settlements. While the upper canopy is formed by scanty growth of *Grewia tiliaefolia*, *Dichrostachys cinerea*, the lower canopy is made of *Randia dumetorum*, *Zizyphus xylopyra*, *Erythroxylon monogynum*, *Acacia leucophloea* and few individuals of *Citrus* spp. The tree

density is 168.3 ha^{-1} ($n=15$) while the mean tree diversity is 1.04 ± 0.11 . Relative dominance for *Randia dumetorum* and *Zizyphus xylopyra* is $55.9 \text{ m}^2 \text{ ha}^{-1}$ and $28.7 \text{ m}^2 \text{ ha}^{-1}$ respectively. IVI is highest for *Randia dumetorum* which is followed by *Zizyphus xylopyra* (Table 5.8).

Table 5.8: IVI of tree species *Randia dumetorum*-*Zizyphus xylopyra* association

Tree species	rD	rF	rd	IVI
<i>Acacia catechu</i>	0.99	2.00	0.09	3.08
<i>Acacia feruginea</i>	1.98	2.00	0.13	4.11
<i>Acacia leucophloea</i>	0.99	2.00	0.03	3.02
<i>Albizzia lebbek</i>	0.99	2.00	0.05	3.04
<i>Bauhinia racemosa</i>	0.99	2.00	0.04	3.03
<i>Cassia fistula</i>	0.99	2.00	0.05	3.04
<i>Cordia mixa</i>	12.87	8.00	11.09	31.96
<i>Dichrostachys cinerea</i>	7.92	8.00	2.21	18.13
<i>Diospyros montana</i>	1.98	4.00	0.38	6.36
<i>Erythroxylon monogynum</i>	2.97	4.00	0.44	7.41
<i>Eucalyptus</i> spp	0.99	2.00	0.03	3.02
<i>Grewia tiliaefolia</i>	1.98	4.00	0.13	6.11
<i>Pterocarpus marsupium</i>	0.99	2.00	0.01	3.00
<i>Randia dumetorum</i>	36.63	24.00	55.99	116.54
<i>Tectona grandis</i>	0.99	2.00	0.15	3.14
<i>Zizyphus xylopyra</i>	22.77	28.00	28.69	79.46

5.3.2.6 *Randia dumetorum* Association (Rd)

A total of 9 species formed this association which was dominated by *Randia dumetorum* with abundance ranging between 35% - >66%. Other major associates are *Erythroxylon monogynum*, *Zizyphus xylopyra*, *Ixora parviflora*, *Diospyros montana* and *Acacia catechu*. The abundance of all other associates

ranged from 5% to 35%. The soil was dark brown and the terrain was gentle with moderate slopes. The tree density is 127.5 trees ha⁻¹ (n=10). Mean tree diversity is 0.57 ± 0.07 . *Randia dumetorum* had the highest relative density and relative dominance. IVI is highest for *Randia dumetorum* (212.9) followed by *Erythroxylon monogynum* (27.6) (Table 5.9).

Table 5.9: IVI of tree species *Randia dumetorum* association

Tree species	rD	rF	rd	IVI
<i>Albizzia amara</i>	1.96	5.00	0.40	7.36
<i>Acacia catechu</i>	1.96	5.00	0.06	7.06
<i>Acacia feruginea</i>	1.96	5.00	0.24	7.20
<i>Cassia fistula</i>	3.92	5.00	0.39	7.48
<i>Diospyros montana</i>	7.84	5.00	1.11	13.96
<i>Erythroxylon monogynum</i>	9.80	15.00	2.84	27.64
<i>Ixora parviflora</i>	1.96	5.00	0.56	7.48
<i>Randia dumetorum</i>	68.63	50.00	94.35	212.98
<i>Zizyphus xylopyra</i>	1.96	5.00	0.10	7.06

5.3.2.7 Mixed-Forest Association (MF)

This association is formed by 29 species, upper canopy of which is formed by *Anogeissus latifolia*, *Bauhinia racemosa*, *Diospyros montana*, *Ixora parviflora* and *Cordia mixa*. The lower canopy formed by stunted and scattered trees of *Randia dumetorum*, *Zizyphus xylopyra*, *Erythroxylon monogynum*, *Acacia chundra*, *Premna tomentosa*, *Grewia tiliaefolia* and *Maytenus emerginata*. Other major associates are *Cassia fistula*, *Lagerstroemia parviflora*, *Albizzia odoratissima* and *Schrebera swietenoides*. The tree density is recorded as 300

ha⁻¹ (n=54). Mean tree diversity is 1.25 ± 0.06 . The IVI is highest for *Erythroxylon monogynum*, followed by *Randia dumetorum* (Table 5.10).

Table 5.10: IVI of tree species in mixed forest association

Tree species	rD	rF	rd	IVI
<i>Acacia catechu</i>	1.39	1.20	0.19	2.79
<i>Acacia chinensis</i>	0.15	0.40	0.01	0.56
<i>Acacia chundra</i>	10.49	9.24	9.50	29.23
<i>Acacia leucophloea</i>	0.46	0.80	0.04	1.30
<i>Acacia pinnata</i>	0.15	0.40	0.01	0.56
<i>Adina cordifolia</i>	0.31	0.40	0.04	0.75
<i>Albizzia odoratissima</i>	0.77	2.01	0.08	2.86
<i>Anogeissus latifolia</i>	6.79	7.23	6.55	20.57
<i>Bauhinia racemosa</i>	4.48	6.43	2.41	13.31
<i>Canthium dicoccum</i>	3.55	3.32	0.74	7.50
<i>Cassia fistula</i>	0.77	1.61	0.04	2.42
<i>Citrus</i> spp	1.85	2.01	0.34	4.20
<i>Cordia mixa</i>	1.54	2.41	0.28	4.24
<i>Diospyros montana</i>	2.62	5.22	0.80	8.65
<i>Erythroxylon monogynum</i>	25.77	10.84	45.43	82.15
<i>Euphorbia</i> spp	0.46	0.80	0.03	1.30
<i>Givotia rottleriformis</i>	1.23	1.20	0.20	2.64
<i>Grewia tiliaefolia</i>	0.77	1.61	0.05	2.42
<i>Ixora parviflora</i>	1.08	1.61	0.20	2.88
<i>Kydia calycina</i>	0.15	0.40	0.01	0.56
<i>Lannea coromandalica</i>	0.15	0.40	0.01	0.56
<i>Maytenus emerginata</i>	2.31	3.21	0.39	5.92
<i>Pterocarpus marsupium</i>	0.15	0.40	0.01	0.56
<i>Premna tomentosa</i>	8.64	7.23	8.43	24.30
<i>Randia dumetorum</i>	15.90	16.06	20.22	52.18
<i>Schrebera siwetenioides</i>	0.15	0.40	0.01	0.56
<i>Zizyphus xylopyra</i>	6.02	10.84	3.55	20.41

5.3.2.8 *Erythroxylon monogynum* - Mixed Forest Association (EMf)

This association is dominated by *Erythroxylon monogynum*, and is composed of 31 species. It occurred in the northern corridor in the parts of Avarhalla Sanctuary Forest and extends to the north-west of part of Sigur RF. The terrain is almost flat with dark to reddish brown soil with much of exposed grounds. The scattered shrubs of *Euphorbia spp* formed the ground cover. The upper canopy is formed by *Anogeissus latifolia* with abundance ranging from 5% - 35%. The lower canopy is formed by *Erythroxylon monogynum*, *Acacia catechu*, *Randia dumetorum* and *Citrus spp*. The tree density is 429.5 ha⁻¹ (n=50) and the mean tree diversity is 1.08±0.06. The IVI is maximum for *Erythroxylon monogynum* (Table 5.11).

Table 5.11 IVI of tree species in *Erythroxylon monogynum*-mixed forest association

Tree species	rD	rF	rd	IVI
<i>Acacia catechu</i>	7.68	6.31	2.50	16.49
<i>Acacia chundra</i>	5.47	9.91	1.09	16.47
<i>Acacia feruginea</i>	0.23	0.90	0.01	1.14
<i>Acacia leucopholea</i>	0.58	2.25	0.02	2.85
<i>Albizzia odoratissima</i>	0.23	0.90	0.01	1.14
<i>Anogeissus latifolia</i>	7.22	9.01	3.07	19.30
<i>Bauhinia racemosa</i>	0.81	1.35	0.04	2.20
<i>Bridella retusa</i>	0.12	0.45	0.01	0.58
<i>Canthium dicoccum</i>	1.16	2.70	0.09	3.96
<i>Cassia fistula</i>	2.79	5.41	0.23	8.43
<i>Citrus spp</i>	2.10	2.25	0.20	4.54
<i>Cordia mixa</i>	0.23	0.90	0.01	0.68
<i>Dichrostachys cinerea</i>	0.58	0.90	0.01	1.14

<i>Diospyros montana</i>	0.23	0.45	0.01	0.68
<i>Erythroxylon monogynum</i>	53.55	22.07	91.14	166.77
<i>Euphorbia</i> spp	0.12	0.45	0.01	0.58
<i>Garuga pinnata</i>	0.23	0.45	0.01	0.69
<i>Givotia rottleriformis</i>	0.70	0.90	0.08	1.68
<i>Grewia tilaeifolia</i>	0.47	0.45	0.01	0.57
<i>Ixora parviflora</i>	0.81	2.25	0.06	3.13
<i>Lamnea coromandalica</i>	0.12	0.45	0.01	0.57
<i>Lagerstroemia parviflora</i>	1.86	4.95	0.25	7.07
<i>Maytenus emerginata</i>	3.03	6.79	0.24	10.02
<i>Premna tomentosa</i>	1.40	2.25	0.13	3.77
<i>Randia dumetorum</i>	4.19	6.31	0.59	11.09
<i>Schlecheria oleosa</i>	0.23	0.45	0.01	0.69
<i>Zizyphus oenoplea</i>	1.40	3.60	0.09	5.09
<i>Zizyphus xylopyra</i>	1.75	4.50	0.11	6.37

5.3.2.9 *Acacia catechu*-*Zizyphus xylopyra* Association (AZ)

This association occurred to the north and north-eastern part of the Sanctuary which formed a part of northern corridor. A total of 18 species formed the association which is dominated by *Acacia catechu* and *Zizyphus xylopyra*. Other associates are *Anogeissus latifolia*, *Shorea roxburghii* and *Maytenus emerginata* which form the upper canopy of the association. The lower canopy is made of *Acacia catechu*, *Randia dumetorum*, *Zizyphus xylopyra* and *Emblica officinalis*. The soil is brown to black with relatively high moisture content. The terrain is undulating with steep slopes towards northern boundary of the Sanctuary forming the Moyar gorge. The under growth has sparse *Lantana camara* and new saplings of *Anogeissus latifolia* with patches of *Heteropogon* spp in between. The average density is calculated to be 198.2 ha⁻¹ (n=14) and the mean tree diversity

is 0.98 ± 0.12 . The relative density, relative dominance and IVI are the highest for *Acacia catechu* (Table 5.12).

