

**A COMPARATIVE ASSESSMENT OF SOIL PROPERTY, FLORISTIC
COMPOSITION, PHYTOSOCIOLOGY AND DIVERSITY OF
ETHNOMEDICINAL PLANTS BASED ON THE EXTENT OF
SELECTED SACRED GROVES AND ADJACENT DISTURBED LAND
IN THE COASTAL REGION OF THRISSUR DISTRICT, KERALA,
INDIA**

Thesis submitted to the University of Calicut
in partial fulfillment of the requirements for
the Degree of

DOCTOR OF PHILOSOPHY IN BOTANY

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ACKNOWLEDGEMENT

First of all I would like to express my deep sense of gratitude to “The Almighty” for showering blessing upon me throughout the venture for the successful completion of this Ph. D work.

I am extremely thankful to my trustworthy esteemed guide Dr. Subin. M. P, Assistant Professor, Department of Botany, Sree Narayana College, Nattika for his masterly guidance, timely help and encouragement throughout my thesis work.

It is my privilege and pleasure to express my heartfelt gratitude to Dr. K. N. Remesh, Former Head of the Department of Botany, Sree Narayana College, Nattika for lending a helping hand when needed.

My sincere thanks to Dr. Reena Ravindran, Principal, Sree Narayana College, Nattika and Dr. Anitha Sankar. C, Former Principal, Sree Narayana College, Nattika for providing adequate facilities in carrying out this study.

I am deeply indebted to Dr. M. A. Suraj, Head of the Department of Botany, Assistant Professors Dr. C. T. Anitha., Dr. G. Chithra., and Dr. Shereena J. Department of Botany, Sree Narayana College, Nattika, their critics were most helpful to me in all stages of this work.

I gratefully acknowledge Dr. A. R. Raju, Former Head of the Department of Botany, Sree Narayana College, Nattika for his constant encouragement, immense help and blessings to accomplish my research work.

I am deeply thankful to Dr. C. N. Sunil, Associate Professor & Research Guide, Department of Botany, S.N.M College, Maliankara; Dr. M. G. Sanil Kumar, Asst. Professor & Research Guide, Department of Botany, S.N.M College, Maliankara; Dr. Stephen Sequeira, Asst. Professor & Research Guide, Department of Botany, Maharajas College, Ernakulam; Dr. K. P. Rajesh & Dr. Manju C. Nair, Asst. Professors, Department of Botany, Zamorin's Guruvayurappan College, Kozhikode and Dr. P. N. Ganesh, Former Associate Professor, Department of Botany, Sree Krishna College, Guruvayoor for their constant support, valuable suggestions and help during identification of plant specimens.

I extend my sincere thanks to Dr. E. C Baiju, Asst. Professor, Department of Botany, S.N.M College, Maliankara, for his valuable help and suggestions during my work.

My sincere thanks to Kerala Agricultural University, Vellanikkara and Regional Soil Analytical Laboratory, Thrissur for their guidance and support during soil analysis.

I am also thankful to the owners of sacred groves for their kind cooperation and support throughout the course of this work.

I wish to express my deep thanks to Mr. Sanal, Herbarium Keeper; Mr. C. S. Suresh and Mr. K. V. Vijayan, Lab Assistants, Department of Botany, Sree Narayana College, Nattika for their kind co-operation during this work.

I wish to express my deep thanks to my research mates Simi. R., Jiji. P. G., and Emily. K. T for their co-operation and constant moral support throughout the course of this work.

My sincere thanks to Mr. Hareesh. V. S, Research scholar, Dept. of Botany, Calicut University and Mr. Naveen Kumar V. V, Research scholar, Dept. of Botany, S.N.M College, Maliankara for their valuable help and support during my work.

My heartfelt thanks to my mother, brother, mother in law and my kids for their prayers, affection and consideration they have shown towards me.

No words to reimburse the love, invaluable help, immense patience and encouragement given to me by my husband Rajith Thottupura, to whom this work is dedicated.

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CHAPTER-1

General introduction

Plants growing together have mutual relationship directly or indirectly among themselves and with the environment and this is said to be the reason behind the ecosystem stability and health. In India about 21.23% of the geographical area is under forest vegetations, out of which 2.54% is very dense forest, 9.70% moderately dense forest, and 8.99 % is open forest (Forest Survey of India, 2013). Each forest has a distinct floristic composition which varies in its species diversity and the abundance of different species. Tropical forests are one of the most species diverse terrestrial ecosystems which generate a variety of natural resources which help to sustain the livelihood of the local communities (Singh & Kushwaha, 2008; Gupta & Kumar, 2014). Human disturbance in tropical forests is not simply a phenomenon of the colonial and modern eras, but dates back to early human occupation in tropical region (Fairhead & Leach, 1998). However, the high population pressure and urbanization now have significantly enhanced the demand for forest resources and forest space for various developmental and cultivation activities compared to earlier times. This has resulted in depletion of natural forest vegetation at an alarming rate of 13.5 million hectares per year, globally. In many regions of the world, the vast areas of forests are drastically reduced and many are being reduced to few hectares to few cents and the forest plant diversity has now become an important issue for long term sustainability of ecosystems (Wang et al., 2011). The most challenging tasks before the ecologist is to understand the relationship of vegetation structure, composition and biodiversity with the functioning and sustainability of ecosystem stability. The protection of environment and life supporting systems are interwoven with floristic richness and biodiversity conservation however, detailed scientific information on the same is still not much enough to understand.

The composition and structure of vegetation in forest ecosystem depends on the assemblage of species population while the spatial distribution pattern of plant species population depends on the dispersal and survival capacity of species, the microclimatic conditions and other biotic and abiotic factors in the area where they grow. The analysis of quantitative characters such as density, frequency, diversity and richness of plants in forest ecosystems are very useful in the assessment of vegetation structure, composition and distribution

pattern. The analysis of phytosociology are very essential to collect the data to describe the population dynamics of each species studied and for understanding how they relate to other species in the same community. The forest vegetation generally have significant number of plants with medicinal value and according to the WHO estimate, about 80% of the population in the developing countries depends directly on plants for its medicines (Pareek, 1996; Mukhopadhyay, 1998). The link between the above ground vegetation features and soil characteristics such as soil biology and associated soil physical and chemical properties are have high relevance with respect to ecological quality and stability. Soil physical properties have been considered to exert great influence on the distribution, growth and development of trees and other plant groups. The chemical properties give insights to the nutrient status of the soil and that actually indicate the type of vegetation existing in the region. Soil microbial community plays a fundamental role in the ecosystem functioning, because it decomposes organic matter, determining the release of mineral nutrients in the soil and consequently influencing primary productivity and nutrient cycling (Hackl et al., 2004). Similarly, the correlation of vegetation structure with microclimatic factors are also essentially a subject of high relevance. However, it is expected that the continued anthropogenic disturbances along with population expansion may led to declining species richness, diversity and habitat degradation and fragmentation leading to less diverse ecosystem and abundance with lower levels of spatial heterogeneity (McKinney, 2002; Rahman et al., 2009). Here comes the relevance of conservation tactics for the protection and preservation of forest at least as patches of forest in the name of sacred groves.

Sacred groves are patches of natural forest vegetation protected by the local people through religious and cultural practices evolved to minimize destruction (Israel et al., 1997). These patches are the true indicators of the type of vegetation that once existed there before the dawn of modern civilization. Sacred groves are actually the treasure house of medicinal, rare and endemic plants, as refugee for relic flora of a region and as centres of seed dispersal (Whittaker, 1975). Many sacred groves have been preserved as sustainable resources, ensuring the basic capital intact and hence considered valuable gene pool and the first major effort to recognize and conserve biodiversity. They provide a country-wide network of protected areas, wherein the inherent diversity of flora and fauna are preserved for present and future human use. While the adjacent areas were all cleared for agriculture and development, the sacred groves are maintained intact for generations to support relic

vegetation and are often among the best places to study endemism (Induchoodan & Balasubramanyan, 1991).

In Kerala, sacred groves are locally known as “Kavu” or “Sarpakkavu” or “Nagavanam”. The people living in the area of groves believe that the God or Goddess or the spirits would manifest their displeasure if their abode is destroyed. This belief system is actually the key factor helpful in the conservation of these micro ecosystems without any anthropogenic disturbances. In turn, they remain as treasure house of biodiversity and gene pool, conserving many endemic and endangered flora and fauna of economic, medicinal and scientific importance and represent as 'mini biosphere reserves' or surviving examples of climax vegetation (Gadgil & Vartak, 1975). Though ancient people established sound socio-cultural practices epitomizing in situ conservation of biological and genetic diversity of sacred groves, in recent times this has been ignored and many groves in Kerala are facing serious threats due to various reasons. One of the main reasons for the threat to the existence of these groves is the disappearance of Tharavadu system and partition of family properties including the grove area. Other anthropogenic interventions found contributing to this include shift in belief systems, market forces and over exploitation, developmental projects, grazing and poaching and other antisocial activities.

In the present scenario, an age old belief system alone is not found enough for the protection and conservation of these sacred forest patches. There should be clear authentic reasons along with scientific explanations to make aware the public and also the local people regarding the relevance of existing groves as valuable resource for the future. However, no concrete steps are being initiated to protect and conserve these relics. Understanding the importance of sacred groves, it is very essential to analyse various aspects of groves such as floristic structure and composition, phytosociology, regenerative status of plants, ethno-medicinal wealth and the quality of soil and microclimatic conditions existing in the groves. These aspects are then need to compare with situations in the nearby non-sacred grove regions which are under various anthropogenic disturbances, to reveal the difference and the impacts of anthropogenic pressures on ecological balance and stability. Several research works have examined the relevance and influence of tree population of sacred groves while, less attention was paid to the rest of the plant groups and other biotic and abiotic factors of groves although, they are important elements in natural forests and largely responsible for ecosystem functioning and stability. Considering the various aspects depicted above, the present study is

carried out under the following heads in the Coastal belt of Thrissur district, Kerala- an area in the districts having large number of sacred groves.

- Detailed survey of sacred groves of different extents in the coastal region of Thrissur District and selection of sacred groves of different extents for detailed study.
- Floristic and phytosociology analysis of major plant groups – trees, shrubs, herbs, climbers and lianas or large woody climbers in the selected sacred groves and adjacent disturbed non-sacred grove lands of different extents.
- Identification and comparison of other plant groups or forms in the selected study sites
- Comparative analysis of tree regeneration status in the selected groves and disturbed lands.
- Comparative analysis in the population of major soil microbes in the selected groves and disturbed lands.
- Comparative analysis of physical and chemical properties of soil in the selected groves and disturbed lands.
- Comparative analysis of ethnomedicinal plant diversity, distribution and the use in traditional medicine in the selected groves and disturbed lands.
- Comparative analysis of microclimatic parameters - temperature and humidity in the soil and atmospheric environment in the selected groves and disturbed lands.
- Comparative analysis between selected sacred groves to assess the impact of difference in extent on various aspects analysed in the study.

References

- Fairhead, J., & Leach, M. (1998). Reframing deforestation, global analysis and local realities: studies in West Africa. Routledge, London. *Journal of Tropical Ecology*, 14(6), 871–872.
- Forest Survey of India. (2013). *India State of Forest*, Ministry of Environment & Forests, Government of India, Dehradun, India.
- Gadgil, M., & Vartak, V. D. (1975). Sacred groves of India –A plea of the continuous conservation. *Journal of Bombay Natural History Society*, 72(2), 313–320.
- Gupta, S. R., & Ravikumar. (2014). Biodiversity conservation and ecosystem services of forests in Siwaliks of Northern India. *International Journal of Ecology and Environmental Sciences*, 40(1), 15–28.
- Hackl, E., Zechmeister, B. S., Bodrossy, L., & Sessitsch, A. (2004). Comparison of diversities and compositions of bacterial populations inhabiting natural forest soils. *Applied and Environmental Microbiology*, 70(9), 5057–5065.
- Induchoodan, N. C., & Balasubramanyan, K. (1991). Sacred Groves- Savior of endemics. Proc. Sym. *Rare, Endangered and Endemic Plants of Western Ghats*. Kerala Forest Department, Trivandrum. 348–353.
- Israel Edok, Chitra, V., & Narasimhan, D. (1997). Sacred groves: traditional ecological heritage. *International Journal of Ecology and Environmental Sciences*, 23(4), 463–470.
- McKinney, M. L. (2002). Urbanization, biodiversity, and conservation the impacts of urbanization on native species are poorly studied, but educating a highly urbanized human population about these impacts can greatly improve species conservation in all ecosystems. *Bioscience*, 52(10), 883–890.
- Mukhopadhyay, S. (1998). Conservation, Protection and Biodiversity of Medicinal Plants. In *Prospects of Medicinal Plants* (Eds. Gautam, P. L. et al.), Indian Society for Plant Genetic Resources, New Delhi, pp. 15–28.
- Pareek, S. K. (1996). Medicinal Plants in India: Present Status and Future Prospects. In *Prospects of Medicinal Plants* (Eds. Gautam, P. L. et al.), Indian Society for Plant Genetic Resources, NBPGR Campus, New Delhi, pp. 5–14.
- Rahman, M., Nishat, A., & Vacik, H. (2009). Anthropogenic disturbances and plant diversity of the Madhupur Sal forests (*Shorea robusta* CF Gaertn) of Bangladesh. *International Journal of Biodiversity Science, Ecosystem Services & Management*, 5(3), 162–173.

- Singh, J. S., & Kushwaha, S. P. S. (2008). Forest biodiversity and its conservation in India. *International Forestry Review*, 10(2), 292-304.
- Wang, X., Piao, S., Ciais, P., Li, J., Friedlingstein, P., Koven, C., & Chen, A. (2011). Spring temperature change and its implication in the change of vegetation growth in North America from 1982 to 2006, *Proc. National Academy of Sciences*, 108(4), 1240–1245.
- Whittaker, R. H. (1975). *Communities and Ecosystems*. New York: Macmillan Publishing Company.

CHAPTER-2

Study area, survey and selection of sacred groves and disturbed non-sacred grove lands

Introduction

It is estimated that there are nearly 100,000 to 150,000 sacred groves in India and the extent of area covered by these groves account to about 33,000 hectares covering 0.01 percent of the total area of the country (Malhotra, 1998; Gokhale et al., 1998). Kerala has a rich tradition of nature conservation. It is roughly reported that Kerala preserves nearly 2000 sacred groves, although a detailed inventory is not available. The size of these sacred groves varies as small as one cent to several hectares. The coastal belt of Thrissur is one of the area in the districts having large number of sacred groves which are distinct and unique in biological diversity. It is understood from people inhabiting the vicinity of groves that many of them have started gradual deterioration in terms of cultural values, floristic richness, composition and diversity. The present chapter of this study is being proposed in the above context. A detailed survey of existing sacred groves in the coastal belt of Thrissur district has not yet been conducted. The study believes the survey and basic data collection of these natural resource pockets is the first and primary step to be carried out to initiate appropriate precautionary measures for the protection and conservation process.

Review of Literature

The details of sacred groves collected by several researchers have recorded the number of these preserved pockets of land in Kerala. Ramachandran and Mohanan (1991) identified 239 sacred groves in Kerala. According to the survey conducted by Prasad and Mohanan (1995) about 500 hectares of forest area of Kerala is under sacred groves which constitute 0.05% of the total forest area (Chandrashekara & Sankar, 1998). The study on the floristic aspects of sacred groves of Kerala reported that there are about 2000 reasonably well-preserved sacred groves in Kerala (Rajendraprasad et al., 1996). Balasubramanyan and Induchoodan (1996) listed 761 important sacred groves in Kerala with floristic wealth of over 722 species belonging to 217 families and 474 genera, out of which 153 species are endemic to peninsular India. The land reforms introduced by the government in 1957 and redistribution of surplus land causing large-scale fragmentation of the land, followed by clearing many such lands for commercial farming ultimately caused the depletion and reduction in the size of sacred groves (Radhakrishnan, 1989; Raj & Michael, 1983). The joint family system abolition act of 1975 led to the fragmentation of joint family lands to nuclear family lands, growing population density, shift in belief system, intensifying developmental activities are other major factors that contributed towards clearing of sacred grove lands (Sreekumar & Richard, 2006; Subhash et al., 1998).

The ownership of the sacred groves is categorized into three based on the management system and which includes the groves managed by individual families, by groups of families and by the statutory agencies for temple management like Devaswom Board (Chandrashekara & Sankar, 1998).

The sacred groves owned by families are mostly dedicated to Snake God or Goddess or both, hence known as “Nagakkavu” or “Sarpakkavu”. The tribal communities preserved a large number of sacred groves which are dedicated to ‘Vanadevatha’, the Goddess of the forest. ‘Yakshikavu’ is yet another group of sacred groves in and around the forest worshiped by the tribal inhabitants. Along the coastal belt of Kerala, the sacred groves are worshipped and conserved by the fishermen and are called ‘Cheerma’ or ‘Cheerumba’ is the Goddess of smallpox and other epidemic diseases. The sacred groves owned collectively by the villagers are mostly dedicated to Lord Ayyappa and called as ‘Ayyappankavu’ or ‘Sasthamkavu’ and to Goddess Bhagavathi called ‘Bhagavathikkavu’ or ‘Ammankavu’.

Materials and Methods

Study area

The study area is the coastal belt of Thrissur district, Kerala which is spread over 16 Panchayats and one municipality. The area lies at 10.52°N 76.21°E and has an average altitude of 2.83m. The average minimum temperature is 22°C and the average maximum temperature is 34°C. Average annual rainfall is 2500mm. The soil is sandy loam to laterite and acidic with pH value ranging from 4.6 to 6.4

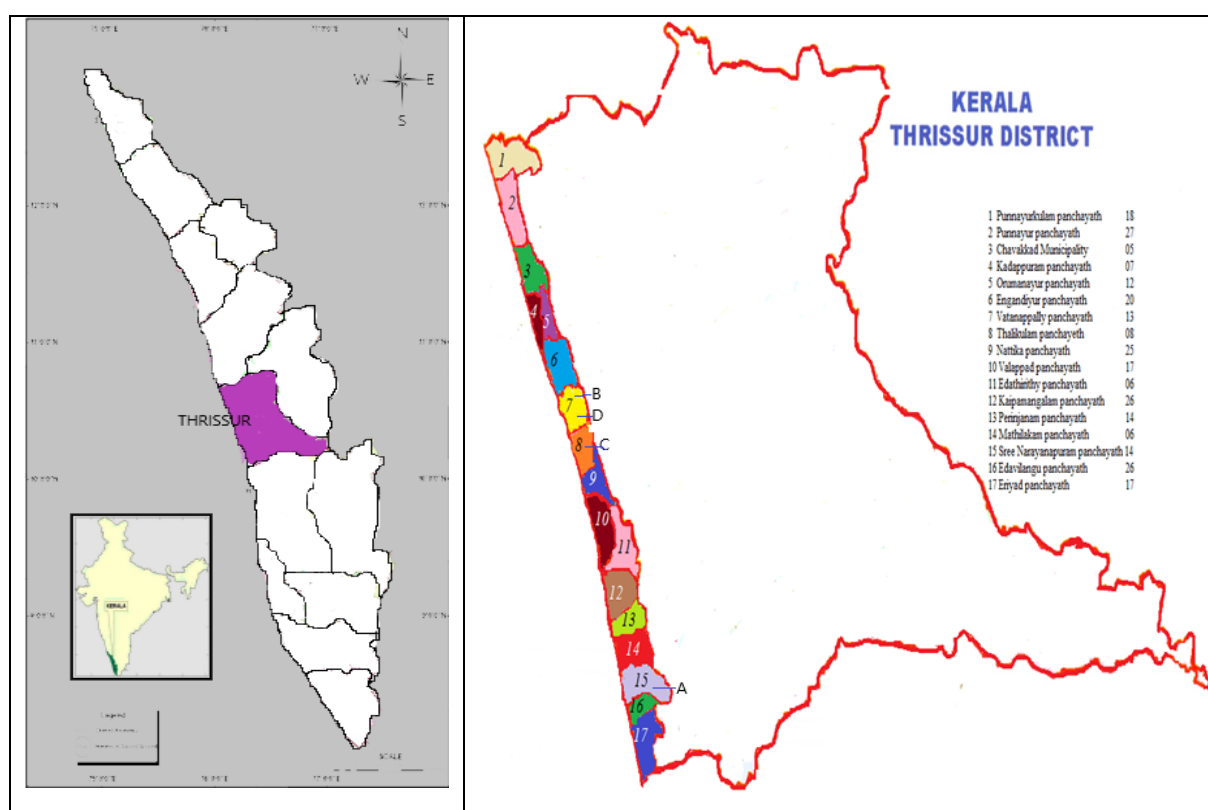


Figure A1: The Map of study area showing the details of various panchayats and the corresponding number of sacred groves existing in the Coastal belt of Thrissur district. A, B, C and D represents the location of selected sacred groves for detailed study – A (Sankulangara sacred grove), B (Palliyana sacred grove), C (Nambiyath sacred grove) and D (Poyyara sacred grove)



Figure A2: Satellite view of selected sacred groves. A- Sankulangara sacred grove, B- Palliyana sacred grove, C- Nambiyath sacred grove and D- Poyyara sacred grove.

A detailed survey and basic data collection of sacred groves in the coastal belt of Thrissur district are carried out during the year 2014. Information on the existence of sacred groves are collected through personal contacts with villagers, temple authorities and various social organizations in the area. The information collected include location, name of sacred grove, ownership/managed by, extent or area and presiding deity of each sacred grove. Whenever any sacred grove is visited, the local people and related temple worshippers are interviewed to confirm the above facts and also to elicit information about the presence of other groves in the locality.

Results

The data obtained from the detailed survey of sacred groves existing in different Panchayat and municipality in the coastal belt of Thrissur district is depicted in table 1-20. The survey revealed the existence of a good number of sacred groves of different extent in the coastal belt of Thrissur district, ranging from 0.00004 Sq. Km (1cent) to 0.00635 Sq. Km (157 cents). Data shows the highest number of sacred groves is recorded in the Punnayur Panchayat with a total number of 27 groves while the lowest is recorded in the Chavakkad Municipality with a total number of 5 groves. However, considering the total area covered by sacred groves, Vatanapally Panchayat occupied the highest position with a total of 0.01052 Sq. Km (260 cents) and is about 0.080% of the entire 13.18 Sq. Km area of the Panchayat while the least area is occupied by the Edathirithy Panchayat with a total grove area of 0.00077 Sq.Km (19 cents) constituting only about 0.005% of the entire 16.63 Sq. Km area of the Panchayat. With respect to individual sacred groves, the highest extent is occupied by Sankulangara Kavu (0.00635 Sq. Km) in Sree Narayanapuram panchayat while sacred grove with lowest area is 0.00004 Sq.Km which is found to exist in many Panchayats.

Table A1: Details of sacred groves existing in the coastal belt of Thrissur district in Kerala

Sl. No	Panchayat/Municipality	Total area of Panchayat/ Municipality (Sq.Kms)	Total no. of sacred groves	Total area of sacred groves (Cent)	Total area of sacred groves (Sq.Kms)	Total area of sacred groves (%)
1	Punnayurkulam	18.71	18	66	0.00267	0.014
2	Punnayur	16.60	27	109	0.00441	0.027
3	Chavakkad Municipality	12.41	5	37	0.00150	0.012
4	Kadappuram	9.63	7	38	0.00154	0.016
5	Orumanayur	5.19	12	79.5	0.00322	0.062
6	Engandiyur	15.68	20	100	0.00405	0.026
7	Vatanappally	13.18	13	260	0.01052	0.080
8	Thalikulam	10.89	8	63	0.00255	0.023
9	Nattika	9.60	25	120	0.00486	0.051
10	Edathirithy	16.63	6	19	0.00077	0.005
11	Valappad	14.33	17	146	0.00591	0.041
12	Kaipamangalam	13.70	26	145	0.00587	0.043
13	Perinjanam	9.30	14	59	0.00239	0.026
14	Mathilakam	12.92	6	41	0.00166	0.013
15	Sree Narayanapuram	19.26	14	246	0.00996	0.052
16	Edavilangu	7.60	26	159	0.00643	0.085
17	Eriyad	16.75	17	70	0.00283	0.017
Grand total in the Coastal belt		222.38	261	1734.5	0.07019	0.032

Table A2: Details of various size range of sacred groves existing in the coastal belt of Thrissur district in Kerala

	Panchayat/ Municipality	Size range of sacred groves			
		1-9 cents	10-49 cents	50-90 cents	91 cents and above
1	Punnayurkulam	17	1	-	-
2	Punnayur	26	1	-	-
3	Chavakkad Municipality	4	1	-	-
4	Kadappuram	5	2	-	-
5	Orumanayur	11	1	-	-
6	Engandiyur	18	2	-	-
7	Vatanappally	6	5	2	-
8	Thalikulam	6	2	-	-
9	Nattika	21	4	-	-
10	Edathirithy	6	-	-	-
11	Valappad	13	4	-	-
12	Kaipamangalam	21	5	-	-
13	Perinjanam	12	2	-	-
14	Mathilakam	5	1	-	-
15	Sree Narayanapuram	10	3	-	1
16	Edavilangu	21	5	-	-
17	Eriyad	15	2	-	-
Total		217	41	2	1

Table A3: Ownership details of sacred groves in the coastal belt of Thrissur district in Kerala

Sl.No	Panchayat/Municipality	Sacred groves owned and maintained by		
		Individual family	Group of family	Temple devaswom/trust
1	Punnayurkulam	9	9	-
2	Punnayur	13	14	-
3	Chavakkad Municipality	0	5	-
4	Kadappuram	0	7	-
5	Orumanayur	10	2	-
6	Engandiyur	7	13	-
7	Vatanappally	5	8	-
8	Thalikulam	4	4	-
9	Nattika	18	7	-
10	Edathirithy	2	3	1
11	Valappad	11	6	-
12	Kaipamangalam	15	10	1
13	Perinjanam	8	6	-
14	Mathilakam	2	4	-
15	Sree Narayanapuram	7	5	2
16	Edavilangu	13	12	1
17	Eriyad	10	7	-
Total		134	122	5

Table A4: Details of sacred groves in Punnayurkulam Panchayat

Panchayat/ Municipality/	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
	1	Edakkara Ashari kavu	Nagaraja and Bhaghavathi	15	Individual family
	2	Padinjakkara kavu	Nagam	4	Individual family
	3	Karimbanakkal Kavu	Nagam	5	Individual family
	4	Payyarlikavu	Nagam	3	Individual family
	5	Kizhakkekara Kavu	Nagam	4	Individual family
	6	Karipayikavu	Nagam	3	Individual family

Punnayurkulam Panchayat	7	Nakkola Kavu	Nagam	3	Individual family
	8	Manayil Kavu	Nagam	3	Individual family
	9	Punnor kshethrakavu	Nagaraja	3	Group of family
	10	Nalappattu Nagakavu	Nagam	2	Group of family
	11	Ambazhathel Kavu	Nagam	4	Group of family
	12	Pavittakulangara Kshetrakavu	Nagaraja	3	Group of family
	13	Kalarikkal Kshetrakavu	Nagam	2	Group of family
	14	Karimpanakkal Kavu	Nagam	3	Individual family
	15	Manikandeswara Kshetrakavu	Nagaraja	3	Group of family
	16	Periyambala Kshetrakavu	Nagaraja	2	Group of family
	17	Ayyappankavu	Ayyappan, Nagaraja	2	Group of family
	18	Sivalaya Kshetrakavu	Nagaraja and Nagayakshi	2	Group of family

Table A5: Details of sacred groves in Punnayur Panchayat

Panchayat/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
<u>Punnayur Panchayat</u>	1	Erancheri Durga Bhagavati Kshetra kavu	Bhagavathi, Nagaraja	4	Group of family
	2	Karuthedath Kshetrakavu	Nagam	3	Group of family
	3	Edakkara Kunnathu Kavu	Nagam	3	Group of family
	4	Patherikavu	Nagam	2	Individual family
	5	Kalathiparambil Kavu	Nagam	3	Individual family
	6	Panthayi Kshetrakavu	Nagaraja	4	Group of family
	7	Akkiparambathu Kavu	Nagam	2	Individual family
	8	Pavittakulangara Kshetrakavu	Nagaraja	6	Group of family
	9	Mambully Kshetrakavu	Nagaraja	3	Group of family
	10	Edakkattu Bhagavathi Kshetrakavu	Bhagavathi, Nagaraja and Nagayakshi	4	Group of family
	11	Periyamballa kavu	Nagam	3	Individual family
	12	Ottaini Kshetra kavu	Nagam	3	Group of family
	13	Anjarekavu	Brahmarakshassu, nagam	4	Individual family
	14	Mathramkottu Kshetra kavu	Nagam	5	Group of family
	15	Ayyappan kavu	Ayyappan and Nagam	5	Group of family
	16	Kalathil kavu	Nagam	3	Individual family
	17	Chandirathil kavu	Nagam	4	Individual family
	18	Aviyoor kalari kavu	Nagam	5	Group of family
	19	Kadampully Bhagavathi kshetra kavu	Bhagavathi, Nagaraja	6	Group of family
	20	Kunnathu kavu	Nagam	20	Individual family
	21	Kalarikkal kavu	Nagam	3	Individual family
	22	Kothamuthithara kavu	Nagam	2	Individual family
	23	Amarayil kavu	Nagam	2	Individual family
	24	Kuranjiyoor kavu	Nagam	2	Individual family
	25	Kizhapattu Kavu	Nagam	3	Individual family
	26	Ambalam kavu	Nagam	3	Group of family
	27	Panikker kavu	Nagam	2	Group of family

Table A6: Details of sacred groves in Chavakkad Municipality

Panchayat/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Chavakkad Municipality	1	Manathala Nagayakhi kavu	Nagaraja and Nagayakshi	20	Group of family
	2	Nariyambully Kshetra kavu	Nagam	4	Group of family
	3	Chamundeshwari Bhagavathy kshetra kavu	Bhagavathy,Nagam	3	Group of family
	4	Nediyedath Kshetra kavu	Nagaraja	5	Group of family
	5	Kalathil Kshetra kavu	Nagaraja and Nagayakshi	5	Group of family

Table A7: Details of sacred groves in Kadappuram Panchayat

Panchayat/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Kadappuram Panchayat	1	Mattummal chanassery Bhagavathi Kshetra kavu	Nagaraja	10	Group of family
	2	Melepurakkal kavu	Nagaraja and Nagayakshi	6	Group of family
	3	Melepurakkal Kshetra kavu	Nagaraja and Nagayakshi	5	Group of family
	4	Kanda karuna Kshetra kavu	Nagam	3	Group of family
	5	Thondekkaran Kshetra kavu	Nagaraja	10	Group of family
	6	Kerachan Bhagavathi kavu	Bhagavathy,Nagam	2	Group of family
	7	Chevidan kulavan Kshetra kavu	Nagam	2	Group of family

Table A8: Details of sacred groves in Orumanayur Panchayat

Panchayat/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Orumanayur Panchayat	1	Chendangotu tharavadu kavu	Nagam	28	Group of family
	2	Mangottu kavu	Nagam	5	Individual family
	3	Vadakkepurakkal kavu	Nagam	3	Individual family
	4	Vattekkattu kavu	Nagam	9	Individual family
	5	Paily kavu	Devi, Nagam	2	Individual family
	6	Koonampurath kavu	Sarpam	3.5	Individual family
	7	Chenda kavu	Nagam	5	Individual family
	8	Kallatt kavu	Nagam	2	Individual family
	9	Kuttikkatt kavu	Nagam	4	Individual family
	10	Valappil kavu	Nagam	2	Individual family
	11	Vadakkepurakkal kavu	Nagam	8	Individual family
	12	Chennangattu Kshetra kavu	Nagam	8	Group of family

Table A9: Details of sacred groves in Engandiyur Panchayat

Panchayat/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
	1	Ellathum kavu	Nagam	25	Individual family
	2	Ayiramkanni Kshetra kavu	Bhagavathy, Nagaraja	10	Group of family
	3	Kalari kadu kavu	Kari nagam	8	Individual family
	4	Kadavil kottukkal kavu	Nagam	2	Individual family
	5	Vadakkekavu Kshetram	Nagam	5	Group of family
	6	Kalathil kavu	Nagam	2	Individual family
	7	Kanda karna kshetra kavu	Nagaraja	5	Group of family
	8	Panayamkulangara Kshetra kavu	Nagaraja	4	Group of family

Engandiyur Panchayat	9	Karapurath kavu	Nagam	2	Individual family
	10	Kondrappassery kavu	Nagam	3	Individual family
	11	Chanassery Kshetra kavu	Nagaraja	5	Group of family
	12	Vadakkumchery Kshetra kavu	Nagaraja	4	Group of family
	13	Thachapully Kshetra kavu	Nagaraja	5	Group of family
	14	Kanjirathara Kshetra kavu	Nagaraja	4	Group of family
	15	Panikkassery Kshetra kavu	Nagam	3	Group of family
	16	Puthiyedathu kavu	Nagam	4	Individual family
	17	Karuppadath Kshetra kavu	Nagam	2	Group of family
	18	Therambil Kshetra kavu	Nagaraja	3	Group of family
	19	Meledath Kshetra kavu	Nagaraja	2	Group of family
	20	Pallithazhath Kshetra kavu	Nagam	2	Group of family

Table A10: Details of sacred groves in Vatanapally Panchayat

Panchayat/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Vatanapally Panchayat	1	Kalappurakkal kavu	Nagam	25	Individual family
	2	Kottai Chalippattu kavu	Nagaraja	25	Group of family
	3	Kozhiparambil kavu	Bhagavathy and Vishnumaya,Nagam	18	Individual family
	4	Vaalath Bhagavathy kshetra kavu	Bhagavathy,Nagaraja	6	Group of family
	5	Palliyanakkadu Temple kavu	Ashtanagangal	90	Group of family
	6	Puthillathu Kavu	Nagam	50	Group of family
	7	Poyyara kavu	Nagaraja and Nagayakhi	10	Group of family
	8	Sangaramangalam Devi temple	Devi, Nagangal	20	Group of family
	9	Meprengattu Kshetra kavu	Nagangal	8	Group of family
	10	Chettikadu Kavu	Nagam	2	Individual family
	11	Vatanapally Thattan kavu	Nagam	2	Individual family
	12	Kongattil Kavu	Nagam	2	Group of family
	13	Elethu Kavu	Nagam	2	Individual family

Table A11: Details of sacred groves in Thalikulam Panchayat

Panchayat/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Thalikulam Panchayat	1	Vallath sarpakavu	Anjana maninagam	3	Individual family
	2	Sree Dharmasastha kshetrakavu	Sasthavu, Nagaraja and Anjana maninagam	10	Group of family
	3	Nambiyathu kavu	Karinagam and Anjana maninagam	30	Individual family
	4	Chettikkadu Sarpakavu	Karinagam and Anjana maninagam	3	Group of family
	5	Aparambathu Sarpakavu	Nagarajavu and Nagayakshi	8	Individual family
	6	Kaliparambil kavu	Nagam	3	Individual family
	7	Sree Paradevatha nagathan kavu	Devi, Nagam	4	Group of family
	8	Sree Eranezhathu Bhagavathi Kshetra kavu	Bhagavathi,Nagarajavu and Nagayakshi	2	Group of family

Table A12: Details of sacred groves in Nattika Panchayat

Panchayat/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Nattika Panchayat	1	Kaliyarakkal kavu	Bhagavathi, Kali and Chithrakoodam	22	Individual family
	2	Eranezhathu kavu	Nagayakshi	2	Individual family
	3	Nhayakkatt kavu	Nagam	2	Individual family
	4	Vellanchery kavu	Nagarajavu and Nagayakhi	2	Group of family
	5	Panapparambil kavu	Nagam	2	Individual family
	6	Panakkal pulakkaparambil kavu	Karinagam and Anjana maninagam	6	Individual family
	7	Panakkal kurumbepadath sree Bhadrakali temple	Bhadrakali, Kainagam and Anjana maninagam	6	Group of family
	8	Pozhekkadavil kavu	Nagam	2	Individual family
	9	Iyyani kavu	Nagam	2	Individual family
	10	Pandamparambil kavu	Nagam	2	Individual family
	11	Njayapilly illam	Nagam	2	Individual family
	12	Chembipparambil kavu	Nagam	2	Individual family
	13	Cherthedath kavu	Nagam	3	Individual family
	14	Arayamparambil kavu	Nagam	2	Individual family
	15	Puthanparambil Kavu	Nagam	2	Individual family
	16	Vallath kavu	Nagam	2	Individual family
	17	Unniyaranpurakkal Kavu	Nagangal	10	Individual family
	18	Pannipulath Kavu	Vanabhuvaneshwari,kari nagam and Maninagam	10	Group of family
	19	Kallingal kavu	Nagaraja, Karinagam, Anjana maninagam and Durga	8	Individual family
	20	Kanjirapparambil kavu	Nagam	2	Individual family
	21	Thekkepanakkal kavu	Nagam	2	Individual family
	22	Kongattil kavu	Nagam	5	Group of family
	23	Vattezhathu kavu	Maninagam	6	Group of family
	24	Pandankulangara Kshetra Kavu	Nagaraja,Nagayakshi,Ka rinagam,Maninagam	15	Group of family
	25	Kalarikkal Sree Mahadurgadevi Kshetra Kavu	Durga,Nagam	1	Group of family

Table A13: Details of sacred groves in Edathiruthy Panchayat

Panchayat/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Edathiruthy Panchayat	1	Kollara Ponnemparambil Yakshi kavu	Nagam	4	Group of family
	2	Choorapetti kavu	Nagam	5	Individual family
	3	Thechi kavu Ayyappan kavu	Ayyappan, Nagam	3	Group of family
	4	Kannanamkulangara Siva temple	Siva, Nagam	1	Devaswom
	5	Kollara Bhagavathi kshetra kavu	Bhagavathi, Nagam	2	Group of family
	6	Kallungal kavu	Nagam	4	Individual family

Table A14: Details of sacred groves in Valappad Panchayat

Panchayat/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Valappad panchayat	1	Adiparambil kavu	Nagayakhi and Sarpam	30	Individual family
	2	Valavath Durga devi temple	Mani nagam Kari nagam and Anjana mani nagam	2	Group of family
	3	Thamburan kavu	Vairanagam, Nagayakshi and Anjana maninagam	40	Group of family
	4	Adiparambil Kshetra kavu	Nagarajavu and Nagayakshi	30	Group of family
	5	Adikarathu sarpakkavu	Nagayakshi and Bhagavathi	2	Individual family
	6	Adikarathu kavu	Nagarajavu Nagayakshi and Annapoorneshwari	15	Individual family
	7	Vazhappully kavu	Nagam	1	Individual family
	8	Kakkaparambil kavu	Nagam	2	Individual family
	9	Valiparambil kavu	Nagam	2	Individual family
	10	Poyyara kavu	Nagam	2	Individual family
	11	Pazhasshi Nagadevatha kavu	Nagam	3	Group of family
	12	Nediyirippil kavu	Nagam	2	Individual family
	13	Pallathu KavU	Nagam	3	Individual family
	14	Moonamkutty KavU	Nagam	2	Individual family
	15	Pathattu KavU	Nagam	2	Individual family
	16	Kozhissery KshetraKavu	Devi, Nagaraja and Nagayakshi	4	Group of family
	17	Njattuvetty Sree Kallada Bhagavathy Kshetra KavU	Bhagavathy,Nagayakshi, Karinagam	4	Group of family

Table A15: Details of sacred groves in Kaipamangalam Panchayat

Panchayat/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Kaipamangalam Panchayat	1	Daivathin kavu	Nagam	10	Group of family
	2	Kalapparambath kavu	Nagam	6	Individual family
	3	Vengaly kavu	Karinagam and Maninagam	3	Individual family
	4	Karayavattathu kavu	Nagam	2	Individual family
	5	Pattathu kavu	Nagam	2	Individual family
	6	Kuttikkattu kshetra kavu	Nagaraja	4	Group of family
	7	Malayattil Kshetra kavu	Nagaraja	30	Group of family
	8	Kottarathu Sree Dharma daiva kavu	Nagaraja	20	Group of family
	9	Kaduvetti Kshetra kavu	Nagam	18	Group of family
	10	Chonipparambil kavu	Nagam	5	Group of family
	11	Njattuvetti Kshetra kavu	Nagam	5	Group of family
	12	Agastheswara Siva Kshetra kavu	Nagam	10	Devaswom
	13	Paraparambil kavu	Nagam	2	Individual family
	14	Kalarikkal kavu	Nagam	2	Individual family
	15	Kilikkottu kavu	Nagam	2	Individual family
	16	Punnakkal kavu	Nagayakshi	5	Individual family
	17	Mundassery parambil kavu	Nagam	2	Individual family
	18	Chennamkulam kavu	Nagam	2	Individual family
	19	Kanjiraparambil kavu	Nagam	1	Individual family
	20	Palliyil kavu	Nagam	2	Individual family
	21	Koottalaparambil kavu	Nagam	3	Individual family

	22	Kozhiparambil kavu	Karinagam and Maninagam	2	Individual family
	23	Anjarassery kavu	Nagam	1	Individual family
	24	Kozhissery kshetra kavu	Nagam	3	Group of family
	25	Chachamaram KavU	Nagaraja, Nagayakshi, Karinagam, Anjanamani nagami	1	Group of family
	26	Karadivalavu KavU	Nagam	2	Group of family

Table A16: Details of sacred groves in Perinjanam Panchayat

Panchayat/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Perinjanam Panchayat	1	Kollara kavu	Nagam	2	Individual family
	2	Ayilyam kavu Kshetram	Nagaraja and Nagayakshi	2	Group of family
	3	Chemmathi kavu	Nagam	3	Group of family
	4	Choorakottu Kshetra kavu	Nagam	2	Group of family
	5	Palliyil Bhagavathi kshetra kavu	Bhagavathi, Nagam	2	Group of family
	6	Mangattu kavu	Nagam	3	Individual family
	7	Peedikaparambil kavu	Nagam	5	Individual family
	8	Puthiyedath kavu	Nagam	2	Individual family
	9	Karayil Kshetra kavu	Nagam	2	Individual family
	10	Puthezath kavu	Nagam	15	Individual family
	11	Tharayil kavu	Nagam	2	Individual family
	12	Tharayapurath Kshetra kavu	Nagaraja	5	Group of family
	13	Keezhillath kavu	Nagam	10	Individual family
	14	Ganesha Kshetra kavu	Ganapathi, Nagam	4	Group of family

Table A17: Details of sacred groves in Mathilakam Panchayat

Panchayat/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Mathilakam Panchayat	1	Killikulangara Kshetra nagakavu	Nagaraja, nagayakshi	20	Group of family
	2	Trippekulam Kshetra kavu	Nagam	8	Group of family
	3	Mannamparambil Kshetra kavu	Nagam	2	Group of family
	4	Nagayakshi KavU	Nagaraja and Nagayakshi	5	Group of family
	5	Kalatheri KavU	Nagam	5	Individual family
	6	Maniyakavu	Nagam	1	Individual family

Table A18: Details of sacred groves in Sree Narayanapuram Panchayat

Panchayat/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Sreenarayanapu ram panchayat	1	Ayyalathu Yakshi KavU	Nagam	10	Individual family
	2	Kumaramangalathu kavu	Nagam	28	Individual family
	3	Sree Sankulangara KavU(1)	Vanadurga and Nagam	157	Devaswom
	4	Sree Sankulangara KavU(2)	Nagam	30	Devaswom
	5	Kanikkedathu KavU	Nagam	5	Individual family
	6	Palapetti KavU	Nagaraja and Nagayakshi	2	Group of family
	7	Ayyappan KavU	Ayyappan, Devi and Nagaraja	2	Group of family
	8	Eramangalathu KavU	Nagaraja, Nagayakshi	2	Individual family
	9	Chanaan Veettil KavU	Nagaraja, Nagayakshi	2	Individual family

			and aninagam		
	10	Thaivalliyil Kavuv	Sarpam	1	Individual family
	11	Kalakkatil Nagakavu	Nagaraja	2	Individual family
	12	Thottapilly Kshetra Kavuv	Nagam	1	Group of family
	13	Nagayakshi Kavuv	Nagayakshi, Nagaraja	2	Group of family
	14	Kazhuvilangu Kshetra Kavuv	Nagam	2	Group of family

Table A19: Details of sacred groves in Edavilangu Panchayat

Panchayat/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Edavilangu Panchayat	1	Cheeriyaparambil Kshetra kavu	Nagam	10	Group of family
	2	Karayil Maruthi kshetra kavu	Nagam and Hanuman	5	Group of family
	3	Kottekkattu kshetra kavu	Nagam	4	Group of family
	4	Edachalil ponnanchery Kshetra kavu	Nagaraja	4	Group of family
	5	Naalumakkal Kshetra kavu	Nagaraja, Nagayakshi	18	Group of family
	6	Karayil kshetra kavu	Nagaraja	5	Group of family
	7	Ponathu Tharavadu Kavuv	Nagaraja	2	Individual family
	8	Sree Vishnu Kshetra kavu	Nagaraja	8	Group of family
	9	Alungal Kavuv	Nagam	5	Individual family
	10	Pindiyathupadi Kshetra kavu	Nagam	8	Group of family
	11	Kunnugaparambil Kavuv	Nagam	5	Individual family
	12	Arrampurakkal	Nagam	3	Individual family
	13	Thayyilkavu	Nagam	2	Individual family
	14	Karayil Kavuv (1)	Nagam	3	Individual family
	15	Kundiyara Kavuv	Nagam	5	Individual family
	16	Mundenchery Kavuv	Nagam	5	Individual family
	17	Illathumparambil Kshetra kavu	Nagaraja, Nagayakshi	15	Group of family
	18	Mullassery Nagasthana Kavuv	Nagam	10	Group of family
	19	Kampilikkal Kavuv	Nagam	3	Individual family
	20	Pidiyathu Kavuv	Nagam	2	Individual family
	21	Karayil Kavuv (2)	Nagam	4	Individual family
	22	Kunnugaparambil Kavuv	Nagam	3	Individual family
	23	Edachalil Bhagavathi Kshetra Kavuv	Nagam	4	Group of family
	24	Poothamveetil Sree Bhuvaneswary Kshetra kavu	Devi, Nagam	7	Group of family
	25	Vylezhathu Kshetra Kavuv	Nagam	15	Devaswom
	26	Kaimaparambil Kavuv	Nagam	4	Individual family

Table A18: Details of sacred groves in Eriyad Panchayat

Panchayat/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Eriyad Panchayat	1	Thevali Kavuv	Nagaraja	10	Individual family
	2	Ayyani Kavuv	Nagam	2	Individual family
	3	Kariyehathu Kavuv	Nagam	3	Individual family
	4	Parutthi Kavuv	Nagam	10	Individual family
	5	Madathiparambil Kshetra kavu	Nagaraja	3	Group of family
	6	Thottarathu Kavuv	Nagam	5	Individual family
	7	Kottikkal Kshetra Kavuv	Nagaraja	4	Group of family
	8	Andirithi kavuv	Nagam	3	Individual family
	9	Panaparambil Kavuv	Nagam	2	Individual family
	10	Kuttathumveetil Kavuv	Nagam	3	Individual family
	11	Akkanveetil Kshetrakavu	Nagam	5	Group of family
	12	Kaimathuruthi Kavuv	Nagam	3	Individual family

	13	Tharaparambil Kshetra Kavu	Nagaraja	5	Group of family
	14	Thadikkaparambil Nagathan Kav	Nagaraja, Nagayakshi, Maninagam&Karinagam	3	Group of family
	15	Aluparambil Kav	Nagam	2	Individual family
	16	Kottikkal Kshetra kavu	Nagaraja	3	Group of family
	17	Sivanaga Kshetra kavu	Nagaraja and Nagayakshi	4	Group of family

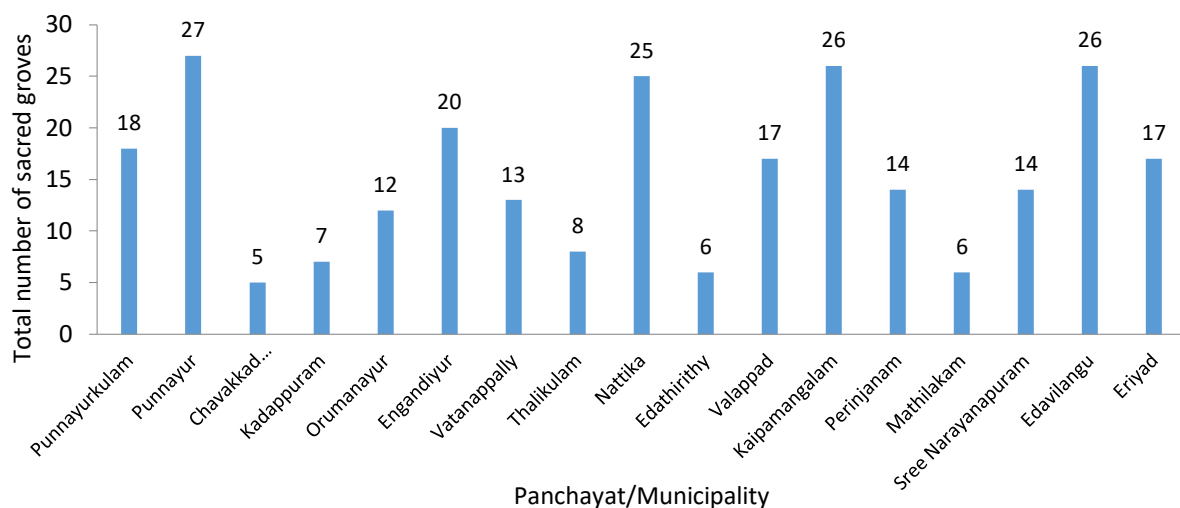


Figure A3: Details of total number of sacred groves of different extents existing along the coastal belt of Thrissur district in Kerala

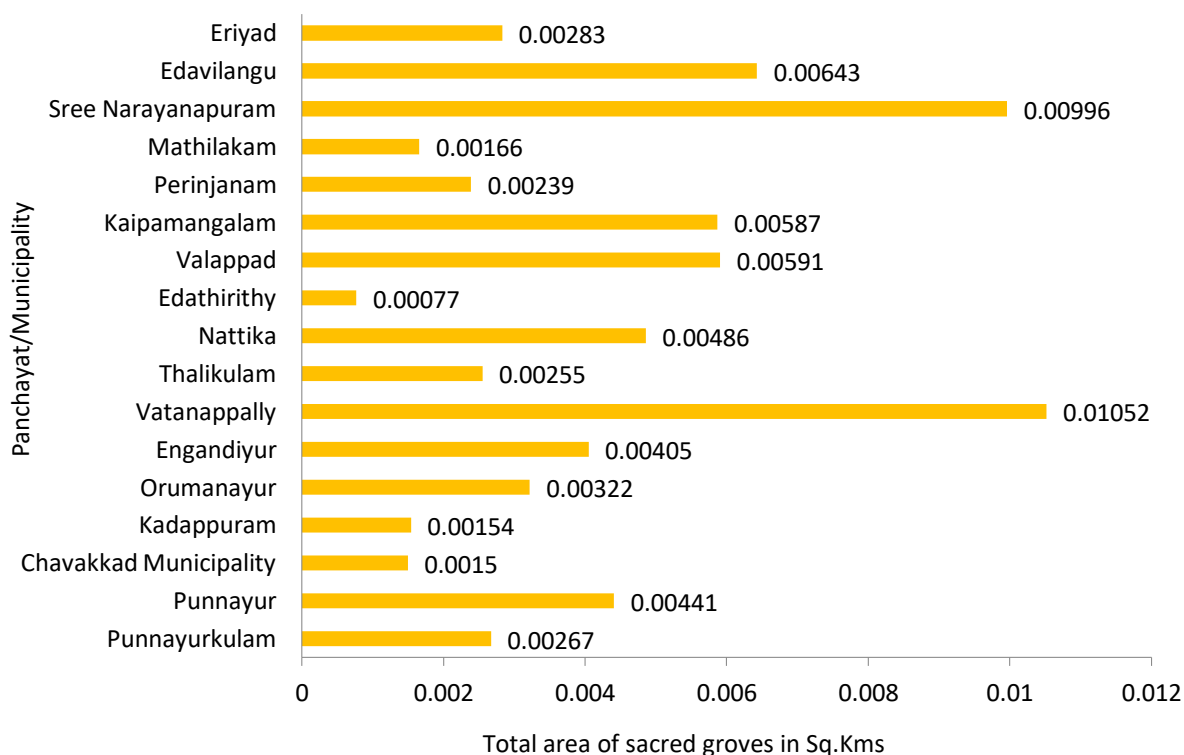


Figure A4: Details of total area covered by sacred groves of different extents along the coastal belt of Thrissur district in Kerala

Discussion

The survey revealed a grand total of 261 groves existing in the coastal belt of Thrissur district which all together cover an area of 0.07019 Sq. Km (1734.5 cents) and constitute about 0.032% of the entire 222.38 Sq. Km area of coastal belt. The survey result showed the size of the sacred grove varies as small as 1cent to as big as 157 cents. The data further revealed that about 83.14% of the total sacred groves are smaller in size and belong to the size range of 1-9 cents, 15.71% belonging to the size range of 10-49 cents, 0.77% belonging to 50-90 cents and 0.38% belonging to the size range of and 91 cents and above (table A2 & figure A5).