Table 5.12: IVI of tree species in *Acacia catechu*-*Zizyphus xylopyra* association

Tree species	rD	rF	rd	IVI
<i>Acacia catechu</i>	42.34	25.53	76.09	143.96
<i>Acacia chundra</i>	2.70	4.26	0.36	7.32
<i>Acacia feruginea</i>	0.90	2.13	0.02	3.05
<i>Acacia nilotica</i>	0.90	2.13	0.02	3.05
<i>Albizzia amara</i>	0.90	2.13	0.28	3.31
<i>Anogeissus latifolia</i>	2.70	4.26	0.36	7.32
<i>Bauhinia racemosa</i>	1.80	4.26	0.18	6.24
<i>Bridella retusa</i>	0.90	2.13	0.08	3.11
<i>Diospyros montana</i>	0.90	2.13	0.04	3.07
<i>Emblica officinalis</i>	0.90	2.13	0.03	3.05
<i>Grewia tiliaefolia</i>	3.60	4.26	0.55	8.41
<i>Lagerstroemia parviflora</i>	1.80	4.26	0.23	6.29
<i>Maytenus emerginata</i>	10.81	8.51	4.32	23.64
<i>Premna tomentosa</i>	0.90	2.13	0.06	3.09
<i>Randia dumetorum</i>	1.80	4.26	0.06	6.11
<i>Santalum album</i>	3.60	6.38	0.28	10.26
<i>Shorea roxburghii</i>	1.80	2.13	0.21	4.14
<i>Zizyphus xylopyra</i>	20.72	17.02	16.88	54.63

5.3.2.10 *Acacia catechu*-*Randia dumetorum*-*Anogeissus latifolia* Association

(ARA)

This association, which is composed of 14 species occurs, towards the south eastern part of the Sanctuary and extends into a portion of the Sigur RF. It is dominated by *Acacia catechu*, *Randia dumetorum* and *Anogeissus latifolia*

(Table 5.13). Other major associate is *Dalbergia latifolia*, which forms the scanty upper canopy. *Maytenus emerginata*, *Grewia tiliaefolia*, and *Premna tomentosa* form the understorey of the association. The terrain is undulating with dark brown to black soil exposed at several places due to trampling by livestock. The tree density is 900 ha⁻¹ (n=10) which is highest among all the 14 vegetation associations. Mean tree diversity is 1.33±0.09.

Table 5.13: IVI of tree species in *Acacia catechu*-*Randia dumetorum*-*Anogeissus latifolia* association

Tree species	rD	rF	rd	IVI
<i>Acacia catechu</i>	21.11	20.93	20.82	62.86
<i>Acacia leucophloea</i>	6.67	9.30	2.11	18.08
<i>Albizzia odoratissima</i>	3.33	2.33	0.79	6.45
<i>Anogeissus latifolia</i>	20.00	16.28	43.41	76.69
<i>Bauhinia racemosa</i>	1.11	2.33	0.04	3.53
<i>Cassia fistula</i>	1.11	2.33	0.10	3.48
<i>Citrus</i> spp	1.11	2.33	0.08	3.51
<i>Diospyros montana</i>	5.56	6.98	1.96	14.49
<i>Emblica officinalis</i>	3.33	4.65	0.85	8.83
<i>Maytenus emerginata</i>	1.11	2.33	0.06	3.49
<i>Randia dumetorum</i>	23.33	18.60	26.30	68.24
<i>Santalum album</i>	6.67	6.98	2.41	16.06
<i>Terminalia arjuna</i>	3.33	2.33	0.63	6.29
<i>Zizyphus xylopyra</i>	2.22	2.33	0.44	4.99

5.3.2.11 *Dalbergia latifolia* Association (DI)

This association is dominated by *Dalbergia latifolia* with abundance ranging from 25% to >66%. Other associates are *Anogeissus latifolia*, *Canthium dicoccum*, *Tectona grandis* and *Maytenus emerginata*. The under story is formed by few scattered trees of *Keydia calycina*, *Bauhinia racemosa* and *Schlechera oleosa*. The tree density is 121.43 ha⁻¹ (n=7) and the mean tree diversity is 0.88±0.19. The IVI value is highest for *Dalbergia latifolia* (table 5.14).

Table 5.14: IVI of tree species in *Dalbergia latifolia* association

Tree species	rD	rF	rd	IVI
<i>Anogeissus latifolia</i>	26.47	14.29	29.46	70.22
<i>Cassia fistula</i>	5.88	9.52	1.07	16.48
<i>Canthium dicoccum</i>	17.65	14.29	17.51	49.44
<i>Dalbergia latifolia</i>	32.35	33.33	46.52	112.20
<i>Kydia calycina</i>	2.94	4.76	0.21	7.92
<i>Maytenus emerginata</i>	2.94	4.76	0.15	7.85
<i>Schlechera oleosa</i>	2.94	4.76	0.97	0.97
<i>tectona grandis</i>	8.82	14.29	4.11	27.22

5.3.2.12 *Anogeissus latifolia* Association (AI)

A total of 40 species formed this association which is dominated by *Anogeissus latifolia*. Other associates which form the upper canopy are *Tectona grandis*, *Dalbergia latifolia*, *Pterocarpus marsupium*, *Ficus officinalis* and *Emblica officinalis*. The understorey is formed by *Cassia fistula*, *Bauhinia racemosa*, *Acacia leucophloea*, *A. catechu*, *Albizzia lebbek*, *Gmelina arborea*, *Ixora parviflora* and *Erythroxylon monogynum*. This association is mainly restricted to the northern-western part of the study area. The soil is mostly black with more

moisture content in it. A network of seasonal streams forms the micro-habitats dominated with *Acacia nilotica* and *Acacia leucophloea* providing ideal browsing sites for elephants and gaurs. The shrub cover is dominated by *Lantana camara* and slowly creeping *Parthenium* spp. The tree density is 286.17 ha⁻¹ (n=56) and the mean tree diversity is 0.94±0.07. The IVI is highest for *Anogeissus latifolia* followed by *Emblica officinalis* (Table 5.15).

Table 5.15: IVI of tree species in *Anogeissus latifolia* association

Tree species	rD	rF	rd	IVI
<i>Acacia catechu</i>	4.21	6.83	1.71	12.75
<i>Acacia chundra</i>	3.28	4.39	1.39	9.05
<i>Acacia feruginea</i>	0.16	0.49	0.06	0.70
<i>Acacia leucophloea</i>	0.47	1.46	0.23	2.16
<i>Adina cordifolia</i>	0.47	0.98	2.23	3.67
<i>Albizzia lebbek</i>	0.31	0.98	0.49	1.77
<i>Albizzia odoratissima</i>	1.40	2.93	1.03	5.36
<i>Bauhinia racemosa</i>	1.25	2.44	0.78	4.47
<i>Bombax ceiba</i>	0.16	0.49	0.56	1.21
<i>Bridella retusa</i>	0.16	0.49	0.14	0.78
<i>Butea monosperma</i>	0.31	0.48	0.18	0.98
<i>Canthium dicoccum</i>	1.71	0.98	1.98	4.67
<i>Cassia fistula</i>	2.18	2.44	0.41	5.03
<i>Cordia mixa</i>	0.31	0.98	0.27	1.56
<i>Dalbergia latifolia</i>	1.25	3.41	1.16	5.82
<i>Diospyros montana</i>	0.16	0.49	0.07	0.71
<i>Emblica officinalis</i>	6.55	6.34	0.07	14.97
<i>Erythroxylon monogynum</i>	0.94	0.98	0.26	2.17
<i>Ficus benghalensis</i>	0.31	0.98	2.16	3.44
<i>Ficus officinalis</i>	0.16	0.49	0.48	1.12
<i>Ficus</i> spp	0.16	0.49	0.77	1.41

<i>Givotia rottleriformis</i>	1.09	2.93	6.31	10.33
<i>Gmelina arborea</i>	0.31	0.98	1.05	2.34
<i>Grewia tiliaefolia</i>	1.40	2.44	0.19	4.03
<i>Ixora parviflora</i>	0.31	0.98	0.48	1.76
<i>Lagerstroemia parviflora</i>	0.78	2.44	0.73	3.95
<i>Maytenus emerginata</i>	0.31	0.49	0.07	0.87
<i>Pterocarpus marsupium</i>	2.34	6.83	5.92	15.09
<i>Premna tomentosa</i>	0.78	2.44	0.65	3.87
<i>Randia dumetorum</i>	0.94	0.98	0.38	2.29
<i>Semecarpus anacardium</i>	0.31	0.49	0.09	0.98
<i>Shorea roxburghii</i>	0.31	0.49	1.20	2.00
<i>Schrebera swietenioides</i>	0.78	0.49	0.14	1.41
<i>Terminalia arjuna</i>	0.78	0.98	1.09	2.84
<i>Terminalia chebula</i>	0.47	0.98	0.44	1.88
<i>Tectona grandis</i>	3.59	6.34	12.55	22.48
<i>Zizyphus xylopyra</i>	1.25	2.93	0.64	4.82

5.3.2.13 *Tectona grandis*-*Anogeissus latifolia* Association (TA)

This association is restricted to the western part of the study area in and around Theppakadu Range. The upper canopy is dominated by *Tectona grandis* and *Anogeissus latifolia*. A total of 14 species are recorded in this association. The abundance of *Tectona grandis* ranged from 25% to >66%, while that of *Anogeissus latifolia* it is 25% to 35%. This part of the study area has relatively higher moisture content due to comparatively higher rainfall and presence of several seasonal streams. Scattered stunted trees of *Acacia catechu*, *A. chundra*, *Albizia lebbek* and *Nephelium longana* form the understorey. The tree density is 275 ha⁻¹ (n=20). Mean tree diversity is 0.94±0.74. The IVI was highest for *Tectona grandis* followed by *Anogeissus latifolia* and *Lagerstroemia parviflora* (Table 5.16).

Table 5.16: IVI of tree species in *Tectona grandis*-*Anogeissus latifolia* association

Tree species	rD	rF	rd	IVI
<i>Acacia chundra</i>	1.82	6.15	0.31	8.28
<i>Adina cordifolia</i>	0.45	1.54	1.33	3.32
<i>Anogeissus latifolia</i>	38.64	27.69	26.64	92.96
<i>Bauhinia racemosa</i>	0.45	1.54	0.22	2.21
<i>Bridella retusa</i>	0.45	1.54	0.33	2.32
<i>Cassia fistula</i>	1.36	3.08	0.24	4.68
<i>Dalbergia latifolia</i>	1.82	3.08	3.09	11.06
<i>Givotia rottleriformis</i>	1.82	4.62	6.58	13.02
<i>Kydia calycina</i>	1.82	3.08	0.74	5.64
<i>Lagerstroemia parviflora</i>	3.64	6.15	4.01	13.80
<i>Maytenus emerginata</i>	0.45	1.54	0.06	2.05
<i>Terminalia arjuna</i>	1.36	3.08	1.77	6.21
<i>Tectona grandis</i>	44.55	30.77	54.28	129.59
<i>Zizyphus xylopyra</i>	1.36	3.08	0.40	4.84

5.3.2.14 *Tectona grandis*-*Anogeissus latifolia*-*Emblica officinalis* Association (TAE)

This association occurred mainly in the south-western part of the study area in Kalmalai RF and is constituted by 18 species. The upper canopy is formed by *Tectona grandis*, *Terminalia arjuna*, and *Anogeissus latifolia*. The understorey is formed by *Emblica officinalis*, *Maytenus emerginata*, *Randia dumetorum* and *Acacia catechu*. The tree density is 347.06 ha^{-1} ($n=17$) and the mean tree diversity is 1.38 ± 0.06 . The abundance of *Tectona grandis* and *Anogeissus latifolia* is between 25% to >66% while for most of other species it is between 5% to 25%. The IVI the highest for *Anogeissus latifolia* (Table 5.17).

Table 5.17: IVI of tree species in *Tectona grandis*-*Anogeissus latifolia*-*Emblia officinalis* association

Tree species	rD	rF	rd	IVI
<i>Acacia catechu</i>	2.97	1.15	0.61	4.73
<i>Acacia chundra</i>	0.95	1.15	0.30	2.30
<i>Anogeissus latifolia</i>	32.30	18.39	22.25	72.84
<i>Bauhinia racemosa</i>	1.69	4.60	2.70	8.99
<i>Bridella retusa</i>	0.85	1.15	0.37	2.37
<i>Cordia mixa</i>	0.42	1.15	0.09	1.66
<i>Dalbergia latifolia</i>	1.27	3.45	0.07	4.79
<i>Diospyros montana</i>	1.69	3.45	1.35	6.49
<i>Emblia officinalis</i>	12.29	14.94	3.00	30.23
<i>Kydia calycina</i>	2.12	2.30	0.87	5.29
<i>Maytenus emerginata</i>	2.54	4.60	0.41	7.55
<i>Randia dumetorum</i>	7.20	8.05	2.73	17.98
<i>Schlechera oleosa</i>	0.85	1.15	0.41	2.41
<i>Schrebera swietenoides</i>	0.85	1.15	0.18	2.17
<i>Terminalia arjuna</i>	5.51	8.05	3.37	16.92
<i>Tectona grandis</i>	23.73	19.54	58.20	101.47
<i>Zizyphus oenoplea</i>	0.42	1.15	0.04	1.62
<i>Zizyphus xylopyra</i>	2.54	4.60	1.07	8.21

5.3.2.15 Comparison of Different Association

A comparative assessment of the abundance values of tree species in different vegetation association suggest that the eastern part is comprised of Ip, Cl, Cm, RC, and RZ associations, which are characterised by stunted and sparsely distributed vegetation (Table 5.18). Of these five associations, Ip and Cl associations constitute part of the northern corridor and Cm, RC and RZ constitute part of the southern corridor. The MF association, which is mostly seen around Masinagudi village, constitute a large chunk of the study area covering parts of

northern corridor and southern corridor. In this association trees are taller and larger in their girth, compare to the trees of the Sigur RF. Towards the north-west direction of Masinagudi around Theppakadu and Kalamalai RF, AI, TA and TAE associations are present, where species are much taller and stouter compare to those of the other associations described earlier. These three associations constitute western part of the northern corridor.

Table 5.18: Comparative assessment of abundance value of tree species in different vegetation association

Tree Species	Range of abundance of species in vegetation association													
	Ip	Cl	Cm	Rc	RZ	Rd	MF	EMf	AZ	AR	DI	AI	TA	TAE
Acacia catechu	0	0	0	Q	0-3	0-3	0-3	0-4	0-5	0-4	0	0-3	0	0-4
Acacia chundra	0-4	0-1	0-2	0	0	0	0-5	0-2	0-2	0	0	0-5	0-2	0-2
Acacia feruginea	0	0	0	0	0-2	0-3	0	0-1	0-2	0	0	0	0	0
Acacia leucophloea	0	0	0	0	0-2	0	0-2	0-2	0	0-5	0	0-2	0	0
Acacia nilotica	0	0	0	0	0	0	0	0	0-3	0	0	0	0	0
Acacia pinnata	0	0	0	0	0	0	0-2	0	0	0	0	0	0	0
Adina cordifolia	0	0	0	0	0	0	0	0	0	0	0	0-3	0-1	0
Aegle marmelos	0	0	0	0-3	0	0	0	0	0	0	0	0	0	0
Albizzia amara	0	0	0	0-2	0	0-3	0	0	0	0-3	0	0	0	0
Albizzia chinensis	0	0	0	0	0	0	0-2	0	0	0	0	0	0	0
Albizzia lebbek	0	0	0-2	0	0	0	0	0	0	0	0	0-2	0	0
Albizzia odoratissima	0	0	0	0	0	0	0-2	0-2	0	0	0	0-2	0	0
Anogeissus latifolia	0	0	0	0	0	0	0-3	0-4	0-2	0-4	0-4	0-5	0-4	0-4
Contd..														

Contd..

<i>Bauhinia racemosa</i>	0	0	0	0	0	0-3	0	0-5	0-5	0-2	0	0-3	0-4	0	0-2
<i>Bombax ceiba</i>	0	0	0	0	0	0	0	0	0	0	0	0	0-3	0	0
<i>Breidella retusa</i>	0	0	0	0	0	0	0	0	0-2	0-2	0	0	0-2	0-2	0-2
<i>Butea monosperma</i>	0-4	0	0	0	0	0	0	0	0	0	0	0	0-3	0	0
<i>Canthium dicoccum</i>	0	0-5	0	0-3	0	0	0	0	0-3	0	0	0-3	0-4	0	0
<i>Cassia fistula</i>	0	0	0	0	0-2	0-2	0-2	0-2	0	0	0-2	0-2	0-3	0-2	0
<i>Citrus spp</i>	0	0	0	0-2	0-4	0	0	0-3	0-4	0	0-2	0	0	0	0
<i>Cordia mixa</i>	0	0-2	0-5	0	0-4	0	0	0-4	0	0	0	0	0-3	0	0-2
<i>Dalbergia latifolia</i>	0	0	0	0	0	0	0	0	0	0	0	0-5	0-3	0-2	0-2
<i>Dichrostachys cinerea</i>	0	0	0	0	0-4	0	0	0	0-2	0	0	0	0	0	0
<i>Diospyros montana</i>	0	0-2	0	0-2	0-2	0-4	0-2	0-2	0-1	0-2	0-3	0	0-2	0	0-2
<i>Emblca officinalis</i>	0	0	0	0	0	0	0	0	0	0-2	0-3	0-3	0-4	0	0-4
<i>Erythroxylon monogynum</i>	0	0-4	0-2	0	0-3	0-3	0-4	0-5	0	0	0	0	0-3	0	0
<i>Eucalyptus spp</i>	0	0	0	0	0-3	0	0	0	0	0	0	0	0	0	0
<i>Euphorbia spp</i>	0	0	0	0	0	0	0-2	0-1	0	0	0	0	0	0	0

Contd..

<i>Santalum album</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Schrebera swietenoides</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Schlechera oleosa</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Semecarpus anacardium</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Shorea roxburghii</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Tectona grandis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Terminalia arjuna</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Terminalia chebula</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Vernonia arborea</i>	0-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Zizyphus oenoplea</i>	0	0-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Zizyphus xylopyra</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Vegetation associations: Ip= *Ixora parviflora*; Cl= *Canthium dicoccum-Ixora parviflora*; Cm = *Cordia mixa*; RC= *Randia dumetorum-Cordia mixa*; RZ= *Randia dumetorum-Zizyphus xylopyra*; Rd= *Randia dumetorum* ; MF= Mixed forest; EMf= *Erythroxylon monogynum-Mixed forest*; AZ= *Acacia catechu-Zizyphus xylopyra*; AR= *Acacia catechu-Randia dumetorum*; Dl= *Dalbergia latifolia*; Al= *Anogeissus latifolia*; TA= *Tectona grandis-Anogeissus latifolia*; TAE= *Tectona grandis-Anogeissus latifolia-Emblica officinalis*

Abundance scale 0 & - = NIL; 1 = 1-5%; 2 = 6-25%; 3 = 26-35%; 4 = 36-66%; 5 = >66%

5.4 DISCUSSION

5.4.1 Vegetation Structure and Composition

Careful examination of the tree height data showed a distinct pattern of the distribution of trees by their height from the eastern to the western portion of the study area. The Sigur RF had the maximum number of trees (90%) of 2-10 m height class. The number of trees of this height class gradually decreased towards north-western part of the study area. An analysis of trees distribution with respect to their girth class also showed a gradual shift from eastern part to the western part of the study area. While in the Sigur RF the larger proportion of trees (86%) were of 21-80 cm GBH class, which gradually decreased towards the west. The stunted and open canopy with poor quality of trees in the Sigur RF may be primarily due to the less rainfall (750-1500 mm annually) as stated by George *et al.*, (1988) and Pascal (1988). As we move from east to west, the rainfall increases and therefore relatively taller and stouter trees are found. This finding has further been strengthened by the findings of Lall (1990).

Distribution of different types of vegetation association showed a gradual shift from thorny scrub to dry deciduous forest and to moist deciduous forest from east to the west of the study area. The eastern most part of the study area has scrub forest with short canopy height (Plate 7 and 8) which gradually changes to dry deciduous type near Masinagudi village (Plate 9) and to moist deciduous forest in the Kalamalai RF and Moyar Sanctuary Forest near Theppakadu (Plate 10) where the upper canopy also reached a considerably good height. George *et al.*, (1988) identified 3 major forest types in Mudumalai Sanctuary. These are

southern tropical moist deciduous forest, southern tropical dry deciduous forest, and southern tropical semi-evergreen forest. All the 14 different vegetation association of the present study will fall under the southern tropical moist deciduous and southern tropical dry deciduous forest types described by George *et al.*, (1988).