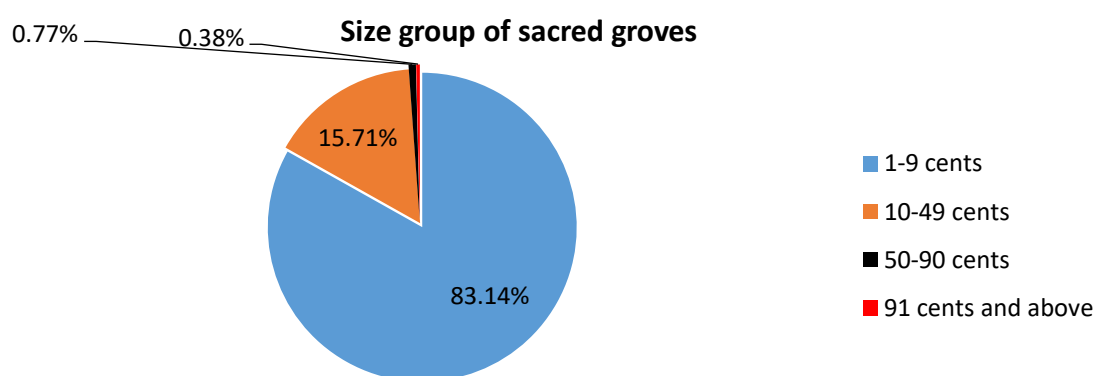


Figure A5: Details of percentage wise distribution of different size range of sacred groves in the coastal belt of Thrissur district in Kerala

The survey results indicated majority of the sacred groves in the coastal belt of Thrissur district are owned either by individual families or group of families and this constituted around 51.34% of ownership by individual families and 46.74% of ownership by group of families while the remaining 1.92% is owned and managed by temple devaswom/trust (table A3 & figure A6). The study revealed that sacred groves in the coastal belt are mostly dedicated to Snake God or Goddess or both. The deities in the sacred groves are variously known as 'Nagam, Nagaraja, Sarpam, Karinagam, Anjana maninagam and Nagayakshi'. Many sacred groves have more than one deity, of which the patron deity is usually a Snake God and has one or more supporting deities like Bhagavathi, Durga, Devi, Ayyappan, Annapoorneshwari, Muthappan, Hanuman etc. However few sacred groves were identified where the Snake God is not the patron deity but the supporting deity and this constituted around 11.49% of total 261 sacred groves surveyed. Other patron deity noted during the

survey includes Bhagavathi, Devi, Ayyappan, Durga, Siva, Brahmarakshassu, Sasthavu, Bhadrakali, Vanabhuvaneshwari, Ganapathi, Vanadurga etc.

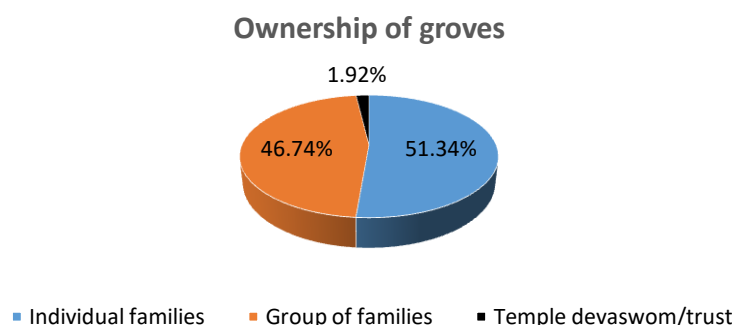


Figure A6: Details of ownership of sacred groves in the coastal belt of Thrissur district in Kerala

The present survey results clearly indicates there is considerable number of small pockets or patches of natural vegetation in the coastal belt of Thrissur district. They represent the ancient Indian way of *in-situ* conservation of genetic diversity and act as nursery and store house of many of the local ayurvedic, tribal and folk medicines. The protection and maintenance of these natural resources is very essential as we all know that the protection of the environment and life supporting systems are interwoven with conservation of these biological diversities. But the encroachment has resulted in the shrinkage of many of sacred groves in the coastal belt of Thrissur district during last few decades. Some of the typical examples include Sree Sankulangara Kavuvu belonging to Sree Narayanapuram Panchayat and Adiparambil kavuvu belonging to Valappad panchayath which were previously reported as having an area of around 499 cents and 84 cents (Chandrashekara & Sankar, 1998; Sujana & Sivaperuman, 2008) respectively. The present survey revealed both the sacred groves have undergone splitting and area has been considerably reduced to 187 cents and 30 cents respectively.

Selection of sacred groves and disturbed non-sacred grove lands

From the data collected on sacred groves via survey, four sacred groves of different extent are selected for the detailed analysis of various objectives of the study in comparison with adjacent disturbed non-sacred grove land of similar extent. This is to reveal what has happened to our natural vegetation and the environment due to anthropogenic disturbances and to reveal the ecological significance of existing climax vegetation, the so called sacred groves. The sacred groves selected for the detailed study in the present investigation is shown in figure A7 & table A19.

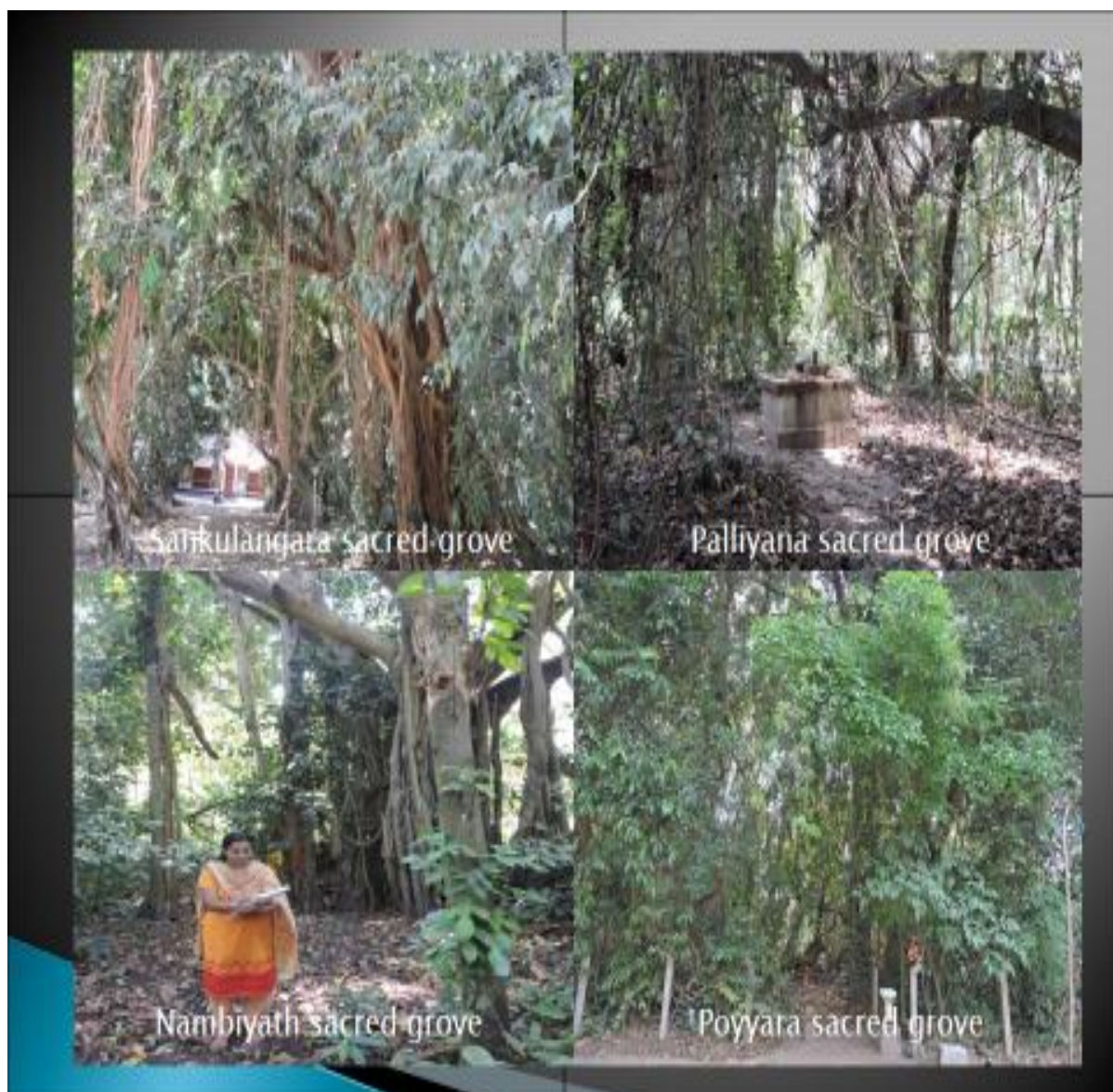


Figure A7: Selected sacred groves for detailed study

Table A19: Details of sacred groves selected for the detailed study

Sl. No	Sacred grove	Location	Deity	Extent/ Area
1	Poyyara Sacred grove	Poyyara, Vatanapally Panchayat	Nagaraja and Nagayakhi	10 cents
2	Nambiath Sacred grove	Thalikulam beach, Thalikulam Panchayat	Karinagam, Anjana maninagam	30 cents
3	Palliyana Sacred grove	Naduvilkkara, Vatanapally Panchayat	Ashtanagangal	90 cents
4	Sankulangara Sacred grove	Sree Narayana puram, S.N puram Panchayat	Vanadurga, Nagam, Sasthav	157 cents

Conclusion

The information on the existence, location, ownership, the presiding deity and extent of each grove in the area collected in the survey may be useful for the public, NGOs and Government organizations to locate and identify the existing groves and initiative action plan towards their protection and conservation. It is suggested that the Government may encourage and support the conservation of these sacred groves by way of providing financial support and technical expertise to its owners. The local bodies, NGOs and forest department may be empowered with stringent law enforcement to safe guard these existing relics from further depletion.

References

- Balasubramanyam, K., & Induchoodan, N. C. (1996). Plant diversity in sacred groves of Kerala. *Evergreen*, 36, 3–4.
- Chandrashekara, U. M., & Sankar, S. (1998). Ecology and management of sacred groves in Kerala, India. *Forest Ecology and Management*, 112(2), 165–177.
- Ghokale, Y., Velankar, R., Chandran, M. D. S., & Gadgil, M. (1998). Sacred woods, Grass lands and Water-bodies as Self-organized systems of Conservation. In: Ramakrishnan, P. S., Saxena, K. G., & Chandrasekhara, U. M. (Ed.), *Conserving the Sacred for Biodiversity Management*. Oxford & IBH Publ. Co. Pvt. Ltd., New Delhi. 365–396.
- Malhotra, K. C. (1998). Anthropological Dimensions of Sacred roves in India: an overview. In: Ramakrishnan, P. S., Saxena, K. G., & Chandrashekara, U. M. (Ed.), *Conserving the Sacred for Biodiversity Management*. Oxford and IBH Publ. Co. Pvt. Ltd., New Delhi. 423–438.
- Prasad, G. A., & Mohanan, C. N. (1995). *The Sacred Groves of Kerala and Biodiversity Conservation*. In: Iyengar, P. K (Ed.), Proc. VII Kerala Science Congress, State Committee on Science, Technology and Environment, Govt. of Kerala. 125–126.
- Radhakrishnan, P. (1989). *Peasant Struggles, Land Reforms and Social Change: Malabar*. New Delhi: Sage, 1836–1982.
- Raj, K. N., & Michael Tharakan. (1983). *Agrarian Reform in Kerala and its Impact on the Rural Economy: A Preliminary Assessment*. In Agrarian Reform in Contemporary Developing Countries. Edited by Ajit Kumar Ghose. London and New York: Groom Helm and St. Martin's Press, 31–42.
- Rajendraprasad, M., Krishnan, P. N., & Pushpangadan, P. (1996). Floristic Wealth and Diversity in Sacred Groves of Kerala. *Natn. Sem. Conservation of Endangered Species and Ecosystems*. Banaras Hindu University, Varanasi, U. P.
- Ramachandran, K. K., & Mohanan, C. N. (1991). *Studies on the sacred groves of Kerala*. Project Report, DOEn, Government of India, CESS, Thiruvananthapuram.
- Srikumar Chattopadhyay., & Richard, W. Franke. (2006). *Striving for Sustainability: Environmental Stress and Democratic Initiatives in Kerala*. New Delhi, Concept Publishing Company.

- Subhash, M. D., Gadgil, M., & Donald Hughes, J. (1998). Sacred Groves of the Western Ghats of India. In *Conserving the Sacred: For Biodiversity Management*. Edited by Sivaswamy Ramakrishnan, P., Saxena, K. G., & Chandrashekara, U. M. Enfield: *Science Publishers*, 211–32.
- Sujana, K. A., & Sivaperuman, C. (2008). Status and conservation of threatened in selected sacred groves of coastal Kerala. *Eco News*, 14(2), 6–10.

CHAPTER- 3

Floristic and phytosociological studies of selected sacred groves and disturbed non-sacred grove lands

Introduction

In a forest ecosystem, among all the anatomical characters of the plant community, the floristic composition is of prime importance and the number of species and their population in the community reflects the gene pool and adaptation potential of the community (Dansereau, 1960). Depending on the interaction among different plants and between plants and their environment, different vegetation types are found to inhabit different areas. The floristic composition, which varies in the abundance of different species and richness of each species, is unique to each forest. The species composition and structure of vegetation which is dependent on several critical factors, regulate the spatial and temporal patterns of vegetation of an ecosystem (Chapin et al., 1993). Disturbances in the forest ecosystems can alter the environmental condition in the forests by changing light availability and soil conditions which ultimately change the species composition of the forests (Singh et al., 1997; Fredericksen & Mostacedo, 2000). The floristic composition and community structure is significantly damaged by anthropogenic interferences attributed to urbanization and population expansion, particularly in the developing world. The quantitative and qualitative analysis of floristic composition, species diversity and their spatial distribution pattern is indicative of the pattern of response to anthropogenic disturbances and change in vegetation leading to ecological changes over time. Hence, floristic and phytosociological analysis and related inventories are essential to interpret and plan conservation strategy for the forest ecosystems.

Review of Literature

Understanding the forest composition and its structure is an essential tool to analyse the various ecological processes, the functioning and dynamics of a forest. Over a time, several workers have been studying the forest vegetation characteristics in India (Meher-Homji, 1973; Saxena & Singh, 1982; Singh & Singh, 1986). The analysis on vegetation done by Mishra et al. in 2008 in the Biosphere Reserves of Similipal noticed that herbs and shrubs are in higher number whereas the trees in lower number in the buffer zone, pointing higher anthropogenic disturbances. Sundriyal and Sharma in the year 1996 while Bhuyan et al. in 2003 observed that the main reason for forest destruction in the eastern region of India is the unsustainable harvesting of trees in general and cutting of certain specific tree species of timber value. The exponential increase in the extinction of tropical species is accelerated by the utilisation of forest for the purpose of agriculture, collection of non-timber products from forest, logging of mature trees, harvesting fuel wood which in turn may cause serious damage to biodiversity (Mishra et al., 2004; Laloo et al., 2006). Gadgil and Vartak (1975) inferred that in various regions of India, sacred groves are paragons of climax vegetation and they furnish a network of preserved area throughout the country, wherein the floral as well as the faunal diversity are protected for the use of present and future generations.

According to Andrew (1998), sacred groves in India have been protected purely based on religious and cultural practices. Due to the existence of rare and endangered plant species of ecological and economic value, the sacred groves maintain high relevance since time immemorial as treasure house plant resources. Nepolion et al. (2014) in their study observed that the disturbed forest have lower number of sapling and richness of seedlings which could be the result of damage which occurs during biomass harvest and may also be the result of reduction in adult individuals species capable of producing seeds for regeneration. Gadgil and Chandran (1989) are of the view that sacred groves can form the epicentre for the recouping of degraded forest ecosystem in an area. According to Vartak et al. (1986), the conservation of forest resources of Western Ghats are maintained by sacred groves, based on their inferences obtained from the study conducted on 17 sacred groves in the area.

Ramachandran and Mohanan (1991) identified 239 major sacred groves in the state of Kerala in their preliminary study. The study conducted on the vegetation of sacred groves in Kerala

by Rajendraprasad et al. (1996) revealed the existence of approximately 2000 sacred groves with natural forest vegetation. Balasubramanyan and Induchoodan (1996) reported 761 sacred groves in Kerala with rich vegetation of more than 722 species and 474 genera categorised under 217 families, which include 153 endemic species specific to peninsular India. A comparative study done between degraded and undisturbed tropical forests of the Bhuban hills in the state of Assam done by Nepolion et al. (2014) revealed poor regeneration for majority of the tree species and absence of many major species of natural occurrence of undisturbed forest in the degraded forest, which in turn badly influenced the structure of community and composition of species. In situations where the anthropogenic disturbances exceed the tolerable limit for the existing plants, it is observed that new plant species emerge with enhanced reproductive capacity and quick colonising capability which can suppress the native community by rapidly acclimatising to the area (Akter & Zuberi, 2009). A survey on the endemic plants in the sacred groves of Kasaragod and Kannur district of Kerala was carried out by Induchoodan and Balasubramanyan (1991) while an eco-folklore analysis on the same area was made by Unnikrishnan (1995). Sujana and Sivaperuman (2008) recommended the conservation of the natural vegetation in the coastal region of Kerala based on their study on five selected sacred groves in Thrissur district. The study conducted by Jayarajan (2004) highlighted the ecological importance of groves being refugee and biodiversity nuclei for many rare and endangered species of high relevance.

The frequency of different plant species in an area reveals the distribution pattern or characteristics of different species in that area in comparison to each other. A species with low frequency indicate either that species is distributed irregularly or rarely in that vegetation stand whereas a species with higher frequency denote wider or uniform distribution in the stand (Kharkwal & Rawat, 2010). Raunkiaer (1934) classified the distribution frequency of species in a community into five classes of frequency distribution (%). These are

A=1-20%

B=21-40%

C=41-60%

D=61-80% and

E=81-100%

Higher density and increased basal area are usually found to be the characteristics of tree population in undisturbed forests however, lower tree density and reduced basal area are generally recorded among the tree species in the forest area which are subjected to extraction.

Therefore, a negative correlation exists in density as well as basal area with disturbance index as inferred by Nepolion et al. (2014).

A plant species of rapid and vigorous growth in an area is usually responsible for dominance of plants (Hart, 1990). The phytosociological structure as well as the ecological significance of a species in an area can be expressed with a single value called importance value index (IVI), as reported by Misra (1968). Richness of seedling and abundance of saplings of a particular plant species in a region is indicative of their persistency and ability to dominate in the future generations but quantitative data in support of this observation are few and only anecdotal evidence are available regarding regeneration process of smaller size classes (Martijena & Bullock, 1994). Lawes et al. (2007) reported that the anthropogenic and other disturbances in the forest area has an impact on diversity, post disturbance regeneration process and tree species dominance.

In tropical forest, most dominant tree species do not show their representation more than 10% of the entire number of individuals in the community (Oliveira-Filho et al., 1995; Felfili, 1995). But in a forest community, if an individual tree species recorded their representation more than 50% of the total number of individuals in the community, then it is called a monodominant forest and these kind of are reported as existing in lowland rainforests of the tropical region (Whitmore, 1975).

The ecosystem balance of an area is significantly related to the diversity of plant species and which in turn is influenced by several anthropogenic disturbances. The preservation and conducive climatic conditions prevailing in an area for long time may play a vital role in building the forest area highly complex and species-abundant while anthropogenic pressures by way of unsustainable exploitation of resources of the forests may lead to the decline of plant diversity and population (Upadhaya, 2003). The study conducted by Prasad and Pandey (1992) observed lesser diversity of plant species and lower dominance due to anthropogenic disturbances in the forest lying 0.5 km radius of habitation compared to forest located within 5 km radius of habitation. The differences in the abundance as well as the diversity of plant species may be related to site characteristics and impacts due to human activities (Parthasarathy & Karthikeyan, 1997) in their study at tropical dry evergreen (sacred grove) forests at Kuzhanthaikuppam and Thirumanikkuzhi on the Coromandel Coast of south India. The main reason behind the decrease of biodiversity is the destruction of tropical forests and

habitat loss due to anthropogenic intervention (Pickett & White, 1985). Borah and Garkoti (2011) reported that the loss in local species and instead the emergence of light demanding species is the result of unsustainable extraction of certain dominant and demanding plant species in the area.

A forest is considered to be of low diversity if on tree species alone occupy 50-80 percentage of the canopy (Connell & Lowman, 1989). Generally when the Shannon diversity index of an ecosystem ranges from 1-2, then it is considered to be moderately disturbed whereas when this index value exceeds 3, such ecosystem is considered to have a stable environment (Nisha et al., 2016). Rajendra Prasad in 1995 has recorded Shannon index of Western Ghats as ranging 3.6 - 4.3. It is observed that when the forest communities are in stressed condition, the diversity lowers as close to zero. The diversity index is noticed to be always high when the dominance of number of species is less. The greater stability of an ecosystem is attributed to higher diversity of plant species. Any ecosystem in a seriously disturbed condition generally are found to exhibit a Shannon index value less than one. The tropical forest in the sub-continent of India generally have a higher Shannon diversity index which range between 0.81-4.1 (Parthasarathy et al., 1992; Visalakshi, 1995; Pande, 1999). The reserve forest of Marakkanam in South India has a Shannon diversity index of 0.83 - 2.43 range as reported by Vishalakshi (1995).

The status of an ecosystem and the measure of its species diversity is usually determined by the richness of species in that area. In an environment, the severity, variability as well as predictability are the factors which decide the species richness of a plant community and it is observed that diversity enhances when the environment tends to be more favourable and predictable (Slobodkin & Sanders, 1969; Putman, 1994). An ecosystem generally exhibits higher level of stability when more plant species are present in it (Nisha et al., 2016). Indrajit et al. in 2009 has observed that anthropogenic interferences has an inverse impact on the species population and Shannon diversity index as observed from the study conducted in Alabama forests. Continued anthropogenic interferences are found to change a forest ecosystem of natural old growth gradually in to man made landscapes (Rahman et al., 2009) causing habitat fragmentation and decrement of plant species population (McKinney, 2002). The composition and population of plant species are the important parameters to be considered for the determination of biodiversity (Husch et al., 2002). The diversity index and disturbances in a natural vegetation are positively as well as significant correlated when

subjected to unsustainable agroforestry practices and severe logging along with the impact of increasing population rate (Noble & Dirzo, 1997).

The basal area of plants in a vegetation is nothing but the ground area penetrated and covered by the stems of plants. The basal area of plant is an important aspect to be considered for assessing the dominance level of plant species in a particular area, as the basal area increases the dominance level also increases. On comparison of the undisturbed Sal forest with the disturbed wild life sanctuary of Achanakmar forest, it is observed the former has higher tree density, increased species diversity and improved basal cover the later (Singh et al., 2005). An inverse correlation is recorded for density of trees and basal cover with respect to disturbance index by Nepolion et al. (2014). He substantiated that the forest sites which are subjected to faster and continuous logging of tree species may record rapid decrease in the density as well as the basal cover of trees compared to undisturbed sites. The range of dominance concentration of tropical forests is reported to be within 0.21 to 0.92 (Bisht, 1989; Parthasarathy et al., 1992; Visalkashi, 1995). The study conducted in the forest area of Agasthyamalai in Kerala by Verghese and Menon (1998) recorded a stand density of 535 trees ha⁻¹, species density of 12 species per 0.1 ha, basal area of 26.57 m² ha⁻¹ and Shannon index of 1.89.

Materials and Methods

Collection, preservation and identification of plant species

All the four selected sacred groves of different extents as well as corresponding adjacent disturbed non-sacred grove lands of similar extents each are marked in to approximately four equal sampling units with the help of ropes and stem cuttings. Different plant groups such as trees, shrubs, herbs, climbers and lianas (large woody climbers) are considered for floristic and phytosociological studies. Plant specimens are collected and herbarium is prepared following the wet method of Fosberg and Sachet (1965) for the identification. Identification of plant specimens are done with the help of the Flora of the Presidency of Madras (Gamble & Fischer, 1915-1936), using field keys devised by Balasubramanyan et al. (1985) and other relevant Floras, Manuals, Revisions, etc. The identifications are further confirmed with the herbaria at Kerala Forest Research Institute, Peechi and the herbaria at Dept. of Botany, University of Calicut. The classification based on Bentham and Hooker (1862-1883) and nomenclature of the specimens was also verified with The Plant List (www.theplantlist.org) where globally accepted nomenclature of plants is available for reference.

Table B1: Study sites, total area and sampling unit size

Study sites	Total area (Grove/Non-sacred grove land)	Sampling unit size (Grove/Non-sacred grove land)
Sankulangara site (Sankulangara sacred grove land and disturbed non-sacred grove land of similar extent)	0.636 ha	0.159 ha
Palliyana site (Palliyana sacred grove land and disturbed non-sacred grove land of similar extent)	0.364 ha	0.091 ha
Nambiyath site (Nambiyath sacred grove land and disturbed non-sacred grove land of similar extent)	0.121 ha	0.030 ha
Poyyara site (Poyyara sacred grove land and disturbed non-sacred grove land of similar extent)	0.040 ha	0.010 ha

Floristic and phytosociological analysis

The floristic analysis carried out in the study includes analysis of various plant groups and the identification and enumeration of different families, genus and species under each plant groups. The phytosociological aspects considered for the study includes analysis of density (D) & relative density (RD) of plant species, frequency (F) & relative frequency (RF) of plant species, basal area (BA) & relative basal area (RBA) of trees, importance value index (IVI) of trees species, importance value index of family (IVIF) of tree species. These parameters are analyzed and calculated following the methods of Curtls and McIntosh (1950), Misra and Purl (1954), Misra (1968, 1969), Mueller and Ellenberg (1974), Werger (1974) and Induchoodan (1998). The species diversity index (SDI) and species richness index (SRI) are analysed in the study. The species diversity index is determined by using Shannon Wiener Index (H') (Shannon, 1949) while the species richness index (SRI) is determined by using Margalef's species richness index (Margalef, 1958). The similarity index in the study is calculated by using the formula given by Sorenson (1948). The floristic and phytosociological analysis are carried out during the period August 2014 to December 2015.

Density of species

The analysis of density used to express the numerical strength of a species in the area.

$$\text{Density of a species (D)} = \frac{\text{Total number of individual species}}{\text{Total number of sampling units studied}}$$

$$\text{Relative Density of a species (RD)} = \frac{\text{Number of individuals of the species}}{\text{Number of individuals of all species}} \times 100$$

Frequency of species

The frequency analysis used to indicate the number of sampling units in which a particular plant species is represented out of the total number of sampling units analysed in the study area. The frequency of plants species in the study is analysed by marking each study area into approximately 8 equal sampling units, instead of 4 sampling units in other cases of data collections.

$$\text{Frequency of a species (F)} = \frac{\text{Number of transects of occurrence of a species}}{\text{Total number of sampling units studied}} \times 100$$

$$\text{Relative frequency of a species (RF)} = \frac{\text{Number of sampling units of occurrence of the species}}{\text{Number of sampling units of occurrence of all species}} \times 100$$

Species Diversity Index (Shannon, 1949)

Species diversity index (SDI) is the mathematical measure of diversity of species in a community.

$$\text{Shannon Wiener Index (H')} = -\sum_{i=1}^S (p_i \ln p_i)$$

Where, p_i = fraction of the entire population made up of species
 s = numbers of species encountered, Σ = sum from species 1 to s

Species Richness Index (Margalef, 1958)

Margalef's species richness index (SRI) is used as a simple measure of species richness in the study

$$d = S/\sqrt{N}$$

Where, S = Number of species, N = Number of individuals of all species

Similarity Index (SI)

The similarity index values are used to analyse the plant community relationships or similarities in the plant species between different study areas.

$$\text{Similarity index} = \frac{2C}{A+B} \times 100$$

Where,

A is the total number of species in site I,

B is the total number of species in site II and

C is the number of species common to both the sites I and II.

The dominance of species, genera and family

The dominance of species, genera and family in the selected sacred groves and disturbed non-sacred grove lands are determined based on the distribution of entire plant species as well as the tree species alone. The different aspects considered for the analysis of dominance in the present study are total number of individual representation, diversity of plant genera and species.

Basal area of trees

Basal area of trees is one of the important parameter used to calculate the importance value index (IVI) and dominance of a tree species and a family. The girth of main bole of the tree at breast height (GBH) above ground level is used to calculate the basal area of trees using the formula

$$\text{Basal area} = \frac{(\text{Girth})^2}{4\pi}$$

Total Basal area of trees (BA) = Sum of the individual basal areas of all trees

Relative Basal Area (RBA) = $\frac{\text{Basal area of the tree species}}{\text{Sum of the individual Basal area of all tree species}} \times 100$

The importance of value index (IVI) of species

The importance of value index (IVI) gives the total picture or the sociological structure of a species in a plant community. The IVI of tree species is calculated based on three important phytosociological characteristics, the RF of the species, RD of the species and RBA of the species.

Importance value index (IVI) of species = RF of the species + RD of the species + RBA of the species

Importance value index of family

Importance value index of family is calculated by adding the IVI of different tree species of the family.

The average mean value and standard deviation of various parameters in selected sacred groves and disturbed non-sacred grove lands are determined and compared statistically using 't' test of SPSS statistics 20.

Results

The data on total floral distribution as well as plant group wise distribution of trees, shrubs, herbs, climbers and lianas in all the four selected sacred groves and adjacent disturbed non-sacred grove lands are collected and various floristic and phytosociological aspects are analyzed in each study sites for comparison.

1) Sankulangara site

Analysis of total floral distribution

The analysis of total floral distribution in the Sankulangara sacred grove showed the presence of 2122 plants belonging to total of 54 families and which comprised of 89 genera and 101 species. The details are depicted in the table B2. The plant species with highest individual population of 318 and highest density (D) & relative density (RD) values of 79.5 & 14.99% in the study are recorded by the climber *Smilax zeylanica*. This is immediately followed by the shrub *Chassalia curviflora* and then the tree species *Hopea ponga*, having a total population of 130 and 101 with D & RD values of 32.5 & 6.126% and 25.25 & 4.76% respectively. The highest frequency (F) and relative frequency (RF) values of 100% & 1.6% respectively recorded by 10 plant species. This includes trees *Hopea ponga*, *Caryota urens*, *Artocarpus hirsutus*, *Quassia indica* and *Hydnocarpus pentandrus*; the shrub *Chassalia curviflora*; climbers *Smilax zeylanica*, *Pothos scandens* and *Cayratia japonica* and the liana species *Gnetum ula*. The immediate highest F & RF values of 87.5% & 1.4% respectively is recorded by 16 plant species. This includes trees such as *Vateria indica*, *Olea dioica*, *Xanthophyllum arnottianum*, *Aporosa cardiosperma*, *Holigarna arnottiana* and *Aphanamixis polystachya*; shrubs such as *Ixora coccinea*, *Ixora malabarica* and *Memecylon grande*; species of herbs like *Panicum notatum*, *Mitracarpus hirtus*, *Biophytum reinwardtii* and *Cheilocostus speciosus*; species of climbers such as *Tiliacora racemosa* and *Strychnos minor* and the liana species *Dalbergia horrida*.

Table B2: Details of total floral distribution in the Sankulangara sacred grove

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Abrus precatorius</i> L.	Leguminosae	19	4.75	0.90	6	75	1.2
2	<i>Adenanthera pavonina</i> L.	Leguminosae	3	0.75	0.14	2	25	0.4
3	<i>Aerva lanata</i> (L.) Juss.	Amaranthaceae	7	1.75	0.33	4	50	0.8

4	<i>Andrographis paniculata</i> (Burm.f.) Nees.	Acanthaceae	7	1.75	0.33	4	50	0.8
5	<i>Anisomeles indica</i> (L.) Kuntze.	Lamiaceae	16	4	0.75	6	75	1.2
6	<i>Anodendron paniculatum</i> A.DC.	Apocynaceae	2	0.5	0.09	2	25	0.4
7	<i>Aphanamixis polystachya</i> (Wall.) R.Parker.	Meliaceae	12	3	0.57	7	87.5	1.4
8	<i>Aporosa cardiosperma</i> (Gaertn.) Merr.	Euphorbiaceae	16	4	0.75	7	87.5	1.4
9	<i>Areca catechu</i> L.	Arecaceae	4	1	0.19	4	50	0.8
10	<i>Aristolochia indica</i> L.	Aristolochiaceae	7	1.75	0.33	4	50	0.8
11	<i>Artocarpus hirsutus</i> Lam.	Moraceae	30	7.5	1.41	8	100	1.6
12	<i>Asparagus racemosus</i> Willd.	Liliaceae	16	4	0.75	6	75	1.2
13	<i>Biophytum reinwardtii</i> (Zucc.) lotzsch	Oxalidaceae	19	4.75	0.90	7	87.5	1.4
14	<i>Brachiaria subquadripa</i> (Trin.) Hitchc.	Poaceae	14	3.5	0.66	6	75	1.2
15	<i>Bridelia stipularis</i> (L.) Blume.	Euphorbiaceae	16	4	0.75	6	75	1.2
16	<i>Cansjera rheedii</i> Blanco.	Opiliaceae	27	6.75	1.27	5	62.5	1
17	<i>Canthium rheedei</i> DC.	Rubiaceae	13	3.25	0.61	5	62.5	1
18	<i>Carallia brachiata</i> (Lour.) Merr.	Rhizophoraceae	3	0.75	0.14	3	37.5	0.6
19	<i>Caryota urens</i> L.	Arecaceae	32	8	1.51	8	100	1.6
20	<i>Cayratia japonica</i> (Thunb.) Gagnep.	Vitaceae	42	10.5	1.98	8	100	1.6
21	<i>Cayratia pedata</i> (Lam.) Gagnep.	Vitaceae	20	5	0.94	5	62.5	1
22	<i>Centella asiatica</i> (L.) Urb.	Apiaceae	18	4.5	0.85	5	62.5	1
23	<i>Chassalia curviflora</i> (Wall.) Thwaites.	Rubiaceae	130	32.5	6.13	8	100	1.6
24	<i>Cheilocostus speciosus</i> (J.Koenig) C.D.Specht.	Costaceae	18	4.5	0.85	7	87.5	1.4
25	<i>Chrysophyllum cainito</i> L.	Sapotaceae	4	1	0.19	2	25	0.4
26	<i>Cinnamomum malabattrum</i> (Burm.f.) J.Presl.	Lauraceae	14	3.5	0.66	6	75	1.2
27	<i>Clitoria ternatea</i> L.	Leguminosae	8	2	0.38	4	50	0.8
28	<i>Coffea travancorensis</i> Wight & Arn.	Rubiaceae	16	4	0.75	6	75	1.2
29	<i>Connarus monocarpus</i> L.	Connaraceae	2	0.5	0.09	2	25	0.4
30	<i>Cyclea peltata</i> (Lam.) Hook.f. & Thomson.	Menispermaceae	16	4	0.75	6	75	1.2
31	<i>Dalbergia horrida</i> (Dennst.) Mabb.	Leguminosae	32	8	1.51	7	87.5	1.4
32	<i>Dalbergia volubilis</i> Roxb.	Leguminosae	14	3.5	0.66	6	75	1.2
33	<i>Desmodium gangeticum</i> (L.) DC.	Leguminosae	11	2.75	0.53	6	75	1.2
34	<i>Dioscorea bulbifera</i> L.	Dioscoreaceae	24	6	1.13	6	75	1.2

35	<i>Dregea volubilis</i> (L.f.) Benth. ex Hook.f.	Asclepiadaceae	7	1.75	0.33	3	37.5	0.6
36	<i>Elephantopus scaber</i> L.	Asteraceae	12	3	0.57	6	75	1.2
37	<i>Emilia sonchifolia</i> (L.) DC. ex DC.	Asteraceae	13	3.25	0.61	6	75	1.2
38	<i>Erycibe paniculata</i> Roxb.	Convolvulaceae	8	2	0.38	3	37.5	0.6
39	<i>Ficus amplissima</i> Sm.	Moraceae	11	2.75	0.52	6	75	1.2
40	<i>Ficus benghalensis</i> L.	Moraceae	1	0.25	0.05	1	12.5	0.2
41	<i>Ficus drupacea</i> Thunb.	Moraceae	4	1	0.19	3	37.5	0.6
42	<i>Ficus religiosa</i> L.	Moraceae	1	0.25	0.05	1	12.5	0.2
43	<i>Garcinia gummi-gutta</i> (L.) Roxb.	Clusiaceae	9	2.25	0.42	5	62.5	1
44	<i>Gloriosa superba</i> L.	Liliaceae	14	3.5	0.66	4	50	0.8
45	<i>Glycosmis pentaphylla</i> (Retz.) DC.	Rutaceae	6	1.5	0.28	4	50	0.8
46	<i>Gnetum ula</i> Brongn.	Gnetaceae	55	13.75	2.59	8	100	1.6
47	<i>Grewia nervosa</i> (Lour.) Panigrahi.	Tiliaceae	3	0.75	0.14	3	37.5	0.6
48	<i>Hemidesmus indicus</i> (L.) R. Br. ex Schult.	Periplocaceae	5	1.25	0.24	3	37.5	0.6
49	<i>Hibiscus rosa-sinensis</i> L.	Malvaceae	13	3.25	0.61	6	75	1.2
50	<i>Holigarna arnottiana</i> Hook.f.	Anacardiaceae	14	3.5	0.66	7	87.5	1.4
51	<i>Hopea ponga</i> (Dennst.) Mabb.	Dipterocarpaceae	101	25.25	4.76	8	100	1.6
52	<i>Hydnocarpus pentandrus</i> (Buch.-Ham.) Oken	Flacourtiaceae	24	6	1.13	8	100	1.6
53	<i>Hyptis capitata</i> Jacq.	Lamiaceae	6	1.5	0.28	4	50	0.8
54	<i>Ichnocarpus frutescens</i> (L.) W.T.Aiton	Apocynaceae	48	12	2.26	6	75	1.2
55	<i>Ixora coccinea</i> L.	Rubiaceae	38	9.5	1.79	7	87.5	1.4
56	<i>Ixora malabarica</i> (Dennst.) Mabb.	Rubiaceae	25	6.25	1.18	7	87.5	1.4
57	<i>Jasminum angustifolium</i> (L.) Willd.	Oleaceae	4	1	0.19	2	25	0.4
58	<i>Kamettia caryophyllata</i> (Roxb.) Nicolson & Suresh	Apocynaceae	12	3	0.57	3	37.5	0.6
59	<i>Laportea interrupta</i> (L.) Chew.	Urticaceae	10	2.5	0.47	3	37.5	0.6
60	<i>Leea indica</i> (Burm. f.) Merr.	Leeaceae	18	4.5	0.85	6	75	1.2
61	<i>Litsea coriacea</i> Hook.f.	Lauraceae	5	1.25	0.24	4	50	0.8
62	<i>Memecylon grande</i> Retz.	Melastomataceae	25	6.25	1.18	7	87.5	1.4
63	<i>Mikania micrantha</i> Kunth.	Asteraceae	24	6	1.13	6	75	1.2
64	<i>Mimusops elengi</i> L.	Sapotaceae	12	3	0.57	6	75	1.2
65	<i>Mitracarpus hirtus</i> (L.) DC.	Rubiaceae	20	5	0.94	7	87.5	1.4
66	<i>Mukia maderaspatana</i> (L.) M.Roem.	Cucurbitaceae	35	8.75	1.65	6	75	1.2

67	<i>Mussaenda frondosa</i> L.	Rubiaceae	6	1.5	0.28	3	37.5	0.6
68	<i>Myxopyrum smilacifolium</i> (Wall.) Blume.	Oleaceae	18	4.5	0.85	6	75	1.2
69	<i>Ocimum basilicum</i> L.	Lamiaceae	2	0.5	0.09	2	25	0.4
70	<i>Ocimum tenuiflorum</i> L.	Lamiaceae	5	1.25	0.24	3	37.5	0.6
71	<i>Olea dioica</i> Roxb.	Oleaceae	19	4.75	0.90	7	87.5	1.4
72	<i>Pandanus kaida</i> Kurz.	Pandanaceae	12	3	0.57	5	62.5	1
73	<i>Panicum notatum</i> Retz.	Poaceae	26	6.5	1.23	7	87.5	1.4
74	<i>Persea macrantha</i> (Nees) Kosterm.	Lauraceae	6	1.5	0.28	5	62.5	1
75	<i>Pinanga dicksonii</i> (Roxb.) Blume.	Arecaceae	9	2.25	0.42	6	75	1.2
76	<i>Piper nigrum</i> L.	Piperaceae	4	1	0.19	3	37.5	0.6
77	<i>Polyalthia korintii</i> Hook. f. & Thomson.	Annonaceae	17	4.25	0.80	6	75	1.2
78	<i>Pothos scandens</i> L.	Araceae	100	25	4.71	8	100	1.6
79	<i>Pouteria campechiana</i> (Kunth) Baehn.	Sapotaceae	1	0.25	0.05	1	12.5	0.2
80	<i>Quassia indica</i> (Gaertn.) Noot.	Simaroubaceae	27	6.75	1.27	8	100	1.6
81	<i>Rourea minor</i> (Gaertn.) Alston.	Connaraceae	28	7	1.32	6	75	1.2
82	<i>Saraca asoca</i> (Roxb.) Willd.	Leguminosae	2	0.5	0.094	2	25	0.4
83	<i>Smilax zeylanica</i> L.	Smilacaceae	318	79.5	14.99	8	100	1.6
84	<i>Sterculia guttata</i> Roxb. ex G.Don	Sterculiaceae	4	1	0.190	3	37.5	0.6
85	<i>Strychnos minor</i> Dennst.	Loganiaceae	53	13.25	2.50	7	87.5	1.4
86	<i>Strychnos nux-vomica</i> L.	Loganiaceae	1	0.25	0.05	1	12.5	0.2
87	<i>Syzygium hemisphericum</i> (Wight) Alston	Myrtaceae	2	0.5	0.09	2	25	0.4
88	<i>Syzygium lanceolatum</i> (Lam.) Wight & Arn.	Myrtaceae	4	1	0.19	3	37.5	0.6
89	<i>Syzygium zeylanicum</i> (L.) DC.	Myrtaceae	11	2.75	0.52	4	50	0.8
90	<i>Tabernaemontana alternifolia</i> L.	Apocynaceae	12	3	0.57	6	75	1.2
91	<i>Terminalia bellirica</i> (Gaertn.) Roxb.	Combretaceae	1	0.25	0.05	1	12.5	0.2
92	<i>Terminalia catappa</i> L.	Combretaceae	1	0.25	0.05	1	12.5	0.2
93	<i>Tetrastigma leucostaphylum</i> (Dennst.) Alston	Vitaceae	20	5	0.94	5	62.5	1
94	<i>Tiliacora racemosa</i> Colebr.	Menispermaceae	78	19.5	3.68	7	87.5	1.4
95	<i>Torenia bicolor</i> Dalzell.	Scrophulariaceae	18	4.5	0.85	4	50	0.8
96	<i>Uvaria narum</i> A.DC.	Annonaceae	35	8.75	1.65	5	62.5	1
97	<i>Vateria indica</i> L.	Dipterocarpaceae	31	7.75	1.46	7	87.5	1.4

98	<i>Vigna umbellata</i> (Thunb.) Ohwi & H. Ohashi	Leguminosae	9	2.25	0.42	3	37.5	0.6
99	<i>Vitex altissima</i> L.f.	Verbenaceae	8	2	0.38	3	37.5	0.6
100	<i>Vitex pinnata</i> L.	Verbenaceae	2	0.5	0.09	2	25	0.4
101	<i>Xanthophyllum arnottianum</i> Wight.	Polygalaceae	17	4.25	0.80	7	87.5	1.4
	Genus-89 ; Species-101	Family-54	2122			500		

The details of total floral distribution in the selected disturbed non-sacred grove land are depicted in the table B3. The total population of 221848 plants belongs to 30 families and total of 53 genera and 60 species recorded. The highest individual population of 30180 and highest D & RD values of 7545 & 13.6% in the study recorded by the herb *Cynodon dactylon*. This is immediately followed by the herb *Desmodium triflorum* (24620 individuals) and then *Commelina diffusa* (20649 individuals) having D & RD values 6155 & 11.1% and 5162 & 9.31% respectively. The highest frequency (F) and relative frequency (RF) values of 100% and 2.69% respectively recorded by 13 herbaceous species. This includes *Cynodon dactylon*, *Desmodium triflorum*, *Commelina diffusa*, *Brachiaria subquadriflora*, *Murdannia pauciflora*, *Mitracarpus hirtus*, *Mimosa pudica*, *Eragrostis amabilis*, *Eragrostis unioides*, *Digitaria ciliaris*, *Aerva lanata*, *Phyllanthus amarus* and *Phyllanthus urinaria*. The immediate highest F & RF values of 87.5% & 2.36% respectively recorded by 3 species of herbs *Ludwigia hyssopifolia*, *Synedrella nodiflora* and *Cyperus rotundus* and 2 species of shrubs *Triumfetta rhomboidea* and *Hyptis suaveolens*.