The tree density in the eastern most part of the study area *i e.*, Sigur RF was least (210.5 ha^{-1}) among all the three sites and it gradually increased as we moved towards the west *i e.*, 258.9 ha^{-1} in northern corridor and 312.9 ha^{-1} in southern corridor respectively. The density figures of the present study sites are much less compared to the figures given by Vyas *et al.*, (1976). In a dry deciduous forest of Bansi in Udaipur of central India, the authors have recorded $970 \text{ trees ha}^{-1}$ for *Tectona-Boswellia* community. Similarly Bandhu (1970) recorded $1020 \text{ trees ha}^{-1}$ for *Shorea robusta* community of a tropical forest of Chalia forest near Varanasi. Study conducted by Agrawal *et al.*, (1988) in the lower Siwalik forest revealed that the range of tree density between was $60\text{-}240 \text{ ha}^{-1}$. Newton (1988) studied the structure and phenology of a moist deciduous forest in the central Indian highlands in Kanha Tiger Reserve in Madhya Pradesh and recorded density of trees as low as 133 ha^{-1} . George *et al.*, (1988) in Mudumalai WLS estimated tree density for the southern tropical dry deciduous forest and moist deciduous forest as 533 ha^{-1} and 330 ha^{-1} respectively. Phytosociological analysis of 10 representative sites of tropical forests in Doon valley of Uttar Pradesh by Singhal & Sharma (1989) revealed that the density of trees of 10 sites ranged between $60\text{-}1360 \text{ ha}^{-1}$. The dominant species recorded by Singhal & Sharma were *Mallotus philleppenensis*, *Acacia catechu*, *Albizzia*

procera, *Emblica officinalis*, *Terminalia tomentosa* and *Butea monosperma*. Singh *et al.*, (1995) studied woody vegetation of Corbett NP and recorded tree density ranging from 180 ha⁻¹ to 860 ha⁻¹. The results of the present study with respect to tree density are comparable to that of the study conducted by Agrawal *et al.*, (1980) and Singhal and Sharma (1989). Analysis of the tree density figures of the present study site show a marked pattern, which may be primarily due to the rainfall pattern. Since the terrain is relatively similar in all the study sites, and other factors such as sporadic fires, wood cutting and trampling by grazing livestock might be affecting the floral composition and structure and the regeneration capacity of the forest.

Species diversity as well as the dominance was comparatively higher in case of southern corridor than the northern corridor which could be attributed due to the moisture regime of the site (Newton, 1988; Singh *et al.*, 1995).

5.4.2 Species Regeneration and Recruitment

Regeneration as well as recruitment of important tree species in the entire study area was very poor, which may be due to excessive grazing (Smirnov, 1972; Liddle, 1975; Bock *et al.*, 1995; Hofstede *et al.*, 1995; Shaetout *et al.*, 1996) and incidence of sporadic fire (Prasad *et al.*, 1983; Neelkantan, 1988; Shanmugvel, 1995). Cattle dung collection by the villagers from the forest floor, as has been described previously in Chapter 4, will further deplete the nutrients of the already depleted soil and thereby aggravate the problems of regeneration of species. Low regeneration and recruitment of important tree species will have an adverse impact on the overall health of the forests of the study area, which if

management wants to improve, biotic pressure upon these forests should be reduced by promoting conservation friendly packages of measures. The emergence of scrub species such as *Zizyphus xylopyra*, *Maytenus emerginata*, *Erythroxylon monogynum* and *Randia dumetorum* in the parts of southern corridor of the study area is an indication of encroachment of this area by more and more scrub and stunted vegetation because of biotic pressure and subsequent changed moisture regime.

CHAPTER 6

6

QUANTIFICATION OF BIOTIC PRESSURE

6.1 INTRODUCTION

Human pressure on PAs appears in a variety of forms. However, for this study, pressure has been defined as, the removal of biomass (in the form of commercial harvesting of timber, grazing and browsing by domestic livestock, lopping of fodder species, grass collection, cutting of firewood and collection of NTFPs to the extent of creating negative impacts on wildlife and their habitat (Berkmuller, 1989). PAs may be too large to be treated for rehabilitation of degraded areas in its entirety. Pressure may not be evenly distributed, and there may be different origins of pressure in different areas. Hence, studies on the geographical distribution of biotic pressure, type, degree and extent are significant from the point of view of identifying the priority areas of the PA, for treatment and within each priority area determining the most suitable and practical management options to mitigate pressure (Berkmuller *et al.*, 1990).

As described earlier in the previous chapters, the corridor forests linking Mudumalai WLS and the Sigur RF, are subjected to heavy biotic pressure chiefly because of the local people and their cattle. In this chapter, therefore, an attempt has been made to study how biotic pressure is distributed in the study area and the type, degree and extent of these pressures in order to help the management

devising suitable management strategies to curtail and mitigate pressure upon the corridor forests.

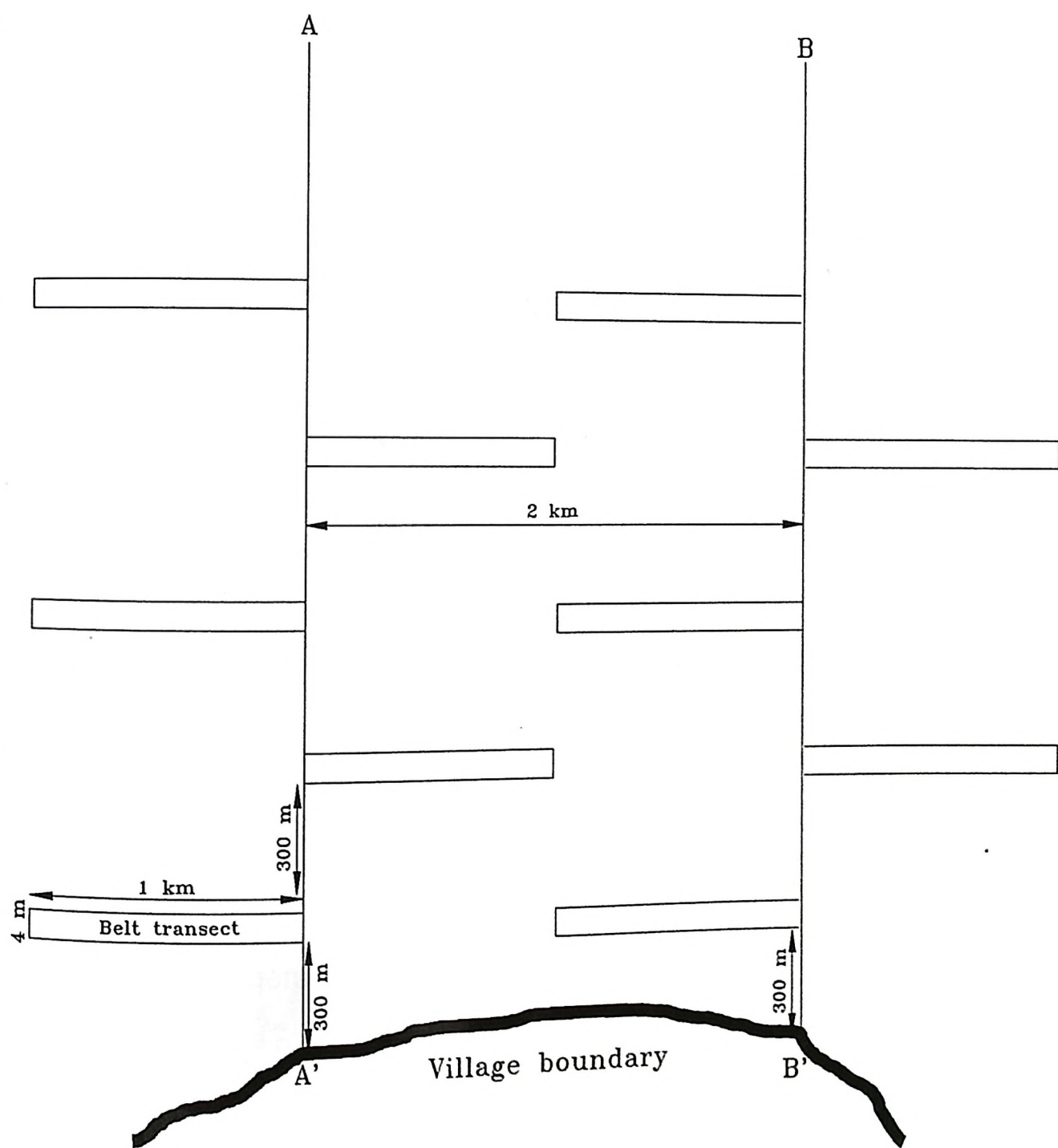
6.2 METHODOLOGY

A total of 100 belt transects of size 1km x 4m were laid inside the Sanctuary Forest and RFs of the study area, to quantify the biotic pressure. Belt transects were laid on either side of 28 imaginary lines of lengths, varying from 4 to 8 km, radiating from the village boundary into the surrounding forest (Fig. 6.1). Care was taken to keep the imaginary lines parallel to each other and at least 2 km apart. To avoid overlapping of belt transects, care was taken to lay them alternatively at an interval of every 300 m on either side these imaginary lines. By adopting above described pattern of transect layout, it was ensured that the entire area was screened thoroughly. Pressure parameters were recorded in 20 sections of 50m length of each 1km x 4m belt transect.

6.2.1 Wood Cutting Pressure

Along the entire length and breadth of the belt transect, species wise enumeration of total standing, and cut trees was done in order to quantify the proportion of cut/uncut trees (Sale and Berkmuller, 1986). The diameter of cut stems was recorded in two classes in order to know the preference of girth class by the villagers. These were 4-8 cm and >8 cm diameter class. It may be noted here that, in the study villages, people prefer tree/wood ranging 4-8 cm diameter (at breast height) for the purpose of firewood and for timber they prefer >8 cm size.

Fig. 6.1: Transect layout for biotic pressure quantification



A A' and B B' are imaginary parallel lines of various length radiating from the village boundary and are 2 km apart

6.2.2 Lopping Pressure

Quantification of lopping pressure was done by enumerating the total standing trees and lopped trees, along the entire length and breadth of a belt transect. Based on the ocular estimation of the intact crown cover of a lopped tree, the percentage of lopping was estimated and thus the lopped trees were categorised under either of the four categories: 1 to 25% (low); 26 to 50% (medium); 51 to 75% (high) and 76 to 100% (very high) lopping intensity. However, before taking the ocular estimation of intact cover of the lopped trees, 100 observations were made using the techniques described by Mishra (1968), to verify the corrections of the ocular observations.

6.2.3 Livestock Grazing Pressure

Quantification of the livestock grazing pressure is based on direct evidences such as livestock density in the forest and frequency of occurrence of livestock dung piles and indirect evidences such as proportion of weed and non-weed species and bare and covered ground.

Livestock density in different forests was estimated as per the method suggested by Rodgers (1990), and was expressed as the number of livestock units (LU) per km². Besides this, the frequency of occurrence of livestock dung piles was estimated based on the observation in each section of 50m length of the belt transect and finally averaged for different study sites.

In each of the belt transect, at every 25 m interval, the presence and absence of weed and non-weed species as well as bare and covered ground

were recorded to find out the proportion of weed and non-weed species and bare and covered ground.

6.2.4 Habitat Use by Elephants

Evidences of habitat use by elephants in and around corridor forests and surrounding RFs, were recorded at 40 points at an interval of 25 m in each belt transect. Signs of habitat use, such as: i) number of elephant dung piles, ii) feeding and browsing, iii) debarking of tree trunks, iv) knocking or pushing down of trees, and v) track marks of elephant movement were recorded. Habitat parameters, such as presence and absence of salt licks and their use by elephants, type of terrain (*i e.*, slope, steep, gentle), micro habitats such as seasonal streams which provided suitable foraging sites for elephants (Sivaganesan, 1992) and water sources, were also recorded. The habitat use data so collected were compared with the livestock grazing data in order to find out the habitat use by elephants along the grazing pressure gradient.