Table B3: Details of total floral distribution in the disturbed non-sacred grove

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Aerva lanata</i> (L.) Juss.	Amaranthaceae	9133.3	2283.33	4.12	8	100	2.75
2	<i>Ailanthus triphysa</i> (Dennst.) Alston	Simaroubaceae	2	0.5	0.001	2	25	0.69
3	<i>Alloteropsis cimicina</i> (L.) Stapf.	Poaceae	4765.2	1191.3	2.15	6	75	2.06
4	<i>Anacardium occidentale</i> L.	Anacardiaceae	2	0.5	0.001	2	25	0.69
5	<i>Annona squamosa</i> L.	Annonaceae	1	0.25	0.001	1	12.5	0.34
6	<i>Areca catechu</i> L.	Arecaceae	13	3.25	0.01	6	75	2.06
7	<i>Artocarpus heterophyllus</i> Lam.	Moraceae	2	0.5	0.001	2	25	0.69
8	<i>Artocarpus hirsutus</i> Lam.	Moraceae	2	0.5	0.001	1	12.5	0.34
9	<i>Biophytum reinwardtii</i> (Zucc.) Klotzsch	Oxalidaceae	2779.7	694.93	1.25	6	75	2.06
10	<i>Brachiaria subquadriflora</i> (Trin.) Hitchc.	Poaceae	13105	3276.25	5.91	8	100	2.75

11	<i>Bridelia retusa</i> (L.) A.Juss.	Euphorbiaceae	1	0.25	0.001	1	12.5	0.34
12	<i>Carallia brachiata</i> (Lour.) Merr.	Rhizophoraceae	1	0.25	0.001	1	12.5	0.34
13	<i>Chassalia curviflora</i> (Wall.) Thwaites	Rubiaceae	9	2.25	0.004	3	37.5	1.03
14	<i>Chromolaena odorata</i> (L.) R.M.King & H.Rob.	Asteraceae	19	4.75	0.01	5	62.5	1.72
15	<i>Cinnamomum verum</i> J.Presl	Lauraceae	2	0.5	0.001	2	25	0.69
16	<i>Clerodendrum infortunatum</i> L.	Verbenaceae	12	3	0.01	5	62.5	1.72
17	<i>Cocos nucifera</i> L.	Arecaceae	16	4	0.01	6	75	2.06
18	<i>Commelina diffusa</i> Burm.f.	Commelinaceae	20649	5162.25	9.31	8	100	2.75
19	<i>Crotalaria pallida</i> Aiton.	Leguminosae	7	1.75	0.003	5	62.5	1.72
20	<i>Cyathula prostrata</i> (L.) Blume.	Amaranthaceae	3573.9	893.48	1.61	6	75	2.06
21	<i>Cynodon dactylon</i> (L.) Pers.	Poaceae	30180	7545	13.6	8	100	2.75
22	<i>Cyperus rotundus</i> L.	Cyperaceae	4765.2	1191.3	2.15	7	87.5	2.41
23	<i>Desmodium triflorum</i> (L.) DC.	Leguminosae	24620	6155	11.1	8	100	2.75
24	<i>Digitaria ciliaris</i> (Retz.) Koeler	Poaceae	9133.3	2283.33	4.12	8	100	2.75
25	<i>Eleutheranthera ruderalis</i> (Sw.) Sch.Bip.	Asteraceae	3176.8	794.2	1.43	6	75	2.06
26	<i>Eragrostis amabilis</i> (L.) Wight & Arn.	Poaceae	9530.4	2382.6	4.30	8	100	2.75
27	<i>Eragrostis unioides</i> (Retz.) Nees ex Steud.	Poaceae	9530.4	2382.6	4.30	8	100	2.75
28	<i>Euphorbia hirta</i> L.	Euphorbiaceae	3176.8	794.2	1.43	5	62.5	1.72
29	<i>Euphorbia thymifolia</i> L.	Euphorbiaceae	3573.9	893.48	1.61	6	75	2.06
30	<i>Garcinia gummi-gutta</i> (L.) Roxb.	Clusiaceae	2	0.5	0.001	2	25	0.69
31	<i>Hewittia malabarica</i> (L.) Suresh	Convolvulaceae	10	2.5	0.01	4	50	1.37
32	<i>Hibiscus surattensis</i> L.	Malvaceae	12	3	0.01	5	62.5	1.72
33	<i>Hydnocarpus pentandrus</i> (Buch.-Ham.) Oken	Flacourtiaceae	3	0.75	0.001	2	25	0.69
34	<i>Hyptis suaveolens</i> (L.) Poit.	Lamiaceae	18	4.5	0.01	7	87.5	2.41
35	<i>Ichnocarpus frutescens</i> (L.) W.T.Aiton	Apocynaceae	9	2.25	0.004	3	37.5	1.03
36	<i>Laportea interrupta</i> (L.) Chew.	Urticaceae	2382.6	595.65	1.07	5	62.5	1.72
37	<i>Leea indica</i> (Burm. f.) Merr.	Leeaceae	8	2	0.004	2	25	0.69
38	<i>Leucas aspera</i> (Willd.) Link	Lamiaceae	3176.8	794.2	1.43	2	25	0.69
39	<i>Ludwigia hyssopifolia</i> (G.Don) Exell	Onagraceae	5956.5	1489.13	2.69	7	87.5	2.41
40	<i>Mangifera indica</i> L.	Anacardiaceae	1	0.25	0.001	1	12.5	0.34
41	<i>Mikania micrantha</i> Kunth.	Asteraceae	20	5	0.01	6	75	2.06

42	<i>Mimosa pudica</i> L.	Leguminosae	9927.5	2481.88	4.48	8	100	2.75
43	<i>Mitracarpus hirtus</i> (L.) DC.	Rubiaceae	10325	2581.25	4.65	8	100	2.75
44	<i>Murdannia pauciflora</i> (G.Brückn.) G.Brückn.	Commelinaceae	10722	2680.5	4.83	8	100	2.75
45	<i>Oldenlandia corymbosa</i> L.	Rubiaceae	2779.7	694.93	1.25	5	62.5	1.72
46	<i>Phyllanthus amarus</i> Schumach. & Thonn.	Euphorbiaceae	7544.9	1886.23	3.40	8	100	2.75
47	<i>Phyllanthus reticulatus</i> Poir.	Euphorbiaceae	13	3.25	0.01	5	62.5	1.72
48	<i>Phyllanthus urinaria</i> L.	Euphorbiaceae	7544.9	1886.23	3.40	8	100	2.75
49	<i>Pouzolzia zeylanica</i> (L.) Benn.	Urticaceae	4368.1	1092.03	1.97	6	75	2.06
50	<i>Sida acuta</i> Burm.f.	Malvaceae	13	3.25	0.01	6	75	2.06
51	<i>Sida cordifolia</i> L.	Malvaceae	12	3	0.01	5	62.5	1.72
52	<i>Sida rhombifolia</i> L.	Malvaceae	14	3.5	0.01	6	75	2.06
53	<i>Swietenia macrophylla</i> King.	Meliaceae	1	0.25	0.001	1	12.5	0.34
54	<i>Synedrella nodiflora</i> (L.) Gaertn.	Asteraceae	5162.3	1290.58	2.33	7	87.5	2.41
55	<i>Tabernaemontana alternifolia</i> L.	Apocynaceae	5	1.25	0.002	3	37.5	1.03
56	<i>Tectona grandis</i> L.f.	Verbenaceae	1	0.25	0.001	1	12.5	0.34
57	<i>Terminalia catappa</i> L.	Combretaceae	1	0.25	0.001	1	12.5	0.34
58	<i>Tiliacora racemosa</i> Colebr.	Menispermaceae	10	2.5	0.01	3	37.5	1.03
59	<i>Triumfetta rhomboidea</i> Jacq.	Tiliaceae	22	5.5	0.01	7	87.5	2.41
60	<i>Vitex altissima</i> L.f.	Verbenaceae	1	0.25	0.001	1	12.5	0.34
	Genus-53; Species-60	Family-30	221848			291		

The distribution frequency range of plant species in Sankulangara sacred grove indicates, 59.4% plant species in the grove are coming under good and fairly good frequency ranges. About 10.89% of species recorded moderate frequency range while rest of the 29.7% of species are in the mostly poor and poor frequency range. The disturbed land showed 63.33% species are in the good and fairly good frequency ranges while only 1.67% of species are in the moderate frequency range whereas, rest of the 35% of species recorded in the mostly poor and poor frequency range (table B4).

Table B4. Distribution frequency range of total plant species

Frequency range	Sankulangara sacred grove		Disturbed land	
	No. of plant species	% of species	No. of plant species	% of species
1- 20% (Poor)	6	5.94	9	15
21-40% (Mostly poor)	24	23.76	12	20
41-60% (Moderate)	11	10.89	1	1.67
61-80% (Fairly good)	34	33.66	20	33.33
81-100% (Good)	26	25.74	18	30

Plant group wise distribution analysis**Trees**

The analysis of tree distribution in the Sankulangara sacred grove showed total 447 trees belonging to a total of 22 families and which comprise of 30 genera and 36 species (table B5). The tree species *Hopea ponga* recorded highest individual population of 101 and highest D and RD of 25.25 and 22.60% respectively. Immediately followed by *Caryota urens* and then *Vateria indica* having total representation of 32 and 31 individuals with D & RD of 8 & 7.16% and 7.5 & 6.94% respectively. The highest RF value of 4.97% recorded by 5 tree species and which includes *Hopea ponga*, *Caryota urens*, *Artocarpus hirsutus*, *Quassia indica* and *Hydnocarpus pentandrus*. This is immediately followed by RF value 4.35% recorded by *Vateria indica*, *Olea dioica*, *Xanthophyllum arnottianum*, *Aporosa cardiosperma*, *Holigarna arnottiana* and *Aphanamixis polystachya*.

The tree distribution details in the disturbed non-sacred grove land is depicted in table B6. The total tree population is 57 which belong to 14 families and comprise of 17 genera and 18 species. The highest individual population of 16 and highest D & RD values of 4 & 28.07% respectively recorded by *Cocos nucifera*. This is immediately followed by tree species *Areca catechu* and *Tabernaemontana alternifolia* which recorded total representation of 13 and 5 and immediate highest D & RD of 3.25 & 22.81% and 1.25 & 8.77% respectively. The highest RF of 16.7% recorded by two tree species *C. nucifera* and *A. catechu*, followed immediately by scoring RF value of 8.33% by *T. alternifolia*.

Table B5: Details of tree distribution in Sankulangara sacred grove

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Adenanthera pavonina</i>	Leguminosae	3	0.75	0.67	2	25	1.24
2	<i>Aphanamixis polystachya</i>	Meliaceae	12	3	2.69	7	87.5	4.35
3	<i>Aporosa cardiosperma</i>	Euphorbiaceae	16	4	3.58	7	87.5	4.35

4	<i>Areca catechu</i>	Arecaceae	4	1	0.90	4	50	2.48
5	<i>Artocarpus hirsutus</i>	Moraceae	30	7.5	6.71	8	100	4.97
6	<i>Carallia brachiata</i>	Rhizophoraceae	3	0.75	0.67	3	37.5	1.86
7	<i>Caryota urens</i>	Arecaceae	32	8	7.16	8	100	4.97
8	<i>Chrysophyllum cainito</i>	Sapotaceae	4	1	0.90	2	25	1.24
9	<i>Cinnamomum malabattrum</i>	Lauraceae	14	3.5	3.13	6	75	3.73
10	<i>Ficus amplissima</i>	Moraceae	11	2.75	2.46	6	75	3.73
11	<i>Ficus benghalensis</i>	Moraceae	1	0.25	0.22	1	12.5	0.62
12	<i>Ficus drupacea</i>	Moraceae	4	1	0.90	3	37.5	1.86
13	<i>Ficus religiosa</i>	Moraceae	1	0.25	0.22	1	12.5	0.62
14	<i>Garcinia gummi-gutta</i>	Clusiaceae	9	2.25	2.01	5	62.5	3.11
15	<i>Holigarna arnottiana</i>	Anacardiaceae	14	3.5	3.13	7	87.5	4.35
16	<i>Hopea ponga</i>	Dipterocarpaceae	101	25.25	22.60	8	100	4.969
17	<i>Hydnocarpus pentandrus</i>	Flacourtiaceae	24	6	5.37	8	100	4.97
18	<i>Litsea coriacea</i>	Lauraceae	5	1.25	1.12	4	50	2.48
19	<i>Mimusops elengi</i>	Sapotaceae	12	3	2.69	6	75	3.73
20	<i>Olea dioica</i>	Oleaceae	19	4.75	4.25	7	87.5	4.35
21	<i>Persea macrantha</i>	Lauraceae	6	1.5	1.34	5	62.5	3.11
22	<i>Pinanga dicksonii</i>	Arecaceae	9	2.25	2.01	6	75	3.73
23	<i>Pouteria campechiana</i>	Sapotaceae	1	0.25	0.22	1	12.5	0.62
24	<i>Quassia indica</i>	Simaroubaceae	27	6.75	6.04	8	100	4.97
25	<i>Saraca asoca</i>	Leguminosae	2	0.5	0.45	2	25	1.24
26	<i>Sterculia guttata</i>	Sterculiaceae	4	1	0.90	3	37.5	1.86
27	<i>Strychnos nux-vomica</i>	Loganiaceae	1	0.25	0.22	1	12.5	0.62
28	<i>Syzygium hemisphericum</i>	Myrtaceae	2	0.5	0.45	2	25	1.24
29	<i>Syzygium lanceolatum</i>	Myrtaceae	4	1	0.90	3	37.5	1.86
30	<i>Tabernaemontana alternifolia</i>	Apocynaceae	12	3	2.69	6	75	3.73
31	<i>Terminalia bellirica</i>	Combretaceae	1	0.25	0.22	1	12.5	0.62
32	<i>Terminalia catappa</i>	Combretaceae	1	0.25	0.22	1	12.5	0.62
33	<i>Vateria indica</i>	Dipterocarpaceae	31	7.75	6.94	7	87.5	4.35
34	<i>Vitex altissima</i>	Verbenaceae	8	2	1.79	3	37.5	1.86
35	<i>Vitex pinnata</i>	Verbenaceae	2	0.5	0.45	2	25	1.24
36	<i>Xanthophyllum arnottianum</i>	Polygalaceae	17	4.25	3.80	7	87.5	4.35
Genus-30; Species-36		Family-21	447			161		

Table B6: Details of tree distribution in the disturbed non-sacred grove land

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Ailanthus triphysa</i>	Simaroubaceae	2	0.5	3.51	2	25	5.56
2	<i>Anacardium occidentale</i>	Anacardiaceae	2	0.5	3.51	2	25	5.56
3	<i>Annona squamosa</i>	Annonaceae	1	0.25	1.75	1	12.5	2.78
4	<i>Areca catechu</i>	Arecaceae	13	3.25	22.81	6	75	16.7
5	<i>Artocarpus heterophyllus</i>	Moraceae	2	0.5	3.51	2	25	5.56
6	<i>Artocarpus hirsutus</i>	Moraceae	2	0.5	3.51	1	12.5	2.78
7	<i>Bridelia retusa</i>	Euphorbiaceae	1	0.25	1.75	1	12.5	2.78
8	<i>Carallia brachiata</i>	Rhizophoraceae	1	0.25	1.75	1	12.5	2.78
9	<i>Cinnamomum verum</i>	Lauraceae	2	0.5	3.51	2	25	5.56
10	<i>Cocos nucifera</i>	Arecaceae	16	4	28.07	6	75	16.7
11	<i>Garcinia gummi-gutta</i>	Clusiaceae	2	0.5	3.51	2	25	5.56
12	<i>Hydnocarpus pentandrus</i>	Flacourtiaceae	3	0.75	5.26	2	25	5.56
13	<i>Mangifera indica</i>	Anacardiaceae	1	0.25	1.75	1	12.5	2.78
14	<i>Swietenia macrophylla</i>	Meliaceae	1	0.25	1.75	1	12.5	2.78
15	<i>Tabernaemontana alternifolia</i>	Apocynaceae	5	1.25	8.77	3	37.5	8.33
16	<i>Tectona grandis</i>	Verbenaceae	1	0.25	1.75	1	12.5	2.78
17	<i>Terminalia catappa</i>	Combretaceae	1	0.25	1.75	1	12.5	2.78
18	<i>Vitex altissima</i>	Verbenaceae	1	0.25	1.75	1	12.5	2.78
Genus-17 ; Species-18		Family-14	57			36		

The distribution frequency range of tree species in Sankulangara grove indicates 50% of the species are coming under good and fairly good frequency range while 44.45% are belonging to poor and mostly poor frequency range whereas, 5.56% recorded moderate frequency range. Disturbed non-sacred grove land showed 11.11% species have fairly good distribution while 88.89% of species exhibited poor and mostly poor frequency range (table B7).

Table B7. Distribution frequency range of tree species

Frequency range	Sankulangara sacred grove		Disturbed land	
	No. of tree species	% of species	No. of tree species	% of species
1- 20% (Poor)	6	16.67	9	50
21-40% (Mostly poor)	10	27.78	7	38.89
41-60% (Moderate)	2	5.56	0	0
61-80% (Fairly good)	7	19.44	2	11.11
81-100% (Good)	11	30.56	0	0

Shrubs

The distribution details of the plant group shrub in the grove is depicted in table B8. Total shrub population is of 360, belong to 10 families and which comprise of 16 genera and 17 species. The highest individual population of 130 with highest D & RD of 32.5 & 36.11% and highest F & RF of 100% & 8.89% are recorded by *Chassalia curviflora*. This is immediately followed by 38 individuals recorded by *Ixora coccinea* and then followed by *Ixora malabarica* and *Memecylon grande* each with 25 individuals. The highest D & RD of 9.5 & 10.56% is recorded by *I. coccinea*, followed immediately by 6.25 & 6.94% each recorded by *I. malabarica* and *M. grande*. The highest F & RF values of 87.5% & 7.78% respectively are recorded by *I. coccinea*, *I. malabarica* and *M. grande*.

In the disturbed non-sacred grove land, the total population is 159 and which belong to 9 families and comprise of 10 genera and 12 species (table B9). The highest individual population of 22 with highest D & RD values of 5.5 & 13.84% is recorded by *Triumfetta rhomboidea*. This is immediately followed by *Chromolaena odorata* and then *Hyptis suaveolens* having 19 and 18 individuals with D & RD of 4.75 & 11.95% and 4.5 & 11.32% respectively. Highest F & RF value of 87.5% & 10.9% each is recorded by *T. rhomboidea* and *H. suaveolens* and this followed immediately by values of 75% & 9.38% each recorded by *Sida rhombifolia* and *Sida acuta*.

Table B8: Distribution details of shrubs in Sankulangara sacred grove

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Bridelia stipularis</i>	Euphorbiaceae	16	4	4.44	6	75	6.67
2	<i>Canthium rheedei</i>	Rubiaceae	13	3.25	3.61	5	62.5	5.56
3	<i>Chassalia curviflora</i>	Rubiaceae	130	32.5	36.11	8	100	8.89
4	<i>Coffea travancorensis</i>	Rubiaceae	17	4.25	4.72	6	75	6.67
5	<i>Glycosmis pentaphylla</i>	Rutaceae	6	1.5	1.67	4	50	4.44
6	<i>Grewia nervosa</i>	Tiliaceae	16	4	4.44	6	75	6.67
7	<i>Hibiscus rosa-sinensis</i>	Malvaceae	3	0.75	0.83	3	37.5	3.33
8	<i>Hyptis capitata</i>	Lamiaceae	13	3.25	3.61	6	75	6.67
9	<i>Ixora coccinea</i>	Rubiaceae	6	1.5	1.67	4	50	4.44
10	<i>Ixora malabarica</i>	Rubiaceae	38	9.5	10.56	7	87.5	7.78
11	<i>Leea indica</i>	Leeaceae	25	6.25	6.94	7	87.5	7.78

12	<i>Memecylon grande</i>	Melastomataceae	18	4.5	5.0	6	75	6.67
13	<i>Mussaenda frondosa</i>	Rubiaceae	25	6.25	6.94	7	87.5	7.78
14	<i>Ocimum tenuiflorum</i>	Lamiaceae	6	1.5	1.67	3	37.5	3.33
15	<i>Pandanus kaida</i>	Pandanaceae	5	1.25	1.39	3	37.5	3.33
16	<i>Polyalthia korintii</i>	Annonaceae	12	3	3.33	5	62.5	5.56
17	<i>Syzygium zeylanicum</i>	Myrtaceae	11	2.75	3.06	4	50	4.44
Genus-16; Species- 17		Family-10	360			90		

Table B9: Distribution details of shrubs in the disturbed non-sacred grove land

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Chassalia curviflora</i>	Rubiaceae	9	2.25	5.66	3	37.5	4.69
2	<i>Chromolaena odorata</i>	Asteraceae	19	4.75	11.95	5	62.5	7.81
3	<i>Clerodendrum infortunatum</i>	Verbenaceae	12	3	7.55	5	62.5	7.81
4	<i>Crotalaria pallida</i>	Leguminosae	7	1.75	4.40	5	62.5	7.81
5	<i>Hibiscus surattensis</i>	Malvaceae	12	3	7.55	5	62.5	7.81
6	<i>Hyptis suaveolens</i>	Lamiaceae	18	4.5	11.32	7	87.5	10.9
7	<i>Leea indica</i>	Leeaceae	8	2	5.03	5	62.5	7.81
8	<i>Phyllanthus reticulatus</i>	Euphorbiaceae	13	3.25	8.18	5	62.5	7.81
9	<i>Sida acuta</i>	Malvaceae	13	3.25	8.18	6	75	9.38
10	<i>Sida cordifolia</i>	Malvaceae	12	3	7.55	5	62.5	7.81
11	<i>Sida rhombifolia</i>	Malvaceae	14	3.5	8.81	6	75	9.38
12	<i>Triumfetta rhomboidea</i>	Tiliaceae	22	5.5	13.84	7	87.5	10.9
Genus-10; Species-12		Family- 9	159			64		

Table B10. Distribution frequency range of shrub species

Frequency range	Sankulangara sacred grove		Disturbed land	
	No. of shrub species	% of species	No. of shrub species	% of species
1- 20% (Poor)	0	0	0	0
21-40% (Mostly poor)	3	17.65	1	8.33
41-60% (Moderate)	3	17.65	0	0
61-80% (Fairly good)	7	41.18	9	75.00
81-100% (Good)	4	23.53	2	16.67

The distribution frequency range of shrubs in Sankulangara grove indicates 64.71% of the species belong to good and fairly good frequency range while 17.65% species each found recorded moderate and mostly poor frequency range (table B10). However in the disturbed

non-sacred grove land, the majority of the species (91.67%) exhibited good and fairly good frequency range and 8.33% of species recorded mostly poor frequency range. None of the species exhibited poor frequency distribution range in both grove and disturbed land.

Herbs

Total population of 211 herbs are recorded in the Sankulangara grove which belong to 12 families and these comprise of 15 genera and 15 species (table B11). The highest individual population, D and RD recorded by the herb *Panicum notatum* and the values are 26, 6.5 and 12.75% respectively. Immediately followed by *Mitracarpus hirtus* and *Biophytum reinwardtii* having total population of 20 and 19 with D & RD values 5 & 9.80% and 4.75 & 9.31% respectively. The highest F & RF values of 87.5 & 8.75% are recorded by 4 species *Panicum notatum*, *Mitracarpus hirtus*, *Biophytum reinwardtii* and *Cheilocostus speciosus*. This is immediately followed by values 75% & 7.5% each recorded by 5 species *Anisomeles indica*, *Brachiaria subquadriflora*, *Emilia sonchifolia*, *Elephantopus scaber* and *Desmodium gangeticum*.

The disturbed land recorded total population of 221583 herbs belong to 12 families and which comprise of 23 genera and 26 species (table B12). The highest individual population, D and RD recorded by the herb *Cynodon dactylon* and the values are 30180, 7545 and 13.62% respectively. This is immediately followed by *Desmodium triflorum* and *Commelina diffusa* having total population of 24620 and 20649 with D & RD values of 6155 & 11.11% and 5162 & 9.32% respectively. The highest F & RF values 100% & 4.42% respectively each recorded by 13 species which include *Cynodon dactylon*, *Desmodium triflorum*, *Commelina diffusa*, *Brachiaria subquadriflora*, *Murdannia pauciflora*, *Mitracarpus hirtus*, *Mimosa pudica*, *Eragrostis amabilis*, *Eragrostis unioides*, *Digitaria ciliaris*, *Aerva lanata*, *Phyllanthus amarus* and *Phyllanthus urinaria*. This immediately followed by values 87.5% & 3.87% each recorded by 3 species *Ludwigia hyssopifolia*, *Synedrella nodiflora* and *Cyperus rotundus*.

Table B11: Distribution details of herbs in Sankulangara sacred grove

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Aerva lanata</i>	Amaranthaceae	7	1.75	3.43	4	50	5
2	<i>Andrographis paniculata</i>	Acanthaceae	7	1.75	3.43	4	50	5
3	<i>Anisomeles indica</i>	Lamiaceae	16	4	7.84	6	75	7.5

4	<i>Biophytum reinwardtii</i>	Oxalidaceae	19	4.75	9.31	7	87.5	8.75
5	<i>Brachiaria subquadriflora</i>	Poaceae	14	3.5	6.86	6	75	7.5
6	<i>Centella asiatica</i>	Apiaceae	18	4.5	8.82	5	62.5	6.25
7	<i>Cheilocostus speciosus</i>	Costaceae	18	4.5	8.82	7	87.5	8.75
8	<i>Desmodium gangeticum</i>	Leguminosae	11	2.75	5.39	6	75	7.5
9	<i>Elephantopus scaber</i>	Asteraceae	12	3	5.88	6	75	7.5
10	<i>Emilia sonchifolia</i>	Asteraceae	13	3.25	6.37	6	75	7.5
11	<i>Laportea interrupta</i>	Urticaceae	10	2.5	4.90	3	37.5	3.75
12	<i>Mitracarpus hirtus</i>	Rubiaceae	20	5	9.80	7	87.5	8.75
13	<i>Ocimum basilicum</i>	Lamiaceae	2	0.5	0.98	2	25	2.5
14	<i>Panicum notatum.</i>	Poaceae	26	6.5	12.75	7	87.5	8.75
15	<i>Torenia bicolor</i>	Scrophulariaceae	18	4.5	8.82	4	50	5
	Genus-15; Species-15	Family-12	211			80		

Table B12: Distribution details of herbs in the disturbed non-sacred grove land

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Aerva lanata</i>	Amaranthaceae	9133.3	2283.33	4.122	8	100	4.57
2	<i>Alloterospis cimicina</i>	Poaceae	4765.2	1191.3	2.151	6	75	3.43
3	<i>Biophytum reinwardtii</i>	Oxalidaceae	2779.7	694.93	1.254	6	75	3.43
4	<i>Brachiaria subquadriflora</i>	Poaceae	13104.6	3276.15	5.914	8	100	4.57
5	<i>Commelina diffusa</i>	Commelinaceae	20649.2	5162.3	9.319	8	100	4.57
6	<i>Cyathula prostrata</i>	Amaranthaceae	3573.9	893.48	1.613	6	75	3.43
7	<i>Cynodon dactylon</i>	Poaceae	30180.0	7545	13.62	8	100	4.57
8	<i>Desmodium triflorum</i>	Leguminosae	24620.2	6155.05	11.11	8	100	4.57
9	<i>Digitaria ciliaris</i>	Poaceae	9133.3	2283.33	4.122	8	100	4.57
10	<i>Eleutheranthera ruderalis</i>	Asteraceae	3176.8	794.2	1.434	6	75	3.43
11	<i>Eragrostis amabilis</i>	Poaceae	9530.4	2382.6	4.301	8	100	4.57
12	<i>Eragrostis unioides</i>	Poaceae	9530.5	2382.63	4.301	8	100	4.57
13	<i>Euphorbia hirta</i>	Euphorbiaceae	3176.8	794.2	1.434	5	62.5	2.86
14	<i>Euphorbia thymifolia</i>	Euphorbiaceae	3573.9	893.48	1.613	6	75	3.43
15	<i>Cyperus rotundus</i>	Cyperaceae	4765.2	1191.3	2.151	7	87.5	4
16	<i>Laportea interrupta</i>	Urticaceae	2382.6	595.65	1.075	2	25	1.14
17	<i>Leucas aspera</i>	Lamiaceae	3176.8	794.2	1.434	2	25	1.14
18	<i>Ludwigia hyssopifolia</i>	Onagraceae	5956.5	1489.13	2.688	7	87.5	4

19	<i>Mimosa pudica</i>	Leguminosae	9927.5	2481.88	4.48	8	100	4.57
20	<i>Mitracarpus hirtus</i>	Rubiaceae	10324.6	2581.15	4.659	8	100	4.57
21	<i>Murdannia pauciflora</i>	Commelinaceae	10721.7	2680.43	4.839	8	100	4.57
22	<i>Oldenlandia corymbosa</i>	Rubiaceae	2779.7	694.93	1.254	5	62.5	2.86
23	<i>Phyllanthus amarus</i>	Euphorbiaceae	7544.9	1886.23	3.405	8	100	4.57
24	<i>Phyllanthus urinaria</i>	Euphorbiaceae	7544.9	1886.23	3.405	8	100	4.57
25	<i>Pouzolzia zeylanica</i>	Urticaceae	4368.1	1092.03	1.971	6	75	3.43
26	<i>Synedrella nodiflora</i>	Asteraceae	5162.3	1290.58	2.33	7	87.5	4
	Genus-23; Species26	Family-12	221583			175		

Table B13. Distribution frequency range of herbaceous species

Frequency range	Sankulangara sacred grove		Disturbed land	
	No. of herbs species	% of species	No. of herbs species	% of species
1- 20% (Poor)	0	0	0	0
21-40% (Mostly poor)	2	13.33	2	7.69
41-60% (Moderate)	3	20	0	0
61-80% (Fairly good)	6	40	8	30.77
81-100% (Good)	4	26.67	16	61.54

The distribution frequency range plant group herbs showed 66.67% of species are coming under good and fairly good frequency range while 20% in the moderate range and 13.33% in the mostly poor frequency range. The disturbed land showed most of the herbaceous plant species (92.31%) are in the good and fairly good frequency range and rest of the 7.69% of species recorded under the mostly poor frequency range (table B13).

Climbers

Climbers in the Sankulangara sacred grove recorded total population of 922 individuals belong to 17 families and which comprise of 24 genera and 25 species (table B14). Highest individual population of 318 with maximum D & RD of 79.5 & 34.49% in the study is recorded by *Smilax zeylanica*. This is immediately followed by *Pothos scandens* and *Tiliacora racemosa* which are having total representation of 100 and 78 individuals and D & RD values of 25 & 10.85% and 19.5 & 8.46% respectively. The species *Smilax zeylanica*, *Pothos scandens* and *Cayratia japonica* recorded the highest F & RF values of 100% & 6.11% respectively each and this is followed by 87.5% & 5.34% each recorded by *Tiliacora racemosa* and *Strychnos minor*.

The disturbed land recorded total population of 49 climbers belong to 4 families and this comprise of 4 genera and 4 species (table B15). Highest individual population of 20 with maximum D & RD values of 5 & 40.82% and maximum F & RF values of 75% & 37.5% respectively in the study recorded by *Mikania micrantha*. This is followed immediately by *Hewittia malabarica* and *Tiliacora racemosa*, both having total representation of 10 with D & RD values of 2.5 & 20.41% each. However, the immediate highest values of F & RF are recorded by *Hewittia malabarica* and are 50% & 25% while, it is 37.5% & 18.75% for *Tiliacora racemosa*.

Table B14: Distribution details of climbers in Sankulangara sacred grove

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Abrus precatorius</i>	Leguminosae	19	4.75	2.06	6	75	4.58
2	<i>Aristolochia indica</i>	Aristolochiaceae	7	1.75	0.76	4	50	3.05
3	<i>Asparagus racemosus</i>	Liliaceae	16	4	1.74	6	75	4.58
4	<i>Cansjera rheedii</i>	Opiliaceae	27	6.75	2.93	5	62.5	3.82
5	<i>Cayratia japonica</i>	Vitaceae	42	10.5	4.56	8	100	6.11
6	<i>Cayratia pedata</i>	Vitaceae	20	5	2.17	5	62.5	3.82
7	<i>Clitoria ternatea</i>	Leguminosae	8	2	0.87	4	50	3.05
8	<i>Cyclea peltata</i>	Menispermaceae	16	4	1.74	6	75	4.58
9	<i>Dalbergia volubilis</i>	Leguminosae	14	3.5	1.52	6	75	4.58
10	<i>Dioscorea bulbifera</i>	Dioscoreaceae	24	6	2.60	6	75	4.58
11	<i>Dregea volubilis</i>	Asclepiadaceae	7	1.75	0.76	3	37.5	2.29
12	<i>Gloriosa superba</i>	Liliaceae	14	3.5	1.52	4	50	3.05
13	<i>Hemidesmus indicus</i>	Periplocaceae	5	1.25	0.54	3	37.5	2.29
14	<i>Ichnocarpus frutescens</i>	Apocynaceae	48	12	5.21	6	75	4.58
15	<i>Jasminum angustifolium</i>	Oleaceae	4	1	0.43	2	25	1.53
16	<i>Kametia caryophyllata</i>	Apocynaceae	12	3	1.30	3	37.5	2.29
17	<i>Mikania micrantha</i>	Asteraceae	24	6	2.60	6	75	4.58
18	<i>Mukia maderaspatana</i>	Cucurbitaceae	35	8.75	3.80	6	75	4.58
19	<i>Myxopyrum smilacifolium</i>	Oleaceae	18	4.5	1.95	6	75	4.58
20	<i>Piper nigrum</i>	Piperaceae	4	1	0.43	3	37.5	2.29
21	<i>Pothos scandens</i>	Araceae	100	25	10.85	8	100	6.11
22	<i>Smilax zeylanica</i>	Smilacaceae	318	79.5	34.49	8	100	6.11
23	<i>Strychnos minor</i>	Loganiaceae	53	13.25	5.75	7	87.5	5.34

24	<i>Tiliacora racemosa</i>	Menispermaceae	78	19.5	8.46	7	87.5	5.34
25	<i>Vigna umbellata</i>	Leguminosae	9	2.25	0.98	3	37.5	2.29
	Genus-24; Species-25	Family-17	922			131		

Table B15: Distribution details of climbers in the disturbed land

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Hewittia malabarica</i>	Convolvulaceae	9	2.25	18.37	3	37.5	18.75
2	<i>Ichnocarpus frutescens</i>	Apocynaceae	10	2.5	20.41	3	37.5	18.75
3	<i>Mikania micrantha</i>	Asteraceae	10	2.5	20.41	4	50	25
4	<i>Tiliacora racemosa</i>	Menispermaceae	20	5	40.82	6	75	37.5
	Genus-4; Species-4	Family-4	49			16		

About 64% of climbing species are recorded good and fairly good frequency range, 12% species in the moderate frequency range while 24% species in the mostly poor range (table B16). However in the disturbed land, very low species diversity and in which 50% of species are belonging to mostly poor frequency range while 25% of species each recorded under moderate and fairly good frequency range.

Table B16. Distribution frequency range of climber species

Frequency range	Sankulangara sacred grove		Disturbed land	
	No. of herbs species	% of species	No. of herbs species	% of species
1- 20% (Poor)	0	0	0	0
21-40% (Mostly poor)	6	24	2	50
41-60% (Moderate)	3	12	1	25
61-80% (Fairly good)	11	44	1	25
81-100% (Good)	5	20	0	0

Lianas

The data presented in the table B17 shows total population of 182 lianas in Sankulanagara grove which belong to 7 families and this comprise of 8 genera and 8 species. Highest individual population of 55 with highest D & RD values of 13.75 & 30.22% and similarly highest F & RF values of 100% & 21.05% respectively in the study are recorded by *Gnetum ula*. The immediate next highest individual representation of 35 and D & RD values of 8.75 & 19.23% recorded by *Uvaria narum*. Whereas, immediate highest F & RF values of 87.5% & 18.42% respectively are recorded by *Dalbergia horrida*. Lianas are totally absent in the disturbed non-sacred grove land.

Table B17: Distribution details of lianas in Sankulangara sacred grove

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Anodendron paniculatum</i>	Apocynaceae	2	0.5	1.10	2	25	5.26
2	<i>Connarus monocarpus</i>	Connaraceae	2	0.5	1.10	2	25	5.26
3	<i>Dalbergia horrida</i>	Leguminosae	32	8	17.58	7	87.5	18.42
4	<i>Erycibe paniculata</i>	Convolvulaceae	8	2	4.40	3	37.5	7.90
5	<i>Gnetum ula</i>	Gnetaceae	55	13.75	30.22	8	100	21.05
6	<i>Rourea minor</i>	Connaraceae	28	7	15.39	6	75	15.79
7	<i>Tetrastigma leucostaphylum</i>	Vitaceae	20	5	10.99	5	62.5	13.16
8	<i>Uvaria narum</i>	Annonaceae	35	8.75	19.23	5	62.5	13.16
	Genus-8; Species-8	Family-7	182			38		

Table B18. Distribution frequency range of liana species

Frequency range	Sankulangara sacred grove		Disturbed land	
	No. of herbs species	% of species	No. of herbs species	% of species
1- 20% (Poor)	0	0	0	0
21-40% (Mostly poor)	3	37.5	0	0
41-60% (Moderate)	0	0	0	0
61-80% (Fairly good)	3	37.5	0	0
81-100% (Good)	2	25	0	0

The distribution frequency range of plant group lianas in the grove indicates majority of the species (62.5%) are occupying in the good and fairly good frequency range and the rest of the species (37.5%) are found distributed under the mostly poor frequency range (table B18).

2) Palliyana site

Analysis of total floral distribution

The total floral distribution in the Palliyana sacred grove showed presence of 1716 plants, 53 families, 91 genera and 101 species (table B19). The highest individual population and D & RD are recorded by the climber *Tiliacora racemosa* and the values are 65 and 16.25 & 3.79% respectively. This is immediately followed by climbers *Ichnocarpus frutescens* and then *Pothos scandens* having total population of 59 and 50 and D & RD values of 14.75 & 3.44% and 12.5 & 2.91% respectively. The highest F & RF values of 100% & 1.63% respectively being recorded by 14 plant species. This include tree species *Artocarpus hirsutus*, *Aphanamixis polystachya*, *Hydnocarpus pentandrus*, *Holigarna arnottiana* and *Sterculia*

guttata; species of shrubs *Ixora coccinea*; *Briedelia stipularis* and *Chassalia curviflora*; species of climbers *Tiliacora racemosa*, *Pothos scandens*, *Ichnocarpus frutescens* and *Strychnos minor* and species of lianas *Gnetum ula* and *Uvaria narum*. This is immediately followed by values of 87.5% & 1.43% recorded by 7 plant species and this includes tree species *Persea macrantha*, *Vitex altissima*, *Pongamia pinnata* and *Mimusops elengi*; species of climbers *Smilax zeylanica* and *Tinospora cordifolia* and the liana species *Salacia fruticosa*.

Table B19: Details of total floral distribution in Palliyana sacred grove

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Abrus precatorius</i> L.	Leguminosae	36	9	2.10	6	75	1.22
2	<i>Adenanthera pavonina</i> L.	Leguminosae	8	2	0.47	5	62.5	1.02
3	<i>Alstonia scholaris</i> (L.) R. Br.	Apocynaceae	1	0.25	0.06	1	12.5	0.20
4	<i>Anacardium occidentale</i> L.	Anacardiaceae	7	1.75	0.41	4	50	0.82
5	<i>Anamirta cocculus</i> (L.) Wight & Arn.	Menispermaceae	24	6	1.40	4	50	0.82
6	<i>Anodendron paniculatum</i> A.DC.	Apocynaceae	9	2.25	0.52	4	50	0.82
7	<i>Aphanamixis polystachya</i> (Wall.) R.Parker	Meliaceae	22	5.5	1.28	8	100	1.63
8	<i>Aporosa cardiosperma</i> (Gaertn.) Merr.	Euphorbiaceae	10	2.5	0.58	5	62.5	1.02
9	<i>Areca catechu</i> L.	Arecaceae	9	2.25	0.52	5	62.5	1.02
10	<i>Aristolochia indica</i> L.	Aristolochiaceae	21	5.25	1.22	4	50	0.82
11	<i>Artocarpus hirsutus</i> Lam.	Moraceae	23	5.75	1.34	8	100	1.63
12	<i>Asparagus racemosus</i> Willd.	Liliaceae	21	5.25	1.22	4	50	0.82
13	<i>Bambusa bambos</i> (L.) Voss	Poaceae	9	2.25	0.52	4	50	0.82
14	<i>Bambusa vulgaris</i> Schrad.	Poaceae	16	4	0.93	6	75	1.22
15	<i>Bauhinia acuminata</i> L.	Leguminosae	1	0.25	0.06	1	12.5	0.20
16	<i>Biophytum reinwardtii</i> (Zucc.) Klotzsch	Oxalidaceae	19	4.75	1.11	4	50	0.82
17	<i>Brachiaria remota</i> (Retz.) Haines	Poaceae	15	3.75	0.87	4	50	0.82
18	<i>Bridelia retusa</i> (L.) A.Juss.	Euphorbiaceae	4	1	0.23	2	25	0.41
19	<i>Bridelia stipularis</i> (L.) Blume	Euphorbiaceae	33	8.25	1.92	8	100	1.63
20	<i>Canthium rheedei</i> DC.	Rubiaceae	20	5	1.17	6	75	1.22
21	<i>Caryota urens</i> L.	Arecaceae	13	3.25	0.76	6	75	1.22
22	<i>Cayratia pedata</i> (Lam.) Gagnep.	Vitaceae	30	7.5	1.75	5	62.5	1.02
23	<i>Chassalia curviflora</i> (Wall.) Thwaites	Rubiaceae	27	6.75	1.57	8	100	1.63
24	<i>Chrysophyllum cainito</i> L.	Sapotaceae	10	2.5	0.58	5	62.5	1.02
25	<i>Cinnamomum malabattrum</i> (Burm.f.) J.Presl	Lauraceae	15	3.75	0.87	6	75	1.22

26	<i>Clerodendrum paniculatum</i> L.	Verbenaceae	15	3.75	0.87	5	62.5	1.02
27	<i>Coffea travancorensis</i> Wight & Arn.	Rubiaceae	16	4	0.93	6	75	1.22
28	<i>Connarus monocarpus</i> L.	Connaraceae	9	2.25	0.52	5	62.5	1.02
29	<i>Curculigo orchiodes</i> Gaertn.	Hypoxidaceae	17	4.25	0.99	5	62.5	1.02
30	<i>Cyanthillium cinereum</i> (L.) H. Rob.	Asteraceae	17	4.25	0.99	6	75	1.22
31	<i>Cyathula prostrata</i> (L.) Blume	Amaranthaceae	24	6	1.40	6	75	1.22
32	<i>Cyclea peltata</i> (Lam.) Hook. f. & Thomson	Menispermaceae	31	7.75	1.81	6	75	1.22
33	<i>Cyperus rotundus</i> L.	Cyperaceae	26	6.5	1.52	4	50	0.82
34	<i>Derris scandens</i> (Roxb.) Benth.	Leguminosae	9	2.25	0.52	3	37.5	0.61
35	<i>Desmodium gangeticum</i> (L.) DC.	Leguminosae	11	2.75	0.64	4	50	0.82
36	<i>Dioscorea bulbifera</i> L.	Dioscoreaceae	21	5.25	1.22	4	50	0.82
37	<i>Diospyros malabarica</i> (Desr.) Kostel.	Ebenaceae	2	0.5	0.12	2	25	0.41
38	<i>Emilia sonchifolia</i> (L.) DC. ex DC.	Asteraceae	19	4.75	1.11	5	62.5	1.02
39	<i>Eragrostis unioides</i> (Retz.) Nees ex Steud.	Poaceae	33	8.25	1.92	6	75	1.22 ₄
40	<i>Ficus benghalensis</i> L.	Moraceae	1	0.25	0.06	1	12.5	0.20
41	<i>Ficus religiosa</i> L.	Moraceae	1	0.25	0.06	1	12.5	0.20
42	<i>Garcinia gummi-gutta</i> (L.) Roxb.	Clusiaceae	12	3	0.70	6	75	1.22
43	<i>Glycosmis pentaphylla</i> (Retz.) DC.	Rutaceae	23	5.75	1.34	6	75	1.22
44	<i>Gnetum ula</i> Brongn.	Gnetaceae	16	4	0.93	8	100	1.63
45	<i>Grewia nervosa</i> (Lour.) Panigrahi	Tiliaceae	12	3	0.70	4	50	0.82
46	<i>Gymnema sylvestre</i> (Retz.) R. Br. ex Sm.	Asclepiadaceae	14	3.5	0.82	4	50	0.82
47	<i>Hibiscus rosa-sinensis</i> L.	Malvaceae	17	4.25	0.99	5	62.5	1.02
48	<i>Holigarna arnottiana</i> Hook. f.	Anacardiaceae	20	5	1.17	8	100	1.63
49	<i>Hydnocarpus pentandrus</i> (Buch.-Ham.) Oken	Flacourtiaceae	20	5	1.17	8	100	1.63
50	<i>Ichnocarpus frutescens</i> (L.) W. T. Aiton	Apocynaceae	59	14.75	3.44	8	100	1.63
51	<i>Ixora coccinea</i> L.	Rubiaceae	38	9.5	2.21	8	100	1.63
52	<i>Ixora malabarica</i> (Dennst.) Mabb.	Rubiaceae	25	6.25	1.46	6	75	1.22
53	<i>Justicia gendarussa</i> Burm. f.	Acanthaceae	5	1.25	0.29	2	25	0.41
54	<i>Justicia procumbens</i> L.	Acanthaceae	20	5	1.17	4	50	0.82
55	<i>Laportea interrupta</i> (L.) Chew	Urticaceae	10	2.5	0.58	2	25	0.41
56	<i>Leea indica</i> (Burm. f.) Merr.	Leeaceae	18	4.5	1.05	5	62.5	1.02
57	<i>Litsea coriacea</i> Hook. f.	Lauraceae	12	3	0.70	6	75	1.22
58	<i>Memecylon depressum</i> Benth.	Melastomataceae	11	2.75	0.64	3	37.5	0.61
59	<i>Mikania micrantha</i> Kunth.	Asteraceae	28	7	1.63	5	62.5	1.02

60	<i>Mimusops elengi</i> L.	Sapotaceae	13	3.25	0.76	7	87.5	1.43
61	<i>Mitracarpus hirtus</i> (L.) DC.	Rubiaceae	20	5	1.17	4	50	0.82
62	<i>Mukia maderaspatana</i> (L.) M.Roem.	Cucurbitaceae	25	6.25	1.46	4	50	0.82
63	<i>Mussaenda frondosa</i> L.	Rubiaceae	6	1.5	0.35	2	25	0.41
64	<i>Naravelia zeylanica</i> (L.) DC.	Ranunculaceae	18	4.5	1.05	4	50	0.82
65	<i>Nothapodytes nimmoniana</i> (J.Graham) Mabb.	Icacinaceae	17	4.25	0.99	5	62.5	1.02
66	<i>Ocimum basilicum</i> L.	Lamiaceae	11	2.75	0.64	4	50	0.82
67	<i>Ocimum tenuiflorum</i> L.	Lamiaceae	2	0.5	0.12	1	12.5	0.20
68	<i>Olea dioica</i> Roxb.	Oleaceae	10	2.5	0.58	6	75	1.22
69	<i>Pandanus kaida</i> Kurz.	Pandanaceae	12	3	0.70	4	50	0.82
70	<i>Panicum notatum</i> Retz.	Poaceae	29	7.25	1.69	6	75	1.22
71	<i>Pavetta indica</i> L.	Rubiaceae	10	2.5	0.58	5	62.5	1.02
72	<i>Persea macrantha</i> (Nees) Kosterm.	Lauraceae	16	4	0.93	7	87.5	1.43
73	<i>Piper nigrum</i> L.	Piperaceae	7	1.75	0.41	3	37.5	0.61
74	<i>Polyalthia korinti</i> (Dunal) Thwaites.	Annonaceae	9	2.25	0.52	5	62.5	1.02
75	<i>Polyalthia longifolia</i> (Sonn.) Thwaites.	Annonaceae	3	0.75	0.18	2	25	0.41
76	<i>Pongamia pinnata</i> (L.) Pierre.	Leguminosae	19	4.75	1.11	7	87.5	1.43
77	<i>Pothos scandens</i> L.	Araceae	50	12.5	2.91	8	100	1.63
78	<i>Quassia indica</i> (Gaertn.) Noot.	Simaroubaceae	14	3.5	0.82	6	75	1.22
79	<i>Rauvolfia serpentina</i> (L.) Benth. ex Kurz.	Apocynaceae	11	2.75	0.64	5	62.5	1.02
80	<i>Rourea minor</i> (Gaertn.) Alston.	Connaraceae	15	3.75	0.87	6	75	1.22
81	<i>Salacia fruticosa</i> Wall.	Hippocrateaceae	19	4.75	1.11	7	87.5	1.43
82	<i>Saraca asoca</i> (Roxb.) Willd.	Leguminosae	1	0.25	0.06	1	12.5	0.20
83	<i>Sarcostigma kleinii</i> Wight & Arn.	Icacinaceae	15	3.75	0.87	6	75	1.22
84	<i>Smilax zeylanica</i> L.	Smilacaceae	44	11	2.56	7	87.5	1.43
85	<i>Sterculia guttata</i> Roxb.	Sterculiaceae	19	4.75	1.11	8	100	1.63
86	<i>Streblus asper</i> Lour.	Moraceae	4	1	0.23	2	25	0.41
87	<i>Strychnos minor</i> Dennst.	Loganiaceae	46	11.5	2.68	8	100	1.63
88	<i>Strychnos nux-vomica</i> L.	Loganiaceae	3	0.75	0.18	2	25	0.41
89	<i>Synedrella nodiflora</i> (L.) Gaertn.	Asteraceae	19	4.75	1.11	4	50	0.82
90	<i>Syzygium caryophyllatum</i> (L.) Alston.	Myrtaceae	5	1.25	0.29	3	37.5	0.61
91	<i>Syzygium cumini</i> (L.) Skeels.	Myrtaceae	11	2.75	0.64	5	62.5	1.02
92	<i>Tabernaemontana alternifolia</i> L.	Apocynaceae	4	1	0.23	2	25	0.41
93	<i>Tabernaemontana divaricata</i> (L.) R.Br. ex Roem. & Schult.	Apocynaceae	4	1	0.23	2	25	0.41

94	<i>Terminalia bellirica</i> (Gaertn.) Roxb.	Combretaceae	2	0.5	0.12	1	12.5	0.20
95	<i>Tiliacora racemosa</i> Colebr.	Menispermaceae	65	16.25	3.80	8	100	1.63
96	<i>Tinospora cordifolia</i> (Willd.) Miers.	Menispermaceae	40	10	2.33	7	87.5	1.43
97	<i>Tinospora sinensis</i> (Lour.) Merr.	Menispermaceae	38	9.5	2.21	6	75	1.22
98	<i>Uvaria narum</i> A.DC.	Annonaceae	18	4.5	1.05	8	100	1.63
99	<i>Vateria indica</i> L.	Dipterocarpaceae	3	0.75	0.18	2	25	0.41
100	<i>Vitex altissima</i> L.f.	Verbenaceae	16	4	0.93	7	87.5	1.43
101	<i>Xanthophyllum arnottianum</i> Wight.	Polygalaceae	8	2	0.47	3	37.5	0.61
	Genus-91; Species-101	Family-53	1716			490		

The analysis of total floral distribution in the disturbed non-sacred grove land at Palliyana site showed total population of 164104 plants, 30 families, 67 genera and 76 species (table B20). The highest individual population of 8903, D & RD values of 2225.9 & 5.43% respectively recorded by the herb *Justicia procumbens*. Immediately followed by *J.procumbens* is also 2 herbs namely *Cynodon dactylon* and *Cyathula prostrata* with total population of 8013 and D & RD values of 2003.3 & 4.88% each. The highest F & RF values of 100% & 2.39% in the study are recorded by 6 species of herbs namely *Cynodon dactylon*, *Cyathula prostrata*, *Grangea maderaspatana*, *Digitaria ciliaris*, *Chamaecrista absus* and *Brachiaria remota*. This is immediately followed by values 87.5% & 2.09% recorded by 7 plant species which includes 2 herbs *Phyllanthus amarus* and *Justicia procumbens*; 3 shrubs *Sida rhombifolia*, *Triumfetta rhomboidea*, *Hyptis suaveolens* and 2 trees *Areca catechu* and *Cocos nucifera*.

Table B20: Details of total floral distribution in the non-sacred grove land

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Abrus precatorius</i> L.	Leguminosae	8	2	0.01	4	50	1.19
2	<i>Aerva lanata</i> (L.) Juss.	Amaranthaceae	6232.4	1558.1	3.80	7	87.5	2.09
3	<i>Ageratum conyzoides</i> (L.) L.	Asteraceae	2671	667.75	1.63	4	50	1.19
4	<i>Allmania nodiflora</i> (L.) R.Br. ex Wight.	Amaranthaceae	5342	1335.5	3.26	7	87.5	2.09
5	<i>Alloteropsis semialata</i> (R.Br.) Hitchc.	Poaceae	3561.4	890.35	2.17	4	50	1.19
6	<i>Alternanthera brasiliana</i> (L.) Kuntze.	Amaranthaceae	1780.7	445.18	1.09	4	50	1.19
7	<i>Anacardium occidentale</i> L.	Anacardiaceae	2	0.5	0.001	3	37.5	0.90
8	<i>Andrographis echinoides</i> (L.) Nees.	Acanthaceae	2671	667.75	1.63	4	50	1.19
9	<i>Andrographis paniculata</i> (Burm.f.) Nees.	Acanthaceae	3561.4	890.35	2.17	5	62.5	1.49

10	<i>Anisomeles indica</i> (L.) Kuntze.	Lamiaceae	2671	667.75	1.63	3	37.5	0.90
11	<i>Areca catechu</i> L.	Arecaceae	13	3.25	0.01	7	87.5	2.09
12	<i>Artocarpus hirsutus</i> Lam.	Moraceae	2	0.5	0.001	3	37.5	0.90
13	<i>Azadirachta indica</i> A.Juss.	Meliaceae	3	0.75	0.002	2	25	0.60
14	<i>Barleria cristata</i> L.	Acanthaceae	12	3	0.007	4	50	1.19
15	<i>Boerhavia diffusa</i> L.	Nyctaginaceae	2671	667.75	1.63	4	50	1.19
16	<i>Brachiaria remota</i> (Retz.) Haines.	Poaceae	6232.4	1558.1	3.80	8	100	2.39
17	<i>Calotropis gigantea</i> (L.) Dryand.	Asclepiadaceae	4	1	0.002	1	12.5	0.30
18	<i>Chamaecrista absus</i> (L.) H.S.Irwin & Barneby.	Leguminosae	6232.4	1558.1	3.80	8	100	2.39
19	<i>Chamaecrista mimosoides</i> (L.) Greene.	Leguminosae	3561.4	890.35	2.17	4	50	1.19
20	<i>Chromolaena odorata</i> (L.) R.M.King & H.Rob.	Asteraceae	12	3	0.01	4	50	1.19
21	<i>Cleome rutidosperma</i> var. <i>burmannii</i> (Wight & Arn.) Siddiqui & S.N.Dixit.	Capparaceae	2671	667.75	1.63	3	37.5	0.90
22	<i>Cleome viscosa</i> L.	Capparaceae	2671	667.75	1.63	2	25	0.60
23	<i>Clerodendrum infortunatum</i> L.	Verbenaceae	12	3	0.01	6	75	1.79
24	<i>Cocos nucifera</i> L.	Arecaceae	14	3.5	0.01	7	87.5	2.09
25	<i>Crotalaria pallida</i> Aiton.	Leguminosae	7	1.75	0.004	3	37.5	0.90
26	<i>Cyathula prostrata</i> (L.) Blume.	Amaranthaceae	8013.1	2003.3	4.90	8	100	2.39
27	<i>Cynodon dactylon</i> (L.) Pers.	Poaceae	8013.1	2003.3	4.90	8	100	2.39
28	<i>Datura stramonium</i> L.	Solanaceae	3	0.75	0.002	1	12.5	0.30
29	<i>Dicliptera paniculata</i> (Forssk.) L.Darbysh.	Acanthaceae	6232.4	1558.1	3.80	7	87.5	2.09
30	<i>Digitaria ciliaris</i> (Retz.) Koeler.	Poaceae	7122.7	1780.7	4.34	8	100	2.39
31	<i>Eleutheranthera ruderalis</i> (Sw.) Sch.Bip.	Asteraceae	3561.4	890.35	2.17	5	62.5	1.49
32	<i>Eragrostis amabilis</i> (L.) Wight & Arn.	Poaceae	6232.4	1558.1	3.80	7	87.5	2.09
33	<i>Euphorbia hirta</i> L.	Euphorbiaceae	3561.4	890.35	2.17	5	62.5	1.49
34	<i>Euphorbia thymifolia</i> L.	Euphorbiaceae	1780.7	445.18	1.09	2	25	0.60
35	<i>Garcinia gummi-gutta</i> (L.) Roxb.	Clusiaceae	2	0.5	0.001	2	25	0.60
36	<i>Gliricidia sepium</i> (Jacq.) Walp.	Leguminosae	4	1	0.002	3	37.5	0.90
37	<i>Grangea maderaspatana</i> (L.) Poir.	Asteraceae	6232.4	1558.1	3.80	8	100	2.39
38	<i>Grewia nervosa</i> (Lour.) Panigrahi.	Tiliaceae	5	1.25	0.003	3	37.5	0.90
39	<i>Hewittia malabarica</i> (L.) Suresh	Convolvulaceae	7	1.75	0.004	3	37.5	0.90
40	<i>Hibiscus hispidissimus</i> Griff.	Malvaceae	5	1.25	0.003	4	50	1.19
41	<i>Hyptis suaveolens</i> (L.) Poit.	Lamiaceae	18	4.5	0.01	7	87.5	2.09

42	<i>Ichnocarpus frutescens</i> (L.) W.T.Aiton.	Apocynaceae	9	2.25	0.01	3	37.5	0.90
43	<i>Indigofera hirsuta</i> L.	Leguminosae	1780.7	445.18	1.09	2	25	0.60
44	<i>Justicia procumbens</i> L.	Acanthaceae	8903.4	2225.9	5.43	7	87.5	2.09
45	<i>Lannea coromandelica</i> (Houtt.) Merr.	Anacardiaceae	2	0.5	0.001	2	25	0.60
46	<i>Lantana camara</i> L.	Verbenaceae	3	0.75	0.002	1	12.5	0.30
47	<i>Laportea interrupta</i> (L.) Chew.	Urticaceae	2671	667.75	1.63	5	62.5	1.49
48	<i>Lawsonia inermis</i> L.	Lythraceae	2	0.5	0.001	1	12.5	0.30
49	<i>Leea indica</i> (Burm. f.) Merr.	Leeaceae	6	1.5	0.004	4	50	1.19
50	<i>Leucas aspera</i> (Willd.) Link.	Lamiaceae	3561.4	890.35	2.17	6	75	1.79
51	<i>Ludwigia hyssopifolia</i> (G.Don) Exell.	Onagraceae	4451.7	1112.9	2.71	5	62.5	1.49
52	<i>Mangifera indica</i> L.	Anacardiaceae	1	0.25	0.001	1	12.5	0.30
53	<i>Merremia umbellata</i> (L.) Hallier f.	Convolvulaceae	12	3	0.01	5	62.5	1.49
54	<i>Mikania micrantha</i> Kunth.	Asteraceae	12	3	0.01	6	75	1.79
55	<i>Mimosa pudica</i> L.	Leguminosae	3561.4	890.35	2.17	6	75	1.79
56	<i>Oldenlandia corymbosa</i> L.	Rubiaceae	3561.4	890.35	2.17	4	50	1.19
57	<i>Pedaliium murex</i> L.	Pedaliaceae	4451.7	1112.9	2.71	4	50	1.19
58	<i>Phyllanthus amarus</i> Schumach. & Thonn.	Euphorbiaceae	5342	1335.5	3.26	7	87.5	2.09
59	<i>Phyllanthus reticulatus</i> Poir.	Euphorbiaceae	13	3.25	0.01	5	62.5	1.49
60	<i>Phyllanthus urinaria</i> L.	Euphorbiaceae	3561.4	890.35	2.17	3	37.5	0.90
61	<i>Physalis angulata</i> L.	Solanaceae	4451.7	1112.9	2.71	4	50	1.19
62	<i>Scoparia dulcis</i> L.	Scrophulariaceae	4451.7	1112.9	2.71	5	62.5	1.49
63	<i>Senna occidentalis</i> (L.) Link.	Leguminosae	3	0.75	0.002	2	25	0.60
64	<i>Sida acuta</i> Burm.f.	Malvaceae	13	3.25	0.01	6	75	1.79
65	<i>Sida cordifolia</i> L.	Malvaceae	9	2.25	0.01	5	62.5	1.49
66	<i>Sida rhombifolia</i> L.	Malvaceae	14	3.5	0.01	7	87.5	2.09
67	<i>Sida mysorensis</i> Wight & Arn.	Malvaceae	7	1.75	0.004	4	50	1.19
68	<i>Acmella ciliata</i> (Kunth) Cass.	Asteraceae	2671	667.75	1.63	5	62.5	1.49
69	<i>Synedrella nodiflora</i> (L.) Gaertn.	Asteraceae	4451.7	1112.9	2.71	6	75	1.79
70	<i>Tectona grandis</i> L.f.	Verbenaceae	1	0.25	0.001	1	12.5	0.30
71	<i>Terminalia catappa</i> L.	Combretaceae	1	0.25	0.001	1	12.5	0.30
72	<i>Tiliacora racemosa</i> Colebr.	Menispermaceae	10	2.5	0.01	3	37.5	0.90
73	<i>Tridax procumbens</i> (L.) L.	Asteraceae	2671	667.75	1.63	5	62.5	1.49
74	<i>Triumfetta rhomboidea</i> Jacq.	Tiliaceae	22	5.5	0.013	7	87.5	2.09
75	<i>Urena lobata</i> L.	Malvaceae	7	1.75	0.004	4	50	1.19

76	<i>Vitex altissima</i> L.f.	Verbenaceae	1	0.25	0.001	1	12.5	0.30
	Genus-67 ; Species-76	Family-30	164104			335		

Table B21: Distribution frequency range of total plant species

Frequency range	Palliyana sacred grove		Disturbed land	
	No. of plant species	% of species	No. of plant species	% of species
1- 20% (Poor)	7	6.93	8	10.53
21-40% (Mostly poor)	16	15.84	18	23.68
41-60% (Moderate)	20	19.80	16	21.05
61-80% (Fairly good)	37	36.63	17	22.37
81-100% (Good)	21	20.79	17	22.37

The distribution frequency range of plant species indicate 57.42% in the grove are coming under good and fairly good frequency ranges and these comprised of good representation of plant species from most of the plant group such as trees, shrubs, climbers and lianas. In the disturbed non-sacred grove land although, 44.74% of plant species are coming under the same frequency ranges, the majority are herbs. The grove recorded 22.77% of the species in the mostly poor and poor frequency ranges while this is 34.21% in the disturbed land. About 19.8% of plant species in the grove recorded moderate level of frequency range but this is 21.05% with respect to the disturbed land (table B21).

Plant group wise distribution analysis

Trees

The details of tree distribution in the Palliyana sacred grove is depicted in table B22. Total of 341 trees, 21 families, 33 genera and 35 species is recorded in the grove. Highest individual population of 23 and the highest D & RD value of 5.75 & 6.75% is recorded by *Artocarpus hirsutus*. This is followed immediately by *Aphanamixis polystachya* and then *Hydnocarpus pentandrus* & *Holigarna arnottiana*, having total representation of 22 by *A. polystachya* and 20 each by *H. pentandrus* and *H. arnottiana*. The immediate highest D & RD values of 5.5 & 6.45% recorded by *A. polystachya* and then followed by values of 5 & 5.87% each respectively recorded by *H. pentandrus* & *H. arnottiana*. The highest F & RF values of 100% & 5.10% in the grove recorded each by *Artocarpus hirsutus*, *Aphanamixis polystachya*, *Hydnocarpus pentandrus*, *Holigarna arnottiana* and *Sterculia guttata*. This is immediately followed by the value 87.5 and 4.46% each recorded by tree species like *Persea macrantha*, *Vitex altissima*, *Pongamia pinnata* and *Mimusops elengi*.

The disturbed land recorded total population of 46 trees, 8 families, 12 genera and 12 species. The details are depicted in table B23. The highest individual population of 14 with highest D & RD value of 3.5 & 30.44% is recorded by *Cocos nucifera*. *C.nucifera* is immediately followed by *Areca catechu* and then *Gliricidia sepium* which are having total representation of 13 and 4 with D & RD value of 3.25 & 28.26% and 1 & 8.70% respectively. The highest F & RF value of 87.5% and 21.21% is recorded by *C. nucifera* and *A. catechu*. This is followed by F value of 37.5% and RF value of 9.09% recorded by *Anacardium occidentale*, *Artocarpus hirsutus* and *Gliricidia sepium*.

Table B22: Details of tree distribution in the Palliyana sacred grove

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Adenanthera pavonina</i>	Leguminosae	8	2	2.35	5	62.5	3.19
2	<i>Alstonia scholaris</i>	Apocynaceae	1	0.25	0.29	1	12.5	0.64
3	<i>Anacardium occidentale</i>	Anacardiaceae	7	1.75	2.05	4	50	2.55
4	<i>Aphanamixis polystachya</i>	Meliaceae	22	5.5	6.45	8	100	5.10
5	<i>Aporosa cardiosperma</i>	Euphorbiaceae	10	2.5	2.93	5	62.5	3.19
6	<i>Areca catechu</i>	Arecaceae	9	2.25	2.63	5	62.5	3.19
7	<i>Artocarpus hirsutus</i>	Moraceae	23	5.75	6.75	8	100	5.10
8	<i>Bridelia retusa</i>	Euphorbiaceae	4	1	1.17	2	25	1.27
9	<i>Caryota urens</i>	Arecaceae	13	3.25	3.81	6	75	3.82
10	<i>Chrysophyllum cainito</i>	Sapotaceae	10	2.5	2.93	5	62.5	3.19
11	<i>Cinnamomum malabattrum</i>	Lauraceae	15	3.75	4.40	6	75	3.82
12	<i>Diospyros malabarica</i>	Ebenaceae	2	0.5	0.59	2	25	1.27
13	<i>Ficus benghalensis</i>	Moraceae	1	0.25	0.29	1	12.5	0.64
14	<i>Ficus religiosa</i>	Moraceae	1	0.25	0.29	1	12.5	0.64
15	<i>Garcinia gummi-gutta</i>	Clusiaceae	12	3	3.51	6	75	3.82
16	<i>Holigarna arnottiana</i>	Anacardiaceae	20	5	5.87	8	100	5.10
17	<i>Hydnocarpus pentandrus</i>	Flacourtiaceae	20	5	5.87	8	100	5.10
18	<i>Litsea coriacea</i>	Lauraceae	12	3	3.52	6	75	3.82
19	<i>Mimusops elengi</i>	Sapotaceae	13	3.25	3.81	7	87.5	4.46
20	<i>Olea dioica</i>	Oleaceae	10	2.5	2.93	6	75	3.82
21	<i>Persea macrantha</i>	Lauraceae	16	4	4.69	7	87.5	4.46
22	<i>Polyalthia longifolia</i>	Annonaceae	3	0.75	0.88	2	25	1.27
23	<i>Pongamia pinnata</i>	Leguminosae	19	4.75	5.57	7	87.5	4.46
24	<i>Quassia indica</i>	Simaroubaceae	14	3.5	4.11	6	75	3.82
25	<i>Saraca asoca</i>	Leguminosae	1	0.25	0.29	1	12.5	0.64

26	<i>Sterculia guttata</i>	Sterculiaceae	19	4.75	5.57	8	100	5.10
27	<i>Streblus asper</i>	Moraceae	4	1	1.17	2	25	1.27
28	<i>Strychnos nux-vomica</i>	Loganiaceae	3	0.75	0.88	2	25	1.27
29	<i>Syzygium caryophyllatum</i>	Myrtaceae	5	1.25	1.47	3	37.5	1.91
30	<i>Syzygium cumini</i>	Myrtaceae	11	2.75	3.23	5	62.5	3.19
31	<i>Tabernaemontana alternifolia</i>	Apocynaceae	4	1	1.17	2	25	1.27
32	<i>Terminalia bellirica</i>	Combretaceae	2	0.5	0.59	1	12.5	0.64
33	<i>Vateria indica</i>	Dipterocarpaceae	3	0.75	0.88	2	25	1.27
34	<i>Vitex altissima</i>	Verbenaceae	16	4	4.69	7	87.5	4.46
35	<i>Xanthophyllum arnottianum</i>	Polygalaceae	8	2	2.35	3	37.5	1.91
	Genus-33; Species-35	Family-21	341			158		

Table B23: Details of tree distribution in the disturbed non-sacred grove land

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Anacardium occidentale</i>	Anacardiaceae	2	0.5	4.35	3	37.5	9.09
2	<i>Areca catechu</i>	Arecaceae	13	3.25	28.26	7	87.5	21.21
3	<i>Artocarpus hirsutus</i>	Moraceae	2	0.5	4.35	3	37.5	9.09
4	<i>Azadirachta indica</i>	Meliaceae	3	0.75	6.52	2	25	6.06
5	<i>Cocos nucifera</i>	Arecaceae	14	3.5	30.44	7	87.5	21.21
6	<i>Garcinia gummi-gutta</i>	Clusiaceae	2	0.5	4.35	2	25	6.06
7	<i>Gliricidia sepium</i>	Leguminosae	4	1	8.70	3	37.5	9.09
8	<i>Lannea coromandelica</i>	Anacardiaceae	2	0.5	4.35	2	25	6.06
9	<i>Mangifera indica</i>	Anacardiaceae	1	0.25	2.17	1	12.5	3.03
10	<i>Tectona grandis</i>	Verbenaceae	1	0.25	2.17	1	12.5	3.03
11	<i>Terminalia catappa</i>	Combretaceae	1	0.25	2.17	1	12.5	3.03
12	<i>Vitex altissima</i>	Verbenaceae	1	0.25	2.17	1	12.5	3.03
	Genus-12; Species-12	Family-8	46			33		

Distribution frequency range of tree species in Palliyana grove indicates 57.14% belongs to good and fairly good range while 40% of species in the poor and mostly poor frequency ranges whereas, 2.86% recorded moderate level of distribution frequency range. The disturbed non-sacred grove land showed 16.67% of species in the fairly good frequency range while 83.33% exhibited mostly poor and poor frequency range.

Table B24: Distribution frequency range of tree species

Frequency range	Palliyana sacred grove		Disturbed land	
	No. of tree species	% of species	No. of tree species	% of species
1- 20% (Poor)	5	14.29	4	33.33
21-40% (Mostly poor)	9	25.71	6	50
41-60% (Moderate)	1	2.86	0	0
61-80% (Fairly good)	11	31.43	0	0
81-100% (Good)	9	25.71	2	16.67

Shrubs

The plant group shrubs in the grove showed total population of 366 individuals belonging to 16 families which comprised of 22 genera and 24 species (table B25). The highest individual population, D, and RD values are recorded by *Ixora coccinea* and are 38, 9.5 and 10.38% respectively. Immediately followed by *I. coccinea* is *Briedelia stipularis* and then *Chassalia curviflora* which are having total population of 33 and 27 individuals and D & RD values of 8.25 & 9.02 and 6.75 & 7.38% respectively. The highest F & RF values of 100% & 6.96% each is recorded by all the above mentioned 3 species and they are immediately followed by values of 75% & 5.22% each recorded by *Bambusa vulgaris*, *Canthium rheedei*, *Glycosmis pentaphylla*, *Ixora malabarica* and *Coffea travancorensis*.

The disturbed non-sacred grove land recorded total population of 177 shrubs belonging to 12 families, comprised of 17 genera and 20 species (table B26). The highest individual representation of 22 and highest D & RD of 5.5 & 12.43% is recorded by *Triumfetta rhomboidea*. This is immediately followed by *Hyptis suaveolens* and then *Sida rhombifolia* which are having a total representation of 18 and 14 individuals and D & RD values of 4.5 & 10.17% and 3.5 & 7.91% respectively. The highest F and RF values of 88% & 8.86% each respectively recorded by 3 species *T. rhomboidea*, *S. rhombifolia* and *H. suaveolens* and this is immediately followed by values 75% & 7.59% each recorded by *Sida acuta* and *Clerodendrum infortunatum*.

Table B25: Distribution details of shrubs in the Palliyana sacred grove

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Bambusa bambos</i>	Poaceae	9	2.25	2.46	4	50	3.48
2	<i>Bambusa vulgaris</i>	Poaceae	16	4	4.37	6	75	5.22
3	<i>Bauhinia acuminata</i>	Leguminosae	1	0.25	0.27	1	12.5	0.87

4	<i>Bridelia stipularis</i>	Euphorbiaceae	33	8.25	9.02	8	100	6.96
5	<i>Canthium rheedei</i>	Rubiaceae	20	5	5.47	6	75	5.22
6	<i>Chassalia curviflora</i>	Rubiaceae	27	6.75	7.38	8	100	6.96
7	<i>Clerodendrum paniculatum</i>	Verbenaceae	15	3.75	4.10	5	62.5	4.35
8	<i>Coffea travancorensis</i>	Rubiaceae	16	4	4.37	6	75	5.22
9	<i>Glycosmis pentaphylla</i>	Rutaceae	23	5.75	6.28	6	75	5.22
10	<i>Grewia nervosa</i>	Tiliaceae	12	3	3.28	4	50	3.48
11	<i>Hibiscus rosa-sinensis</i>	Malvaceae	17	4.25	4.65	5	62.5	4.35
12	<i>Ixora coccinea</i>	Rubiaceae	38	9.5	10.38	8	100	6.96
13	<i>Ixora malabarica</i>	Rubiaceae	25	6.25	6.83	6	75	5.22
14	<i>Justicia gendarussa</i>	Acanthaceae	5	1.25	1.37	2	25	1.74
15	<i>Leea indica</i>	Leeaceae	18	4.5	4.92	5	62.5	4.35
16	<i>Memecylon depressum</i>	Melastomataceae	11	2.75	3.01	3	37.5	2.61
17	<i>Mussaenda frondosa</i>	Rubiaceae	6	1.5	1.64	2	25	1.74
18	<i>Nothapodytes nimmoniana</i>	Icacinaceae	17	4.25	4.65	5	62.5	4.35
19	<i>Ocimum tenuiflorum</i>	Lamiaceae	11	2.75	3.01	4	50	3.48
20	<i>Pandanus kaida</i>	Pandanaceae	12	3	3.28	4	50	3.478
21	<i>Pavetta indica</i>	Rubiaceae	10	2.5	2.73	5	62.5	4.35
22	<i>Polyalthia korinti</i>	Annonaceae	9	2.25	2.46	5	62.5	4.35
23	<i>Rauvolfia serpentina</i>	Apocynaceae	11	2.75	3.01	5	62.5	4.35
24	<i>Tabernaemontana divaricata</i>	Apocynaceae	4	1	1.09	2	25	1.74
Genus-22; Species-24		Family-16	366			115		

Table B26: Distribution details of shrubs in the disturbed non-sacred grove land

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Barleria cristata</i>	Acanthaceae	12	3	6.78	4	50	5.06
2	<i>Calotropis gigantea</i>	Asclepiadaceae	4	1	2.26	1	12.5	1.27
3	<i>Chromolaena odorata</i>	Asteraceae	12	3	6.78	4	50	5.06
4	<i>Clerodendrum infortunatum</i>	Verbenaceae	12	3	6.78	6	75	7.60
5	<i>Crotalaria pallida</i>	Leguminosae	7	1.75	3.96	3	37.5	3.80
6	<i>Datura stramonium</i>	Solanaceae	3	0.75	1.70	1	12.5	1.27
7	<i>Grewia nervosa</i>	Tiliaceae	5	1.25	2.83	3	37.5	3.80
8	<i>Hibiscus hispidissimus</i>	Malvaceae	5	1.25	2.83	4	50	5.06
9	<i>Hyptis suaveolens</i>	Lamiaceae	18	4.5	10.17	7	87.5	8.86
10	<i>Lantana camara</i>	Verbenaceae	3	0.75	1.70	1	12.5	1.27
11	<i>Lawsonia inermis</i>	Lythraceae	2	0.5	1.13	1	12.5	1.27

12	<i>Leea indica</i>	Leeaceae	6	1.5	3.39	4	50	5.06
13	<i>Phyllanthus reticulatus</i>	Euphorbiaceae	13	3.25	7.35	5	62.5	6.33
14	<i>Senna occidentalis</i>	Leguminosae	3	0.75	1.70	2	25	2.53
15	<i>Sida acuta</i>	Malvaceae	13	3.25	7.35	6	75	7.60
16	<i>Sida cordifolia</i>	Malvaceae	9	2.25	5.09	5	62.5	6.33
17	<i>Sida mysorensis</i>	Malvaceae	7	1.75	3.96	4	50	5.06
18	<i>Sida rhombifolia</i>	Malvaceae	14	3.5	7.91	7	87.5	8.86
19	<i>Triumfetta rhomboidea</i>	Tiliaceae	22	5.5	12.42	7	87.5	8.86
20	<i>Urena lobata</i>	Malvaceae	7	1.75	3.96	4	50	5.06
	Genus-17; Species-20	Family-12	177			79		

62.5% of shrub species in Palliyana grove are in the good and fairly good distribution frequency range while 20.84% in the mostly poor and poor frequency range whereas, the rest of the 16.67% in the moderate frequency range. However in the disturbed non-sacred grove land, more or less uniform distribution of shrub species are found represented in most of the frequency ranges (table B27).

Table B27: Distribution frequency range of shrub species

Frequency range	Palliyana sacred grove		Disturbed land	
	No. of shrub species	% of species	No. of shrub species	% of species
1- 20% (Poor)	1	4.17	4	20
21-40% (Mostly poor)	4	16.67	3	15
41-60% (Moderate)	4	16.67	6	30
61-80% (Fairly good)	12	50	4	20
81-100% (Good)	3	12.5	3	15

Herbs

The distribution details of plant group herbs in the Palliyana sacred grove is depicted in the table B28. Total population of 281 individuals belonging to 11 families recorded which comprise of 15 genera and 15 species. The highest individual population, D and RD are recorded by *Eragrostis unioides* and the values are 33, 8.25 and 11.74% respectively. Immediately followed by *E. unioides* is *Panicum notatum* and then *Cyperus rotundus*, which are having total representation of 29 and 26 with D & RD of 7.25 & 10.32% and 6.5 & 9.25% respectively. The highest F & RF values are recorded by 4 species *Eragrostis unioides*, *Panicum notatum*, *Cyathula prostrata* and *Cyanthillium cinereum* and these are

75% & 9.23% each respectively. This is immediately followed by values 62.5% & 7.69% each recorded by *Curculigo orchoides* and *Emilia sonchifolia*.

The disturbed land recorded total population of 163823 herbs which are belonging to 15 families and this comprise of 36 genera and 38 species (table B29). The highest individual population of 8903 and D & RD values of 2225.85 & 5.44% in the area is recorded by *Justicia procumbens*. It is immediately followed by *Cynodon dactylon* and *Cyathula prostrata* with individual population of 8013 and D & RD values of 2003.28 & 4.89% each. The highest F of 100% and RF of 4.02% is recorded by 6 species and these are *Cynodon dactylon*, *Cyathula prostrata*, *Digitaria ciliaris*, *Grangea maderaspatana*, *Brachiaria remota* and *Chamaecrista absus*. This is immediately followed by values of 87.5% and 3.52% recorded by 6 species *Justicia procumbens*, *Eragrostis amabilis*, *Dicliptera paniculata*, *Aerva lanata*, *Allmania nodiflora* and *Phyllanthus amarus*.

Table B28: Distribution details of herbs in the Palliyana sacred grove

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Biophytum reinwardtii</i>	Oxalidaceae	19	4.75	6.76	4	50	6.15
2	<i>Brachiaria remota</i>	Poaceae	15	3.75	5.34	4	50	6.15
3	<i>Curculigo orchoides</i>	Hypoxidaceae	17	4.25	6.05	5	62.5	7.69
4	<i>Cyanthillium cinereum</i>	Asteraceae	17	4.25	6.05	6	75	9.23
5	<i>Cyathula prostrata</i>	Amaranthaceae	24	6	8.54	6	75	9.23
6	<i>Cyperus rotundus</i>	Cyperaceae	26	6.5	9.25	4	50	6.15
7	<i>Desmodium gangeticum</i>	Leguminosae	11	2.75	3.92	4	50	6.15
8	<i>Emilia sonchifolia</i>	Asteraceae	19	4.75	6.76	5	62.5	7.69
9	<i>Eragrostis unioides</i>	Poaceae	33	8.25	11.74	6	75	9.23
10	<i>Justicia procumbens</i>	Acanthaceae	20	5	7.12	4	50	6.15
11	<i>Laportea interrupta</i>	Urticaceae	10	2.5	3.56	2	25	3.08
12	<i>Mitracarpus hirtus</i>	Rubiaceae	20	5	7.12	4	50	6.15
13	<i>Ocimum basilicum</i>	Lamiaceae	2	0.5	0.71	1	12.5	1.54
14	<i>Panicum notatum</i>	Poaceae	29	7.25	10.32	6	75	9.23
15	<i>Synedrella nodiflora</i>	Asteraceae	19	4.75	6.76	4	50	6.15
	Genus-15; Species-15	Family-11	281			65		

Table B29: Distribution details of herbs in the disturbed non-sacred grove land

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Acmella ciliata</i>	Asteraceae	2671	667.75	1.63	5	62.5	2.51
2	<i>Aerva lanata</i>	Amaranthaceae	6232.4	1558.1	3.80	7	87.5	3.52
3	<i>Ageratum conyzoides</i>	Asteraceae	2671	667.75	1.63	4	50	2.01
4	<i>Allmania nodiflora</i>	Amaranthaceae	5342	1335.5	3.26	7	87.5	3.52
5	<i>Alloteropsis semialata</i>	Poaceae	3561.4	890.35	2.17	4	50	2.01
6	<i>Alternanthera brasiliana</i>	Amaranthaceae	1780.7	445.175	1.09	4	50	2.01
7	<i>Andrographis echiioides</i>	Acanthaceae	2671	667.75	1.63	4	50	2.01
8	<i>Andrographis paniculata</i>	Acanthaceae	3561.4	890.35	2.17	5	62.5	2.51
9	<i>Anisomeles indica</i>	Lamiaceae	2671	667.75	1.63	3	37.5	1.51
10	<i>Boerhavia diffusa</i>	Nyctaginaceae	2671	667.75	1.63	4	50	2.01
11	<i>Brachiaria remota</i>	Poaceae	6232.4	1558.1	3.80	8	100	4.02
12	<i>Chamaecrista absus</i>	Leguminosae	6232.4	1558.1	3.80	8	100	4.02
13	<i>Chamaecrista mimosoides</i>	Leguminosae	3561.4	890.35	2.17	4	50	2.01
14	<i>Cleome rutidosperma</i> var. <i>burmannii</i>	Capparaceae	2671	667.75	1.63	3	37.5	1.51
15	<i>Cleome viscosa</i>	Capparaceae	2671	667.75	1.63	2	25	1.01
16	<i>Cyathula prostrata</i>	Amaranthaceae	8013.1	2003.28	4.89	8	100	4.02
17	<i>Cynodon dactylon</i>	Poaceae	8013.1	2003.28	4.89	8	100	4.02
18	<i>Dicliptera paniculata</i>	Acanthaceae	6232.4	1558.1	3.80	7	87.5	3.52
19	<i>Digitaria ciliaris</i>	Poaceae	7122.7	1780.68	4.35	8	100	4.02
20	<i>Eleutheranthera ruderalis</i>	Asteraceae	3561.4	890.35	2.17	5	62.5	2.51
21	<i>Eragrostis amabilis</i>	Poaceae	6232.4	1558.1	3.80	7	87.5	3.52
22	<i>Euphorbia hirta</i>	Euphorbiaceae	3561.4	890.35	2.17	5	62.5	2.51
23	<i>Euphorbia thymifolia</i>	Euphorbiaceae	1780.7	445.175	1.09	2	25	1.01
24	<i>Grangea maderaspatana</i>	Asteraceae	6232.4	1558.1	3.80	8	100	4.02
25	<i>Indigofera hirsuta</i>	Leguminosae	1780.7	445.175	1.09	2	25	1.01
26	<i>Justicia procumbens</i>	Acanthaceae	8903.4	2225.85	5.44	7	87.5	3.52
27	<i>Laportea interrupta</i>	Urticaceae	2671	667.75	1.63	5	62.5	2.51
28	<i>Leucas aspera</i>	Lamiaceae	3561.4	890.35	2.17	6	75	3.02
29	<i>Ludwigia hyssopifolia</i>	Onagraceae	4451.7	1112.93	2.72	5	62.5	2.51
30	<i>Mimosa pudica</i>	Leguminosae	3561.4	890.35	2.17	6	75	3.02
31	<i>Oldenlandia corymbosa</i>	Rubiaceae	3561.4	890.35	2.17	4	50	2.01
32	<i>Pedaliium murex</i>	Pedaliaceae	4451.7	1112.93	2.72	4	50	2.01
33	<i>Phyllanthus amarus</i>	Euphorbiaceae	5342	1335.5	3.26	7	87.5	3.52
34	<i>Phyllanthus urinaria</i>	Euphorbiaceae	3561.4	890.35	2.17	3	37.5	1.51
35	<i>Physalis angulata</i>	Solanaceae	4451.7	1112.93	2.72	4	50	2.01

36	<i>Scoparia dulcis</i>	Scrophulariaceae	4451.7	1112.93	2.72	5	62.5	2.51
37	<i>Synedrella nodiflora</i>	Asteraceae	4451.7	1112.93	2.72	6	75	3.02
38	<i>Tridax procumbens</i>	Asteraceae	2671	667.75	1.63	5	62.5	2.51
	Genus-36; Species-38	Family-15	163823			199		

Table B30: Distribution frequency range of herbaceous species

Frequency range	Palliyana sacred grove		Disturbed land	
	No. of herbs species	% of species	No. of herbs species	% of species
1- 20% (Poor)	1	6.67	0	0
21-40% (Mostly poor)	1	6.67	6	15.79
41-60% (Moderate)	7	46.66	9	23.68
61-80% (Fairly good)	6	40	11	28.95
81-100% (Good)	0	0	12	31.58

Distribution of herbs showed the majority of the species (86.66%) in the grove are coming under the frequency range of moderate and fairly good while rest of the species (13.34%) are in the poor and mostly poor frequency range. However in the disturbed land 60.53% species are in the good and fairly good frequency range while, 23.68% in the moderate level. The remaining 15.79% in the mostly poor frequency range (table B30).

Climbers

Total population of 618 climbers belonging to 15 families recorded in the grove which comprise of 18 genera and 19 species (table B31). The highest individual representation of 65 with maximum D & RD values of 16.25 & 10.52% is recorded by *Tiliacora racemosa*. It is immediately followed by *Ichnocarpus frutescens* and then *Pothos scandens* which are having total representation of 59 and 50 and D & RD values of 14.75 & 9.55% and 12.5% & 8.09% respectively. The highest F & RF values is recorded by 4 species *T. racemosa*, *P. scandens*, *I. frutescens* and *Strychnos minor* and the values are 100% & 7.62% respectively each. This is immediately followed by values of 87.5% & 6.67% each recorded by *Smilax zeylanica* and *Tinospora cordifolia*.