6.3 RESULTS

6.3.1 Wood Cutting Pressure

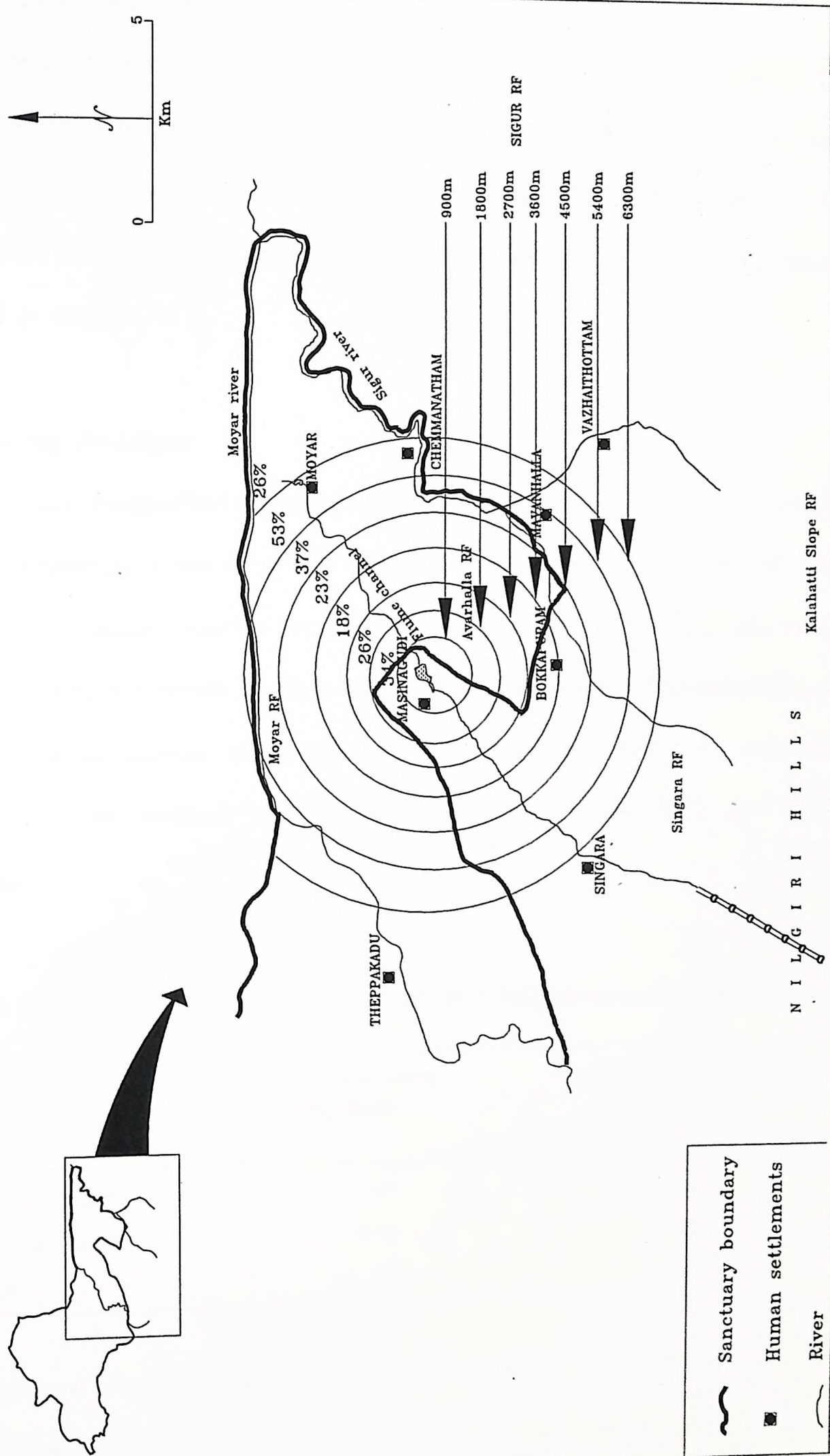
Table 6.1 gives the percentage of cut stems for all three study sites. Results revealed that southern corridor suffered maximum due to wood cutting pressure where 39%, of the total trees were found cut as compare to northern corridor with 25% cut trees. Sigur RF suffered the least damage with 19% cut trees. It is interesting to note that in all the 3 study sites, of the total cut trees 80% were >8 cm diameter while the rest 20% had 4-8 cm diameter. Elephant food trees suffered the maximum damage due to wood cutting.

Table 6.1: Wood cutting pressure

Forest area	% Cut trees		
	Total (all diameter class)	4-8 cm diameter	>8 cm diameter
Northern corridor	25	19	81
Southern corridor	39	20	80
Sigur RF	18	19	81

Fig. 6.2 shows the gradient of wood cutting pressure. Results suggest that there is a continuum of wood cutting pressure upto more than 6 km. Within the first 900 m from the habitation, 34% of the total trees were cut and as we move away from the habitation the percent of cut trees reduces to 23% upto 3.6 km, but again increases to 53% upto 4.5 km. As we moved further away it reduced again to 26% at 6.3 km.

Fig. 6.2: Wood cutting pressure gradient



6.3.2 Lopping Pressure

Fodder lopping was almost absent in the entire study area. The fodder for 2% stall-fed cattle population was either grown in the agricultural fields or fodder grass was collected from the forest to feed the young ones during pinch period. The data on the quantity of grass collected from the study has already been described in chapter 4.

6.3.3 Grazing Pressure

Southern corridor had the maximum density of grazing livestock *i.e.*, 179 LU per km², followed by northern corridor with 82 LU per km², while the Sigur RF had the least cattle density with 68 LU per km² (Table 6.2). The finding has been supplemented by the results of the analysis of data pertaining to the frequency of livestock dung occurrence, which was recorded maximum (100%) for southern corridor while for northern corridor and Sigur RF it was 89% and 88% respectively.

Table 6.2: Density of grazing livestock and frequency of dung piles

Site	Livestock units (no./km ²)	Dung piles frequency
Northern corridor	82	89
Southern corridor	179	100
Sigur RF	68	88

Southern corridor had the highest frequency of occurrence of weed species (43%) followed by northern corridor (41%) and the Sigur RF (21%). But

surprisingly, the northern corridor had the largest percentage of exposed area compared to southern corridor and the Sigur RF (Table 6.3).

Table 6.3: Frequency of weed species and exposed ground

Site	Frequency of occurrence (%)	
	Weed species	Exposed ground
Northern corridor	41	31
Southern corridor	43	25
Sigur RF	21	24

6.3.4 Habitat Use by Elephants

In Sigur RF, all evidences of habitat use by elephants were found to be the highest (55%) followed by northern corridor (37%) and southern corridor (34%) (Table 6.4).

Table 6.4: Elephant evidences

Site	Habitat use (% frequency)				
	Feeding	Debarking	Knocking down	Track Marks	All* Evidence
Northern corridor	14.0	4.1	4.5	11.1	37.4
Southern corridor	10.7	0.4	2.0	6.7	34.2
Sigur RF	19.6	0.9	4.4	3.2	54.9

* Including dung

The comparison of livestock and elephant dung occurrence showed a positive correlation. Southern corridor, with 100% frequency of livestock dung had the least percent of frequency of elephant dung piles (29%), while the Sigur RF recorded the highest frequency of occurrence of elephant dung (48%) where the

livestock dung frequency was 88% (Table 6.5). Significantly, elephants made use of disturbed areas near Masinagudi (within 3 km radial distance from the village boundary).

Table 6.5: Cattle vs Elephant dung

Site	Frequency of occurrence (%)	
	Cattle dung	Elephant dung
Northern corridor	89	42
Southern corridor	100	29
Sigur RF	88	48

6.4 DISCUSSION

6.4.1 Impact of Biotic Pressure on Corridor Forests

An analysis of wood cutting and livestock grazing pressure helped in demarcation of three distinct pressure zones (high, medium and low) of the study area. The southern corridor, which is situated between Masinagudi and Singara village, experienced the highest biotic pressure in terms of both wood cutting and livestock grazing. Compared to this, the biotic pressure on the northern corridor, situated between Masinagudi and Moyar village was rated as "medium" and that of the Sigur RF as "low". The severity of pressure on the southern corridor compare to the northern corridor can be explained by the presence of 5 human settlements and their large livestock population (6000) right inside this forest. Besides this, the legal/management status of the Singara-Kalahatti and Kalamalai Forests, which together constitute the southern corridor is that of a "Reserve Forest", where protection is less stringent compare to the "Sanctuary Forest" status of the northern corridor. On top of this, a substantial part of the southern corridor forest, which belongs to a private coffee estate owner is lying uncultivated and is left free for the villagers and their cattle.

An analysis of the gradient of wood cutting pressure around the Masinagudi village showed that the severity of pressure did not decline from a higher percentage to lower as we moved away from the village and was expected. The higher percentage (54%) of cut wood around 5.4 km radial distance from Masinagudi village boundary can be accounted due to the overlapping of pressure

zones of the neighbouring villages as well as their cumulative effect. Elephant food trees suffered the maximum due to cutting.

Even though the cattle keeping is an important occupation of majority of the villagers in the region, surprisingly people did not lop fodder species. This could be accounted due to emphasis given by the villagers on free grazing in the forest which require practically no cost even labour! As mentioned earlier the 98% of the livestock are left free to graze. The fodder requirement of 2% stall-fed cattle population was met either from the fodder grass grown in the agricultural fields or the grass collected from the forests and stored for the juvenile animals for the dry months.

Overgrazing alters the ecosystem structure organisation and function (Putman, 1986; Holmwood and Rodgers, 1987; Picket and Armestongi, 1989; Skarpe, 1991). Reduced species richness and diversity supplemented by increased proportion of unpalatable weed species, because of excessive grazing, has been reported in the literature (Reynolds and Nautiyal, 1990; Rawat and Uniyal, 1993; Pettit *et al.*, 1995). Excessive grazing followed by trampling, accelerates the process of soil erosion and thereby deplete the nutrient pool (Mashalla, 1988). The combined impact of excessive grazing and wood cutting can be seen throughout the present study area in the form of retarded species regeneration and their recruitment, preponderance of unpalatable species and accelerated erosion accompanied by deterioration of site quality. However, evidences of these impacts are more prominent in southern corridor compare to northern corridor. With the decreasing availability of palatable grass species,

grazier are forced to burn the ground cover as well as the new forests. This practice not only increase the occurrence of forest fire, but also adversely affect the species regeneration (Saharia, 1984; Rai, 1985; Moench, 1989) and the site quality of already degraded habitat. Frequent occurrence of forest fires in the Sigur RF is a good example of this.