The disturbed land recorded total population of 58 climbers belonging to 5 families and comprising of 6 genera and 6 species (table B32). *Mikania micrantha* and *Merremia umbellata* recorded the highest individual representation of 12 and D & RD values of 3 & 20.69% respectively each. This is immediately followed by *Tiliacora racemosa* (10 and 2.5 & 17.24% respectively) and then *Ichnocarpus frutescens* (9 and 2.25 & 15.52% respectively). With respect to F & RF values, the species *M. micrantha* recorded the highest values (75%

& 25% respectively) and this immediately followed by *M. umbellata* (62.5% & 20.83% and then *Abrus precatorius* (50% & 16.67% respectively).

Table B31: Distribution details of climbers in the Palliyana sacred grove

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Abrus precatorius</i>	Leguminosae	36	9	5.8252	6	75	5.714
2	<i>Anamirta cocculus</i>	Menispermaceae	24	6	3.8835	4	50	3.81
3	<i>Aristolochia indica</i>	Aristolochiaceae	21	5.25	3.3981	4	50	3.81
4	<i>Asparagus racemosus</i>	Liliaceae	21	5.25	3.3981	4	50	3.81
5	<i>Cayratia pedata</i>	Vitaceae	30	7.5	4.8544	5	62.5	4.762
6	<i>Cyclea peltata</i>	Menispermaceae	31	7.75	5.0162	6	75	5.714
7	<i>Dioscorea bulbifera</i>	Dioscoreaceae	21	5.25	3.3981	4	50	3.81
8	<i>Gymnema sylvestre</i>	Asclepiadaceae	14	3.5	2.2654	4	50	3.81
9	<i>Ichnocarpus frutescens</i>	Apocynaceae	59	14.75	9.5469	8	100	7.619
10	<i>Mikania micrantha</i>	Asteraceae	28	7	4.5307	5	62.5	4.762
11	<i>Mukia maderaspatana</i>	Cucurbitaceae	25	6.25	4.0453	4	50	3.81
12	<i>Naravelia zeylanica</i>	Ranunculaceae	18	4.5	2.9126	4	50	3.81
13	<i>Piper nigrum</i>	Piperaceae	7	1.75	1.1327	3	37.5	2.857
14	<i>Pothos scandens</i>	Araceae	50	12.5	8.0906	8	100	7.619
15	<i>Smilax zeylanica</i>	Smilacaceae	44	11	7.1197	7	87.5	6.667
16	<i>Strychnos minor</i>	Loganiaceae	46	11.5	7.4434	8	100	7.619
17	<i>Tiliacora racemosa</i>	Menispermaceae	65	16.25	10.518	8	100	7.619
18	<i>Tinospora cordifolia</i>	Menispermaceae	40	10	6.4725	7	87.5	6.667
19	<i>Tinospora sinensis</i>	Menispermaceae	38	9.5	6.1489	6	75	5.714
	Genus-18; Species-19	Family-15	618			105		

Table B32: Distribution details of climbers in the disturbed non-sacred grove land

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Abrus precatorius</i>	Leguminosae	8	2	13.793	4	50	16.667
2	<i>Hewittia malabarica</i>	Convolvulaceae	7	1.75	12.069	3	37.5	12.5
3	<i>Ichnocarpus frutescens</i>	Apocynaceae	9	2.25	15.517	3	37.5	12.5
4	<i>Merremia umbellata</i>	Convolvulaceae	12	3	20.69	5	62.5	20.833
5	<i>Mikania micrantha</i>	Asteraceae	12	3	20.69	6	75	25

6	<i>Tiliacora racemosa</i>	Menispermaceae	10	2.5	17.241	3	37.5	12.5
	Genus-6; Species-6	Family-5	58			24		

Table B33: Distribution frequency range of climbers

Frequency range	Palliyana sacred grove		Disturbed land	
	No. of herbs species	% of species	No. of herbs species	% of species
1- 20% (Poor)	0	0	0	0
21-40% (Mostly poor)	1	5.26	3	50
41-60% (Moderate)	7	36.84	1	16.67
61-80% (Fairly good)	5	26.32	2	33.33
81-100% (Good)	6	31.58	0	0

The species distribution frequency range of climbers showed 57.9% are belonging to the good and fairly good range, the moderate level range is exhibited by 36.84% and the remaining 5.26% exhibited mostly poor frequency range (table B33). However in the disturbed land, the majority of the species (50%) are in the mostly poor frequency range, 33.33% recorded fairly good frequency range and the rest of the species recorded moderate level frequency range (16.67%).

Lianas

The distribution details of lianas in the Palliyana grove is depicted in the table B34. Total population of 110 lianas belonging to 7 families which included 8 genera and 8 species. The species with highest individual representation of 19 and D & RD value of 4.75 & 17.27% is recorded by *Salacia fruticosa*. This is immediately followed by *Uvaria narum* and then *Gnetum ula* which are having total representation of 18 and 16 respectively and the D & RD of 4.5 & 16.36% & 4 & 14.55% respectively. The highest F and RF values of 100% and 17.02% respectively recorded each by *U. narum* and *G. ula*. The immediate highest F and RF values of 87.5% and 14.89% respectively are recorded by *S. fruticosa*. The plant group lianas are totally absent in the disturbed land.

Table B34: Distribution details of lianas in the Palliyana sacred grove

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Anodendron paniculatum</i>	Apocynaceae	9	2.25	8.1818	4	50	8.511
2	<i>Connarus monocarpus</i>	Connaraceae	9	2.25	8.1818	5	62.5	10.64
3	<i>Derris scandens</i>	Leguminosae	9	2.25	8.1818	3	37.5	6.383

4	<i>Gnetum ula</i>	Gnetaceae	16	4	14.545	8	100	17.02
5	<i>Rourea minor</i>	Connaraceae	15	3.75	13.636	6	75	12.77
6	<i>Salacia fruticosa</i>	Hippocrateaceae	19	4.75	17.273	7	87.5	14.89
7	<i>Sarcostigma kleinii</i>	Icacinaceae	15	3.75	13.636	6	75	12.77
8	<i>Uvaria narum</i>	Annonaceae	18	4.5	16.364	8	100	17.02
	Genus-8; Species-8	Family-7	110			47		

Table B35: Distribution frequency range of lianas

Frequency range	Palliyana sacred grove		Disturbed land	
	No. of herbs species	% of species	No. of herbs species	% of species
1- 20% (Poor)	0	0	0	0
21-40% (Mostly poor)	1	12.5	0	0
41-60% (Moderate)	1	12.5	0	0
61-80% (Fairly good)	3	37.5	0	0
81-100% (Good)	3	37.5	0	0

The distribution frequency range of plant group lianas in the grove indicates majority of the species (75%) are in the good and fairly good range. In the remaining 25% species, 12.5% each exhibited moderate and mostly poor frequency range (table B35). No data available for lianas in the disturbed land.

3) Nambiyath site

Analysis of total floral distribution

The details of total floral distribution in the Nambiyath sacred grove is depicted in the table B36. Total population of 918 plants belonging to 44 families which comprise of 77 genera and 81 species recorded. The highest individual population of 55 and D & RD values of 13.75 & 6.04% in the grove is recorded by the liana species *Gnetum ula*. This is immediately followed by liana members *Uvaria narum* and then *Sarcostigma kleinii* with total population of 35 and 32 and D & RD values of 8.75 & 3.84% and 8 & 3.51% respectively. The highest F & RF values of 100% & 1.98% respectively in the grove recorded each by 11 plant species. This include one tree member *Artocarpus hirsutus*; 3 shrubs *Ixora coccinea*; *Briedelia stipularis* and *Hibiscus rosasinensis*; 3 herbs *Panicum notatum*, *Biophytum reinwardtii* and *Aerva lanata*; one climber *Ichnocarpus frutescens* and 3 liana members *Gnetum ula*, *Uvaria narum* and *Sarcostigma kleinii*. The immediate highest F & RF values of 87.5% & 1.73% recorded by 13 plant species and this include 3 trees *Pterygota alata*, *Hydnocarpus pentandrus* and *Quassia indica*; 4 shrubs *Clerodendrum paniculatum*, *Breynia vitis-idaea*, *Coffea travancorensis* and *Leea indica*; 4 herbs *Mitracarpus hirtus*, *Brachiaria*

subquadripara, *Cyathula prostrata* and *Boerhaavia diffusa*; 1 climber *Tiliacora racemosa* and one liana member *Connarus monocarpus*.

Table B36: Details of total floral distribution in Nambiyath sacred grove

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Abrus precatorius</i> L.	Leguminosae	18	4.5	1.96	3	37.5	0.71
2	<i>Adenanthera pavonina</i> L.	Leguminosae	4	1	0.44	3	37.5	0.74
3	<i>Aerva lanata</i> (L.) Juss.	Amaranthaceae	10	2.5	1.09	8	100	1.98
4	<i>Alstonia scholaris</i> (L.) R. Br.	Apocynaceae	1	0.25	0.11	1	12.5	0.25
5	<i>Anacardium occidentale</i> L.	Anacardiaceae	4	1	0.44	3	37.5	0.74
6	<i>Aphanamixis polystachya</i> (Wall.) R.Parker	Meliaceae	7	1.75	0.76	5	62.5	1.24
7	<i>Artocarpus hirsutus</i> Lam.	Moraceae	23	5.75	2.51	8	100	1.98
8	<i>Asparagus racemosus</i> Willd.	Liliaceae	10	2.5	1.09	2	25	0.49
9	<i>Bambusa bambos</i> (L.) Voss.	Poaceae	11	2.75	1.2	6	75	1.48
10	<i>Bambusa vulgaris</i> Schrad.	Poaceae	10	2.5	1.09	4	50	0.99
11	<i>Biophytum reinwardtii</i> (Zucc.) Klotzsch.	Oxalidaceae	15	3.75	1.63	8	100	1.98
12	<i>Boerhaavia diffusa</i> L.	Nyctaginaceae	12	3	1.31	7	87.5	1.73
13	<i>Brachiaria subquadripara</i> (Trin.) Hitchc.	Poaceae	14	3.5	1.53	7	87.5	1.73
14	<i>Breynia vitis-idaea</i> (Burm.f.) C.E.C.Fisch.	Euphorbiaceae	13	3.25	1.42	7	87.5	1.73
15	<i>Bridelia stipularis</i> (L.) Blume.	Euphorbiaceae	23	5.75	2.51	8	100	1.98
16	<i>Carallia brachiata</i> (Lour.) Merr.	Rhizophoraceae	2	0.5	0.22	2	25	0.49
17	<i>Caryota urens</i> L.	Arecaceae	3	0.75	0.33	3	37.5	0.74
18	<i>Chrysophyllum cainito</i> L.	Sapotaceae	8	2	0.87	6	75	1.48
19	<i>Cinnamomum malabattrum</i> (Burm.f.) J.Presl.	Lauraceae	7	1.75	0.76	6	75	1.48
20	<i>Cissus latifolia</i> Lam.	Vitaceae	10	2.5	1.09	4	50	0.99
21	<i>Clerodendrum paniculatum</i> L.	Verbenaceae	16	4	1.74	7	87.5	1.73
22	<i>Coffea travancorensis</i> Wight & Arn.	Rubiaceae	13	3.25	1.42	7	87.5	1.73
23	<i>Combretum latifolium</i> Blume.	Combretaceae	9	2.25	0.98	3	37.5	0.74
24	<i>Connarus monocarpus</i> L.	Connaraceae	28	7	3.05	7	87.5	1.73
25	<i>Coscinium fenestratum</i> (Goetgh.) Colebr.	Menispermaceae	14	3.5	1.53	6	75	1.48
26	<i>Curculigo orchiodes</i> Gaertn.	Hypoxidaceae	16	4	1.74	5	62.5	1.24
27	<i>Cyanthillium cinereum</i> (L.) H.Rob.	Asteraceae	12	3	1.31	5	62.5	1.24
28	<i>Cyathula prostrata</i> (L.) Blume	Amaranthaceae	13	3.25	1.42	7	87.5	1.73
29	<i>Cyclea peltata</i> (Lam.) Hook.f. & Thomson	Menispermaceae	6	1.5	0.65	3	37.5	0.74

30	<i>Cyperus rotundus</i> L.	Cyperaceae	18	4.5	1.96	6	75	1.48
31	<i>Desmodium gangeticum</i> (L.) DC.	Leguminosae	11	2.75	1.2	6	75	1.48
32	<i>Dioscorea bulbifera</i> L.	Dioscoreaceae	8	2	0.87	3	37.5	0.74
33	<i>Diospyros malabarica</i> (Desr.) Kostel.	Ebenaceae	5	1.25	0.54	4	50	0.99
34	<i>Dracaena terniflora</i> Roxb.	Dracaenaceae	13	3.25	1.42	5	62.5	1.24
35	<i>Emilia sonchifolia</i> (L.) DC. ex DC.	Asteraceae	17	4.25	1.85	6	75	1.48
36	<i>Euphorbia hirta</i> L.	Euphorbiaceae	7	1.75	0.76	5	62.5	1.24
37	<i>Ficus amplissima</i> Sm.	Moraceae	4	1	0.44	3	37.5	0.74
38	<i>Ficus benghalensis</i> L.	Moraceae	1	0.25	0.11	1	12.5	0.25
39	<i>Garcinia gummi-gutta</i> (L.) Roxb.	Clusiaceae	3	0.75	0.33	3	37.5	0.74
40	<i>Gardenia jasminoides</i> J.Ellis.	Rubiaceae	15	3.75	1.63	6	75	1.48
41	<i>Gnetum ula</i> Brongn.	Gnetaceae	55	13.75	5.99	8	100	1.98
42	<i>Grangea maderaspatana</i> (L.) Poir.	Asteraceae	8	2	0.87	4	50	0.99
43	<i>Grewia nervosa</i> (Lour.) Panigrahi.	Tiliaceae	6	1.5	0.65	5	62.5	1.24
44	<i>Hibiscus rosa-sinensis</i> L.	Malvaceae	18	4.5	1.96	8	100	1.98
45	<i>Holigarna arnottiana</i> Hook.f.	Anacardiaceae	7	1.75	0.76	5	62.5	1.24
46	<i>Hydnocarpus pentandrus</i> (Buch.-Ham.) Oken.	Flacourtiaceae	14	3.5	1.53	7	87.5	1.73
47	<i>Ichnocarpus frutescens</i> (L.) W.T.Aiton.	Apocynaceae	18	4.5	1.96	8	100	1.98
48	<i>Ixora coccinea</i> L.	Rubiaceae	27	6.75	2.94	8	100	1.98
49	<i>Ixora malabarica</i> (Dennst.) Mabb.	Rubiaceae	9	2.25	0.98	6	75	1.48
50	<i>Jasminum multiflorum</i> (Burm.f.) Andrews.	Oleaceae	8	2	0.87	3	37.5	0.74
51	<i>Kametia caryophyllata</i> (Roxb.) Nicolson & Suresh.	Apocynaceae	12	3	1.31	4	50	0.99
52	<i>Lannea coromandelica</i> (Houtt.) Merr.	Anacardiaceae	5	1.25	0.54	4	50	0.99
53	<i>Laportea interrupta</i> (L.) Chew.	Urticaceae	12	3	1.31	3	37.5	0.74
54	<i>Leea indica</i> (Burm. f.) Merr.	Leeaceae	10	2.5	1.09	7	87.5	1.73
55	<i>Mikania micrantha</i> Kunth.	Asteraceae	14	3.5	1.53	6	75	1.48
56	<i>Mimusops elengi</i> L.	Sapotaceae	5	1.25	0.54	4	50	0.99
57	<i>Mitracarpus hirtus</i> (L.) DC.	Rubiaceae	15	3.75	1.63	7	87.5	1.73
58	<i>Mukia maderaspatana</i> (L.) M.Roem.	Cucurbitaceae	11	2.75	1.2	4	50	0.99
59	<i>Mussaenda frondosa</i> L.	Rubiaceae	5	1.25	0.54	3	37.5	0.74
60	<i>Naregamia alata</i> Wight & Arn.	Meliaceae	9	2.25	0.98	6	75	1.48
61	<i>Pandanus kaida</i> Kurz .	Pandanaceae	6	1.5	0.65	2	25	0.49
62	<i>Panicum notatum</i> Retz.	Poaceae	23	5.75	2.51	8	100	1.98
63	<i>Pavetta indica</i> L.	Rubiaceae	12	3	1.31	6	75	1.48

64	<i>Pinanga dicksonii</i> (Roxb.) Blume.	Arecaceae	6	1.5	0.65	3	37.5	0.74
65	<i>Plumeria rubra</i> L.	Apocynaceae	1	0.25	0.11	1	12.5	0.25
66	<i>Polyalthia longifolia</i> (Sonn.) Thwaites.	Annonaceae	4	1	0.44	3	37.5	0.74
67	<i>Pterygota alata</i> (Roxb.) R.Br.	Sterculiaceae	15	3.75	1.63	7	87.5	1.73
68	<i>Quassia indica</i> (Gaertn.) Noot.	Simaroubaceae	14	3.5	1.53	7	87.5	8
69	<i>Saraca asoca</i> (Roxb.) Willd.	Leguminosae	2	0.5	0.22	2	25	04
70	<i>Sarcostigma kleinii</i> Wight & Arn.	Icacinaceae	32	8	3.49	8	100	1.98
71	<i>Sterculia balanghas</i> L.	Sterculiaceae	2	0.5	0.22	2	25	0.49
72	<i>Strychnos nux-vomica</i> L.	Loganiaceae	3	0.75	0.33	3	37.5	0.74
73	<i>Syzygium cumini</i> (L.) Skeels.	Myrtaceae	2	0.5	0.22	2	25	0.49
74	<i>Tabernaemontana alternifolia</i> L.	Apocynaceae	9	2.25	0.98	6	75	1.48
75	<i>Tabernaemontana divaricata</i> (L.) R.Br. ex Roem. & Schult.	Apocynaceae	9	2.25	0.98	5	62.5	1.24
76	<i>Terminalia bellirica</i> (Gaertn.) Roxb.	Combretaceae	2	0.5	0.22	1	12.5	0.25
77	<i>Tiliacora racemosa</i> Colebr.	Menispermaceae	17	4.25	1.85	7	87.5	1.73
78	<i>Tinospora sinensis</i> (Lour.) Merr.	Menispermaceae	7	1.75	0.76	5	62.5	1.24
79	<i>Trema orientalis</i> (L.) Blume.	Ulmaceae	9	2.25	0.98	5	62.5	1.24
80	<i>Uvaria narum</i> A.DC.	Annonaceae	35	8.75	3.81	8	100	1.98
81	<i>Vitex altissima</i> L.f.	Verbenaceae	6	1.5	0.65	5	62.5	1.24
	Genus-77; Species-81	Family-44	918			405		

The disturbed non-sacred grove land at Nambiyath site showed total population of 49750 plants belonging to 22 families which comprise of 50 genera and 54 species (table B37). The highest individual population of 3750 and D & RD values of 937.5 & 7.54% is recorded by the herb *Aerva lanata*. This is immediately followed by values of 2732 and 683 & 5.49% respectively each recorded by herbaceous members *Cynodon dactylon* and *Achyranthes aspera*. The highest value of F (100%) & RF (3.23%) in the disturbed land recorded by three herbs *A. lanata*, *C. dactylon* and *A. aspera* and one climber *Mikania micrantha* and this is immediately followed by values of 87.5% & 2.82% respectively each recorded by 8 plant species. This includes four herbs (*Eragrostis amabilis*, *Brachiaria remota*, *Andrographis paniculata* and *Alloteropsis cimicina*), 3 shrubs (*Chromolaena odorata*, *Sida rhombifolia* and *Clerodendrum infortunatum*) and one climber (*Tiliacora racemosa*).

Table B37: Details of total floral distribution in the disturbed non-sacred grove land

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Abrus precatorius</i> L.	Leguminosae	10	2.5	0.02	6	75	2.42
2	<i>Acacia mangium</i> Willd.	Leguminosae	1	0.25	0.002	1	12.5	0.40
3	<i>Achyranthes aspera</i> L.	Amaranthaceae	2732	682.93	5.49	8	100	3.23
4	<i>Aerva lanata</i> (L.) Juss.	Amaranthaceae	3750	937.5	7.54	8	100	3.23
5	<i>Ageratum conyzoides</i> (L.) L.	Asteraceae	1821	455.3	3.66	6	75	2.42
6	<i>Allmania nodiflora</i> (L.) R.Br. ex Wight.	Amaranthaceae	1518	379.4	3.05	4	50	1.61
7	<i>Allotroopsis cimicina</i> (L.) Stapf.	Poaceae	2125	531.18	4.27	7	87.5	2.82
8	<i>Alternanthera brasiliana</i> (L.) Kuntze.	Amaranthaceae	2428	607.05	4.88	6	75	2.42
9	<i>Anacardium occidentale</i> L.	Anacardiaceae	3	0.75	0.01	3	37.5	1.21
10	<i>Andrographis echinoides</i> (L.) Nees.	Acanthaceae	2125	531.18	4.27	5	62.5	2.02
11	<i>Andrographis paniculata</i> (Burm.f.) Nees	Acanthaceae	2125	531.18	4.27	7	87.5	2.82
12	<i>Anisomeles indica</i> (L.) Kuntze.	Lamiaceae	1518	379.4	3.05	4	50	1.61
13	<i>Areca catechu</i> L.	Arecaceae	2	0.5	0.004	2	25	0.81
14	<i>Artocarpus hirsutus</i> Lam.	Moraceae	2	0.5	0.004	2	25	0.81
15	<i>Bambusa bambos</i> (L.) Voss.	Poaceae	4	1	0.01	2	25	0.81
16	<i>Boerhavia diffusa</i> L.	Nyctaginaceae	1518	379.4	3.05	5	62.5	2.02
17	<i>Brachiaria remota</i> (Retz.) Haines.	Poaceae	2428	607.05	4.88	7	87.5	2.82
18	<i>Chamaecrista mimosoides</i> (L.) Greene.	Leguminosae	1821	455.3	3.66	5	62.5	2.02
19	<i>Chromolaena odorata</i> (L.) R.M.King & H.Rob.	Asteraceae	12	3	0.02	7	87.5	2.82
20	<i>Clerodendrum infortunatum</i> L.	Verbenaceae	9	2.25	0.02	7	87.5	2.82
21	<i>Cocos nucifera</i> L.	Arecaceae	4	1	0.01	4	50	1.61
22	<i>Cynodon dactylon</i> (L.) Pers.	Poaceae	2732	682.93	5.49	8	100	3.23
23	<i>Cyperus rotundus</i> L.	Cyperaceae	2125	531.18	4.27	5	62.5	2.02
24	<i>Dalbergia latifolia</i> Roxb.	Leguminosae	1	0.25	0.002	1	12.5	0.40
25	<i>Dicliptera paniculata</i> (Forssk.) I.Darbysh.	Acanthaceae	1214	303.53	2.44	3	37.5	1.21
26	<i>Digitaria ciliaris</i> (Retz.) Koeler	Poaceae	1821	455.3	3.66	6	75	2.42
27	<i>Eragrostis amabilis</i> (L.) Wight & Arn.	Poaceae	2428	607.05	4.88	7	87.5	2.82
28	<i>Euphorbia hirta</i> L.	Euphorbiaceae	2125	531.18	4.27	6	75	2.42
29	<i>Grewia nervosa</i> (Lour.) Panigrahi.	Tiliaceae	5	1.25	0.01	4	50	1.61
30	<i>Hibiscus hispidissimus</i> Griff.	Malvaceae	5	1.25	0.01	4	50	1.613
31	<i>Hibiscus surattensis</i> L.	Malvaceae	6	1.5	0.012	5	62.5	2.02

32	<i>Ichnocarpus frutescens</i> (L.) W.T.Aiton.	Apocynaceae	11	2.75	0.022	5	62.5	2.02
33	<i>Lantana camara</i> L.	Verbenaceae	3	0.75	0.01	2	25	0.81
34	<i>Leea indica</i> (Burm. f.) Merr.	Leeaceae	6	1.5	0.012	4	50	1.61
35	<i>Leucas aspera</i> (Willd.) Link.	Lamiaceae	1821	455.3	3.66	4	50	1.61
36	<i>Mangifera indica</i> L.	Anacardiaceae	3	0.75	0.01	3	37.5	1.21
37	<i>Mikania micrantha</i> Kunth.	Asteraceae	19	4.75	0.04	8	100	3.23
38	<i>Mimosa pudica</i> L.	Leguminosae	1518	379.4	3.05	3	37.5	1.21
39	<i>Mitracarpus hirtus</i> (L.) DC.	Rubiaceae	1518	379.4	3.05	5	62.5	2.02
40	<i>Oldenlandia corymbosa</i> L.	Rubiaceae	1214	303.53	2.44	4	50	1.61
41	<i>Phyllanthus amarus</i> Schumach. & Thonn.	Euphorbiaceae	1214	303.53	2.44	4	50	1.61
42	<i>Quassia indica</i> (Gaertn.) Noot.	Simaroubaceae	1	0.25	0.002	1	12.5	0.40
43	<i>Scoparia dulcis</i> L.	Scrophulariaceae	910.6	227.65	1.83	3	37.5	1.21
44	<i>Sida cordifolia</i> L.	Malvaceae	9	2.25	0.02	6	75	2.42
45	<i>Sida mysorensis</i> Wight & Arn.	Malvaceae	7	1.75	0.014	5	62.5	2.02
46	<i>Sida rhombifolia</i> L.	Malvaceae	10	2.5	0.02	7	87.5	2.82
47	<i>Stachytarpheta jamaicensis</i> (L.) Vahl.	Verbenaceae	6	1.5	0.012	3	37.5	1.21
48	<i>Synedrella nodiflora</i> (L.) Gaertn.	Asteraceae	910.6	227.65	1.83	3	37.5	1.21
49	<i>Tectona grandis</i> L.f.	Verbenaceae	1	0.25	0.002	1	12.5	0.40
50	<i>Tiliacora racemosa</i> Colebr.	Menispermaceae	17	4.25	0.03	7	87.5	2.82
51	<i>Trema orientalis</i> (L.) Blume.	Ulmaceae	2	0.5	0.004	2	25	0.81
52	<i>Tridax procumbens</i> (L.) L.	Asteraceae	2125	531.18	4.27	6	75	2.42
53	<i>Urena lobata</i> L.	Malvaceae	7	1.75	0.014	5	62.5	2.02
54	<i>Vitex altissima</i> L.f.	Verbenaceae	2	0.5	0.004	2	25	0.81
	Genus-50 ; Species-54	Family-22	49750			248		

The distribution frequency range indicates, majority of plant species in the grove (59.26%) as well as in the disturbed land (51.85%) are coming under good and fairly good frequency ranges. In the rest of the plant species in the grove, 30.86% are found belonging to mostly poor and poor frequency range and the remaining 9.88% exhibited moderate level of frequency range. In the disturbed land, 31.48% of species exhibited mostly poor and poor frequency range and the remaining 16.67% exhibited moderate frequency range (table B38). However in the grove, the species distribution in most of the frequency ranges are comprised of more or less uniform distribution of plant species from all the plant groups such as trees,

shrubs, herbs, climbers and lianas while in the disturbed land, herbs and shrubs are the dominating plant groups.

Table B38: Distribution frequency range of total plant species

Frequency range	Nambiyath sacred grove		Disturbed land	
	No. of plant species	% of species	No. of plant species	% of species
1- 20% (Poor)	4	4.94	4	7.41
21-40% (Mostly poor)	21	25.92	13	24.07
41-60% (Moderate)	8	9.88	9	16.67
61-80% (Fairly good)	24	29.63	16	29.63
81-100% (Good)	24	29.63	12	22.22

Plant group wise distribution analysis

Trees

The tree distribution details in the Nambiyath grove is depicted in table B39. Total population of 178 trees, 20 families, 29 genera and 30 species are recorded in the grove. The highest individual representation of 23 and the highest D & RD of 5.75 & 11.92% respectively are recorded by *Artocarpus hirsutus*. This is immediately followed by 15 individuals and D & RD values of 3.75 & 7.77% being recorded by *Pterygota alata* and this is then followed immediately by individual population of 14 and D & RD of 3.5 & 7.25% respectively each recorded by *Hydnocarpus pentandrus* and *Quassia indica*. The highest F & RF values of 100% & 6.96% respectively are recorded by *A. hirsutus* and this followed immediately by values of 87.5 & 6.09% each are recorded by *P. alata*, *H. pentandrus* and *Q. indica*.

The disturbed land non-sacred grove land showed that the total tree population is 22, family 7, genera 11 and species 11 (table B40). The tree species with highest representation, D & RD and F & RF values of 4, 1 & 8.18% and 50% & 18.18% respectively are recorded by *Cocos nucifera*. Immediately followed by *Anacardium occidentale* and *Mangifera indica* each with individual population of 3, D & RD of 0.75 & 13.64% and F & RF of 37.5% & 13.64% respectively.

Table B39: Details of tree distribution in the Nambiyath sacred grove

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Adenanthera pavonina</i>	Leguminosae	4	1	2.073	3	37.5	2.6087
2	<i>Alstonia scholaris</i>	Apocynaceae	1	0.25	0.518	1	12.5	0.86957
3	<i>Anacardium occidentale</i>	Anacardiaceae	4	1	2.073	3	37.5	2.6087
4	<i>Aphanamixis polystachya</i>	Meliaceae	7	1.75	3.627	5	62.5	4.34783
5	<i>Artocarpus hirsutus</i>	Moraceae	23	5.75	11.92	8	100	6.95652
6	<i>Carallia brachiata</i>	Rhizophoraceae	2	0.5	1.036	2	25	1.73913
7	<i>Caryota urens</i>	Arecaceae	3	0.75	1.554	3	37.5	2.6087
8	<i>Chrysophyllum cainito</i>	Sapotaceae	8	2	4.145	6	75	5.21739
9	<i>Cinnamomum malabattrum</i>	Lauraceae	7	1.75	3.627	6	75	5.21739
10	<i>Diospyros malabarica</i>	Ebenaceae	5	1.25	2.591	4	50	3.47826
11	<i>Ficus amplissima</i>	Moraceae	4	1	2.073	3	37.5	2.6087
12	<i>Ficus benghalensis</i>	Moraceae	1	0.25	0.518	1	12.5	0.86957
13	<i>Garcinia gummi-gutta</i>	Clusiaceae	3	0.75	1.554	3	37.5	2.6087
14	<i>Holigarna arnottiana</i>	Anacardiaceae	7	1.75	3.627	5	62.5	4.34783
15	<i>Hydnocarpus pentandrus</i>	Flacourtiaceae	14	3.5	7.254	7	87.5	6.08696
16	<i>Lannea coromandelica</i>	Anacardiaceae	5	1.25	2.591	4	50	3.47826
17	<i>Mimusops elengi</i>	Sapotaceae	5	1.25	2.591	4	50	3.47826
18	<i>Pinanga dicksonii</i>	Arecaceae	6	1.5	3.109	3	37.5	2.6087
19	<i>Plumeria rubra</i>	Apocynaceae	1	0.25	0.518	1	12.5	0.86957
20	<i>Polyalthia longifolia</i>	Annonaceae	4	1	2.073	3	37.5	2.6087
21	<i>Pterygota alata</i>	Sterculiaceae	15	3.75	7.772	7	87.5	6.08696
22	<i>Quassia indica</i>	Simaroubaceae	14	3.5	7.254	7	87.5	6.08696
23	<i>Saraca asoca</i>	Leguminosae	2	0.5	1.036	2	25	1.73913
24	<i>Sterculia balanghas</i>	Sterculiaceae	2	0.5	1.036	2	25	1.73913
25	<i>Strychnos nux-vomica</i>	Loganiaceae	3	0.75	1.554	3	37.5	2.6087
26	<i>Syzygium cumini</i>	Myrtaceae	2	0.5	1.036	2	25	1.73913
27	<i>Tabernaemontana alternifolia</i>	Apocynaceae	9	2.25	4.663	6	75	5.21739
28	<i>Terminalia bellirica</i>	Combretaceae	2	0.5	1.036	1	12.5	0.86957
29	<i>Trema orientalis</i>	Ulmaceae	9	2.25	4.663	5	62.5	4.34783

30	<i>Vitex altissima</i>	Verbenaceae	6	1.5	3.109	5	62.5	4.34783
	Genus-29; Species-30	Family-20	178			115		

Table 40: Details of tree distribution in the disturbed non-sacred grove land

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Acacia mangium</i>	Leguminosae	1	0.25	4.545	1	12.5	4.5455
2	<i>Anacardium occidentale</i>	Anacardiaceae	3	0.75	13.64	3	37.5	13.636
3	<i>Areca catechu</i>	Arecaceae	2	0.5	9.091	2	25	9.0909
4	<i>Artocarpus hirsutus</i>	Moraceae	2	0.5	9.091	2	25	9.0909
5	<i>Cocos nucifera</i>	Arecaceae	4	1	18.18	4	50	18.182
6	<i>Dalbergia latifolia</i>	Leguminosae	1	0.25	4.545	1	12.5	4.5455
7	<i>Mangifera indica</i>	Anacardiaceae	3	0.75	13.64	3	37.5	13.636
8	<i>Quassia indica</i>	Simaroubaceae	1	0.25	4.545	1	12.5	4.5455
9	<i>Tectona grandis</i>	Verbenaceae	1	0.25	4.545	1	12.5	4.5455
10	<i>Trema orientalis</i>	Ulmaceae	2	0.5	9.091	2	25	9.0909
11	<i>Vitex altissima</i>	Verbenaceae	2	0.5	9.091	2	25	9.0909
	Genus-11; Species-11	Family-7	22			22		

Table 41: Distribution frequency range of tree species

Frequency range	Nambiyath sacred grove		Disturbed land	
	No. of tree species	% of species	No. of tree species	% of species
1- 20% (Poor)	4	13.33	4	36.36
21-40% (Mostly poor)	12	40	6	54.55
41-60% (Moderate)	3	10	1	9.09
61-80% (Fairly good)	7	23.33	0	0
81-100% (Good)	4	13.33	0	0

The distribution frequency range of tree species showed about 36.66% of species recorded good and fairly good frequency range in Nambiyath grove while it is nil in the case of disturbed land. When 53.33% of total tree species in the grove showed mostly poor and poor frequency ranges, 90.91% of the tree species in the disturbed land (90.91%) are in these ranges. About 10% and 9.09% of the species are found distributed under the moderate range in the grove and disturbed land respectively (table B41).

Shrubs

The distribution of shrubs in the Nambiyath grove showed 216 individuals, 10 families, 15 genera and 17 species (table B42). The highest individual representation and D & RD values recorded by *Ixora coccinea* and the values are 27, 6.75 & 13.37% respectively. Immediately followed by *I. coccinea* is *Briedelia stipularis* and then *Hibiscus rosa-sinensis* which are having total representation of 23 and 18 and D & RD of 5.75 & 13.45% and 4.5 & 8.91% respectively. The highest F & RF value of 100% & 8% respectively are recorded each by the above 3 species of shrubs. The immediate highest values of 87.5 & 7.0% each is recorded by 4 species namely *Clerodendrum paniculatum*, *Breynia vitis-idaea*, *Coffea travancorensis* and *Leea indica*.

With respect to the disturbed land, total population of 89 shrubs, 6 families, 10 genera and 13 species are recorded (table B43). The highest individual representation and D & RD values recorded by *Chromolaena odorata* and the values are 12 and 3 & 13.48% respectively. This is immediately followed by *Sida rhombifolia* (10 and 2.5 & 11.24% respectively). The highest F & RF values of 87.5% & 11.48% respectively are recorded by 3 species such as *Chromolaena odorata*, *Clerodendrum infortunatum* and *Sida rhombifolia* and these values are immediately followed by 75% & 9.84% recorded by *Sida cordifolia*.

Table B42: Distribution details of shrubs in the Nambiyath sacred grove

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Bambusa bambos</i>	Poaceae	11	2.75	5.446	6	75	6
2	<i>Bambusa vulgaris</i>	Poaceae	10	2.5	4.95	4	50	4
3	<i>Breynia vitis-idaea</i>	Euphorbiaceae	13	3.25	6.436	7	87.5	7
4	<i>Briedelia stipularis</i>	Euphorbiaceae	23	5.75	13.45	8	100	8
5	<i>Clerodendrum paniculatum</i>	Verbenaceae	16	4	7.921	7	87.5	7
6	<i>Coffea travancorensis</i>	Rubiaceae	13	3.25	6.436	7	87.5	7
7	<i>Dracaena terniflora</i>	Dracaenaceae	13	3.25	6.436	5	62.5	5
8	<i>Gardenia jasminoides</i>	Rubiaceae	15	3.75	7.426	6	75	6
9	<i>Grewia nervosa</i>	Tiliaceae	6	1.5	2.97	5	62.5	5
10	<i>Hibiscus rosa-sinensis</i>	Malvaceae	18	4.5	8.911	8	100	8
11	<i>Ixora coccinea</i>	Rubiaceae	27	6.75	13.37	8	100	8
12	<i>Ixora malabarica</i>	Rubiaceae	9	2.25	4.455	6	75	6

13	<i>Leea indica</i>	Leeaceae	10	2.5	4.95	7	87.5	7
14	<i>Mussaenda frondosa</i>	Rubiaceae	5	1.25	2.475	3	37.5	3
15	<i>Pandanus kaida</i>	Pandanaceae	6	1.5	2.97	2	25	2
16	<i>Pavetta indica</i>	Rubiaceae	12	3	5.941	6	75	6
17	<i>Tabernaemontana divaricata</i>	Apocynaceae	9	2.25	4.455	5	62.5	5
	Genus-15; Species-17	Family-10	216			100		

Table B43: Distribution details of shrubs in the disturbed non-sacred grove land

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Bambusa bambos</i>	Poaceae	4	1	4.494	2	25	3.2787
2	<i>Chromolaena odorata</i>	Asteraceae	12	3	13.48	7	87.5	11.475
3	<i>Clerodendrum infortunatum</i>	Verbenaceae	9	2.25	10.11	7	87.5	11.475
4	<i>Grewia nervosa</i>	Tiliaceae	5	1.25	5.618	4	50	6.5574
5	<i>Hibiscus hispidissimus</i>	Malvaceae	5	1.25	5.618	4	50	6.5574
6	<i>Hibiscus surattensis</i>	Malvaceae	6	1.5	6.742	5	62.5	8.1967
7	<i>Lantana camara</i>	Verbenaceae	3	0.75	3.371	2	25	3.2787
8	<i>Leea indica</i>	Leeaceae	6	1.5	6.742	4	50	6.5574
9	<i>Sida cordifolia</i>	Malvaceae	9	2.25	10.11	6	75	9.8361
10	<i>Sida rhombifolia</i>	Malvaceae	10	2.5	11.24	7	87.5	11.475
11	<i>Sida mysorensis</i>	Malvaceae	7	1.75	7.865	5	62.5	8.1967
12	<i>Stachytarpheta jamaicensis</i>	Verbenaceae	6	1.5	6.742	3	37.5	4.918
13	<i>Urena lobata</i>	Malvaceae	7	1.75	7.865	5	62.5	8.1967
	Genus-10; Species-13	Family-6	89			61		

Table B44: Distribution frequency range of shrub species

Frequency range	Nambiyath sacred grove		Disturbed land	
	No. of shrub species	% of species	No. of shrub species	% of species
1- 20% (Poor)	0	0	0	0
21-40% (Mostly poor)	2	11.76	3	23.08
41-60% (Moderate)	1	5.88	3	23.08
61-80% (Fairly good)	7	41.18	4	30.76
81-100% (Good)	7	41.18	3	23.08

The distribution frequency range of shrubby species in the Nambiyath grove showed comparatively higher percentage of species (82.36%) belong to good and fairly good frequency range compared to disturbed land (53.84%). However in the moderate and mostly poor frequency range, comparatively higher percentage of shrubby species (46.16%) is recorded in the disturbed land compared to grove (17.64%). None of the species are recorded under the poor frequency range of 1-20% in both the study area (table B44).

Herbs

The herbaceous plants distribution in the Nambiyath grove showed a total of 212 individuals belong to 12 families which comprised of 16 genera and 16 species (table B45). *Panicum notatum* recorded the maximum individual population of 23 and highest D & RD values of 5.75 & 13.37%. This is immediately followed by *Emilia sonchifolia* and then *Curculigo orchoides* with total representation of 17 and 16 and D & RD values of 4.25 & 9.88% and 4 & 9.30% respectively. The highest F & RF values of 100% & 8.16% recorded each by 3 species *Panicum notatum*, *Biophytum reinwardtii* and *Aerva lanata* and this is immediately followed by values 87.5% & 7.14% which are recorded each by 4 species *Mitracarpus hirtus*, *Brachiaria subquadripara*, *Cyathula prostrata* and *Boerhaavia diffusa*.

However, the distribution of herbs in the disturbed land showed total population of 49582 individuals. This comprised of 25 genera and 26 species which are belonging to 9 families (table B46). The highest individual representation and D & RD values are recorded by *Aerva lanata* (3339 and 834.7 & 6.69% respectively) and this is immediately followed by *Cynodon dactylon* and *Achyranthes aspera* (2732 and 682.9 & 5.56% each respectively). The highest F & RF values of 100% & 5.76% in the disturbed land is recorded by the above said species and these species are immediately followed by *Eragrostis amabilis*, *Brachiaria remota*, *Andrographis paniculata* and *Alloteropsis cimicina* (87.5% & 5.03% each).

Table B45: Distribution details of herbs in the Nambiyath sacred grove

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Aerva lanata</i>	Amaranthaceae	10	2.5	4.72	8	100	8.16327
2	<i>Biophytum reinwardtii</i>	Oxalidaceae	15	3.75	7.08	8	100	8.16327
3	<i>Boerhaavia diffusa</i>	Nyctaginaceae	12	3	5.66	7	87.5	7.14286
4	<i>Brachiaria subquadripara</i>	Poaceae	14	3.5	6.6	7	87.5	7.14286

5	<i>Curculigo orchioides</i>	Hypoxidaceae	16	4	7.55	5	62.5	5.10204
6	<i>Cyanthillium cinereum</i>	Asteraceae	12	3	5.66	5	62.5	5.10204
7	<i>Cyathula prostrata</i>	Amaranthaceae	13	3.25	6.13	7	87.5	7.14286
8	<i>Cyperus rotundus</i>	Cyperaceae	18	4.5	8.49	6	75	6.12245
9	<i>Desmodium gangeticum</i>	Leguminosae	11	2.75	5.19	6	75	6.12245
10	<i>Emilia sonchifolia</i>	Asteraceae	17	4.25	8.02	6	75	6.12245
11	<i>Euphorbia hirta</i>	Euphorbiaceae	7	1.75	3.3	5	62.5	5.10204
12	<i>Grangea maderaspatana</i>	Asteraceae	8	2	3.77	4	50	4.08163
13	<i>Laportea interrupta</i>	Urticaceae	12	3	5.66	3	37.5	3.06122
14	<i>Mitracarpus hirtus</i>	Rubiaceae	15	3.75	7.08	7	87.5	7.14286
15	<i>Naregamia alata</i>	Meliaceae	9	2.25	4.25	6	75	6.12245
16	<i>Panicum notatum</i>	Poaceae	23	5.75	10.8	8	100	8.16327
	Genus-16; Species-16	Family-12	212			98		

Table B46: Distribution details of herbs in the disturbed non-sacred grove land

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Achyranthes aspera</i>	Amaranthaceae	2731.7	682.93	5.51	8	100	5.755
2	<i>Aerva lanata</i>	Amaranthaceae	3750.0	937.5	7.56	8	100	5.755
3	<i>Ageratum conyzoides</i>	Asteraceae	1821.2	455.3	3.67	6	75	4.317
4	<i>Allmania nodiflora</i>	Amaranthaceae	1517.6	379.4	3.06	4	50	2.878
5	<i>Alloteropsis cimicina</i>	Poaceae	2124.7	531.18	4.29	7	87.5	5.036
6	<i>Alternanthera brasiliana</i>	Amaranthaceae	2428.2	607.05	4.9	6	75	4.317
7	<i>Andrographis echioides</i>	Acanthaceae	2124.7	531.18	4.29	5	62.5	3.597
8	<i>Andrographis paniculata</i>	Acanthaceae	2124.7	531.18	4.29	7	87.5	5.036
9	<i>Anisomeles indica</i>	Lamiaceae	1517.6	379.4	3.06	4	50	2.878
10	<i>Boerhavia diffusa</i>	Nyctaginaceae	1517.6	379.4	3.06	5	62.5	3.597
11	<i>Brachiaria remota</i>	Poaceae	2428.2	607.05	4.9	7	87.5	5.036
12	<i>Chamaecrista mimosoides</i>	Leguminosae	1821.2	455.3	3.67	5	62.5	3.597
13	<i>Cynodon dactylon</i>	Poaceae	2731.7	682.93	5.51	8	100	5.755
14	<i>Cyperus rotundus</i>	Cyperaceae	2124.7	531.18	4.29	5	62.5	3.597
15	<i>Dicliptera paniculata</i>	Acanthaceae	1214.1	303.53	2.45	3	37.5	2.158
16	<i>Digitaria ciliaris</i>	Poaceae	1821.2	455.3	3.67	6	75	4.317

17	<i>Eragrostis amabilis</i>	Poaceae	2428.2	607.05	4.9	7	87.5	5.036
18	<i>Euphorbia hirta</i>	Euphorbiaceae	2124.7	531.18	4.29	6	75	4.317
19	<i>Leucas aspera</i>	Lamiaceae	1821.2	455.3	3.67	4	50	2.878
20	<i>Mimosa pudica</i>	Leguminosae	1517.6	379.4	3.06	3	37.5	2.158
21	<i>Mitracarpus hirtus</i>	Rubiaceae	1517.6	379.4	3.06	5	62.5	3.597
22	<i>Oldenlandia corymbosa</i>	Rubiaceae	1214.1	303.53	2.45	4	50	2.878
23	<i>Phyllanthus amarus</i>	Euphorbiaceae	1214.1	303.53	2.45	4	50	2.878
24	<i>Scoparia dulcis</i>	Scrophulariaceae	910.58	227.65	1.84	3	37.5	2.158
25	<i>Synedrella nodiflora</i>	Asteraceae	910.58	227.65	1.84	3	37.5	2.158
26	<i>Tridax procumbens</i>	Asteraceae	2124.7	531.18	4.29	6	75	4.317
	Genus-25; Species-26	Family-9	49582			139		

The major proportion of herbaceous species in the grove (87.5%) are coming under the good and fairly good frequency range while this is 65.38% in the disturbed land. However, the proportion of species exhibited moderate and mostly poor frequency range is comparatively higher in the disturbed land (34.61%) compared to grove (12.5%). No herbaceous species recorded under the poor frequency range of 1-20% in both the study sites (table B47).

Table B47: Distribution frequency range of herbaceous species

Frequency range	Nambiyath sacred grove		Disturbed land	
	No. of herbs species	% of species	No. of herbs species	% of species
1- 20% (Poor)	0	0	0	0
21-40% (Mostly poor)	1	6.25	4	15.38
41-60% (Moderate)	1	6.25	5	19.23
61-80% (Fairly good)	7	43.75	10	38.46
81-100% (Good)	7	43.75	7	26.92

Climbers

The climbers in the Nambiyath grove showed total population of 148 individuals which comprise of 13 genera and 13 species belong to 10 families (table B48). Highest individual representation of 18 and highest D & RD values of 4.5 & 12.16% are recorded each by *Abrus precatorius* and *Ichnocarpus frutescens*. This is immediately followed by *Tiliacora racemosa* having 17 individuals and D & RD values of 4.25 & 11.49% respectively. *I. frutescens*

recorded the highest F and RF values (100% and 14.55% respectively) and this is immediately followed by *T. racemosa* (87.5% and 12.73% respectively).

In the disturbed land, total population is 57 which comprise of 4 genera and 4 species belong to 4 families (table B49). *Mikania micrantha* recorded the highest individual representation and D & RD values (19 and 4.75 & 33.33% respectively) and this is immediately followed by *Tiliacora racemosa* (17 and 4.25 & 29.82% respectively) and then *Ichnocarpus frutescens* (11 and 2.75 & 19.3% respectively). The highest F & RF values are recorded by *M. micrantha* (100% & 30.8% respectively) and this is followed immediately by *T. racemosa* (87.5% & 26.9% respectively).

Table B48: Distribution details of climbers in the Nambiyath sacred grove

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Abrus precatorius</i>	Leguminosae	18	4.5	12.16	3	37.5	5.455
2	<i>Asparagus racemosus</i>	Liliaceae	10	2.5	6.757	2	25	3.636
3	<i>Cissus latifolia</i>	Vitaceae	10	2.5	6.757	4	50	7.273
4	<i>Combretum latifolium</i>	Combretaceae	9	2.25	6.081	3	37.5	5.455
5	<i>Cyclea peltata</i>	Menispermaceae	6	1.5	4.054	3	37.5	5.455
6	<i>Dioscorea bulbifera</i>	Dioscoreaceae	8	2	5.405	3	37.5	5.455
7	<i>Ichnocarpus frutescens</i>	Apocynaceae	18	4.5	12.16	8	100	14.55
8	<i>Jasminum multiflorum</i>	Oleaceae	8	2	5.405	3	37.5	5.455
9	<i>Kamettia caryophyllata</i>	Apocynaceae	12	3	8.108	4	50	7.273
10	<i>Mikania micrantha</i>	Asteraceae	14	3.5	9.459	6	75	10.91
11	<i>Mukia maderaspatana</i>	Cucurbitaceae	11	2.75	7.432	4	50	7.273
12	<i>Tiliacora racemosa</i>	Menispermaceae	17	4.25	11.49	7	87.5	12.73
13	<i>Tinospora sinensis</i>	Menispermaceae	7	1.75	4.73	5	62.5	9.091
	Genus-13; Species-13	Family-10	148			55		

Table B49: Distribution details of climbers in the disturbed non-sacred grove land

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Abrus precatorius</i>	Leguminosae	10	2.5	17.54	6	75	23.1
2	<i>Ichnocarpus frutescens</i>	Apocynaceae	11	2.75	19.3	5	62.5	19.2
3	<i>Mikania micrantha</i>	Asteraceae	19	4.75	33.33	8	100	30.8

4	<i>Tiliacora racemosa</i>	Menispermaceae	17	4.25	29.82	7	87.5	26.9
	Genus-4; Species-4	Family-4	57			26		

The grove showed 30.76% of the species in the good and fairly good frequency range while, the major proportion of the species (69.23%) in the moderate and mostly poor frequency range (table B50). However in the disturbed land, only 4 species of climbers recorded and all are coming under the good and fairly good frequency range. No climbers are recorded under the poor frequency range of 1-20% in both the study areas.

Table B50: Frequency distribution range of climbers

Frequency range	Nambiyath sacred grove		Disturbed land	
	No. of herbs species	% of species	No. of herbs species	% of species
1- 20% (Poor)	0	0	0	0
21-40% (Mostly poor)	6	46.15	0	0
41-60% (Moderate)	3	23.08	0	0
61-80% (Fairly good)	2	15.38	2	50
81-100% (Good)	2	15.38	2	50

Lianas

The distribution details of lianas in the Nambiyath grove is depicted in table B51. Total population is 164 members belonging to 5 families which comprise of 5 genera and 5 species. The highest individual representation of 55 members and D & RD values of 13.75 & 33.54% respectively are recorded by *Gnetum ula* and which is immediately followed by *Uvaria narum* and then *Sarcostigma kleinii* which are having individual population of 35 and 32 respectively and D & RD of 8.75 & 21.34% and 8 & 19.51% respectively. The highest F and RF values of 100% & 21.62% are recorded each by the above 3 species and they are immediately followed by *Connarus monocarpus* (87.5% & 18.92% respectively). The plant group lianas are totally absent in the disturbed land.

Table B51: Distribution details of lianas in the Nambiyath sacred grove

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Connarus monocarpus</i>	Connaraceae	28	7	17.07	7	87.5	18.92
2	<i>Coscinium fenestratum</i>	Menispermaceae	14	3.5	8.537	6	75	16.22
3	<i>Gnetum ula</i>	Gnetaceae	55	13.75	33.54	8	100	21.62
4	<i>Sarcostigma kleinii</i>	Icacinaeae	32	8	19.51	8	100	21.62

5	<i>Uvaria narum</i>	Annonaceae	35	8.75	21.34	8	100	21.62
	Genus-5; Species-5	Family-5	164			37		

Table B52: Distribution frequency range of lianas

Frequency range	Nambiyath sacred grove		Disturbed land	
	No. of herbs species	% of species	No. of herbs species	% of species
1- 20% (Poor)	0	0	0	0
21-40% (Mostly poor)	0	0	0	0
41-60% (Moderate)	0	0	0	0
61-80% (Fairly good)	1	20	0	0
81-100% (Good)	4	80	0	0

The distribution frequency range of lianas in the grove indicate all the species are in the good and fairly good frequency range. Lianas are absent in the disturbed land (table B52).

4) Poyyara site

Analysis of total floral distribution

The analysis of total floral distribution in the Poyyara sacred grove showed the presence of 622 plants belong to a total of 38 families which comprise of 57 genera and 59 species (table B53). The highest individual population of 47 and the highest D & RD values of 11.75 & 7.56% in the grove are recorded by the climber *Tiliacora racemosa*. This is immediately followed by climbers *Pothos scandens* and then *Strychnos minor* with total population of 44 and 41 individuals respectively and D & RD values of 11 & 7.07% and 10.25 & 6.59% respectively. The highest F & RF values of 100% & 2.84% respectively being recorded by 8 plant species. This include the shrubs *Ixora coccinea* and *Briedelia stipularis*; the climbers *Tiliacora racemosa*, *Pothos scandens*, *Strychnos minor*, *Dioscorea bulbifera* and *Abrus precatorius* and the liana *Rourea minor*. These values are immediately followed by 87.5% & 2.48% respectively for F and RF recorded by 9 plant species and this include the shrubs *Polyalthia korintii* and *Grewia nervosa*; the herbs *Spermacoce articularis* and *Panicum notatum*; the climbers *Cyphostemma trilobata*, *Asparagus racemosus*, *Cyclea peltata* and *Mukia maderaspatana* and the liana *Gnetum ula*.

Table B53: Details of total floral distribution in the Poyyara sacred grove

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Abrus precatorius</i> L.	Leguminosae	20	5	3.22	8	100	2.84
2	<i>Adenanthera pavonina</i> L.	Leguminosae	4	1	0.64	3	37.5	1.06
3	<i>Aegle marmelos</i> (L.) Corrêa.	Rutaceae	1	0.25	0.16	1	12.5	0.35
4	<i>Aerva lanata</i> (L.) Juss.	Amaranthaceae	6	1.5	0.97	4	50	1.42
5	<i>Alstonia scholaris</i> (L.) R. Br.	Apocynaceae	1	0.25	0.16	1	12.5	0.35
6	<i>Aphanamixis polystachya</i> (Wall.) R.Parker.	Meliaceae	5	1.25	0.80	4	50	1.42
7	<i>Asparagus racemosus</i> Willd.	Liliaceae	18	4.5	2.89	7	87.5	2.48
8	<i>Bambusa bambos</i> (L.) Voss.	Poaceae	12	3	1.93	2	25	0.71
9	<i>Bauhinia acuminata</i> L.	Leguminosae	5	1.25	0.80	4	50	1.42
10	<i>Biophytum reinwardtii</i> (Zucc.) Klotzsch.	Oxalidaceae	6	1.5	0.97	4	50	1.42
11	<i>Boerhavia diffusa</i> L.	Nyctaginaceae	4	1	0.64	3	37.5	1.06
12	<i>Breynia vitis-idaea</i> (Burm.f.) C.E.C.Fisch.	Euphorbiaceae	6	1.5	0.97	4	50	1.42
13	<i>Bridelia stipularis</i> (L.) Blume.	Euphorbiaceae	18	4.5	2.89	8	100	2.84
14	<i>Caryota urens</i> L.	Arecaceae	5	1.25	0.80	5	62.5	1.77
15	<i>Chassalia curviflora</i> (Wall.) Thwaites.	Rubiaceae	13	3.25	2.09	6	75	2.13
16	<i>Clerodendrum paniculatum</i> L.	Verbenaceae	9	2.25	1.45	5	62.5	1.77
17	<i>Combretum latifolium</i> Blume.	Combretaceae	9	2.25	1.45	5	62.5	1.77
18	<i>Cyathula prostrata</i> (L.) Blume.	Amaranthaceae	10	2.5	1.61	5	62.5	1.77
19	<i>Cyclea peltata</i> (Lam.) Hook.f. & Thomson.	Menispermaceae	18	4.5	2.89	7	87.5	2.48
20	<i>Cyperus rotundus</i> L.	Cyperaceae	8	2	1.29	4	50	1.42
21	<i>Cyphostemma trilobata</i> (Lam.) M.R.Almeida.	Vitaceae	20	5	3.22	7	87.5	2.48
22	<i>Desmodium gangeticum</i> (L.) DC.	Leguminosae	6	1.5	0.97	4	50	1.42
23	<i>Dioscorea bulbifera</i> L.	Dioscoreaceae	23	5.75	3.70	8	100	2.84
24	<i>Emilia sonchifolia</i> (L.) DC. ex DC.	Asteraceae	5	1.25	0.80	3	37.5	1.06
25	<i>Euphorbia hirta</i> L.	Euphorbiaceae	6	1.5	0.97	4	50	1.42
26	<i>Ficus amplissima</i> Sm.	Moraceae	3	0.75	0.48	2	25	0.71
27	<i>Ficus benghalensis</i> L.	Moraceae	1	0.25	0.16	1	12.5	0.35
28	<i>Garcinia gummi-gutta</i> (L.) Roxb.	Clusiaceae	3	0.75	0.48	3	37.5	1.06
29	<i>Glycosmis pentaphylla</i> (Retz.) DC.	Rutaceae	16	4	2.57	6	75	2.13
30	<i>Gnetum ula</i> Brongn.	Gnetaceae	13	3.25	2.09	7	87.5	2.48

31	<i>Grewia nervosa</i> (Lour.) Panigrahi.	Tiliaceae	17	4.25	2.73	7	87.5	2.48
32	<i>Holigarna arnottiana</i> Hook.f.	Anacardiaceae	3	0.75	0.48	3	37.5	1.06
33	<i>Hopea ponga</i> (Dennst.) Mabb.	Dipterocarpaceae	1	0.25	0.16	1	12.5	0.35
34	<i>Hydnocarpus pentandrus</i> (Buch.-Ham.) Oken.	Flacourtiaceae	4	1	0.64	4	50	1.42
35	<i>Ichnocarpus frutescens</i> (L.) W.T.Aiton.	Apocynaceae	15	3.75	2.41	6	75	2.13
36	<i>Ixora coccinea</i> L.	Rubiaceae	18	4.5	2.89	8	100	2.84
37	<i>Leea indica</i> (Burm. f.) Merr.	Leeaceae	7	1.75	1.13	4	50	1.42
38	<i>Mimusops elengi</i> L.	Sapotaceae	2	0.5	0.32	2	25	0.71
39	<i>Mukia maderaspatana</i> (L.) M.Roem.	Cucurbitaceae	18	4.5	2.89	7	87.5	2.48
40	<i>Mussaenda frondosa</i> L.	Rubiaceae	14	3.5	2.25	6	75	2.13
41	<i>Nothapodytes nimmoniana</i> (J.Graham) Mabb.	Icacinaceae	12	3	1.93	6	75	2.13
42	<i>Panicum notatum</i> Retz.	Poaceae	12	3	1.93	7	87.5	2.48
43	<i>Polyalthia korintii</i> Hook. f. & Thomson.	Annonaceae	13	3.25	2.09	7	87.5	2.48
44	<i>Pongamia pinnata</i> (L.) Pierre.	Leguminosae	1	0.25	0.16	1	12.5	0.35
45	<i>Pothos scandens</i> L.	Araceae	44	11	7.07	8	100	2.84
46	<i>Pterygota alata</i> (Roxb.) R.Br.	Sterculiaceae	4	1	0.64	3	37.5	1.06
47	<i>Quassia indica</i> (Gaertn.) Noot.	Simaroubaceae	3	0.75	0.48	3	37.5	1.06
48	<i>Rourea minor</i> (Gaertn.) Alston.	Connaraceae	15	3.75	2.41	8	100	2.84
49	<i>Sarcostigma kleinii</i> Wight & Arn.	Icacinaceae	6	1.5	0.97	5	62.5	1.77
50	<i>Spermaceoce articularis</i> L.f.	Rubiaceae	15	3.75	2.41	7	87.5	2.48
51	<i>Sterculia balanghas</i> L.	Sterculiaceae	5	1.25	0.80	4	50	1.42
52	<i>Strychnos minor</i> Dennst.	Loganiaceae	41	10.25	6.59	8	100	2.84
53	<i>Syzygium cumini</i> (L.) Skeels.	Myrtaceae	3	0.75	0.48	3	37.5	1.06
54	<i>Tabernaemontana alternifolia</i> L.	Apocynaceae	4	1	0.64	4	50	1.42
55	<i>Tabernaemontana divaricata</i> (L.) R.Br. ex Roem. & Schult.	Apocynaceae	7	1.75	1.13	5	62.5	1.77
56	<i>Terminalia bellirica</i> (Gaertn.) Roxb.	Combretaceae	1	0.25	0.16	1	12.5	0.35
57	<i>Tiliacora racemosa</i> Colebr.	Menispermaceae	47	11.75	7.56	8	100	2.84
58	<i>Uvaria narum</i> A.DC.	Annonaceae	10	2.5	1.61	6	75	2.13
59	<i>Vitex altissima</i> L.f.	Verbenaceae	6	1.5	0.97	5	62.5	1.77
	Genus-57; Species-59	Family-38	622			282		

The total floral distribution in the disturbed non-sacred grove land at Poyyara site is depicted in table B54. Total plant population of 6153 members belong to 16 families which comprise of 26 genera and 26 species recorded in the area. The highest individual population of 607 and D & RD values of 151.78 & 9.87% recorded by the herb *Brachiaria subquadrupara*. This is immediately followed by 7 herbaceous members *Aerva lanata*, *Cynodon dactylon*, *Achyranthes aspera*, *Anisomeles indica*, *Cyperus rotundus*, *Leucas aspera* and *Phyllanthus amarus* each with a total population of 506 individuals and D & RD values of 126.48 & 8.22% respectively. The highest F & RF values of 100% & 6.84% respectively recorded by the climber *Mikania micrantha* and this is immediately followed by values of 87.5% & 5.98% respectively recorded each by the shrub *Urena lobata* and the herb *Brachiaria subquadrupara*.

Table B54: Details of total floral distribution in the non-sacred grove land

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Abrus precatorius</i> L.	Leguminosae	8	2	0.13	6	75	5.13
2	<i>Achyranthes aspera</i> L.	Amaranthaceae	505.9	126.48	8.22	5	62.5	4.27
3	<i>Aerva lanata</i> (L.) Juss.	Amaranthaceae	505.9	126.48	8.22	4	50	3.42
4	<i>Anacardium occidentale</i> L.	Anacardiaceae	1	0.25	0.02	1	12.5	0.85
5	<i>Andrographis paniculata</i> (Burm.f.) Nees.	Acanthaceae	404.7	101.18	6.58	3	37.5	2.56
6	<i>Anisomeles indica</i> (L.) Kuntze.	Lamiaceae	505.9	126.48	8.22	5	62.5	4.27
7	<i>Areca catechu</i> L.	Arecaceae	3	0.75	0.05	3	37.5	2.56
8	<i>Boerhavia diffusa</i> L.	Nyctaginaceae	404.7	101.18	6.58	4	50	3.42
9	<i>Brachiaria subquadrupara</i> (Trin.) Hitchc.	Poaceae	607.1	151.78	9.87	7	87.5	5.98
10	<i>Chromolaena odorata</i> (L.) R.M.King & H.Rob.	Asteraceae	6	1.5	0.10	5	62.5	4.27
11	<i>Clerodendrum infortunatum</i> L.	Verbenaceae	4	1	0.07	3	37.5	2.56
12	<i>Cocos nucifera</i> L.	Arecaceae	2	0.5	0.03	2	25	1.71
13	<i>Cynodon dactylon</i> (L.) Pers.	Poaceae	505.9	126.48	8.22	6	75	5.13
14	<i>Cyperus rotundus</i> L.	Cyperaceae	505.9	126.48	8.22	4	50	3.42
15	<i>Euphorbia hirta</i> L.	Euphorbiaceae	404.7	101.18	6.58	6	75	5.13
16	<i>Grewia nervosa</i> (Lour.) Panigrahi.	Tiliaceae	5	1.25	0.08	3	37.5	2.56
17	<i>Lantana camara</i> L.	Verbenaceae	4	1	0.07	3	37.5	2.56
18	<i>Leea indica</i> (Burm. f.) Merr.	Leeaceae	5	1.25	0.08	4	50	3.42
19	<i>Leucas aspera</i> (Willd.) Link.	Lamiaceae	505.9	126.48	8.22	6	75	5.13

20	<i>Mikania micrantha</i> Kunth.	Asteraceae	20	5	0.33	8	100	6.84
21	<i>Mimosa pudica</i> L.	Leguminosae	303.5	75.875	4.93	3	37.5	2.56
22	<i>Phyllanthus amarus</i> Schumach. & Thonn.	Euphorbiaceae	505.9	126.48	8.22	6	75	5.13
23	<i>Sida cordifolia</i> L.	Malvaceae	8	2	0.13	6	75	5.13
24	<i>Trema orientalis</i> (L.) Blume.	Ulmaceae	3	0.75	0.05	3	37.5	2.56
25	<i>Tridax procumbens</i> (L.) L.	Asteraceae	404.7	101.18	6.58	4	50	3.42
26	<i>Urena lobata</i> L.	Malvaceae	13	3.25	0.21	7	87.5	5.98
	Genus-26 ; Species-26	Family-16	6153			117		

Table B55: Distribution frequency range of total plant species

Frequency range	Poyyara sacred grove		Disturbed land	
	No. of plant species	% of species	No. of plant species	% of species
1- 20% (Poor)	6	10.17	1	3.85
21-40% (Mostly poor)	11	18.64	8	30.77
41-60% (Moderate)	12	20.34	5	19.23
61-80% (Fairly good)	13	22.03	9	34.62
81-100% (Good)	17	28.81	3	11.54

The distribution frequency range of plant species showed about 50.84% of species in the grove and 46.16% of species in the disturbed land are coming under good and fairly good ranges. Similarly 42.37% of species in the grove and 50% of the species in the disturbed land recorded moderate and mostly poor frequency range. The rest of the 10.17% of species in the grove and 3.85% in the disturbed land showed poor frequency range (table B55). The analysis in the proportion of species distribution revealed, the most of the frequency range class in the grove comprised of more or less uniform representation of species from all the plant groups such as trees, shrubs, herbs, climbers and lianas. But in the disturbed land, species of plant groups herbs and shrubs are found most dominated and even total absence of plant group lianas recorded.

Plant group wise distribution analysis

Trees

The tree distribution in the Poyyara grove showed total population of 60 trees belong 16 families and which comprise of 19 genera and 20 species (table B56). The highest individual representation of 6 and D & RD of 1.5 & 10% are recorded by *Vitex altissima* and this is immediately followed by values of 5 and 1.25 & 8.33% respectively each recorded by 3 species *Aphanamixis polystachya*, *Caryota urens* and *Sterculia balanghas*. With respect to

the F and RF, *V. altissima* and *C. urens* recorded the highest values (62.5% & 9.26% each) and this is immediately followed by tree species like *Aphanamixis polystachya*, *Hydnocarpus pentandrus*, *Sterculia balanghas* and *Tabernaemontana alternifolia* (50% & 7.41% each).

The disturbed non-sacred grove land recorded a total population of 9 trees which are belonging to 3 families and comprised of 4 genera and 4 species (table B57). The highest individual representation and D & RD values of 3 and 0.75 & 33.33% respectively recorded each by *Areca catechu* and *Trema orientalis*. This is immediately followed by *Cocos nucifera* (2 and 0.50 & 22.22% respectively). The highest F and RF values recorded by *Areca catechu* and *Trema orientalis* and the values are 37.5% and 33.33% respectively each. This is immediately followed by values of 25% and 22.22% respectively recorded by *Cocos nucifera*.

Table B56: Details of tree distribution in the Poyyara sacred grove

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Adenanthera pavonina</i>	Leguminosae	4	1	6.67	3	37.5	5.556
2	<i>Aegle marmelos</i>	Rutaceae	1	0.25	1.67	1	12.5	1.852
3	<i>Alstonia scholaris</i>	Apocynaceae	1	0.25	1.67	1	12.5	1.852
4	<i>Aphanamixis polystachya</i>	Meliaceae	5	1.25	8.33	4	50	7.407
5	<i>Caryota urens</i>	Arecaceae	5	1.25	8.33	5	62.5	9.259
6	<i>Ficus amplissima</i>	Moraceae	3	0.75	5.0	2	25	3.704
7	<i>Ficus benghalensis</i>	Moraceae	1	0.25	1.67	1	12.5	1.852
8	<i>Garcinia gummi-gutta</i>	Clusiaceae	3	0.75	5.0	3	37.5	5.556
9	<i>Holigarna arnottiana</i>	Anacardiaceae	3	0.75	5.0	3	37.5	5.556
10	<i>Hopea ponga</i>	Dipterocarpaceae	1	0.25	1.67	1	12.5	1.852
11	<i>Hydnocarpus pentandrus</i>	Flacourtiaceae	4	1	6.67	4	50	7.407
12	<i>Mimusops elengi</i>	Sapotaceae	2	0.5	3.33	2	25	3.704
13	<i>Pongamia pinnata</i>	Leguminosae	1	0.25	1.67	1	12.5	1.852
14	<i>Pterygota alata</i>	Sterculiaceae	4	1	6.67	3	37.5	5.556
15	<i>Quassia indica</i>	Simaroubaceae	3	0.75	5.0	3	37.5	5.556
16	<i>Sterculia balanghas</i>	Sterculiaceae	5	1.25	8.33	4	50	7.407
17	<i>Syzygium cumini</i>	Myrtaceae	3	0.75	5.0	3	37.5	5.556
18	<i>Tabernaemontana alternifolia</i>	Apocynaceae	4	1	6.67	4	50	7.407
19	<i>Terminalia bellirica</i>	Combretaceae	1	0.25	1.67	1	12.5	1.852
20	<i>Vitex altissima</i>	Verbenaceae	6	1.5	10.0	5	62.5	9.259
	Genus-19; Species-20	Family-16	60			54		

Table B57: Distribution details of trees in the disturbed non-sacred grove land

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Anacardium occidentale</i>	Anacardiaceae	1	0.25	11.11	1	12.5	11.11
2	<i>Areca catechu</i>	Arecaceae	3	0.75	33.33	3	37.5	33.33
3	<i>Cocos nucifera</i>	Arecaceae	2	0.5	22.22	2	25	22.22
4	<i>Trema orientalis</i>	Ulmaceae	3	0.75	33.33	3	37.5	33.33
	Genus-4; Species-4	Family-3	9			9		

In the disturbed land all the tree species are belonging to mostly poor and poor frequency range. However in the grove, although the majority of the tree species (70%) are belonging to mostly poor and poor frequency range, the rest of the 30% tree species are belonging to fairly good and moderate distribution frequency ranges (table B58).

Table B58: Distribution frequency range of tree species in the Poyyara sacred grove and disturbed land

Frequency range	Poyyara sacred grove		Disturbed land	
	No. of tree species	% of species	No. of tree species	% of species
1- 20% (Poor)	6	30	1	25
21-40% (Mostly poor)	8	40	3	75
41-60% (Moderate)	4	20	0	0
61-80% (Fairly good)	2	10	0	0
81-100% (Good)	0	0	0	0

Shrubs

The distribution details of shrubs in the Poyyara sacred grove is depicted in table B59. Total population of 167 individuals, 11 families, 14 genera and 14 species are recorded in the area. Highest individual population of 18 and D & RD values of 4.5 & 10.78% respectively each is recorded by *Ixora coccinea* and *Briedelia stipularis*. This is immediately followed by *Grewia nervosa* and then *Glycosmis pentaphylla* which are having total representations of 17 and 16 and D & RD of 4.25 & 10.18% and 4 & 9.58% respectively. Highest F value of 100% and RF value of 10.26% in the area recorded each by *I. coccinea* and *B. stipularis*, followed immediately by values of 87.5% and 7% each recorded by *Polyalthia korintii* and *Grewia nervosa*.

The disturbed land consists of 5 families, 7 genera, 7 species and total population of 45 individuals (table B60). The highest individual representation and D & RD values are recorded by *Urena lobata* (13 and 3.25 & 28.89% respectively), immediately followed by *Sida cordifolia* (8 and 2 & 17.78% respectively). The highest F & RF values among the shrubs are recorded by *U. lobata* (87.5% & 22.58% respectively) and this is immediately followed by *S. cordifolia* (75% & 19.35%).

Table B59: Distribution details of shrubs in the Poyyara sacred grove

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Bambusa bambos</i>	Poaceae	12	3	7.19	2	25	2.564
2	<i>Bauhinia acuminata</i>	Leguminosae	5	1.25	2.10	4	50	5.128
3	<i>Bridelia stipularis</i>	Euphorbiaceae	18	4.5	10.78	8	100	10.26
4	<i>Breynia vitis-idaea</i>	Euphorbiaceae	6	1.5	3.59	4	50	5.128
5	<i>Chassalia curviflora</i>	Rubiaceae	13	3.25	7.78	6	75	7.692
6	<i>Clerodendrum paniculatum</i>	Verbenaceae	9	2.25	5.39	5	62.5	6.41
7	<i>Glycosmis pentaphylla</i>	Rutaceae	16	4	9.58	6	75	7.692
8	<i>Grewia nervosa</i>	Tiliaceae	17	4.25	10.18	7	87.5	8.974
9	<i>Ixora coccinea</i>	Rubiaceae	18	4.5	10.78	8	100	10.26
10	<i>Leea indica</i>	Leeaceae	7	1.75	4.19	4	50	5.128
11	<i>Mussaenda frondosa</i>	Rubiaceae	14	3.5	8.38	6	75	7.692
12	<i>Nothapodytes nimmoniana</i>	Icacinaceae	12	3	7.19	6	75	7.692
13	<i>Polyalthia korintii</i>	Annonaceae	13	3.25	7.78	7	87.5	8.974
14	<i>Tabernaemontana divaricata</i>	Apocynaceae	7	1.75	4.19	5	62.5	6.41
	Genus-14; Species-14	Family-11	167			78		

Table B60: Distribution details of shrubs in the disturbed non-sacred grove land

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Chromolaena odorata</i>	Asteraceae	6	1.5	13.33	5	62.5	16.13
2	<i>Clerodendrum infortunatum</i>	Verbenaceae	4	1	8.89	3	37.5	9.677
3	<i>Grewia nervosa</i>	Tiliaceae	5	1.25	11.11	3	37.5	9.677
4	<i>Lantana camara</i>	Verbenaceae	4	1	8.89	3	37.5	9.677
5	<i>Leea indica</i>	Leeaceae	5	1.25	11.11	4	50	12.9
6	<i>Sida cordifolia</i>	Malvaceae	8	2	17.78	6	75	19.35
7	<i>Urena lobata</i>	Malvaceae	13	3.25	28.89	7	87.5	22.58
	Genus-7; Species-7	Family-5	45			31		

The distribution frequency range of shrubby species in the grove showed 71.43% of species are belonging to good and fairly good frequency range while this is only 42.86% in the disturbed land. The rest of the species in the grove showed 21.43% in the moderate and 7.14% in the mostly poor frequency range while in the disturbed land, this is 14.29% in the moderate and 42.86% in the mostly poor frequency range. No species are recorded under the poor frequency range of 1-20% in both the study area (table B61).

Table B61: Distribution frequency range of shrubby species

Frequency range	Poyyara sacred grove		Disturbed land	
	No. of shrub species	% of species	No. of shrub species	% of species
1- 20% (Poor)	0	0	0	0
21-40% (Mostly poor)	1	7.14	3	42.86
41-60% (Moderate)	3	21.43	1	14.29
61-80% (Fairly good)	6	42.86	2	28.57
81-100% (Good)	4	28.57	1	14.29

Herbs

The distribution of herbs in the Poyyara sacred grove showed that total population of 78 herbs belong to 9 families, which comprise of 10 genera and 10 species (table B62). Highest individual population of 15 and highest D & RD values of 3.75 & 19.23% respectively are recorded by *Spermacoce articularis*, immediately followed by *Panicum notatum* and then *Cyathula prostrata* with a total representation of 12 and 10 and D & RD values of 3 & 15.38% and 2.5 & 12.82% respectively. The highest F & RF values of 87.5% & 15.56% respectively are recorded each by *S. articularis* and *P. notatum*. The immediate highest value of 62.5% & 11.11% respectively for F & RF are recorded by *C. prostrata*.

The disturbed land showed the total population of herb is 6071 and this comprise of 13 genera and 13 species which are belonging to a total of 9 families (table B63). The highest individual representation of 607 and the highest D & RD values of 151.75 & 10% respectively in the disturbed land recorded by *Brachiaria subquadriflora*. This immediately is followed by *Aerva lanata*, *Cynodon dactylon*, *Achyranthes aspera*, *Anisomeles indica*, *Cyperus rotundus*, *Leucas aspera* and *Phyllanthus amarus* (506 individuals and D & RD values of 126.5 & 8.33% respectively each). The highest F and RF values are recorded by *B.*

subquadrifida (87.5% & 11.11% respectively), followed immediately by *C. dactylon* and *P. amarus* (75% & 9.52% respectively each).

Table B62: Distribution details of herbs in the Poyyara sacred grove

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Aerva lanata</i>	Amaranthaceae	6	1.5	7.69	4	50	8.889
2	<i>Biophytum reinwardtii</i>	Oxalidaceae	6	1.5	7.69	4	50	8.889
3	<i>Boerhavia diffusa</i>	Nyctaginaceae	4	1	5.13	3	37.5	6.667
4	<i>Cyathula prostrata</i>	Amaranthaceae	10	2.5	12.82	5	62.5	11.11
5	<i>Cyperus rotundus</i>	Cyperaceae	8	2	10.26	4	50	8.889
6	<i>Desmodium gangeticum</i>	Leguminosae	6	1.5	7.69	4	50	8.889
7	<i>Emilia sonchifolia</i>	Asteraceae	5	1.25	6.41	3	37.5	6.667
8	<i>Euphorbia hirta</i>	Euphorbiaceae	6	1.5	7.69	4	50	8.889
9	<i>Panicum notatum</i>	Poaceae	12	3	15.38	7	87.5	15.56
10	<i>Spermacoce articularis</i>	Rubiaceae	15	3.75	19.23	7	87.5	15.56
	Genus-10; Species-10	Family-9	78			45		

Table B63: Distribution details of herbs in the disturbed non-sacred grove land

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Achyranthes aspera</i>	Amaranthaceae	506	126.5	8.33	5	62.5	7.937
2	<i>Aerva lanata</i>	Amaranthaceae	506	126.5	8.33	4	50	6.349
3	<i>Andrographis paniculata</i>	Acanthaceae	405	101.25	6.67	3	37.5	4.762
4	<i>Anisomeles indica</i>	Lamiaceae	506	126.5	8.33	5	62.5	7.937
5	<i>Boerhavia diffusa</i>	Nyctaginaceae	405	101.25	6.67	4	50	6.349
6	<i>Brachiaria subquadrifida</i>	Poaceae	606	151.75	10.0	7	87.5	11.11
7	<i>Cynodon dactylon</i>	Poaceae	506	126.5	8.33	6	75	9.524
8	<i>Cyperus rotundus</i>	Cyperaceae	506	126.5	8.33	4	50	6.349
9	<i>Euphorbia hirta</i>	Euphorbiaceae	405	101.25	6.67	6	75	9.524
10	<i>Leucas aspera</i>	Lamiaceae	506	126.5	8.33	6	75	9.524
11	<i>Mimosa pudica</i>	Leguminosae	303	76	5.0	3	37.5	4.762
12	<i>Phyllanthus amarus</i>	Euphorbiaceae	506	126.5	8.33	6	75	9.524
13	<i>Tridax procumbens</i>	Asteraceae	405	101.25	6.67	4	50	6.349
	Genus-13; Species-13	Family-9	6071			63		

The distribution frequency range showed the majority of the herbaceous species (53.84%) in the disturbed land are coming under the good and fairly good frequency range and 30.77% are belonging to the moderate frequency range while rest of the 15.38% showed mostly poor range. However in the grove, the majority of the species (50%) showed moderate frequency range but good and fairly good range is recorded only by 30% and the rest of the 20% recorded mostly poor range (table B64). No species is recorded under the poor frequency range of 1-20% in both the study areas.

Table B64: Distribution frequency range of herbaceous species

Frequency range	Poyyara sacred grove		Disturbed land	
	No. of herbs species	% of species	No. of herbs species	% of species
1- 20% (Poor)	0	0	0	0
21-40% (Mostly poor)	2	20	2	15.38
41-60% (Moderate)	5	50	4	30.77
61-80% (Fairly good)	1	10	6	46.15
81-100% (Good)	2	20	1	7.69

Climbers

The distribution of climbers in the Poyyara grove showed total population of 273 individuals belong to 10 families and this include 11 genera and 11 species (table B65). The climber *Tiliacora racemosa* recorded the highest individual representation of 47 and D & RD values of 11.75 & 17.22%. This is immediately followed by *Pothos scandens* (44 and 11 & 16.12% respectively) and then *Strychnos minor* (41 and 10.25 & 15.02% respectively). The highest F & RF values of 100% & 10.13% respectively in the area recorded each by *T. racemosa*, *P. scandens*, *S. minor*, *Dioscorea bulbifera* and *Abrus precatorius*. Immediately followed by these values are 87.5% & 8.86% each recorded by *Cyphostemma trilobata*, *Asparagus racemosus*, *Cyclea peltata* and *Mukia maderaspatana*.

The distribution of climbers in the disturbed land showed total population is 28 and this comprise of 2 genera and 2 species, which are belonging to 2 families (table B66). The climber *Mikania micrantha* recorded the highest individual representation of 20 and highest D & RD values of 5 & 71.43% and highest F & RF values of 100% & 57.14% respectively. This is followed by *Abrus precatorius* which recorded total of 8 individuals, D & RD values of 2 & 28.57% and F & RF values of 75% & 4.56% respectively.

Table B65: Distribution details of climbers in the Poyyara sacred grove

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Abrus precatorius</i>	Leguminosae	20	5	7.33	8	100	10.13
2	<i>Asparagus racemosus</i>	Liliaceae	18	4.5	6.59	7	87.5	8.861
3	<i>Cyphostemma trilobata</i>	Vitaceae	20	5	7.33	7	87.5	8.861
4	<i>Combretum latifolium</i>	Combretaceae	9	2.25	3.30	5	62.5	6.329
5	<i>Cyclea peltata</i>	Menispermaceae	18	4.5	6.59	7	87.5	8.861
6	<i>Dioscorea bulbifera</i>	Dioscoreaceae	23	5.75	8.43	8	100	10.13
7	<i>Ichnocarpus frutescens</i>	Apocynaceae	15	3.75	5.5	6	75	7.595
8	<i>Mukia maderaspatana</i>	Cucurbitaceae	18	4.5	6.59	7	87.5	8.861
9	<i>Pothos scandens</i>	Araceae	44	11	16.12	8	100	10.13
10	<i>Strychnos minor</i>	Loganiaceae	41	10.25	15.02	8	100	10.13
11	<i>Tiliacora racemosa</i>	Menispermaceae	47	11.75	17.22	8	100	10.13
	Genus-11; Species-11	Family-10	273			79		

Table B66: Distribution details of climbers in the disturbed non-sacred grove land

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Abrus precatorius</i>	Leguminosae	8	2	28.57	6	75	42.86
2	<i>Mikania micrantha</i>	Asteraceae	20	5	71.43	8	100	57.14
	Genus-2; Species-2	Family-2	28			14		

All the climbers in both the study sites are in the good and fairly good frequency range (table B67). However in the grove, comparatively higher percentage of species (81.82%) recorded in the good frequency range of 81-100% compared to disturbed land (50%).

Table B67: Frequency distribution range of climber species

Frequency range	Poyyara sacred grove		Disturbed land	
	No. of herbs species	% of species	No. of herbs species	% of species
1- 20% (Poor)	0	0	0	0
21-40% (Mostly poor)	0	0	0	0
41-60% (Moderate)	0	0	0	0
61-80% (Fairly good)	2	18.18	1	50
81-100% (Good)	9	81.82	1	50

Lianas

The distribution details of lianas in the Poyyara grove is depicted in table B68. The data showed total population of 44 individuals belong to 4 families and which comprise of 4 genera and 4 species. The highest individual representation of 15 and D & RD values of 3.75 & 34.09% respectively in the grove are recorded by *Rourea minor* and which is immediately following is *Gnetum ula* (13 and 3.25 & 29.55% respectively for total representation and D & RD values). The highest F and RF values are also recorded by *R. minor* (100% & 30.77% respectively) and similarly this is immediately followed by *G. ula* (87.5% & 26.92% respectively). The plant group liana is totally absent in the disturbed land.

Table B68: Distribution details of lianas in the Poyyara sacred grove

Sl. No	The name of the plant	Family	No. of plants	D	RD (%)	Occur. in the sampling units	F (%)	RF (%)
1	<i>Gnetum ula</i>	Gnetaceae	13	3.25	29.55	7	87.5	26.92
2	<i>Rourea minor</i>	Connaraceae	15	3.75	34.09	8	100	30.77
3	<i>Sarcostigma kleinii</i>	Icacinaceae	6	1.5	13.64	5	62.5	19.23
4	<i>Uvaria narum</i>	Annonaceae	10	2.5	22.73	6	75	23.08
	Genus-4; Species-4	Family-4	44			26		

Table B69: Frequency distribution range of liana species

Frequency range	Poyyara sacred grove		Disturbed land	
	No. of herbs species	% of species	No. of herbs species	% of species
1- 20% (Poor)	0	0	0	0
21-40% (Mostly poor)	0	0	0	0
41-60% (Moderate)	0	0	0	0
61-80% (Fairly good)	2	50	0	0
81-100% (Good)	2	50	0	0

The distribution frequency range of liana species in the grove indicates all the species are belonging to good and fairly good frequency range. No lianas are recorded in the disturbed land (table B69).

Species diversity index (SDI) and Species richness index (SRI)

The analysis of species diversity index (SDI) based on the entire plant species and based on the tree species alone in the selected sacred groves as well as the disturbed non-sacred grove lands of different extent are carried out and results obtained are depicted in the table B70. The data showed the SDI values based on entire plant species are found ranging from 3.63 to

4.29 in the groves while the values in the non-sacred grove lands under disturbances are found ranging from 1.07 to 1.25. The highest SDI value for the total plant species is recorded at Palliyana site among groves as well as among non-sacred groves. This is immediately followed by Nambiyath site and Sankulangara site and the lowest value is recorded at Poyyara site. However, when considering the SDI values of the groves based on the tree species alone, the values are found ranging from 2.52 to 3.20 while in the disturbed non sacred grove lands the values are found ranging from 0.72 to 1.56. Although, the similar trend is recorded in the SDI values of tree species as in the case of total plant species among sacred groves, the disturbed non-sacred grove lands exhibited a different trend. The highest SDI value for the tree species in the disturbed lands is recorded at Nambiyath site, followed immediately by Sankulangara, then Palliyana and the lowest value recorded at Poyyara site.

Table B70: Mean value and SD of species diversity index (SDI) in sacred groves and disturbed non-sacred grove lands at various study sites

Study area		Sacred groves				Disturbed non-sacred grove lands			
		SaSG	PaSG	NaSG	PoySG	DLSa	DLPa	DLNa	DLPoy
SDI of total plants	Mean	3.81	4.29	3.94	3.63	1.09	1.25	1.18	1.07
	<i>SD ±</i>	<i>0.31</i>	<i>0.06</i>	<i>0.19</i>	<i>0.05</i>	<i>0.02</i>	<i>0.10</i>	<i>0.05</i>	<i>0.08</i>
SDI of trees alone	Mean	2.85	3.20	2.92	2.52	1.48	1.42	1.56	0.72
	<i>SD ±</i>	<i>0.12</i>	<i>0.16</i>	<i>0.10</i>	<i>0.11</i>	<i>0.94</i>	<i>0.68</i>	<i>0.26</i>	<i>0.52</i>

SaSG- Sankulangara sacred grove, PaSG- Palliyana sacred grove, NaSG- Nambiyath sacred grove and PoySG- Poyyara sacred grove DLSa- Disturbed land Sankulangara, DLPa- Disturbed land Palliyana, DLNa- Disturbed land Nambiyath and DLPoy- Disturbed land Poyyara

The results of species richness index (SRI) for the total plants and for the plant group trees alone are depicted in table B71. The SRI values for the total plants are found ranging from 2.19 to 2.68 in the groves while in the non-sacred grove lands, the values are ranging from 0.13 to 0.33. The highest SRI value for the total plants is recorded by Nambiyath grove (2.68) among all the groves. The Nambiyath grove is followed by the order of Palliyana grove (2.45), Poyyara grove (2.38) and the lowest value is recorded by Sankulangara grove (2.19). The SRI value for the trees alone is found ranging from 1.70 to 2.58 in the groves while, it is found ranging from 0.93 to 1.28 in the disturbed non-sacred grove lands. The highest SRI value for the tree species is recorded by the Poyyara grove and this is immediately followed by Nambiyath grove, Palliyana grove and then lowest value recorded by Sankulangara grove.

However in the disturbed lands, the highest SRI value for the trees recorded at Sankulangara site, followed immediately by Nambiyath site, then Palliyana site and the lowest value recorded at Poyyara site.

Table B71: Mean value and SD of species richness index (SRI) in sacred groves and disturbed non-sacred grove lands at various study sites

Study area		Sacred groves				Disturbed non-sacred grove lands			
		SaSG	PaSG	NaSG	PoySG	DLSa	DLPa	DLNa	DLPoy
SRI of total plants	Mean	2.19	2.45	2.68	2.38	0.13	0.19	0.24	0.33
	SD $\pm$	0.39	0.07	0.12	0.09	0.02	0.009	0.007	0.02
SRI of trees alone	Mean	1.70	1.90	2.26	2.58	1.28	1.09	1.15	0.93
	SD $\pm$	0.22	0.09	0.13	0.19	0.14	0.14	0.31	0.19

Similarity Index (SI)

The analysis of community relationships between selected sacred groves with their adjacent disturbed non-sacred grove lands of similar extent showed significantly lower similarity index (table B72). However, comparatively higher similarity index (SI) value of 12.59% is recorded between the Nambiyath grove and adjacent disturbed land. This is immediately followed by the SI value recorded between Sankulangara grove and disturbed land (9.32%), followed by Palliyana grove and disturbed land (9.04%) and the lowest SI value of 8.24% is recorded between Poyyara grove and disturbed land. Overall, 17 plant species are recorded as common at Nambiyath site while, this is 16 common plant species in Palliyana site, 15 common plant species in Sankulangara site and the lowest number of 7 common species recorded at Poyyara site. SI values are not recorded for the plant group lianas as they are totally absent in all the selected disturbed lands.

Table B72: Similarity index (SI) values between sacred groves and disturbed non-sacred groves lands of similar extent

Plant groups/ Study site	Sankulangara site SG X DNSG		Palliyana site SG X DNSG		Nambiyath site SG X DNSG		Poyyara site SG X DNSG	
	No of common species	SI value (%)	No of common species	SI value (%)	No of common species	SI value (%)	No of common species	SI value (%)
Trees	7	12.96	5	10.64	5	12.2	0	--
Shrubs	2	6.9	2	4.55	3	10.0	2	9.52
Herbs	4	9.76	5	9.43	5	11.90	4	17.39
Climbers	2	6.9	4	16.0	4	23.53	1	7.69

Lianas	0	0	0	--	0	--	0	--
Total	15	9.32	16	9.04	17	12.59	7	8.24

SG- sacred grove; DNSG- disturbed non-sacred grove

The similarity index analysis between sacred groves of different extents showed the Sankulangara grove of largest extent selected for the study recorded highest SI value with Palliyana grove of immediate largest extent (32.18%). This is followed immediately with Nambiyath grove having SI value of 28.02% and the lowest SI value of 25% with Poyyara grove of smallest extent selected for the study. The study recorded overall 65 common plant species between Sankulangara and Palliyana groves, 51 common plant species between Sankulangara and Nambiyath groves while this is 40 plant species between Sankulangara and Poyyara groves. In all the above said cases, the plant groups from which the highest number of plant species shared as common is from trees, followed immediately by the plant group climbers and shrubs (table B73). Similarly, the community relationship studies between selected disturbed non-sacred grove lands of different extents showed 17 common plant species and SI value of 19.77% recorded between Sankulangara and Poyyara disturbed lands; 26 common plant species and 22.81% SI value between Sankulangara and Nambiyath and 40 common plant species and 29.41% SI value between the disturbed lands of Sankulangara and Palliyana. The plant groups from which the highest number of plant species shared as common is from herbs, followed immediately by shrubs, trees and then climbers (table B74).