Significantly elephants used the disturbed areas near Masinagudi village (within the 3 km radius from the village boundary) more than the adjoining areas. This may be accounted for more preferred forage species, availability of water, natural salt licks and gentle terrain. Because of the presence of human settlements and the severity of biotic pressure, elephants are less frequently visiting the southern corridor compare to the northern corridor as evidenced from the analysis of the results of habitat use by elephants. This situation will be further aggravated by the proliferation of hotels and lodges in Mavanhalla and Bokkapuram villages. Therefore, there is an urgent need to halt the growth of hotels close to the southern corridor.

CHAPTER 7

7

MANAGEMENT IMPLICATIONS OF THE IMPORTANT FINDINGS & RECOMMENDATIONS

7.1 INTRODUCTION

The major conservation problems, identified in the present study area are: i) fast expanding population of migrant labourers and their cattle; ii) construction activities of hydroelectric projects around forest corridors at Masinagudi, Moyar and Singara villages; and iii) proliferation of hotel industry attracting the large number of tourists around the elephant migration routes. The combined destructive impacts of all these have been seen in the form of high biotic pressures of resource dependent population of seven villages, mainly for fuelwood, grass, cattle dung collection and free grazing by almost 9000 livestock. The increasing quantum of biotic pressure have threatened the viability of the corridor forest, and therefore, the survival of elephant population in its largest contiguous habitat in southern India is at stake! One of the major objectives of this study was, to come out with the management recommendations which would help in reducing the mounting tide of biotic pressure and rehabilitating the degraded corridor forests for ensuring the long-term survival of elephant population in this region.

7.2 Possibility of Reducing Biotic Pressure

7.2.1 Check of Encroachment

The continuous increase of human population urgently needs a check, by keeping proper vigil on the illegal encroachment of waste land lying in and around the study area, to facilitate easy movement of migratory elephants. The construction of new settlements around the corridor forest should be discouraged by the district development authorities and the revenue departments. Care should also be taken by these departments for not granting permission of the construction of new hotels in and around the corridor forests as was seen in the Mavanhalla and Bokkapuram village.

7.2.2 Phase-Wise Reduction and Replacement of Scrub Cattle

Since the entire livestock population is totally dependent on the corridor forest and the surrounding reserved forests for grazing, and annual increment ($20,737 \text{ t yr}^{-1}$; Chapter 4) of the fodder grass in these forests can support only 3234 cattle unit (40% of the total livestock population) without seriously depleting the resources, an interesting challenge is put forth before the development planners and natural resource managers. In order to come out with practical solutions to the above problems, the planners need to answer the following questions: (i) how to feed the excess livestock population (60% of the total population) of these villages ?, or otherwise (ii) how to reduce the livestock population to 40% of total population ?. Crop byproducts contributed only a fraction of the fodder requirement as most of the agricultural land is rainfed and the quality and quantity of these byproducts is not enough to supplement the forest fodder. Thus the question of meeting fodder deficit arises. The fodder deficit may possibly be

met by growing fodder on a co-operative basis on the encroached government land as well as on the private lands those are lying uncultivated. This type of land which is available in these villages is about 1478 ha. Considering the annual average of grass production of $2.5 \text{ t ha}^{-1} \text{ yr}^{-1}$, 1478 ha can meet only 7% of the total annual requirement of fodder if the land is simply protected from grazing and illegal grass cutting and left to natural regeneration of grass. However, if the cultivation of fodder grass is done on this land with little bit of irrigation, it can meet at least 10-15% of the fodder requirement of the village if one considers the average annual productivity at $3-5 \text{ t ha}^{-1} \text{ yr}^{-1}$ as a very conservative scale. Therefore, reduction in the livestock population to the 40% of the present number seems to be a sensible and more practical alternative. This means the remaining 60% population should go out of the study area! But the task of reducing the present livestock population to 40% of its size needs to be evaluated critically. In this context, major questions needed to be answered are: i) which 60% population should go, or in other words, which families would become the target ?, ii) will the suggested reduction in cattle number seriously impact on the economy of the target families ?, and iii) how the process of reducing the cattle population will be carried out ?.

As has been discussed in Chapter 4, of the total cattle owning families, 29% (176 families) possess >10 cattle and all of them together hold 73% of the total cattle population of these villages. These 176 number of cattle owning families could be our target ! Forest Department as an implementing agency may put restrictions on these families by not issuing grazing permits for more than 5-6 cattle and persuading them to replace their scrub cattle with 1-2 number of good

breed stallfed cattle. However, before recommending such measures, there is a need of evaluating the economic status of these people in the light of the following. Whether these 176 families are economically rich, and do they have other sources of income for sustenance so that they will not be affected severely by reducing their cattle number? Again all of these families can not be treated equally. Different package of alternative measures should be thought of for different sub-groups of the cattle owners based on their occupation, sources of income and willingness to adopt the suggested innovations.

A careful analysis of the economic status, occupation and land holding etc. of these 176 targeted families suggests that, 16 and 27 families who are having >5 acres and between 2.5-5 acres of agricultural land respectively could be the first target group. Such families should be persuaded to keep 1-2 good breed stall-fed cattle which will yield more milk. Protected Area Extension Services (proposed) or any extension worker or NGOs employed by the PA can play a major role in providing the farmers know how about the technical details with respect to the dairy farming, loans, subsidies and developmental schemes of the various Government Departments. Of the remaining 133 families, 80 families are landless and 53 families are marginal farmers without any other economic support. This group may be given benefits of subsidies provided by government through various schemes, and be encouraged by the Animal Husbandry Department to introduce 1-2 number of high yielding stall-ed cattle. Further, the 80 landless families may be thoroughly scrutinised to find out the jobless ones and different employment schemes may be recommended for their daily sustenance.

There is also a need of evaluating the current rates of milk that are being paid to registered members by milk co-operative societies. Animal Husbandry Department besides monitoring the health of the cattle, should also take necessary steps for improving local breed through artificial insemination programmes. Even the villagers may be trained about the proper ways of taking care of health of their livestock through effective extension education programmes. Vaccination of livestock population at regular interval is a must, to stop outbreak of any kind of disease into the wild population.

7.2.3 Control of the Migratory Cattle

A proper vigil by the Forest department is required all along the border between Tamil Nadu and Karnataka near Moyar gorge to stop the seasonal migration of cattle into the Sanctuary Forest. A constant patrolling is required during between May to November to stop the migratory cattle entering into the Sanctuary Forest.

7.2.4 Ecodevelopment Planning for the Needy People

The reduction in livestock population may be supplemented by a shift of economy from cattle dung selling to fodder farming, bee keeping, mushroom cultivation, sericulture and eco-tourism etc. Such package of measures, however, can best be planned through systematic ecodevelopment planning exercises using PRA methods (Chambers, 1992; Mascarenhas *et al.*, 1991; Mukherjee, 1995) as suggested by Panwar (1992) and Pabla *et al.*, (1995). Ecodevelopment concept has emerged in recent times and in the context of PA management it advocates meeting the basic biomass needs of the rural poors that inhabit close to them, and

encourages the grassroot participation of resource dependent population in the development process ensuring sustainable utilisation of natural resources (Barbier, 1987; Mishra, 1995).

A complete ban on the collection of cattle dung from the forest floor may be strictly imposed by the Sanctuary management so that the fertility of forest can be renewed. Reduction in the grazing pressure by promoting rotational grazing would help in proper regeneration of species and also provide sufficient forage and browse to the migrating elephant population.

7.2.5 Substituting Fuelwood With Other Alternatives

Local hotels consume a large chunk of fuel wood to feed the local population, and transit tourists, passing through Masinagudi village. They may be encouraged to substitute the fuelwood with LPG, kerosene and biogas, costs of which they can easily afford. Thus the total fuelwood extraction and consumption can be reduced to some extent. Through ecodevelopment schemes, local residents may be encouraged to use fuel efficient chullah, biogas, LPG and solar cookers. Even they can be encouraged to use dung cakes and agricultural waste as fuel, as practiced in other parts of the country where there is scarcity of firewood. Opening of fuelwood depot at Masinagudi village may be suggested where the fallen dead wood collected from the Sanctuary Forest and/or RFs may be sold by the Forest Department at nominal rates to the villagers. This would restrict villagers to go into the forest for firewood collection and check frequent forest fires caused by the illegal wood cutters.

7.3 Land Acquisition

The study villages adjoining the Sanctuary Forest have three categories of land i.e., i) poromboke land which is revenue land and either lying vacant (as no man's land - waste land status) or encroached; ii) privately owned patta land and iii) land under the control of Electricity Board.

7.3.1 Acquisition of Poromboke Land

All of the three categories of land described above, are distributed mainly on the south-eastern periphery of Sanctuary, which form a vital link between Mudumalai WLS and Sigur RF. Under present situations the main focus of the management should be on maintaining the physical continuity between these two forests for ensuring safe movement of the elephants on their usual migrating routes. This continuity can be maintained by acquiring the poromboke land lying in between Masinagudi and Bokkapuram (Survey no. 315/1), Mavanhalla and Vazhaithottam (around Chedapatti hemlet; Survey no. 111 and 239), and near Masinagudi (Survey no. 176, 177, 178, 180, 185 and 246) by the forest department and elevating their status.

7.3.2 Acquisition of Private Land

To facilitate the free movement of elephants, private forest which is owned by one coffee estate owner, and is lying between Masinagudi and Singara village may be acquired by the Forest Department. This patch of forest (about 160 ha), currently lying uncultivated, has dense tree growth along the banks of flume channel and used by elephants during migration. The elephant herds may be seen grazing in this area especially near Kalahalla bridge during their seasonal

movement. This patch of acquired land may be given a status of Sanctuary Forest to put legal restrictions on the resource exploitation by villagers.