Table B73: Similarity index (SI) values between sacred groves of different extents

Plant groups/ Study site	Sankulangara grove X Palliyana grove		Sankulangara grove X Nambiyath grove		Sankulangara grove X Poyyara grove	
	No of common species	SI value (%)	No of common species	SI value (%)	No of common species	SI value (%)
Trees	25	35.21	21	31.82	15	26.79
Shrubs	14	34.15	9	26.47	8	25.81
Herbs	7	23.33	8	25.81	5	20.0
Climbers	14	31.82	10	26.32	9	25.0
Lianas	5	31.25	3	23.08	3	25.0
Total	65	32.18	51	28.02	40	25.0

Table B74: Similarity index (SI) values between disturbed non-sacred grove lands of different extents

Plant groups/ Study site	Sankulangara X Palliyana		Sankulangara X Nambiyath		Sankulangara X Poyyara	
	No of common species	SI value (%)	No of common species	SI value (%)	No of common species	SI value (%)
Trees	9	30.0	6	20.69	3	13.64
Shrubs	10	31.25	5	20.0	5	26.32
Herbs	18	28.13	13	25.0	8	20.51

Climbers	3	30.0	2	25.0	1	16.67
Lianas	0	--	0	--	0	--
Total	40	29.41	26	22.81	17	19.77

Dominance of family, genera and species

1) Sankulangara study site

The details of family, genera and species of plants in the Sankulangara sacred grove and the disturbed non-sacred grove land of similar extent are depicted in the table B75 and table B76.

a) Based on total plant population

The dominance level of family when considered based on total number of individuals in each families, Smilacaceae is identified as most dominant in Sankulangara grove with a total of 318 individuals. This is immediately followed by the family Rubiaceae and then Dipterocarpaceae with a total of 248 and 132 individuals respectively. The family Smilacaceae covers 14.99% of the entire population in the grove while Rubiaceae and Dipterocarpaceae covers 11.69% and 6.22% respectively. In the disturbed land, the most dominant family is Poaceae with a total plant population of 76245 individuals and this constituted 34.37% of the entire population in the area. The family Poaceae is immediately followed by Leguminosae and then Commelinaceae with a total population of 34555 and 31372 respectively which were 15.58% and 14.14% of the entire population in the disturbed land. However, the dominance of family when considered based on the diversity of plants under each families, the family Leguminosae is identified as the most dominant in the grove and this consists of 8 genus and 8 species. Leguminosae is immediately followed by Rubiaceae and then Apocynaceae, consisting of 6 genus and 7 species and 4 genus and 4 species respectively. However in the disturbed land, Poaceae is the most dominant family with 5 genus and 6 species. This is immediately followed by the family Euphorbiaceae and then Asteraceae which consists of 4 genus and 6 species and 4 genus and 4 species respectively.

The most dominant genera as well as the species identified in Sankulangara grove is the climber *Smilax zeylanica* which is having a total representation of 318 with RD value of 14.99%. *S. zeylanica* is immediately followed by the shrub *Chassalia curviflora* (130 nos. with RD value 6.13%) and then the tree *Hopea ponga* (101 nos. with RD value 4.76%). However in disturbed land, the most dominant genera as well as the species is the herb

Cynodon dactylon with a total representation of 30180 and RD value of 13.60%. Immediately followed by the *Cynodon dactylon* is also another herb *Desmodium triflorum* and then *Commelina diffusa* which are having total representations of 24620 and 20649 and RD values of 11.08% and 9.31% respectively.

b) Based on tree population

The analysis of dominance when considered based on the plant group trees alone revealed the family Dipterocarpaceae as most dominant in Sankulangara grove with a total population of 132 individuals and this constitutes around 29.53% of the total tree population. Immediately followed by Dipterocarpaceae is Moraceae and then Arecaceae which are having total of 47 and 32 individuals respectively and these constituted around 10.51% and 7.16% of the total tree population respectively. The most dominant tree genera as well as the species is *Hopea ponga* with a total of 101 individuals and RD value of 22.6%. This is immediately followed by *Caryota urens* and then *Vateria indica* which are having a total representation of 32 and 31 individuals and RD values of 7.16% and 6.94% respectively.

The disturbed land showed the Arecaceae as the most dominant family with a total tree representation of 29 individuals which constituted 50.88% of the entire tree population in the area. This is immediately followed by the family Apocynaceae and then Moraceae in which a total of 5 and 4 individuals represented respectively and this constituted 8.77% and 7.02% of the total tree population. The most dominant genera as well as the species identified is *Cocos nucifera* with a total of 16 individuals and RD value of 28.1%. *C. nucifera* is immediately followed by *Areca catechu* and then *Tabernaemontana alternifolia* which are having a total representation of 13 & 5 individuals and RD values of 22.81% & 8.77% respectively.

Table B75: Details of family, genus and species in the Sankulangara sacred grove

Sl. No	Family	Trees	No	Shrubs	No	Herbs	No	Climber	No	Lianas	No	Family total
1	Leguminosae	<i>Adenanthera pavonina</i>	3			<i>Desmodium gangeticum</i>	11	<i>Clitoria ternatea</i>	8	<i>Dalbergia horrida</i>	32	98
		<i>Saraca asoca</i>	2					<i>Dalbergia volubilis</i>	14			
								<i>Vigna umbellata</i>	9			
								<i>Abrus precatorius</i>	19			
2	Meliaceae	<i>Aphanamix polystachya</i>	12									12
3	Euphorbiaceae	<i>Aporosa cardiosperma</i>	16	<i>Bridelia stipularis</i>	16							32
4	Arecaceae	<i>Areca catechu</i>	4									45
		<i>Pinanga dicksonii</i>	9									
		<i>Caryota urens</i>	32									
		<i>Pouteria campechiana</i>	1									
9	Lauraceae	<i>Cinnamomum malabathrum</i>	14									25
		<i>Litsea coriacea</i>	5									
		<i>Persea macrantha</i>	6									
10	Clusiaceae	<i>Garcinia gummi-gutta</i>	9									9
11	Dipterocarpaceae	<i>Hopea ponga</i>	101									132
		<i>Vateria indica</i>	31									
12	Flacourtiaceae	<i>Hydnocarpus pentandrus</i>	24									24
13	Oleaceae	<i>Olea diocia</i>	19					<i>Jasminum angustifolium</i>	4			41
								<i>Mycopyrum smilacifolium</i>	18			
14	Simaroubaceae	<i>Quassia indica</i>	27									27
15	Melastomataceae			<i>Memecylon grande</i>	25							25
16	Sterculiaceae	<i>Sterculia guttata</i>	4									4
17	Loganiaceae	<i>Strychnos nux-vomica</i>	1					<i>Strychnos minor</i>	53			54
18	Myrtaceae	<i>Syzygium hemisphaericum</i>	2	<i>Syzygium zeylanicum</i>	11							17
		<i>Syzygium lanceolatum</i>	4									
19	Apocynaceae	<i>Tabernaemontana alternifolia</i>	12					<i>Ichmocarpus frutescens</i>	48	<i>Anodendron paniculatum</i>	2	74
								<i>Kametia caryophyllata</i>	12			
20	Combretaceae	<i>Terminalia bellirica</i>	1									2
		<i>Terminalia catappa</i>	1									
21	Verbenaceae	<i>Vitex altissima</i>	8									10

		<i>Vitex pinnata</i>	2									
22	Lamiaceae			<i>Ocimum tenuiflorum</i>	5	<i>Anisomeles indica</i>	16					29
				<i>Hyptis capitata</i>	6	<i>Ocimum basilicum</i>	2					
23	Rubiaceae			<i>Canthium rheedei</i>	13	<i>Mitracarpus hirtus</i>	20					248
				<i>Chassalia curviflora</i>	130							
				<i>Ixora coccinea</i>	38							
				<i>Ixora malabarica</i>	25							
				<i>Mussaenda frondosa</i>	6							
				<i>Coffea travancorensis</i>	16							
24	Costaceae					<i>Cheilocostus speciosus</i>	18					18
25	Rutaceae			<i>Glycosmis pentaphylla</i>	6							6
26	Malvaceae			<i>Hibiscus rosa-sinensis</i>	13							13
27	Leeaceae			<i>Leea indica</i>	18							18
	Ammonaceae									<i>Uvaria narum</i>	35	52
28				<i>Polyalthia korinti</i>	17							
29	Pandanaceae			<i>Pandanus kaida</i>	12							12
30	Tiliaceae			<i>Grewia nervosa</i>	3							3
31	Polygalaceae	<i>Xanthophyllum amottianum</i>	17									17
32	Amaranthaceae					<i>Aerva lanata</i>	7					7
33	Acanthaceae					<i>Andrographis paniculata</i>	7					7
34	Oxalidaceae					<i>Biophytum reinwardtii</i>	19					19
35	Poaceae					<i>Brachiaria subquadriflora</i>	14					40
						<i>Panicum notatum</i>	26					
36	Apiaceae					<i>Centella asiatica</i>	18					18
37	Asteraceae					<i>Elephantopus scaber</i>	12	<i>Mikania micrantha</i>	24			49
						<i>Emilia sonchifolia</i>	13					
38	Urticaceae					<i>Laportea interrupta</i>	10					10
39	Scrophulariaceae					<i>Torenia bicolor</i>	18					18
40	Gnetaceae									<i>Gnetum ula</i>	55	55
	Conmaraceae									<i>Rourea minor</i>	28	30
41										<i>Commersonia monocarpus</i>	2	
42	Aristolochiaceae							<i>Aristolochia indica</i>	7			7
43	Liliaceae							<i>Asparagus racemosus</i>	16			30
								<i>Gloriosa superba</i>	14			
44	Opiliaceae							<i>Canjara rheedii</i>	27			27

45	<i>Vitaceae</i>						<i>Cayratia japonica</i>	42	<i>Tetrastigma leucostaphyllum</i>	20	82
							<i>Cayratia pedata</i>	20			
46	<i>Menispermaceae</i>						<i>Cyclea peltata</i>	16			94
							<i>Tiliocora racemosa</i>	78			
47	<i>Dioscoreaceae</i>						<i>Dioscorea bulbifera</i>	24			24
48	<i>Convolvulaceae</i>								<i>Erycibe paniculata</i>	8	8
49	<i>Periplocaceae</i>						<i>Hemidesmus indicus</i>	5			5
50	<i>Cucurbitaceae</i>						<i>Mukia</i>	35			35
							<i>maderaspatana</i>				
51	<i>Piperaceae</i>						<i>Piper nigrum</i>	4			4
52	<i>Araceae</i>						<i>Pothos scandens</i>	100			100
53	<i>Smilacaceae</i>						<i>Smilax zeylanica</i>	318			318
54	<i>Asclepiadaceae</i>						<i>Dragea volubilis</i>	7			7

Table B76: Details of family, genus and species in the disturbed non-sacred grove land at Sankulangara site

SL No	Family	Trees	No	shrubs	No	Herbs	No	Climber	No	Family total
1	Simaroubaceae	<i>Ailanthus triphylla</i>	2							2
		<i>Anacardium occidentale</i>	2							3
2	Anacardiaceae	<i>Mangifera indica</i>	1							
3	Annonaceae	<i>Annona reticulata</i>	1							1
	Arecaceae	<i>Areca catechu</i>	13							29
4		<i>Cocos nucifera</i>	16							
	Moraceae	<i>Artocarpus heterophyllus</i>	2							4
5		<i>Artocarpus hirsutus</i>	2							
	Euphorbiaceae	<i>Briedelia retusa</i>	1	<i>Phyllanthus reticulatus</i>	13	<i>Euphorbia hirta</i>	3176.8			21854.5
						<i>Euphorbia thymifolia</i>	3573.9			
						<i>Phyllanthus amarus</i>	7544.9			
						<i>Phyllanthus urinaria</i>	7544.9			
7	Rhizophoraceae	<i>Carallia branchiata</i>	1							1
8	Lauraceae	<i>Cinnamomum zeylanicum</i>	2							2
9	Clusiaceae	<i>Garcinia gummi-gutta</i>	2							2
10	Flacourtiaceae	<i>Hydnocarpus pentandrus</i>	3							3

11	Meliaceae	<i>Swietenia macrophylla</i>	1						1
12	Apocynaceae	<i>Tabernaemontana alternifolia</i>	5				<i>Ichmocarpus frutescens</i>	9	14
13	Verbenaceae	<i>Tectona grandis</i>	1	<i>Clerodendrum infortunatum</i>	12				14
14	Combretaceae	<i>Vitex altissima</i>	1						
		<i>Terminalia catappa</i>	1						1
15	Rubiaceae			<i>Chassalia curviflora</i>	9	<i>Mitracarpus hirtus</i>	10325		13113.3
						<i>Oldenlandia corymbosa</i>	2779.7		
16	Asteraceae			<i>Chromolaena odorata</i>	19	<i>Eleutheranthera ruderalis</i>	3176.8	<i>Mikania micrantha</i>	20 8378.1
						<i>Synedrella nodiflora</i>	5162.3		
17	Leguminosae			<i>Crotalaria pallida</i>	7	<i>Desmodium triflorum</i>	24620		34554.7
						<i>Mimosa pudica</i>	9927.5		
18	Malvaceae			<i>Hibiscus surattensis</i>	12				51
				<i>Sida acuta</i>	13				
				<i>Sida cordifolia</i>	12				
				<i>Sida rhombifolia</i>	14				
19	Tiliaceae			<i>Triumfetta rhomboidea</i>	22				22
20	Leeaceae			<i>Leea indica</i>	8				8
21	Amaranthaceae					<i>Aerva lanata</i>	9133.3		12707.2
						<i>Cyathula prostrata</i>	3573.9		
22	Poaceae					<i>Allotetrasporis cimicina</i>	4765.2		76243.9
						<i>Brachiaria subquadriflora</i>	13105		
						<i>Cynodon dactylon</i>	30180		
						<i>Digitaria ciliaris</i>	9133.3		
						<i>Eragrostis amabilis</i>	9530.4		
						<i>Eragrostis unioides</i>	9530.4		
23	Oxaladaceae					<i>Biophytum reinwardtii</i>	2779.7		2779.7
24	Commelinaceae					<i>Commelina diffusa</i>	20649		31370.9
						<i>Murdannia pauciflora</i>	10722		
25	Cyperaceae					<i>Kyllinga nemoralis</i>	4765.2		4765.2
26	Urticaceae					<i>Laportea interrupta</i>	2382.6		6750.7
						<i>Pouzolzia zeylanica</i>	4368.1		
27	Lamiaceae			<i>Hyptis suaveolens</i>	18	<i>Leucas aspera</i>	3176.8		3194.8
28	Onagraceae					<i>Ludwigia hyssopifolia</i>	5956.5		5956.5
29	Convolvulaceae							<i>Hewittia malabarica</i>	10 10
30	Menispermaceae							<i>Tiliacora racemosa</i>	10 10

2) Palliyana study site

The details of family, genera and species of plants in the Palliyana sacred grove and adjacent disturbed non-sacred grove land of similar extent are depicted in the table B77 and table B78.

a) Based on total plant population

The most dominant family in Palliyana grove is Menispermaceae with a total of 198 individuals, immediately followed by Rubiaceae and then Poaceae with total population of 162 and 102 respectively. The family Menispermaceae covers 11.54% of the entire population while Rubiaceae and Poaceae covers 9.44% and 5.94% respectively. The disturbed land showed Poaceae as the most dominant family with a total of 31161 individuals and this constituted 18.99% of the entire population. This is immediately followed by Asteraceae and then Acanthaceae with a total population of 22282 and 21379 individuals respectively which are 13.58% and 13.03% of the entire population. However regarding the dominance of family based on the diversity of plants, Leguminosae is the most dominant in the grove and this consists of 7 genus and 7 species. This is immediately followed by Rubiaceae and then Apocynaceae and they consist of 6 genus and 7 species and 5 genus and 6 species respectively. In the disturbed land, Asteraceae is recorded as most dominant and this consists of 8 genus and 8 species. This is immediately followed by Leguminosae and then Poaceae consisting of 7 genus and 8 species and 5 genus and 5 species respectively.

The most dominant genera as well as the species in Palliyana grove is a climber *Tiliacora racemosa* with a total representation of 65 and RD value of 3.79%. *T. racemosa* is immediately followed by climbers *Ichnocarpus frutescens* (59 individuals and RD value 3.44%) and then *Pothos scandens* (50 individuals and RD value 2.91%). In the disturbed land, the most dominant plant genera as well as the species is the herb *Justicia procumbens* with a total representation of 8903 and RD value of 5.43%. Immediately followed by *J. procumbens* is also herbaceous plants namely *Cynodon dactylon* and *Cyathula prostrata*, both having a total representations of 8013 and RD value of 4.88% each.

b) Based on tree population

Based on tree population, Lauraceae is the most dominant family in Palliyana grove with 43 individuals which constitute 12.61% of the total tree population. Lauraceae is immediately followed by Leguminosae and Moraceae both having a total of 29 individuals each constitute around 8.50% of the total tree population. The most dominant genera as well as the species in

the grove is *Artocarpus hirsutus* with a total representation of 23 trees with RD value of 6.74%. This is immediately followed by *Aphanamixis polystachya* and then *Hydnocarpus pentandrus*, having total representations of 22 and 20 and RD values of 6.45% and 5.87% respectively. In the disturbed land, Arecaceae is the most dominant family with a total of 27 trees and this constituted 58.7% of the entire tree population. Arecaceae is immediately followed by Anacardiaceae and then Leguminosae with a total representation of 5 and 4 trees and are 10.87% and 8.7% of the total tree population respectively in the area. *Cocos nucifera* is identified as the most dominant genera as well as species in the disturbed land with a total representation of 14 and RD value of 30.43%. This is immediately followed by *Areca catechu* and then *Gliricidia sepium* (total representations of 13 & 4 and RD values of 28.26% and 8.7% respectively).

Table B77: Details of family, genus and species in the Palliyana sacred grove

Sl. No	Family	Trees	No	shrubs	No	Herbs	No	Climber	No	Lianas	No	Family total
1	Acanthaceae			<i>Justicia gendarussa</i>	5	<i>Justicia procumbens</i>	20					25
2	Amaranthaceae					<i>Cyathula prostrata</i>	24					24
3	Anacardiaceae	<i>Anacardium occidentale</i>	7									26
		<i>Holigarna amottiana</i>	19									
4	Ammonaceae	<i>Polyalthia longifolia</i>	3	<i>Polyalthia korinti</i>	9					<i>Uvaria narum</i>	18	30
5	Apocynaceae	<i>Alstonia scholaris</i>	1	<i>Rauvolfia serpentina</i>	11			<i>Ichmocarpus frutescens</i>	59	<i>Anodendron paniculatum</i>	9	88
		<i>Tabernaemontana alternifolia</i>	4	<i>Tabernaemontana divaricata</i>	4							
6	Araceae							<i>Pothos scandens</i>	50			50
7	Arecaceae	<i>Areca catechu</i>	9									22
		<i>Caryota urens</i>	13									
8	Aristolochiaceae							<i>Aristolochia indica</i>	21	0	0	21
9	Asclepiadaceae							<i>Gymnema sylvestre</i>	14	0	0	14
10	Asteraceae					<i>Emilia sonchifolia</i>	19	<i>Mikania micrantha</i>	28			83
						<i>Synedrella nodiflora</i>	19					
						<i>Cyanthillium cinereum</i>	17					
11	Clusiaceae	<i>Garcinia gummi-gutta</i>	12									12
12	Combretaceae	<i>Terminalia bellirica</i>	2									2
										<i>Commarius</i>	9	

13	Connaraceae								monocarpus			
									Rourea minor	15		24
14	Cucurbitaceae							Mukia maderaspatana	25			25
15	Cyperaceae				Cyperus rotundus	26						26
16	Dioscoreaceae							Dioscorea bulbifera	21			21
17	Dipterocarpaceae	Vateria indica	3									3
18	Ebenaceae	Diospyros malabarica	2									2
19	Euphorbiaceae	Aporosa cardiosperma	10	Briedelia stipularis	33							47
		Briedelia retusa	4									
20	Leguminosae	Adenanthera pavonina	8	Bauhinia acuminata	1	Desmodium gangeticum	11	Abrus precatorius	36	Derris scandens	9	86
		Pongamia pinnata	20									
		Saraca asoca	1									
21	Flacourtiaceae	Hydnocarpus pentandrus	22									22
22	Gnetaceae								Gnetum ula	16		16
23	Hippocrateaceae								Salacia fruticosa	19		19
24	Hypoxidaceae	0	0	0	0	Curculigo orchoides	17					17
25	Icacinaeae			Nothapodytes nimmoniana	17				Sarcostigma kleinii	15		32
26	Lamiaceae			Ocimum tenuiflorum	11	Ocimum basilicum	2					13
27	Lauraceae	Cinnamomum malabarium	15									43
		Litsea coriacea	12									
		Persea macrantha	16									
28	Leeaceae			Leea indica	18							18
29	Liliaceae							Asparagus racemosus	21			21
30	Loganiaceae	Strychnos nuxvomica	3					Strychnos minor	46			49
31	Malvaceae			Hibiscus rosa-sinensis	17							17
32	Melastomataceae	0	0	Memecylon depressum	11							11
33	Meliaceae	Aphanamixis polystachya	12									12
34	Menispermaceae							Anamirta cocculus	24			198
								Cyclea peltata	31			
								Tiliacora racemosa	65			
								Tinospora cordifolia	40			
								Tinospora sinensis	38			

35	Moraceae	<i>Artocarpus hirsutus</i>	23								29
		<i>Ficus benghalensis</i>	1								
		<i>Ficus religiosa</i>	1								
		<i>Streblus asper</i>	4								
36	Myrtaceae	<i>Syzygium caryophyllatum</i>	5								16
		<i>Syzygium cumini</i>	11								
37	Oleaceae	<i>Olea dioica</i>	10								10
38	Oxalidaceae					<i>Biophytum reinwardtii</i>	19				19
39	Pandanaceae			<i>Pandanus kaida</i>	12						12
40	Piperaceae			0	0			<i>Piper nigrum</i>	7		7
41	Poaceae			<i>Bambusa bambos</i>	9	<i>Bracharia remota</i>	15				102
				<i>Bambusa</i>	16	<i>Eragrostis</i>	33				
				<i>vulgaris</i>		<i>unioloides</i>					
						<i>Panicum notatum</i>	29				
42	Polygalaceae	<i>Xanthophyllum amottianum</i>	8								8
43	Ranunculaceae							<i>Naravelia zeylanica</i>	18		18
44	Rubiaceae			<i>Canthium rheedei</i>	20						162
				<i>Chassalia curviflora</i>	27						
				<i>Ixora coccinea</i>	38						
				<i>Ixora malabarica</i>	25						
				<i>Mussaenda frondosa</i>	6	<i>Mitracarpus hirtus</i>	20				
				<i>Pavetta indica</i>	10						
				<i>Coffea travancorensis</i>	16						
45	Rutaceae			<i>Glycosmis pentaphylla</i>	23						23
46	Sapotaceae	<i>Chrysophyllum cainito</i>	10								31
		<i>Mimusops elengi</i>	21								
47	Simaroubaceae	<i>Quassia indica</i>	14								14
48	Smilacaceae							<i>Smilax zeylanica</i>	44		44
49	Sterculiaceae	<i>Sterculia guttata</i>	19								19
50	Tiliaceae			<i>Grewia nervosa</i>	12						12
51	Urticaceae					<i>Laportea interrupta</i>	10				10

Table B78: Details of family, genus and species in the disturbed non-sacred grove land at Palliyana site

Sl. No	Family	Trees	No	shrubs	No	Herbs	No	Climber	No	Family total
1	Acanthaceae			<i>Barleria cristata</i>	12	<i>Andrographis echinoides</i>	2671			21379
						<i>Andrographis paniculata</i>	3561			
						<i>Dicliptera paniculata</i>	6232			
						<i>Justicia procumbens</i>	8903			
2	Amaranthaceae					<i>Aerva lanata</i>	6232			21368
						<i>Allmania nodiflora</i>	5342			
						<i>Alternanthera brasiliana</i>	1781			
						<i>Cyathula prostrata</i>	8013			
3	Anacardiaceae	<i>Anacardium occidentale</i>	2							5
		<i>Lannea coromandelica</i>	2							
		<i>Mangifera indica</i>	1							
4	Apocynaceae							<i>Ichmocarpus frutescens</i>	9	9
5	Arecaceae	<i>Areca catechu</i>	13							27
		<i>Cocos nucifera</i>	14							
6	Asclepiadaceae			<i>Calotropis gigantea</i>	4					4
7	Asteraceae			<i>Chromolaena odorata</i>	12	<i>Ageratum conyzoides</i>	2671	<i>Mikania micrantha</i>	12	22282
						<i>Eleutheranthera ruderalis</i>	3561			
						<i>Grangea maderaspatana</i>	6232			
						<i>Acmella ciliata</i>	2671			
						<i>Synedrella nodiflora</i>	4452			
						<i>Tridax procumbens</i>	2671			
8	Capparaceae					<i>Cleome burmannii</i>	2671			5342
						<i>Cleome viscosa</i>	2671			
9	Chusiaceae	<i>Garcinia gummi-gutta</i>	2							2
10	Combretaceae	<i>Terminalia catappa</i>	1							1
11	Convolvulaceae							<i>Hewittia malabarica</i>	7	19
								<i>Merremia umbellata</i>	12	
12	Euphorbiaceae			<i>Phyllanthus reticulatus</i>	13	<i>Euphorbia hirta</i>	3561			14258
						<i>Euphorbia thymifolia</i>	1781			
						<i>Phyllanthus amarus</i>	5342			
						<i>Phyllanthus urinaria</i>	3561			
13	Leguminosae	<i>Gliricidia sepium</i>	4	<i>Crotalaria pallida</i>	7	<i>Chamaecrista absus</i>	6232	<i>Abrus precatorius</i>	8	15157
				<i>Senna occidentalis</i>	3	<i>Chamaecrista mimosoides</i>	3561			

					<i>Indigofera hirsuta</i>	1781			
					<i>Mimosa pudica</i>	3561			
14	Lamiaceae			<i>Hyptis suaveolens</i>	18	<i>Anisomeles indica</i>	2671		
						<i>Leucas aspera</i>	3561		6250
15	Leeaceae			<i>Leea indica</i>	6				6
16	Lythraceae			<i>Lawsonia inermis</i>	2				2
17	Malvaceae			<i>Hibiscus hispidissimus</i>	5				
				<i>Sida acuta</i>	13				
				<i>Sida cordifolia</i>	9				
				<i>Sida rhombifolia</i>	14				55
				<i>Sida mysorensis</i>	7				
				<i>Urena lobata</i>	7				
18	Meliaceae	<i>Azadirachta indica</i>	3						3
19	Menispermaceae						<i>Tiliacora racemosa</i>	10	10
20	Moraceae	<i>Artocarpus hirsutus</i>	2						2
21	Nyctaginaceae					<i>Boerhavia diffusa</i>	2671		2671
22	Onagraceae					<i>Ludwigia hyssopifolia</i>	4452		4452
23	Pedaliaceae					<i>Pedaliium murex</i>	4452		4452
						<i>Alloteroopsis semialata</i>	3561		31161
24	Poaceae					<i>Brachiaria remota</i>	6232		
						<i>Cynodon dactylon</i>	8013		
						<i>Digitaria ciliaris</i>	7123		
						<i>Eragrostis amabilis</i>	6232		
25	Rubiaceae					<i>Oldenlandia corymbosa</i>	3561		3561
26	Scrophulariaceae					<i>Scoparia dulcis</i>	4452		4452
27	Solanaceae			<i>Datura stramonium</i>	3	<i>Physalis angulata</i>	4452		4455
28	Tiliaceae			<i>Grewia nervosa</i>	5				
				<i>Triumfetta rhomboidea</i>	22				27
29	Urticaceae					<i>Laportea interrupta</i>	2675		2675
30	Verbenaceae	<i>Tectona grandis</i>	1	<i>Clerodendrum infortunatum</i>	12				
		<i>Vitex altissima</i>	1	<i>Lantana camara</i>	3				17

3) Nambiyath study site

The details of family, genera and species of plants in the Nambiyath sacred grove and adjacent disturbed non-sacred grove land of similar extent are depicted in the table B79 and table B80.

a) Based on total plant population

Rubiaceae is the most dominant family in Nambiyath grove which has a total of 96 individuals. This is immediately followed by Poaceae and then Gnetaceae with a total of 58 and 55 individuals respectively. The family Rubiaceae covers 10.54% of the entire population while Poaceae and Gnetaceae covers 6.37% and 6.04% respectively. However in the disturbed land, the most dominant family is Poaceae with a total population of 11538 and this constituted 23.39% of the entire population in the area. This is immediately followed by Amaranthaceae and then Acanthaceae with a total population of 10016 and 5461 respectively which are covering 20.30% and 11.07% of the entire population. The dominance when considered based on the diversity of plants, the family Rubiaceae is also identified as the most dominant in the grove and consists of 6 genus and 7 species. This is immediately followed by Apocynaceae consisting of 5 genus and 6 species. Similarly, Poaceae is most dominant in disturbed land which consists of 6 genus and 6 species. This is immediately followed by the families Leguminosae, Verbanaceae and Asteraceae and each consisting of 5 genus and 5 species.

The most dominant genera as well as the species in Nambiyath grove is liana *Gnetum ula* which have a total representation of 55 with RD value of 6.04%. This is followed immediately by the liana *Uvaria narum* (35 individuals with RD value 3.84%) and then the liana *Sarcostigma kleinii* (32 nos with RD value 3.51%). In the disturbed land, the most dominant genera as well as the species is the herb *Aerva lanata* with a total of 3339 individuals and RD value of 6.77%. *A. lanata* is immediately followed by the herbs *Cynodon dactylon* and *Achyranthes aspera* having a total representations of 2732 and RD value of 5.54% each for both genus and species.

a) Based on tree population

The analysis of dominance based on total number of tree population, Moraceae is identified as the most dominant family in Nambiyath grove. Total of 28 trees are represented in the family which constitute 15.73% of the total tree population. Moraceae is immediately

followed by Sterculiaceae and then Anacardiaceae which are having a total of 17 and 16 trees and are 9.55% and 8.99% of the total tree population respectively. The most dominant genera as well as the species identified in the grove is *Artocarpus hirsutus* (23 trees and RD value 11.92%). Immediately followed by *A. hirsutus* is *Pterygota alata* and then *Hydnocarpus pentandrus* and *Quassia indica*, having a total representation of 15 for *P. alata* and 14 each for *H. pentandrus* and *Q. indica* and RD value of 7.77% and 7.25% each respectively. In the disturbed land, both Arecaceae and Anacardiaceae are identified as the most dominant families with a total tree representation of 6 each and constitute 27.27% of the total tree population. This is immediately followed by Verbenaceae with a total of 3 individuals and is about 13.64% of the total tree population. *Cocos nucifera* is identified as the most dominant genera and the species with a total representation of 4 and RD value of 18.18%. *C. nucifera* is immediately followed by *Anacardium occidentale* and *Mangifera indica*, both have total representation of 3 and RD values of 13.63% each.

Table B79: Details of family, genus and species in the Nambiyath sacred grove

Sl. No	Family	Trees	No	shrubs	No	Herbs	No	Climber	No	Lianas	No	Family total
1	Amaranthaceae					<i>Aerva lanata</i>	10					23
						<i>Cyathula prostrata</i>	13					
2	Anacardiaceae	<i>Anacardium occidentale</i>	4									16
		<i>Holigarna amottiana</i>	7									
		<i>Lamnea coromandelica</i>	5									
3	Annonaceae	<i>Polyalthia longifolia</i>	4							<i>Uvaria narum</i>	35	39
4	Apocynaceae	<i>Alstonia scholaris</i>	1	<i>Tabernaemontana divaricata</i>	9			<i>Ichmocarpus frutescens</i>	18			50
		<i>Plumeria rubra</i>	1					<i>Kametia caryophyllata</i>	12			
		<i>Tabernaemontana alternifolia</i>	9									
5	Arecaceae	<i>Caryota urens</i>	3									9
		<i>Pinanga dicksonii</i>	6									
6	Asteraceae					<i>Emilia sonchifolia</i>	17	<i>Mikania micrantha</i>	14			51
						<i>Grangea maderaspatana</i>	8					
						<i>Cyanthillium cinereum</i>	12					
7	Clusiaceae	<i>Garcinia gunni-gutta</i>	3									3
8	Combretaceae	<i>Terminalia bellirica</i>	2					<i>Combretum latifolium</i>	9			11
9	Connaraceae									<i>Connarus monacarpus</i>	28	28
10	Cucurbitaceae							<i>Mukia</i>	11			11

								<i>maderaspatan</i> <i>a</i>				
11	Cyperaceae					<i>Cyperus</i> <i>rotundus</i>	11					11
12	Dioscoreaceae							<i>Dioscorea</i> <i>bulbifera</i>	8			8
13	Dracaenaceae			<i>Dracaena</i> <i>terniflora</i>	13							13
14	Ebenaceae	<i>Diospyros</i> <i>malabarica</i>	5									5
15	Euphorbiaceae			<i>Breynia vitis-</i> <i>idaea</i>	13	<i>Euphorbia hirta</i>	7					43
				<i>Briedelia</i> <i>stipularis</i>	23							
16	Leguminosae	<i>Adenantha</i> <i>pavonina</i>	4			<i>Desmodium</i> <i>gangeticum</i>	11	<i>Abrus</i> <i>precatorius</i>	18			35
		<i>Saraca asoca</i>	2									
17	Flacourtiaceae	<i>Hydnocarpus</i> <i>pentandrus</i>	14									14
18	Gnetaceae									<i>Gnetum ula</i>	55	55
19	Hypoxidaceae					<i>Curculigo</i> <i>orchioidea</i>	16					16
20	Icacinaeae									<i>Sarcostigma</i> <i>kleinii</i>	32	32
21	Lauraceae	<i>Cinnamomum</i> <i>malabarium</i>	7									7
22	Leeaceae			<i>Leea indica</i>	10							10
23	Liliaceae							<i>Asparagus</i> <i>racemosus</i>	10			10
24	Loganiaceae	<i>Strychnos nux-</i> <i>vomica</i>	3									3
25	Malvaceae			<i>Hibiscus rosa-</i> <i>sinensis</i>	18							18
26	Meliaceae	<i>Aphanamixis</i> <i>polystachya</i>	7			<i>Naregamia</i> <i>alata</i>	9					16
										<i>Coscinium</i> <i>fenestratum</i>	14	44
27	Menispermaceae							<i>Cyclea peltata</i>	6			
								<i>Tiliacora</i> <i>racemosa</i>	17			
								<i>Tinospora</i> <i>cordifolia</i>	7			
28	Moraceae	<i>Artocarpus</i> <i>hirsutus Lam</i>	23									28
		<i>Ficus</i> <i>amplissima</i>	4									
		<i>Ficus</i> <i>benghalensis</i>	1									
29	Myrtaceae	<i>Syzygium</i> <i>cumini</i>	2									2
30	Nyctaginaceae					<i>Boerhaavia</i> <i>diffusa</i>	12					12
31	Oleaceae							<i>Jasminum</i> <i>multiflorum</i>	8			8
32	Oxalidaceae					<i>Biophytum</i> <i>reinwardtii</i>	15					15
33	Pandanaceae			<i>Pandanus kaida</i>	6							6

34	Poaceae			<i>Bambusa vulgaris</i>	10	<i>Brachiaria subquadriflora</i>	14				58
				<i>Bambusa bambos</i>	11	<i>Panicum notatum</i>	23				
35	Rhizophoraceae	<i>Carallia branchiata</i>	2								2
36	Rubiaceae			<i>Gardenia jasminoides</i>	15	<i>Mitracarpus hirtus</i>	15				96
				<i>Exora coccinea</i>	27						
				<i>Exora malabarica</i>	9						
				<i>Mussaenda frondosa</i>	5						
				<i>Pavetta indica</i>	12						
				<i>Coffea travancorensis</i>	13						
37	Sapotaceae	<i>Chrysophyllum cainito</i>	8								13
		<i>Mimusops elengi</i>	5								
38	Simaroubaceae	<i>Quassia indica</i>	14								14
39	Sterculiaceae	<i>Pterygota alata</i>	15								17
		<i>Sterculia balanghas</i>	2								
40	Tiliaceae			<i>Grewia nervosa</i>	6						6
41	Ulmaceae	<i>Trema orientalis</i>	9								9
42	Urticaceae					<i>Laportea interrupta</i>	12				12
43	Verbenaceae	<i>Vitex altissima</i>	6	<i>Clerodendrum paniculatum</i>	16						22
44	Vitaceae							<i>Cissus latifolia</i>	10		10

Table B80: Details of family, genus and species in the disturbed non-sacred grove land at Nambiyath site

Sl. No	Family	Trees	No	Shrubs	No	Herbs	No	Climber	No	Family total
1	Acanthaceae					<i>Andrographis echinoides</i>	2124.7			5460.5
						<i>Andrographis paniculata</i>	2124.7			
						<i>Dicliptera paniculata</i>	1214.1			
2	Amaranthaceae					<i>Achyranthes aspera</i>	2731.7			10016.3
						<i>Aerva lanata</i>	3338.8			
						<i>Allmania nodiflora</i>	1517.6			
						<i>Alternanthera brasiliana</i>	2428.2			
3	Anacardiaceae	<i>Anacardium occidentale</i>	3							

		<i>Mangifera indica</i>	3							6
4	Apocynaceae							<i>Ichnocarpus frutescens</i>	11	11
5	Arecaceae	<i>Areca catechu</i>	2							6
		<i>Cocos nucifera</i>	4							
6	Asteraceae			<i>Chromolaena odorata</i>	12	<i>Ageratum conyzoides</i>	1821.2	<i>Mikania micrantha</i>	19	4856.5
						<i>Synedrella nodiflora</i>	910.6			4887.5
						<i>Tridax procumbens</i>	2124.7			
7	Cyperaceae					<i>Cyperus rotundus</i>	2124.7			2124.7
8	Euphorbiaceae					<i>Euphorbia hirta</i>	2124.7			3338.8
						<i>Phyllanthus amarus</i>	1214.1			
9	Leguminosae	<i>Dalbergia latifolia</i>	1			<i>Chamaecrista mimosoides</i>	1821.2	<i>Abrus precatorius</i>	10	3338.8
		<i>Acacia mangium</i>	1			<i>Mimosa pudica</i>	1517.6			3350.8
10	Lamiaceae					<i>Anisomeles indica</i>	1517.6			3338.8
						<i>Leucas aspera</i>	1821.2			
11	Leeaceae			<i>Leea indica</i>	6					6
12	Malvaceae			<i>Hibiscus hispidissimus</i>	5					50
				<i>Hibiscus surattensis</i>	6					
				<i>Sida rhombifolia</i>	10					
				<i>Sida mysorensis</i>	7					
				<i>Sida cordifolia</i>	9					
				<i>Urena lobata</i>	7					
13	Menispermaceae							<i>Tiliacora racemosa</i>	17	17
14	Moraceae	<i>Artocarpus hirsutus</i>	2							2
15	Nyctaginaceae					<i>Boerhavia diffusa</i>	1517.6			1517.6
16	Poaceae			<i>Bambusa bambos</i>	4	<i>Alloteropsis cimicina</i>	2124.7			11534
						<i>Brachiaria remota</i>	2428.2			11538
						<i>Cynodon dactylon</i>	2731.7			
						<i>Digitaria ciliaris</i>	1821.2			
						<i>Eragrostis amabilis</i>	2428.2			

17	Rubiaceae					<i>Mitracarpus hirtus</i>	1517.6			2731.7
						<i>Oldenlandia corymbosa</i>	1214.1			
18	Scrophulariaceae					<i>Scoparia dulcis</i>	910.6			910.6
19	Simaroubaceae	<i>Quassia indica</i>	1							1
20	Tiliaceae			<i>Grewia nervosa</i>	5					5
21	Ulmaceae	<i>Trema orientalis</i>	2							2
22	Verbenaceae	<i>Tectona grandis</i>	1	<i>Clerodendrum infortunatum</i>	9					
		<i>Vitex altissima</i>	2	<i>Lantana camara</i>	3					21
				<i>Stachytarpheta jamaicensis</i>	6					

4) Poyyara study site

The details of family, genera and species of plants in the Poyyara sacred grove and disturbed non-sacred grove land of similar extent are depicted in the table B81 and table B82.

a) Based on total plant population

The analysis of dominance based on total plant population, the family Menispermaceae identified as most dominant in Poyyara grove, which have a total of 65 individuals. This is immediately followed by Rubiaceae and then Araceae with a total of 60 and 44 individuals respectively. The family Menispermaceae covers 10.45% of the entire population while Rubiaceae and Araceae covers 9.65% and 7.07% respectively. However in the disturbed land, the most dominant family is Poaceae with a total plant population of 1113 and this constituted 18.09% of the total population in the area. This is immediately followed by Amaranthaceae and Lamiaceae with a total of 1012 each and each constituted 16.45% of total population. The dominance of family when considered based on the diversity of plants, the family Leguminosae is most dominant in the grove and this consists of 5 genus and 5 species. The Rubiaceae is the next dominant family consisting of 4 genus and 4 species and this followed by Apocynaceae (3 genus and 4 species). While in the disturbed land, Asteraceae is the most dominant, which consists of 3 genus and 3 species and this is immediately followed by the families Amaranthaceae, Arecaceae, Euphorbiaceae, Leguminosae, Lamiaceae, Malvaceae, Poaceae and Verbenaceae, each having 2 genus and 2 species.

The most dominant genera as well as the species identified in the Poyyara grove is a climber namely *Tiliacora racemosa* which have a total representation of 47 with RD value of 7.56%. This is immediately followed by climbers *Pothos scandens* (44 individuals and RD value 7.07%) and then *Strychnos minor* (41 individuals and RD value 6.59%). However in disturbed land, the most dominant genera as well as the species is the herb *Brachiaria subquadriflora* with a total representation of 607 and RD value of 9.87%. *B. subquadriflora* is immediately followed by the herbs *Achyranthes aspera*, *Aerva lanata*, *Cyperus rotundus*, *Phyllanthus amarus*, *Anisomeles indica*, *Leucas aspera* and *Cynodon dactylon*, each having total representations of 506 and RD value of 8.22%.

b) Based on tree population

The dominance based on tree population showed that the family Sterculiaceae is the most dominant in Poyyara sacred grove. Total of 9 trees are represented in the family which constitute 15% of the total tree population. Immediately followed by Sterculiaceae is Verbenaceae (6 trees and constitute 10%) and then followed by families Apocynaceae, Leguminosae, Arecaceae and Meliaceae (5 trees and constitute 8.33% each). The most dominant genera as well as the species in the grove is *Vitex altissima* having a total representation of 6 trees and RD value of 10%. *V.altissima* is immediately followed by *Sterculia balanghas*, *Aphanamixis polystachya* and *Caryota urens* with a total representation of 5 and RD value 8.33% each. In the disturbed land, the Arecaceae is the most dominant family with a total of 5 trees and this covers 55.56% of total tree population, immediately followed by the family Ulmaceae, which consists of 3 trees and this constitute about 33.33% of the total tree population. Both *Areca catechu* and *Trema orientalis* are recorded as most dominant tree genera as well as the species in the disturbed land with a total representation of 3 and RD value of 33.33% each. This is immediately followed by *Cocos nucifera* (2 individuals and RD values of 22.22% each for genera and species).