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APPENDICES

APPENDIX I

QUAESTIONNAIRE FOR COLLECTION OF GENERAL INFORMATION OF VILLAGES

1. Name of the village:
2. Name of the headman:
3. Gram panchayat:
4. Revenue block: Tahsil: Distt HQ: Police station:
5. Human population*:
6. Livestock population*:
(* From the Census or Block Office)
7. Village groups**
(** Social groups/Youth groups/Mahial groups/NGO)
8. Total area of the village (from Village Development Officer):
 - i) Settlements:
 - ii) Cultivated land:
 - iii) Barren land:
 - iv) Cultivable waste land:
 - v) Community grass land:
 - vi) Community forest land:
 - vii) Land under enchroachment/illegal occupation:

9. Facilities available:

Type	Yes/No (if No, distance from village)
Health	
Drinking Water	
School	
Post Office	
Banking	
Veterinary Hospital	
Irrigation	
Co-operative Societies	
Transport	
Electricity	
Industry	

APPENDIX II

QUESTIONNAIRE FOR DOOR TO DOOR SURVEY IN VILLAGES

1. Name of the head of family
Caste

2. Main occupation of the family
a) Agriculture b) labour c) Service (Govt/Private)
d) Self employment e) others (specify)

3. Details of family members

Name	Age	M/F	Relation with head	Educational status					Occupation			
				1	2	3	4	5	a	b	c	d

Note: 1= Primary; 2= Secondary; 3= High school; 4= College; 5= Illiterate
a= Household activity; b= Agriculture; c= Labour; d= Others

4. a) Agricultural information
i) Total own land (acres/ha):
ii) Land taken on lease (acre/ha):
iii) Land given on lease:

b) Cropping pattern

Crop type	area sown	Crop of previous year				Opinion
		yield (Q)	quantity sold (Q)	Market value (Rs)	Cause* a/b/c	

a= Surplus; b= Buying other material; c= Paying debts.

c) Uncultivated Land

i) Area (acre/ha):

ii) Cause of not cultivating:

iii) Landuse suitability:

d) Fertility Status

i) Soil fertility-Good/Poor/Bad

ii) Terrain-Flat/Valley/Hill slope

iii) Erosion-Absent/Sheet/Rill/Gulley

iv) Top soil depth-Rock exposed/Scanty/Good

e) Land improvement methods

Q. Do they know any method for land improvement Y/N:

i) Land preparation like terracing, bunding etc.

ii) Irrigation improvement

iii) Cover crops to check erosion

Q. If they know and not adopted what is the reason?

(lack of money/initiative/others)

5. Crop damage (if reported)

Crop type	Animal	Month	Plant parts	Stage of life cycle

6. Irrigation information

- i) Is the land irrigation (Y/N)
- ii) Source of irrigation (lift/canal/river/gul)

7. Manuring methods

Manure type	Name	Source a/b/c/d	Market value (Rs)	Manure application time			Harvesting time
				Quantity applied	Month	No. of application	
Organic							
Inorganic							
Both							

a= Own composed pit; b= Gathered; c= Purchased within village (specify the cost); d= Purchased from outside village (specify the cost)

8. Livestock information

Type	No. of		Milk yield/day (lit)	No. of grazing animal	No. of stallfed animal	Remarks
	Milking	Non- milking				
Cow						
Buffalo						
Bull						
Cow calf						
Buffalo calf						
Mature Sheep						
Immature Sheep						
Mature goat						
Immature goat						
Donkey						
Mule						
Horse						

9. Milk yield and Marketing

- i) Milk sold (Lit/day):
- ii) Market value (Rs./Lit):
- iii) Marketing: direct/middlemen/co-operative society

10. Sericulture (Y/N) If yes:

- i) Cocoon production (Kg):
- ii) Marketing method: direct/middlemen/co-operative

11. Income from meat

Type	No. sold/year		Rate		Marketing D/M/C
	Mature	Immature	Mature	Immature	

Marketing : D= Direct; M= Middlemen; C= Co-operative

12. a) Type of fuel used and their sources

Fuel type	Use type 1/2/3	Source a/b/c/d/e/f	Who collects M/F/C
Wood spp			
Dung cakes			
Kerosene			
LPG			
Biogas			
Agri waste			

Use type: 1= Cooking; 2= Lighting; 3= Room heating; 4= Others

Source: a= Sanctuary Forest; b= Reserved Forest; c= Agricultural Fields; d= Own Cowshed; e= Gathered from Pasture Land; f= Purchased (specify the cost)

(b) Fuel storage method for future use (specify):

(c) Gobar gas plant information:

i) Type and size of plant

ii) Use (cooking/lighting/slurry for manure)

iii) Evaluate performance

13. (a) Type of fodder/feed consumed and their source:

Animal type	Month	Fodder type	Amount consumed (kg/day)	Source 1/2/3/4/5 & market price	who collects M/F/C
Grazed Livestock					
Stallfed Livestock					

1= Sanctuary Forest; 2= Reserved Forest; 3= Agricultural Waste; 4= Pasture Land; 5= Purchased (specify the cost and place)

(b) Storage method if any:

14. Information on house/cowshed (own observation):

Main building	Type		Size (ft x ft)	Main construction material
	Kachcha	Pukka		
House				
Cowshed				

Roof	Type (1/2/3/4)	Size (ft x ft)	Turn over time (year)
House			
Cowshed			

1= Concrete; 2= Tiles; 3= Thatched; 4= Tin Sheets

15. Electrified (Y/N):

16. Drinking water facility (Y/N):

If yes source (well/hand pump/river/pond/town water supply)

17. Involvement in rural development (RD) programme (specify)

Rd activity	Kind of involvement	No.of family member involved	Average monthly income (Rs)	Resource base 1/2/3/4
Agriculture				
Animal husbandry				
Dairy development				
Sericulture				
Pisciculture				
Small-scale industry				
Handicrafts				

Resource base: 1= Agriculture Land; 2= Pasture Land; 3= Forest Land; 4= Water Sources

APPENDIX III

LIST OF TREE SPECIES OF THE STUDY AREA

Botanical Names	Tamil Names	Family
<i>Acacia catechu</i>	Karungali	Leguminosae
<i>A. chundra</i>	Karungali	-do-
<i>A. ferruginea</i>	Parambai	-do-
<i>A. leucophloea</i>	Billijali	-do-
<i>A. nilotica</i>		-do-
<i>A. pinnata</i>	Siyakai	-do-
<i>Adina cordifolia</i>	Manja-kadambai	Rubiaceae
<i>Aegle marmelos</i>	Viluam	Rutaceae
<i>Albizzia amara</i>	Unjal	Leguminosae
<i>A. chinensis</i>		-do-
<i>A. lebbek</i>	Baggemaram	-do-
<i>A. odoratissima</i>	Selaidmaram	-do-
<i>Anogeissus latifolia</i>	Vellaivagai	Combretaceae
<i>Bauhinia racemosa</i>	Achalmaram	Leguminosae
<i>Bombax ceiba</i>	Panjimaram	Bombacaceae
<i>Bridelia retusa</i>	Konjemara	Euphorbiaceae
<i>Butea monosperma</i>	Palasu	Leguminosae
<i>Canthium dicoccum</i>	Kakkorle	Rubiaceae
<i>Cassia fistula</i>	Konnai	Leguminosae
<i>Citrus spp</i>	Kattunarathai	Rutaceae
<i>Cordia myxa</i>	Challemara	Boraginaceae
<i>Dalbergia latifolia</i>	Itli/Eetti	Leguminosae
<i>Dichrostachys cinerea</i>	Vedathalam	Mimosoideae
<i>Diospyros montana</i>	Vellaithuvavai	Ebenaceae
<i>Emblica officinalis</i>	Nelli	Euphorbiaceae
<i>Erythroxylon monogynum</i>	Jeendal	Linaceae
<i>Eucalyptus spp</i>		Myrtaceae
<i>Euphorbia spp</i>	Pachangi	Euphorbiaceae

<i>Ficus benghalensis</i>	Alamaram	Moraceae
<i>Ficus officinale</i>	Alamaram	Moraceae
<i>Ficus religiosa</i>	Alasumaram	Moraceae
<i>Garuga pinnata</i>	Karivembu	Burseraceae
<i>Givotia rottleriformis</i>	Bhoothali	Euphorbiaceae
<i>Gmelina arborea</i>	Kumalimara	Verbnaceae
<i>Grewia tiliaefolia</i>	Tadachi	Tiliaceae
<i>Ixora parviflora</i>	Korivi	Rubiaceae
<i>Kydia calycina</i>	Vendai	Malvaceae
<i>Lagerstroemia parviflora</i>	Peikadukkai	Lythraceae
<i>Lannea coromandelica</i>	Goddanmaram	Anacardiaceae
<i>Maytenus emerginata</i>	Tandurchi	Celastraceae
<i>Nephelium longana</i>	Doolai	Sapindacea
<i>Premna tomentosa</i>	Kollukattai	Verbenaceae
<i>Pterocarpus marsupium</i>	Vengai	Leguminoseae
<i>Randia dumetorum</i>	Kare	Rubiaceae
<i>Santalum album</i>	Sandanam	Santalaceae
<i>Semecarpus anacardium</i>	Geremara	Anacardiaceae
<i>Schrebera swietenoides</i>	Gantemara	Oleaceae
<i>Schleichera oleosa</i>	Chagade	Sapindaceae
<i>Semicarpus anacardium</i>	Garmare	Anacardiaceae
<i>Shorea roxburghii</i>	Sambrani	Dipterocarpaceae
<i>Tamarindus indica</i>	Puli	Leguminoceae
<i>Tectona grandis</i>	Thekku	Verbenaceae
<i>Terminalia arjuna</i>	Neermatti	Combretaceae
<i>T. bellerica</i>	Thani	-do-
<i>T. chebula</i>	Kadukkai	-do-
<i>Vernonia arborea</i>		Asteraceae
<i>Zizyphus mauritiana</i>	Ilanthei	Rhamnaceae
<i>Z. oenoplea</i>	Sollimara	-do-
<i>Z. rugosa</i>	Kootmere	-do-
<i>Z. xylopyrus</i>	Elanthai	-do-

SUMMARY

STUDY OF PRESSURE AND DEPENDENCY OF LOCAL PEOPLE ON THE NATURAL RESOURCES OF MUDUMALAI WILDLIFE SANCTUARY WITH A VIEW TO DEVISING COMPATIBLE MANAGEMENT STRATEGIES

SUMMARY

Introduction

Mudumalai Wildlife Sanctuary (WLS) ($11^{\circ} 32' - 11^{\circ} 42' \text{ N}$ and $76^{\circ} 21' - 76^{\circ} 45' \text{ E}$) and the adjoining forests of Bandipur National Park (NP), Nagarhole NP, Wynad WLS and Sigur Reserve Forest (RF) form the largest contiguous elephant tract in the peninsular India. The connecting forest between Mudumalai WLS and Sigur RF, which lies between the deep Moyar gorge and the steep Nilgiri hills is not more than 5-6 kilometres wide, and is composed of Moyar-Avarhalla Sanctuary Forest situated between Masinagudi and Moyar village (northern corridor), and Singara-Kalahatti RF situated between Masinagudi and Singara village (southern corridor). Scattered within this narrow belt of forest, Masinagudi village is situated alongwith its 6 hamlets. Location of Masinagudi village right in the middle of the link forest divide it to still narrower corridors (north and south corridors). A large chunk of the inhabitants of Masinagudi and its hamlets are landless labourers who came to this area in the recent past from the adjoining areas to work in a hydro-electric project. Most of the villagers in these villages maintain large herds of cattle in the surrounding forests for selling cow dung manure to the nearby tea and coffee estates. Many of them cut firewood from these forests to sell in the local market for making a living. All other biomass requirements of villagers are also met from the surrounding forests. The corridor forests between Mudumalai WLS and Sigur RF is thus subjected to heavy biotic pressure from the local people and their grazing cattle.

Viability of the above mentioned corridor forest is crucial for the long-term conservation of elephants in this area. If the degraded elephant habitat of the corridor forest has to be rehabilitated, besides improvement in the general protection of the forests, ecodevelopment measures have to be under taken in Masinagudi and adjoining villages so as to make the rural ecosystem as self relied as possible and thereby help mitigating pressure upon the forests. Therefore, the present study which is a multi-disciplinary one, was undertaken with the following objectives:

Objectives

- (i) to investigate the socio-economic and cultural dimensions of sustenance problem of the local people,
- (ii) to quantify and analyze the pressure of local people and their cattle on the biomass resources of the corridor forest, and
- (iii) to design viable alternatives for people for mitigating their sustenance problem as well as reducing pressure upon the resource of the corridor forest and the surrounding elephant habitat.

Findings of Socio-Economic Study

Analysis of socio-economic data revealed that 76% of the resident families are landless, while 43% possessed nearly 9,000 livestock of which 90% are unproductive and raised only for dung manure. Of the total cattle owning families,

29% possess >10 cattle and all of them together hold 73% of the total cattle population. Annually, villagers sold about 2100 t cattle dung to the adjoining tea and coffee estates. Economy of 3% families was totally based on the selling of Non-Timber Forest Produces (NTFPs). Of the total land owners, 87% are marginal and small farmers having 1-5 acres of land who grow ragi, maize and groundnut as main crops. Of the total agriculture land, 71% is owned by 3.7% of the total number of agricultural families who are basically large land holders each having >25 acres of land and grow mainly coffee. Interestingly, of the total land available for agriculture, only 37% is cultivated and the rest 63% is lying as cultivable waste, most of which belongs to the owners of coffee estates residing outside the study area.

Findings of Pressure and resource Dependency Study

Analysis of the degree and extant of biotic pressure upon the corridor forest showed that while 39% of trees were found cut in Singara-Kalahatti forest (southern corridor), 25% were cut in Moyar-Avarhalla forest (northern corridor). Of total cut trees 80% were >8 cm in diameter while the rest were 4-8 cm. Elephant food trees suffered the maximum due to cutting. Observation on distribution of cattle dung revealed that the grazing pressure was all throughout. Significantly elephants made use of disturbed areas near Masinagudi village (within 3 km radial distance from village boundary) more than the adjoining areas. This was accounted for more preferred forage species, availability of water, natural salt licks and gentle terrain.

It was estimated that villagers removed 2803 t of firewood, 324 t of grass and gathered 495 t of cattle dung annually from the corridor forest. Average grass production was estimated to be the highest in case of Singara-Kalahatti forest (3.16 t ha⁻¹ yr⁻¹) followed by Sigur RF (2.70 t ha⁻¹ yr⁻¹) and Moyar-Avarhalla forest (1.92 t ha⁻¹ yr⁻¹). Annual fodder (grass) requirement for the village cattle was 52,700 t yr⁻¹ which is 2.5 times more than the availability of grass in this area. Implications of these results have been discussed in the context of fuel and fodder dependency and mitigating pressure on the elephant corridor forest. Local hotels annually consumed 58 t of fuelwood to cater the needs of 2,49,000 transit tourists. this requirement is likely to increase in near future, which will have direct bearing on the wood cutting pressure in the study area.

Management Implications of Important Findings and Recommendations

1. Forests adjoining Masinagudi group of villages can support only 3234 cattle unit. Reduction in livestock number to 40% of the present population, substitution of scrub cattle with high yielding varieties alongwith promotion of stall-feeding have been suggested. For reducing the number of cattle, 176 families each having >10 cattle have been identified as the target group for persuasion. Different packages of alternatives measures have been suggested for these families.
2. Fodder plantation on a co-operative basis on 1478 ha of encroached Government as well as on the private land those are lying uncultivated, has also been suggested which would meet 7-15% fodder deficit.

3. To reduce fuelwood consumption in domestic sector, use of fuel-efficient chullah have been suggested alongwith substitution of fuelwood with *gobar* gas, LPG and Kerosene. It is also suggested to persuade the local hoteliers to use LPG and Kerosene instead of firewood for cooking purpose.
4. To facilitate free movement of elephants 160 ha of private forest belonging to one coffee estate and situated between Masinagudi and Singara village has been suggested to be acquired the by Forest Department and to give the forest a status of Sanctuary.

PLATES



Plate 1: Villagers maintain large herds of cattle for selling cowdung manure to nearby tea and coffee estates



Plate 2: Huge quantity of firewood is cut from the corridor forest by the villagers for own use and also to sell in the local market



Plate 3: Cattle of Masinagudi and surrounding villages graze freely in the corridor forest through out the year



Plate 4: A large proportion of the cow dung is sold to the owners of tea and coffee estates instead of being used in the agricultural fields



Plate 5: Poor villagers collect cattle dung even from the forest floor for selling

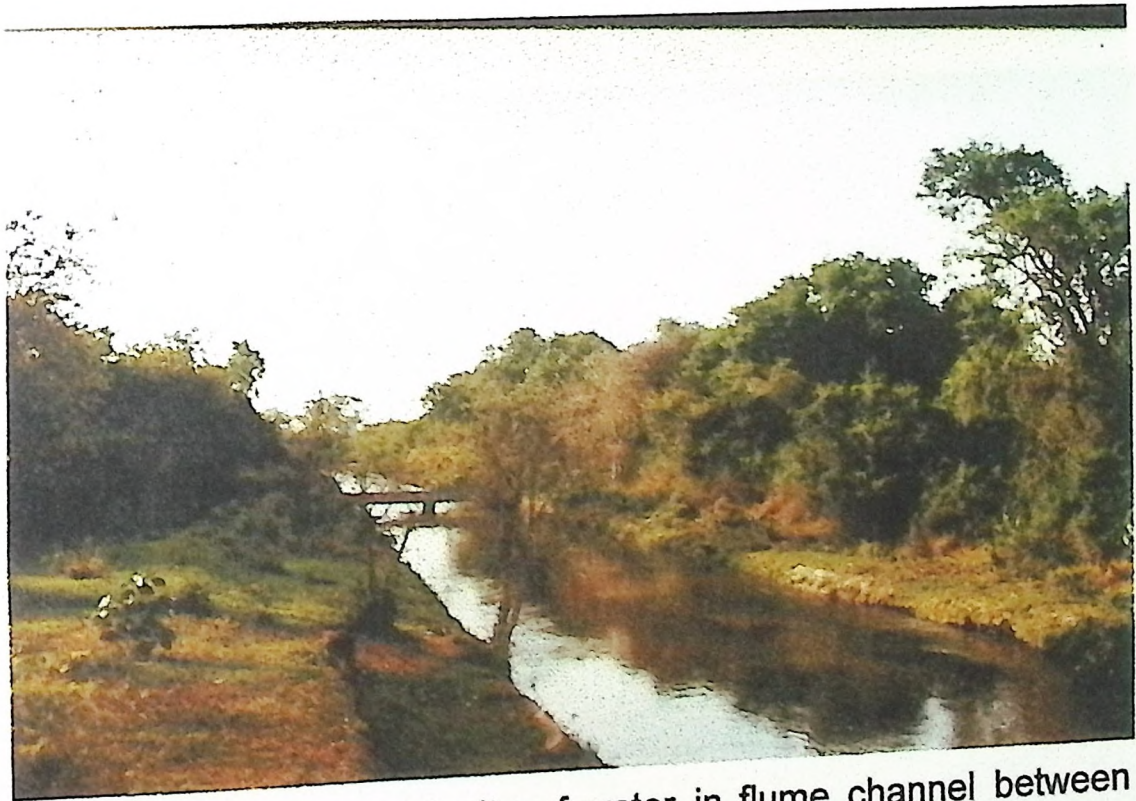


Plate 6: Quantum and velocity of water in flume channel between Singara and Moyar is expected to increase in near future and thereafter will obstruct the migrating elephants

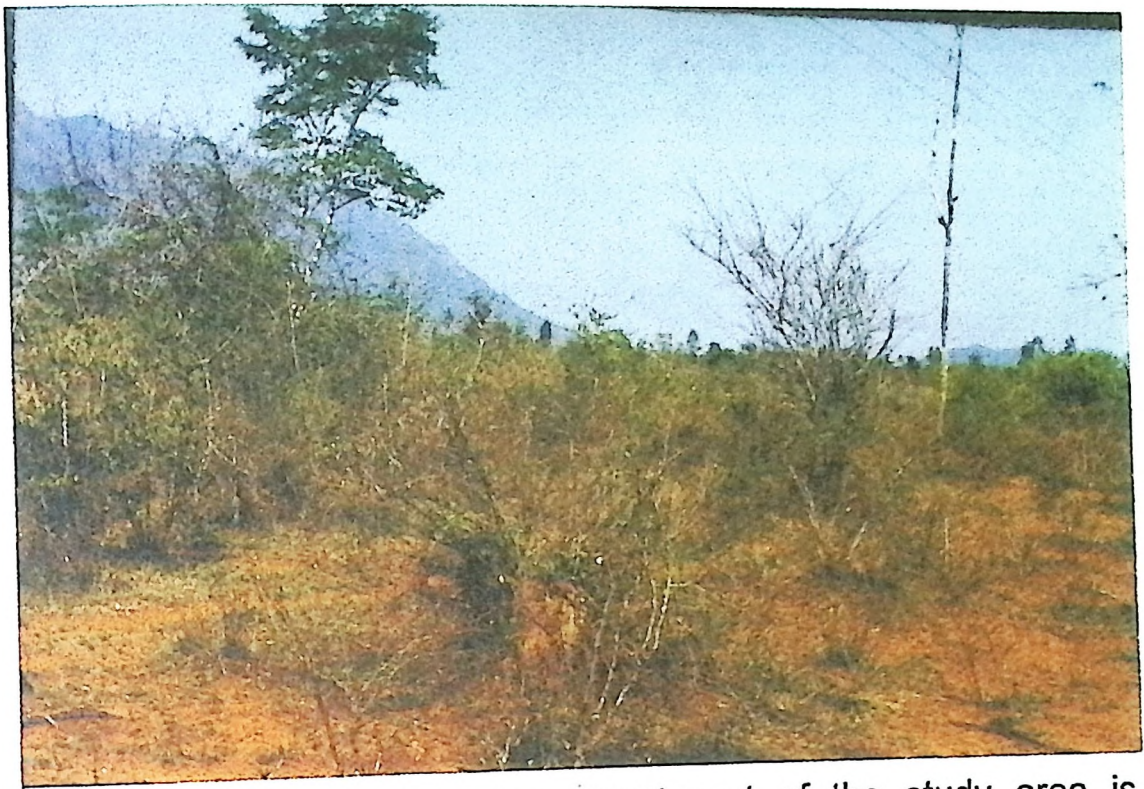


Plate 7: Scrub forest of eastern most part of the study area is dominated by *Randia dumetorum* and *Zizyphus xylopyra*



Plate 8: Dry deciduous forest near Mavanhalla village dominated by stunted *Anogeissus latifolia*