Table B81: Details of family, genus and species in the Poyyara sacred grove

Sl. No	Family	Trees	No	shrubs	No	Herbs	No	Climber	No	Lianas	No	Family total
1	Amaranthaceae					<i>Aerva lanata</i>	6					16
						<i>Cyathula prostrata</i>	10					
2	Anacardiaceae	<i>Holigarna amottiana</i>	3									3
3	Annonaceae			<i>Polyalthia korintii</i>	13					<i>Uvaria narum</i>	10	23

4	Apocynaceae	<i>Alstonia scholaris</i>	1	<i>Tabernaemontana divaricata</i>	7		<i>Ichmocarpus frutescens</i>	15			
		<i>Tabernaemontana alternifolia</i>	4								27
5	Araceae						<i>Pothos scandens</i>	44			44
6	Arecaceae	<i>Caryota urens</i>	5								5
7	Asteraceae					<i>Emilia sonchifolia</i>	5				5
8	Combretaceae	<i>Terminalia bellirica</i>	1				<i>Combretum latifolium</i>	9			10
9	Connaraceae								<i>Rourea minor</i>	15	15
10	Cucurbitaceae						<i>Mukia maderaspatana</i>	18			18
11	Cyperaceae					<i>Cyperus rotundus</i>	8				8
12	Dioscoreaceae						<i>Dioscorea bulbifera</i>	23			23
13	Dipterocarpaceae	<i>Hopea ponga</i>	1								1
14	Euphorbiaceae			<i>Briedelia stipularis</i>	18						
				<i>Breynia vitis-idaea</i>	6	<i>Euphorbia hirta</i>	6				31
15	Leguminosae	<i>Adenanthera pavonina</i>	4	<i>Bauhinia acuminata</i>	5	<i>Desmodium gangeticum</i>	6	<i>Abrus precatorius</i>	20		
		<i>Pongamia pinnata</i>	1								36
16	Flacourtiaceae	<i>Hydnocarpus pentandrus</i>	4								4
17	Gnetaceae								<i>Gnetum ula</i>	13	13
18	Clusiaceae	<i>Garcinia gummi-gutta</i>	3								3
19	Icacinaceae			<i>Nothapodytes nimmoniana</i>	12				<i>Sarcostigma kleimii</i>	6	18
20	Leeaceae			<i>Leea indica</i>	7						7
21	Liliaceae						<i>Asparagus racemosus</i>	18			18
22	Loganiaceae						<i>Strychnos minor</i>	41			41
23	Meliaceae	<i>Aphanamixis polystachya</i>	5								5
24	Menispermaceae						<i>Cyclea peltata</i>	18			
							<i>Tiliacora racemosa</i>	47			65
25	Moraceae	<i>Ficus amplissima</i>	3								
		<i>Ficus benghalensis</i>	1								4
26	Myrtaceae	<i>Syzygium cumini</i>	3								3
27	Nyctaginaceae					<i>Boerhaavia diffusa</i>	4				4
28	Oxalidaceae					<i>Biophytum reinwardtii</i>	6				6
29	Poaceae			<i>Bambusa bambos</i>	12	<i>Panicum notatum</i>	12				24
30	Rubiaceae			<i>Chassalia curviflora</i>	13	<i>Spermacoce articularis</i>	15				
				<i>Ixora coccinea</i>	18						
				<i>Mussaenda frondosa</i>	14						60
31	Rutaceae	<i>Aegle marmelos</i>	1	<i>Glycosmis pentaphylla</i>	16						17
32	Sapotaceae	<i>Mimusops</i>	2								2

		<i>elengi</i>									
33	Simaroubaceae	<i>Quassia indica</i>	3								3
34	Sterculiaceae	<i>Pterygota alata</i>	4								9
		<i>Sterculia balanghas</i>	5								
35	Tiliaceae			<i>Grewia nervosa</i>	17						17
36	Verbenaceae	<i>Vitex altissima</i>	6	<i>Clerodendrum paniculatum</i>	9						15
37	Vitaceae						<i>Cyphostemma trilobata</i>	20			20

Table B82: Details of family, genus and species in the disturbed non-sacred grove land at Poyyara site

SL NO	Family	Trees	No	shrubs	No	Herbs	No	Climber	No	Family total
1	Acanthaceae					<i>Andrographis paniculata</i>	404.7			404.7
2	Amaranthaceae					<i>Achyranthes aspera</i>	505.9			1012
						<i>Aerva lanata</i>	505.9			
3	Anacardiaceae	<i>Anacardium occidentale</i>	1							1
4	Arecaceae	<i>Areca catechu</i>	3							5
		<i>Cocos nucifera</i>	2							
5	Asteraceae			<i>Chromolaena odorata</i>	6	<i>Tridax procumbens</i>	404.7	<i>Mikania micrantha</i>	20	430.7
6	Cyperaceae					<i>Cyperus rotundus</i>	505.9			506
7	Euphorbiaceae					<i>Euphorbia hirta</i>	404.7			910.6
						<i>Phyllanthus amarus</i>	505.9			
8	Leguminosae					<i>Mimosa pudica</i>	303.5	<i>Abrus precatorius</i>	8	311.5
9	Lamiaceae					<i>Anisomeles indica</i>	505.9			1012
						<i>Leucas aspera</i>	505.9			
10	Leeaceae			<i>Leea indica</i>	5					5
11	Malvaceae			<i>Sida cordifolia</i>	8					21
				<i>Urena lobata</i>	13					
12	Nyctaginaceae					<i>Boerhavia diffusa</i>	404.7			404.7
13	Poaceae					<i>Brachiaria subquadriflora</i>	607.1			1113
						<i>Cynodon dactylon</i>	505.9			
14	Tiliaceae			<i>Grewia nervosa</i>	5					5
15	Ulmaceae	<i>Trema orientalis</i>	3							3
16	Verbenaceae			<i>Clerodendrum infortunatum</i>	4					8
				<i>Lantana camara</i>	4					

Basal area of trees

The total basal area (TBA) and relative basal area (RBA) of trees in the selected sacred groves and the corresponding disturbed non-sacred grove lands of similar extent are analysed and the results are presented in table B83 to B90. Total basal area of 40.2m², 10.81 m², 1.572m² and 0.116m² are recorded for trees respectively in sacred groves at Sankulangara (0.636 hectare), Palliyana (0.364ha), Nambiyath (0.1214ha) and Poyyara (0.0404ha) study sites. The TBA for trees in the disturbed lands of similar extent at respective study sites are 3.496m², 1.882m², 0.312m² and 0.030m². The highest TBA of 40.2m² recorded at Sankulangara grove of largest extent is the sum total of 447 trees, which comprised of 36 different tree species while, the highest TBA of 3.496m² among the disturbed land recorded at Sankulangara site is the sum total of 57 trees and which comprised of 18 different tree species. Similarly, the TBA of 10.81m² recorded at Palliyana grove is the sum total of 341 trees, which comprised of 35 different tree species while the TBA of 1.882m² recorded in the disturbed land at Palliyana site is the sum total of 46 trees, which comprised of 12 different tree species ; the TBA of 1.572m² recorded at Nambiyath grove is the sum total of 178 trees, which comprised of 30 different tree species while the TBA of 0.312m² recorded in the disturbed land at Nambiyath site is the sum total of 22 trees, which comprised of 11 different tree species. The lowest TBA of 0.116m² recorded in the Poyyara grove and this is the sum total of 60 trees and which comprised of 20 different tree species while, the lowest TBA value of 0.030 m² among the disturbed land recorded at Poyyara study site is the sum total of 9 trees and which comprised of 4 different tree species.

The BA and RBA analysis of trees at Sankulangara study site showed the highest value in the grove is recorded by *Hopea ponga* of Dipterocarpaceae and the values are 15.78 m² and 39.26% respectively for BA and RBA. *H. ponga* is immediately followed by the tree species *Artocarpus hirsutus* of Moraceae (BA– 4.505 m² and RBA–11.21%) and then followed by *Vateria indica* of Dipterocarpaceae (BA–3.398 m² and RBA–8.454%). However in the disturbed land, the highest BA of 1.794m² and RBA of 51.31% are recorded by the tree species *Cocos nucifera* of Arecaceae. This is immediately followed by the tree species *Artocarpus heterophyllus* (BA– 0.289 m² and RBA–8.254%) and then *Artocarpus hirsutus* (BA–0.263 m² and RBA–7.511%) of family Moraceae.

In the Palliyana grove, the highest BA of 1.649 m² and RBA of 15.2% are recorded by the tree species *Artocarpus hirsutus* of Moraceae and this is immediately followed by *Garcinia*

gummi-gutta of Clusiaceae (BA– 1.361m² and RBA–12.6%) and then *Hydnocarpus pentandrus* of Flacourtiaceae (BA–0.887 m² and RBA–8.2%). The disturbed land showed the highest BA of 0.548 m² and RBA of 29.54% which are recorded by the tree species *Cocos nucifera* of Arecaceae. *C. nucifera* is immediately followed by *Mangifera indica* of Anacardiaceae (BA– 0.461m² and RBA–24.51%) and then *Tectona grandis* of Verbenaceae (BA–0.359 m² and RBA–19.06%).

The tree species *Artocarpus hirsutus* of Moraceae recorded the highest BA (0.267 m²) and RBA (17%) in the Nambiyath grove, followed immediately by *Alstonia scholaris* of Apocynaceae (BA– 0.212 m² and RBA–13.49%) and then *Syzygium cumini* of Myrtaceae (BA–0.178 m² and RBA–11.36%). However the disturbed land at Nambiyath site, the highest BA of 0.071m² and RBA of 22.79% are recorded by the tree species *Mangifera indica* of Anacardiaceae. This is immediately followed by *Cocos nucifera* of Arecaceae (TBA– 0.067 m² and RBA–21.38%) and then *Artocarpus hirsutus* of Moraceae (BA–0.052 m² and RBA–6.77%).

The highest BA and RBA in the grove at Poyyara study site recorded by *Alstonia scholaris* of Apocyanaceae and the values are 0.0181m² and 15.659% respectively for BA and RBA. Immediately followed by *A. scholaris* is *Terminalia bellirica* of Combretaceae (TBA– 0.0165m² and RBA–14.25%) and then followed by *Garcinia gummi-gutta* of Clusiaceae (TBA–0.0114 m² and RBA–9.8799%). The disturbed land at Poyyara site showed the tree species *Cocos nucifera* of Arecaceae recorded as the highest BA (0.012 m²) and RBA (45.053%). This is immediately followed by the tree species *Anacardium occidentale* of Anacardiaceae (TBA– 0.009m² and RBA–32.684%) and then *Trema orientalis* of Ulmaceae (TBA–0.003 m² and RBA–11.435%).

Table B83: Total basal area (TBA) and relative basal area (RBA) of trees in the Sankulangara sacred grove

SI	The name of the plant	Family	TBA (m ² /0.636ha)	RBA (%)
1	<i>Adenanthera pavonina</i>	Leguminosae	0.069	0.171
2	<i>Aphanamixis polystachya</i>	Meliaceae	0.171	0.425
3	<i>Aporosa cardiosperma</i>	Euphorbiaceae	0.047	0.116
4	<i>Areca catechu</i>	Arecaceae	0.028	0.07
5	<i>Artocarpus hirsutus</i>	Moraceae	4.505	11.21
6	<i>Carallia branchiata</i>	Rhizophoraceae	0.349	0.867
7	<i>Caryota urens</i>	Arecaceae	2.175	5.411
8	<i>Chrysophyllum cainito</i>	Sapotaceae	0.023	0.056
9	<i>Cinnamomum malabattrum</i>	Lauraceae	0.332	0.826
10	<i>Ficus amplissima</i>	Moraceae	1.979	4.923

11	<i>Ficus benghalensis</i>	Moraceae	1.327	3.301
12	<i>Ficus drupaceae</i>	Moraceae	0.083	0.207
13	<i>Ficus religiosa</i>	Moraceae	0.157	0.39
14	<i>Garcinia gummi-gutta</i>	Clusiaceae	1.018	2.532
15	<i>Holigarna arnottiana</i>	Anacardiaceae	2.024	5.034
16	<i>Hopea ponga</i>	Dipterocarpaceae	15.78	39.26
17	<i>Hydnocarpus pentandrus</i>	Flacourtiaceae	2.257	5.615
18	<i>Litsea coriacea</i>	Lauraceae	0.035	0.088
19	<i>Mimusops elengi</i>	Sapotaceae	0.075	0.186
20	<i>Olea dioica</i>	Oleaceae	0.037	0.092
21	<i>Persea macrantha</i>	Lauraceae	0.025	0.062
22	<i>Pinanga dicksonii</i>	Arecaceae	0.074	0.183
23	<i>Pouteria campechiana</i>	Sapotaceae	0.078	0.194
24	<i>Quassia indica</i>	Simaroubaceae	0.143	0.356
25	<i>Saraca asoca</i>	Leguminosae	0.014	0.034
26	<i>Sterculia guttata</i>	Sterculiaceae	0.029	0.071
27	<i>Strychnos nux-vomica</i>	Loganiaceae	0.011	0.026
28	<i>Syzygium hemisphericum</i>	Myrtaceae	1.606	3.994
29	<i>Syzygium lanceolatum</i>	Myrtaceae	1.266	3.148
30	<i>Tabernaemontana alternifolia</i>	Apocynaceae	0.06	0.15
31	<i>Terminalia bellirica</i>	Combretaceae	0.32	0.795
32	<i>Terminalia catappa</i>	Combretaceae	0.32	0.795
33	<i>Vateria indica</i>	Dipterocarpaceae	3.398	8.454
34	<i>Vitex altissima</i>	Verbenaceae	0.194	0.481
35	<i>Vitex pinnata</i>	Verbenaceae	0.042	0.104
36	<i>Xanthophyllum arnottianum</i>	Polygalaceae	0.15	0.374
Genus-30; Species-36		Family-21	40.2	100

Table B84: Total basal area (TBA) and relative basal area (RBA) of trees in the disturbed non-sacred grove land at Sankulangara site

Sl No	The name of the plant	Family	TBA (m ² /0.636ha)	RBA (%)
1	<i>Ailanthus triphysa</i>	Simaroubaceae	0.241	6.883
2	<i>Anacardium occidentale</i>	Anacardiaceae	0.03	0.858
3	<i>Annona squamosa</i>	Annonaceae	0.03	0.858
4	<i>Areca catechu</i>	Arecaceae	0.174	4.974
5	<i>Artocarpus heterophyllus</i>	Moraceae	0.289	8.254
6	<i>Artocarpus hirsutus</i>	Moraceae	0.263	7.511
7	<i>Briedelia retusa</i>	Euphorbiaceae	0.084	2.402
8	<i>Carallia branchiata</i>	Rhizophoraceae	0.14	4.014
9	<i>Cinnamomum verum</i>	Lauraceae	0.021	0.602
10	<i>Cocos nucifera</i>	Arecaceae	1.794	51.31
11	<i>Garcinia gummi-gutta</i>	Clusiaceae	0.046	1.321
12	<i>Hydnocarpus pentandrus</i>	Flacourtiaceae	0.017	0.486
13	<i>Mangifera indica</i>	Anacardiaceae	0.14	4.014
14	<i>Swietenia macrophylla</i>	Meliaceae	0.054	1.556
15	<i>Tabernaemontana alternifolia</i>	Apocynaceae	0.029	0.835
16	<i>Tectona grandis</i>	Verbenaceae	0.084	2.402
17	<i>Terminalia catappa</i>	Combretaceae	0.03	0.858
18	<i>Vitex altissima</i>	Verbenaceae	0.03	0.858
Genus-17 ; Species-18		Family-14	3.496	100

Table B85: Total basal area (TBA) and relative basal area (RBA) of trees in the Palliyana sacred grove

SI	The name of the plant	Family	TBA (m ² /0.364ha)	RBA (%)
1	<i>Adenanthera pavonina</i>	Leguminosae	0.023	0.21
2	<i>Alstonia scholaris</i>	Apocynaceae	0.665	6.15
3	<i>Anacardium occidentale</i>	Anacardiaceae	0.077	0.71
4	<i>Aphanamixis polystachya</i>	Meliaceae	0.838	7.75
5	<i>Aporosa cardiosperma</i>	Euphorbiaceae	0.041	0.38
6	<i>Areca catechu</i>	Arecaceae	0.06	0.55
7	<i>Artocarpus hirsutus</i>	Moraceae	1.649	15.2
8	<i>Briedelia retusa</i>	Euphorbiaceae	0.047	0.43
9	<i>Caryota urens</i>	Arecaceae	0.679	6.28
10	<i>Chrysophyllum cainito</i>	Sapotaceae	0.055	0.51
11	<i>Cinnamomum malabattrum</i>	Lauraceae	0.076	0.7
12	<i>Diospyros malabarica</i>	Ebenaceae	0.656	6.06
13	<i>Ficus benghalensis</i>	Moraceae	0.09	0.83
14	<i>Ficus religiosa</i>	Moraceae	0.041	0.38
15	<i>Garcinia gummi-gutta</i>	Clusiaceae	1.361	12.6
16	<i>Holigarna arnottiana</i>	Anacardiaceae	0.842	7.79
17	<i>Hydnocarpus pentandrus</i>	Flacourtiaceae	0.887	8.2
18	<i>Litsea coriacea</i>	Lauraceae	0.141	1.31
19	<i>Mimusops elengi</i>	Sapotaceae	0.066	0.61
20	<i>Olea diocia</i>	Oleaceae	0.048	0.44
21	<i>Persea macrantha</i>	Lauraceae	0.074	0.69
22	<i>Polyalthia longifolia</i>	Annonaceae	0.146	1.35
23	<i>Pongamia pinnata</i>	Leguminosae	0.083	0.76
24	<i>Quassia indica</i>	Simaroubaceae	0.045	0.41
25	<i>Saraca asoca</i>	Leguminosae	0.014	0.13
26	<i>Sterculia guttata</i>	Sterculiaceae	0.05	0.46
27	<i>Streblus asper</i>	Moraceae	0.477	4.42
28	<i>Strychnos nux-vomica</i>	Loganiaceae	0.037	0.34
29	<i>Syzygium caryophyllatum</i>	Myrtaceae	0.02	0.19
30	<i>Syzygium cumini</i>	Myrtaceae	0.39	3.61
31	<i>Tabernaemontana alternifolia</i>	Apocynaceae	0.013	0.12
32	<i>Terminalia bellirica</i>	Combretaceae	0.097	0.9
33	<i>Vateria indica</i>	Dipterocarpaceae	0.8	7.4
34	<i>Vitex altissima</i>	Verbenaceae	0.208	1.93
35	<i>Xanthophyllum arnottianum</i>	Polygalaceae	0.018	0.17
Genus-33; Species-35		Family-21	10.81	100

Table B86: Total basal area (TBA) and relative basal area (RBA) of trees in the disturbed non-sacred grove land at Palliyana site

SI	The name of the plant	Family	TBA (m ² /0.364ha)	RBA (%)
1	<i>Anacardium occidentale</i>	Anacardiaceae	0.097	5.18
2	<i>Areca catechu</i>	Arecaceae	0.087	4.639
3	<i>Artocarpus hirsutus</i>	Moraceae	0.101	5.375
4	<i>Azadirachta indica</i>	Meliaceae	0.035	1.874
5	<i>Cocos nucifera</i>	Arecaceae	0.548	29.14
6	<i>Garcinia gummi-gutta</i>	Clusiaceae	0.024	1.261
7	<i>Gliricidia sepium</i>	Leguminosae	0.018	0.94
8	<i>Lannea coromandelica</i>	Anacardiaceae	0.063	3.343
9	<i>Mangifera indica</i>	Anacardiaceae	0.461	24.51
10	<i>Tectona grandis</i>	Verbenaceae	0.359	19.06

11	<i>Terminalia catappa</i>	Combretaceae	0.08	4.27
12	<i>Vitex altissima</i>	Verbenaceae	0.008	0.414
	Genus-12; Species-12	Family-8	1.882	100

Table B87: Total basal area (TBA) and relative basal area (RBA) of trees in the Nambiyath sacred grove

SI	The name of the plant	Family	TBA (m ² /0.1214ha)	RBA (%)
1	<i>Adenanthera pavonina</i>	Leguminosae	0.01	0.637
2	<i>Alstonia scholaris</i>	Apocynaceae	0.212	13.49
3	<i>Anacardium occidentale</i>	Anacardiaceae	0.016	1.043
4	<i>Aphanamixis polystachya</i>	Meliaceae	0.113	7.188
5	<i>Artocarpus hirsutus</i>	Moraceae	0.267	17.0
6	<i>Carallia branchiata</i>	Rhizophoraceae	0.041	2.62
7	<i>Caryota urens</i>	Arecaceae	0.052	3.282
8	<i>Chrysophyllum cainito</i>	Sapotaceae	0.006	0.412
9	<i>Cinnamomum malabattrum</i>	Lauraceae	0.009	0.565
10	<i>Diospyros malabarica</i>	Ebenaceae	0.054	3.424
11	<i>Ficus amplissima</i>	Moraceae	0.081	5.133
12	<i>Ficus benghalensis</i>	Moraceae	0.152	9.661
13	<i>Garcinia gummi-gutta</i>	Clusiaceae	0.047	3.004
14	<i>Holigarna arnottiana</i>	Anacardiaceae	0.113	7.215
15	<i>Hydnocarpus pentandrus</i>	Flacourtiaceae	0.057	3.645
16	<i>Lannea coromandelica</i>	Anacardiaceae	0.009	0.576
17	<i>Mimusops elengi</i>	Sapotaceae	0.036	2.274
18	<i>Pinanga dicksonii</i>	Arecaceae	0.006	0.386
19	<i>Plumeria rubra</i>	Apocynaceae	0.004	0.224
20	<i>Polyalthia longifolia</i>	Annonaceae	0.017	1.065
21	<i>Pterygota alata</i>	Sterculiaceae	0.036	2.264
22	<i>Quassia indica</i>	Simaroubaceae	0.008	0.508
23	<i>Saraca asoca</i>	Leguminosae	0.003	0.164
24	<i>Sterculia balanghas</i>	Sterculiaceae	0.001	0.073
25	<i>Strychnos nux-vomica</i>	Loganiaceae	0.002	0.098
26	<i>Syzygium cumini</i>	Myrtaceae	0.178	11.36
27	<i>Tabernaemontana alternifolia</i>	Apocynaceae	0.006	0.351
28	<i>Terminalia bellirica</i>	Combretaceae	0.016	1.008
29	<i>Trema orientalis</i>	Ulmaceae	0.007	0.414
30	<i>Vitex altissima</i>	Verbenaceae	0.014	0.919
	Genus-29; Species-30	Family-20	1.572	100

Table B88: Total basal area (TBA) and relative basal area (RBA) of trees in the disturbed non-sacred grove land at Nambiyath site

SI	The name of the plant	Family	TBA (m ² /0.1214ha)	RBA (%)
1	<i>Anacardium occidentale</i>	Anacardiaceae	0.048	15.39
2	<i>Areca catechu</i>	Arecaceae	0.006	1.915
3	<i>Artocarpus hirsutus</i>	Moraceae	0.052	16.77
4	<i>Cocos nucifera</i>	Arecaceae	0.067	21.38
5	<i>Dalbergia latifolia</i>	Leguminosae	0.036	11.62
6	<i>Mangifera indica</i>	Anacardiaceae	0.071	22.79
7	<i>Quassia indica</i>	Simaroubaceae	0.001	0.366
8	<i>Acacia mangium</i>	Leguminosae	0.016	5.082
9	<i>Tectona grandis</i>	Verbenaceae	0.01	3.293
10	<i>Trema orientalis</i>	Ulmaceae	0.003	0.835
11	<i>Vitex altissima</i>	Verbenaceae	0.002	0.559
	Genus-11; Species-11	Family-7	0.312	100

Table B89: Total basal area (TBA) and relative basal area (RBA) of trees in the Poyyara sacred grove

SI	The name of the plant	Family	TBA (m ² /0.0404ha)	RBA (%)
1	<i>Adenanthera pavonina</i>	Leguminosae	0.0029	2.4962
2	<i>Aegle marmelos</i>	Rutaceae	0.0009	0.7381
3	<i>Alstonia scholaris</i>	Apocynaceae	0.0181	15.659
4	<i>Aphanamixis polystachya</i>	Meliaceae	0.0093	8.056
5	<i>Caryota urens</i>	Arecaceae	0.0069	5.9224
6	<i>Ficus amplissima</i>	Moraceae	0.0082	7.0956
7	<i>Ficus benghalensis</i>	Moraceae	0.0019	1.6273
8	<i>Garcinia gummi-gutta</i>	Clusiaceae	0.0114	9.8799
9	<i>Holigarna arnottiana</i>	Anacardiaceae	0.0099	8.5731
10	<i>Hopea ponga</i>	Dipterocarpaceae	0.0061	5.2487
11	<i>Hydnocarpus pentandrus</i>	Flacourtiaceae	0.0081	6.9743
12	<i>Mimusops elengi</i>	Sapotaceae	0.0011	0.9116
13	<i>Pongamia pinnata</i>	Leguminosae	0.0002	0.1735
14	<i>Pterygota alata</i>	Sterculiaceae	0.0008	0.6757
15	<i>Quassia indica</i>	Simaroubaceae	0.0005	0.4392
16	<i>Sterculia balanghas</i>	Sterculiaceae	0.0011	0.9468
17	<i>Syzygium cumini</i>	Myrtaceae	0.0099	8.527
18	<i>Tabernaemontana alternifolia</i>	Apocynaceae	0.0005	0.4392
19	<i>Terminalia bellirica</i>	Combretaceae	0.0165	14.25
20	<i>Vitex altissima</i>	Verbenaceae	0.0016	1.3684
Genus-19; Species-20		Family-16	0.116	100

Table B90: Total basal area (TBA) and relative basal area (RBA) of trees in the disturbed non-sacred grove land at Poyyara site

SI No	The name of the plant	Family	TBA (m ² /0.0404ha)	RBA (%)
1	<i>Anacardium occidentale</i>	Anacardiaceae	0.009	32.684
2	<i>Areca catechu</i>	Arecaceae	0.003	10.708
3	<i>Cocos nucifera</i>	Arecaceae	0.012	45.053
4	<i>Trema orientalis</i>	Ulmaceae	0.003	11.435
Genus-4; Species-4		Family-3	0.03	100

Importance value index (IVI)

The importance value index (IVI) of tree species and family of tree species in the Sankulangara study site of largest extent selected for the study is shown in table B91 & table B92. The IVI values of tree species in the grove are in the range of 66.83 to 0.87 while in the disturbed non-sacred grove land of similar extent it is in the range of 96.08 to 5.39. Similarly, the IVI values of families in the grove are in the range of 86.57 to 0.87 whereas in the disturbed land, it is in the range of 140.52 to 5.39. The tree species which recorded comparatively higher IVI values in the grove includes *Hopea ponga*, *Artocarpus hirsutus*, *Vateria indica*, *Caryota urens*, *Hydnocarpus pentandrus*, *Holigarna arnottiana*, *Quassia indica* and *Ficus amplissima*. The highest IVI score for the tree species is recorded by *Hopea ponga* (66.83) and this is immediately followed by *Artocarpus hirsutus* (22.89) and *Vateria*

indica (19.74). The families of tree species with comparatively higher values include Dipterocarpaceae, Moraceae, Arecaceae, Flacourtiaceae, Lauraceae, Anacardiaceae, Myrtaceae and Simaroubaceae. The highest IVI value for the family is recorded by Dipterocarpaceae (86.57), which comprised of two tree species in the grove namely *Hopea ponga* and *Vateria indica*. Dipterocarpaceae is immediately followed by Moraceae (42.34) and then Arecaceae (26.92). However, the disturbed non-sacred grove land of similar extent showed *Cocos nucifera*, *Areca catechu*, *Tabernaemontana alternifolia*, *Artocarpus heterophyllus*, *Ailanthus triphysa*, *Artocarpus hirsutus*, *Hydnocarpus pentandrus* and *Garcinia gummi-gutta* are tree species have comparatively higher IVI values and for the families, Arecaceae, Moraceae, Anacardiaceae, Apocynaceae, Simaroubaceae, Verbenaceae, Flacourtiaceae and Clusiaceae recorded higher values. The highest IVI score for the tree species in the disturbed land recorded by *Cocos nucifera* (96.08), immediately followed by *Areca catechu* (44.44) and then *Tabernaemontana alternifolia* (17.94). The highest IVI value for the family in the disturbed land is recorded by Arecaceae (140.52), which comprised of two tree species namely *Cocos nucifera* and *Areca catechu*. Arecaceae is immediately followed by Moraceae (31.12) and then Anacardiaceae (18.47).

Table B91: Importance value index (IVI) of tree species and family of trees in Sankulangara sacred grove

Sl. No	Family	Tree species	IVI of Species	IVI of Families
1	Dipterocarpaceae	<i>Hopea ponga</i>	66.83	86.57
		<i>Vateria indica</i>	19.74	
2	Moraceae	<i>Artocarpus hirsutus</i>	22.89	42.34
		<i>Ficus amplissima</i>	11.11	
		<i>Ficus drupaceae</i>	2.962	
		<i>Ficus bengalensis</i>	4.145	
		<i>Ficus religiosa</i>	1.234	
3	Arecaceae	<i>Caryota urens</i>	17.54	26.92
		<i>Pinanga dicksonii</i>	5.926	
		<i>Areca catechu</i>	3.445	
4	Flacourtiaceae	<i>Hydnocarpus pentandrus</i>	15.95	15.95
5	Lauraceae	<i>Cinnamomum malabathrum</i>	7.688	15.88
		<i>Litsea coriacea</i>	3.687	
		<i>Persea macrantha</i>	4.504	
6	Anacardiaceae	<i>Holigarna arnottiana</i>	12.52	12.52
7	Myrtaceae	<i>Syzygium lanceolatum</i>	5.903	11.58
		<i>Syzygium hemisphericum</i>	5.681	
8	Simaroubaceae	<i>Quassia indica</i>	11.37	11.37
9	Sapotaceae	<i>Mimusops elengi</i>	6.601	9.83
		<i>Chrysophyllum cainito</i>	2.191	
		<i>Pouteria campechiana</i>	1.038	
10	Oleaceae	<i>Olea diocia</i>	8.693	8.69
11	Polygalaceae	<i>Xanthophyllum arnottianum</i>	8.53	8.53
12	Euphorbiaceae	<i>Aporosa cardiosperma</i>	8.045	8.05

13	Clusiaceae	<i>Garcinia gummi-gutta</i>	7.645	7.65
14	Meliaceae	<i>Aphanamixis polystachya</i>	7.46	7.46
15	Apocynaceae	<i>Tabernaemontana alternifolia</i>	6.565	6.57
16	Verbenaceae	<i>Vitex altissima</i>	4.131	5.92
		<i>Vitex pinnata</i>	1.791	
17	Leguminosae	<i>Adenanthera pavonina</i>	2.082	3.8
		<i>Saraca asoca</i>	1.721	
18	Rhizophoraceae	<i>Carallia branchiata</i>	3.398	3.4
19	Combretaceae	<i>Terminalia bellirica</i>	1.639	3.28
		<i>Terminalia catappa</i>	1.639	
20	Sterculiaceae	<i>Sterculia guttata</i>	2.826	2.83
21	Loganiaceae	<i>Strychnos nux-vomica</i>	0.87	0.87

Table B92: Importance value index (IVI) of tree species and family of tree species in disturbed non-sacred grove land at Sankulangara site

Sl. No	Family	Tree species	IVI of Species	IVI of Families
1	Arecaceae	<i>Cocos nucifera</i>	96.08	140.52
		<i>Areca catechu</i>	44.44	
2	Moraceae	<i>Artocarpus heterophyllus</i>	17.32	31.12
		<i>Artocarpus hirsutus</i>	13.8	
3	Anacardiaceae	<i>Anacardium occidentale</i>	9.928	18.47
		<i>Mangifera indica</i>	8.544	
4	Apocynaceae	<i>Tabernaemontana alternifolia</i>	17.94	17.94
5	Simaroubaceae	<i>Ailanthus triphysa</i>	15.95	15.95
6	Verbenaceae	<i>Tectona grandis</i>	6.932	12.32
		<i>Vitex altissima</i>	5.388	
7	Flacourtiaceae	<i>Hydnocarpus pentandrus</i>	11.31	11.31
8	Clusiaceae	<i>Garcinia gummi-gutta</i>	10.39	10.39
9	Lauraceae	<i>Cinnamomum verum</i>	9.672	9.67
10	Rhizophoraceae	<i>Carallia branchiata</i>	8.544	8.54
11	Euphorbiaceae	<i>Briedelia retusa</i>	6.932	6.93
12	Meliaceae	<i>Swietenia macrophylla</i>	6.086	6.09
13	Combretaceae	<i>Terminalia catappa</i>	5.388	5.39
14	Annonaceae	<i>Annona squamosa</i>	5.388	5.39

The details of IVI of trees and families in the Palliyana sacred grove and disturbed non-sacred grove land are shown in table B93 and B94 respectively. The IVI values of trees are in the range of 27.04 to 1.06 and for the families in the range of 36.98 to 2.12 in the grove while the same in the case of disturbed land is in the range is 80.79 to 5.62 for trees and 134.9 to 9.47 for families of tree species. The tree species *Artocarpus hirsutus*, *Garcinia gummi-gutta*, *Aphanamixis polystachya*, *Hydnocarpus pentandrus*, *Holigarna arnottiana*, *Caryota urens*, *Sterculia guttata*, *Vitex altissima*, *Pongamia pinnata* and *Syzygium cumini* recorded comparatively higher IVI values in the grove. The highest IVI score is recorded by *Artocarpus hirsutus* (27.04) and this is immediately followed by *Garcinia gummi-gutta* (19.94) and then *Aphanamixis polystachya* (19.30). The families that recorded comparatively

higher values include Moraceae, Anacardiaceae, Lauraceae, Arecaceae, Clusiaceae, Meliaceae, Flacourtiaceae, Leguminosae, Sapotaceae and Myrtaceae. The family that recorded the highest IVI value is Moraceae (36.98), followed immediately by Anacardiaceae (27.56) and then Lauraceae (27.41). The disturbed land at Palliyana site showed tree species such as *Cocos nucifera*, *Areca catechu*, *Mangifera indica*, *Tectona grandis*, *Artocarpus hirsutus*, *Gliricidia sepium* and *Anacardium occidentale* have comparatively higher IVI values whereas the families include Arecaceae, Anacardiaceae and Verbenaceae. The highest IVI score recorded by the tree species and the family in the disturbed land are *Cocos nucifera* (80.79) and Arecaceae (134.9) respectively. *Cocos nucifera* is immediately followed by *Areca catechu* (54.11) and then *Mangifera indica* (29.71) while the family Arecaceae is immediately followed by Anacardiaceae (62.08) and Verbenaceae (29.88).

Table B93: Importance value index (IVI) of tree species and family of trees in Palliyana sacred grove

Sl. No	Family	Tree species	IVI of Species	IVI of Families
1	Moraceae	<i>Artocarpus hirsutus</i>	27.04	36.98
		<i>Ficus benghalensis</i>	1.76	
		<i>Ficus religiosa</i>	1.31	
		<i>Streblus asper</i>	6.87	
2	Anacardiaceae	<i>Anacardium occidentale</i>	5.31	27.56
		<i>Holigarna arnottiana</i>	18.75	
3	Lauraceae	<i>Cinnamomum malabattrum</i>	8.92	27.41
		<i>Litsea coriacea</i>	8.65	
		<i>Persea macrantha</i>	9.84	
4	Arecaceae	<i>Areca catechu</i>	6.37	20.28
		<i>Caryota urens</i>	13.91	
5	Clusiaceae	<i>Garcinia gummi-gutta</i>	19.94	19.94
6	Meliaceae	<i>Aphanamixis polystachya</i>	19.3	19.3
7	Flacourtiaceae	<i>Hydnocarpus pentandrus</i>	19.16	19.16
8	Leguminosae	<i>Adenanthera pavonina</i>	5.74	17.59
		<i>Pongamia pinnata</i>	10.79	
		<i>Saraca asoca</i>	1.06	
9	Sapotaceae	<i>Chrysophyllum cainito</i>	6.63	15.51
		<i>Mimusops elengi</i>	8.88	
10	Myrtaceae	<i>Syzygium caryophyllatum</i>	3.57	13.59
		<i>Syzygium cumini</i>	10.02	
11	Sterculiaceae	<i>Sterculia guttata</i>	11.13	11.13
12	Verbenaceae	<i>Vitex altissima</i>	11.08	11.08
13	Apocynaceae	<i>Alstonia scholaris</i>	7.08	9.65
		<i>Tabernaemontana alternifolia</i>	2.57	
14	Dipterocarpaceae	<i>Vateria indica</i>	9.55	9.55
15	Euphorbiaceae	<i>Aporosa cardiosperma</i>	6.5	9.38
		<i>Briedelia retusa</i>	2.88	
16	Simaroubaceae	<i>Quassia indica</i>	8.34	8.34
17	Ebenaceae	<i>Diospyros malabarica</i>	7.92	7.92

18	Oleaceae	<i>Olea diocia</i>	7.19	7.19
19	Polygalaceae	<i>Xanthophyllum arnottianum</i>	4.43	4.43
20	Annonaceae	<i>Polyalthia longifolia</i>	3.5	3.5
21	Loganiaceae	<i>Strychnos nux-vomica</i>	2.49	2.49
22	Combretaceae	<i>Terminalia bellirica</i>	2.12	2.12

Table B94: Importance value index (IVI) of tree species and family of tree species in disturbed non-sacred grove land at Palliyana site

Sl. No	Family	Tree species	IVI of Species	IVI of Families
1	Arecaceae	<i>Areca catechu</i>	54.11	134.9
		<i>Cocos nucifera</i>	80.79	
2	Anacardiaceae	<i>Anacardium occidentale</i>	18.62	62.08
		<i>Lannea coromandelica</i>	13.75	
		<i>Mangifera indica</i>	29.71	
3	Verbenaceae	<i>Tectona grandis</i>	24.26	29.88
		<i>Vitex altissima</i>	5.62	
4	Moraceae	<i>Artocarpus hirsutus</i>	18.81	18.81
5	Leguminosae	<i>Gliricidia sepium</i>	18.73	18.73
6	Meliaceae	<i>Azadirachta indica</i>	14.46	14.46
7	Clusiaceae	<i>Garcinia gummi-gutta</i>	11.67	11.67
8	Combretaceae	<i>Terminalia catappa</i>	9.47	9.47

The details of IVI of trees and families in the Nambiyath grove and disturbed non-sacred grove land are shown in table B95 and B96 respectively. The IVI values of tree species in the grove ranged from 35.88 to 1.61 while in the disturbed land ranged from 57.74 to 9.46. The IVI values for the families ranged from 56.74 to 2.91 in the grove while, it is 92.74 to 9.46 for the disturbed land. The tree species *Artocarpus hirsutus*, *Hydnocarpus pentandrus*, *Pterygota alata*, *Holigarna arnottiana*, *Aphanamixis polystachya*, *Alstonia scholaris*, *Syzygium cumini* and *Quassia indica* are recorded comparatively higher IVI values in the grove. The *Artocarpus hirsutus* recorded the highest IVI value (35.88) among trees, immediately followed by *Hydnocarpus pentandrus* (16.99) and then *Pterygota alata* (16.12). The families which recorded comparatively higher values includes Moraceae, Anacardiaceae, Apocynaceae, Flacourtiaceae, Sterculiaceae, Sapotaceae, Meliaceae, Myrtaceae, Simaroubaceae and Arecaceae. The highest IVI value for the family recorded by Moraceae (56.74), immediately followed by Anacardiaceae (27.56) and then Apocynaceae (26.72). With respect to the disturbed land, *Cocos nucifera*, *Mangifera indica*, *Anacardium occidentale*, *Artocarpus hirsutus*, *Dalbergia latifolia* and *Areca catechu* are the tree species and Anacardiaceae, Arecaceae, Moraceae, Leguminosae and Verbenaceae are the families which recorded comparatively higher IVI scores. *Cocos nucifera* (57.74) recorded the highest IVI score in the disturbed land, immediately followed by *Mangifera indica* (50.07) and then

Anacardium occidentale (42.67). The highest IVI score for the family recorded by Anacardiaceae (92.74) and this is immediately followed by Arecaceae (77.84) and then Moraceae (34.95).

Table B95: Importance value index (IVI) of tree species and family of trees in Nambiyath sacred grove

Sl. No	Family	Tree species	IVI of Species	IVI of Families
1	Moraceae	<i>Artocarpus hirsutus</i>	35.88	56.74
		<i>Ficus amplissima</i>	9.81	
		<i>Ficus benghalensis</i>	11.05	
2	Anacardiaceae	<i>Anacardium occidentale</i>	5.72	27.56
		<i>Holigarna arnottiana</i>	15.19	
		<i>Lannea coromandelica</i>	6.65	
3	Apocynaceae	<i>Alstonia scholaris</i>	14.88	26.72
		<i>Plumeria rubra</i>	1.61	
		<i>Tabernaemontana alternifolia</i>	10.23	
4	Flacourtiaceae	<i>Hydnocarpus pentandrus</i>	16.99	19.99
5	Sterculiaceae	<i>Pterygota alata</i>	16.12	18.97
		<i>Sterculia balanghas</i>	2.85	
6	Sapotaceae	<i>Chrysophyllum cainito</i>	9.78	18.12
		<i>Mimusops elengi</i>	8.34	
7	Meliaceae	<i>Aphanamixis polystachya</i>	15.16	15.16
8	Myrtaceae	<i>Syzygium cumini</i>	14.14	14.14
9	Simaroubaceae	<i>Quassia indica</i>	13.85	13.85
10	Arecaceae	<i>Caryota urens</i>	7.44	13.54
		<i>Pinanga dicksonii</i>	6.1	
11	Ebenaceae	<i>Diospyros malabarica</i>	9.49	9.49
12	Ulmaceae	<i>Trema orientalis</i>	9.42	9.42
13	Lauraceae	<i>Cinnamomum malabattrum</i>	9.41	9.41
14	Verbenaceae	<i>Vitex altissima</i>	8.38	8.38
15	Leguminosae	<i>Adenanthera pavonina</i>	5.32	8.26
		<i>Saraca asoca</i>	2.94	
16	Clusiaceae	<i>Garcinia gummi-gutta</i>	7.17	7.17
17	Annonaceae	<i>Polyalthia longifolia</i>	5.75	5.75
18	Rhizophoraceae	<i>Carallia branchiata</i>	5.4	5.4
19	Loganiaceae	<i>Strychnos nux-vomica</i>	4.26	4.26
20	Combretaceae	<i>Terminalia bellirica</i>	2.91	2.91

Table B96: Importance value index (IVI) of families of tree species in disturbed non-sacred grove land at Nambiyath site

Sl. No	Family	Tree species	IVI of Species	IVI of Families
1	Anacardiaceae	<i>Anacardium occidentale</i>	42.67	92.74
		<i>Mangifera indica</i>	50.07	
2	Arecaceae	<i>Areca catechu</i>	20.1	77.84
		<i>Cocos nucifera</i>	57.74	
3	Moraceae	<i>Artocarpus hirsutus</i>	34.95	34.95
4	Leguminosae	<i>Dalbergia latifolia</i>	20.71	34.88
		<i>Acacia mangium</i>	14.17	

5	Verbenaceae	<i>Tectona grandis</i>	12.38	31.12
		<i>Vitex altissima</i>	18.74	
6	Ulmaceae	<i>Trema orientalis</i>	19.02	19.02
7	Simaroubaceae	<i>Quassia indica</i>	9.46	9.46

The Poyyara sacred grove of smallest extent selected for the study showed the IVI values of tree species in the range of 23.8 to 3.69 while in the disturbed land, the values ranged from 89.49 to 54.9. Similarly, the IVI values of families in the grove are in the range of 33.69 to 4.26 and in the disturbed land is in the range of 166.86 to 54.9 (table B97 & table B98). The tree species *Aphanamixis polystachya*, *Caryota urens*, *Hydnocarpus pentandrus*, *Vitex altissima*, *Garcinia gummi-gutta*, *Alstonia scholaris*, *Holigarna arnottiana* and *Syzygium cumini* and the families Apocynaceae, Sterculiaceae, Meliaceae, Arecaceae, Flacourtiaceae, Moraceae, Verbenaceae, Clusiaceae, Anacardiaceae, Myrtaceae and Leguminosae recorded comparatively higher IVI scores in the grove. The highest IVI score among the tree species is recorded by *Aphanamixis polystachya* (23.8) and this is immediately followed by *Caryota urens* (23.51) and then *Hydnocarpus pentandrus* (21.05). The highest IVI values among the families of tree species are for Apocynaceae (33.69), followed immediately by Sterculiaceae (29.59) and then Meliaceae (23.8). In the disturbed land, *Cocos nucifera* recorded the highest IVI value (89.49) among tree species and this is immediately followed by *Areca catechu* (77.37). The family which recorded highest IVI value is Arecaceae (166.86), immediately followed by Ulmaceae (78.1).

Table B97: Importance value index (IVI) of tree species and family of trees in Poyyara sacred grove

Sl. No	Family	Tree species	IVI of Species	IVI of Families
1	Apocynaceae	<i>Alstonia scholaris</i>	19.18	33.69
		<i>Tabernaemontana alternifolia</i>	14.51	
2	Sterculiaceae	<i>Pterygota alata</i>	12.9	29.59
		<i>Sterculia balanghas</i>	16.69	
3	Meliaceae	<i>Aphanamixis polystachya</i>	23.8	23.8
4	Arecaceae	<i>Caryota urens</i>	23.51	23.51
5	Flacourtiaceae	<i>Hydnocarpus pentandrus</i>	21.05	21.05
6	Moraceae	<i>Ficus amplissima</i>	15.8	20.95
		<i>Ficus benghalensis</i>	5.15	
7	Verbenaceae	<i>Vitex altissima</i>	20.63	20.63
8	Clusiaceae	<i>Garcinia gummi-gutta</i>	20.44	20.44
9	Anacardiaceae	<i>Holigarna arnottiana</i>	19.13	19.13
10	Myrtaceae	<i>Syzygium cumini</i>	19.08	19.08
11	Leguminosae	<i>Adenanthera pavonina</i>	14.72	18.41
		<i>Pongamia pinnata</i>	3.69	
12	Combretaceae	<i>Terminalia bellirica</i>	17.77	17.77

13	Simaroubaceae	<i>Quassia indica</i>	11	11
14	Dipterocarpaceae	<i>Hopea ponga</i>	8.77	8.77
15	Sapotaceae	<i>Mimusops elengi</i>	7.95	7.95
16	Rutaceae	<i>Aegle marmelos</i>	4.26	4.26

Table B98: Importance value index (IVI) of tree species and family of tree species in disturbed non-sacred grove land at Poyyara site

Sl. No	Family	Tree species	IVI of Species	IVI of Families
1	Arecaceae	<i>Cocos nucifera</i>	89.49	166.86
		<i>Areca catechu</i>	77.37	
2	Ulmaceae	<i>Trema orientalis</i>	78.1	78.1
3	Anacardiaceae	<i>Anacardium occidentale</i>	54.9	54.9

Discussion

Floristic and phytosociological studies

The results of the investigation clearly indicated considerable difference in the distribution of plants between selected sacred groves and disturbed non-sacred grove lands of similar extents. The study also revealed differences among sacred groves of different extents and among disturbed lands of different extents. The comparative evaluation showed the total number of plant genus ranged from 57 to 91 in the grove regions in comparison to 26 to 67 in the disturbed non-sacred grove regions. This constituted an overall average reduction of 37.38% in disturbed regions over grove regions. The number of total plant species found ranged from 59 to 101 in the grove regions in comparison to 26 to 76 in the disturbed regions and this recorded an overall average reduction of 36.84% in disturbed regions over grove regions. The analysis in the average number of different plant genus per sampling units in various study regions showed the number of plant genus ranged from 49.25 to 83.50 among sacred groves while this is ranged from 19.50 to 44.25 among disturbed non-sacred grove regions. Similarly, the average number of different plant species per sampling units found ranged from 49.50 to 89.25 among sacred groves whereas, this is ranged from 19.50 to 49.25 among disturbed non-sacred grove regions. The comparative analysis revealed that the number of plant genus as well as the number of plant species are significantly higher in all the studied groves compared to their corresponding disturbed non-sacred grove regions of similar extents (table B99 & Figure B1 and table B100 & Figure B2).

Table B99: Details of plant genus in sacred groves and disturbed non-sacred grove lands at different study sites

Mean value and SD of number of plant genus/sampling unit								
Study area	Sacred groves				Disturbed non-sacred grove lands			
	SaSG	PaSG	NaSG	PoySG	DLSa	DLPa	DLNa	DLPoy
Mean	73.75	83.50	63.75	49.25	40.50	44.25	38.00	19.50
SD ±	9.00	3.87	4.99	1.50	6.40	4.27	3.56	1.29
The 't' value and significant level of number of plant genus obtained from comparison								
Comparison between study area	SaSG X DLSa	PaSG X DLPa	NaSG X DLNa	PoySG X DLPoy	SaSG X PaSG	SaSG X NaSG	SaSG X PoySG	
't' value	6.02	13.61	8.40	30.07	-1.99	1.94	5.37	
Sig. level	P<0.001	P<0.001	P<0.001	P<0.001	NS*	NS*	P<0.05	

*NS- No significance

SaSG- Sankulangara sacred grove, PaSG- Palliyana sacred grove, NaSG- Nambiyath sacred grove and PoySG- Poyyara sacred grove DLSa- Disturbed land Sankulangara, DLPa- Disturbed land Palliyana, DLNa- Disturbed land Nambiyath and DLPoy- Disturbed land Poyyara

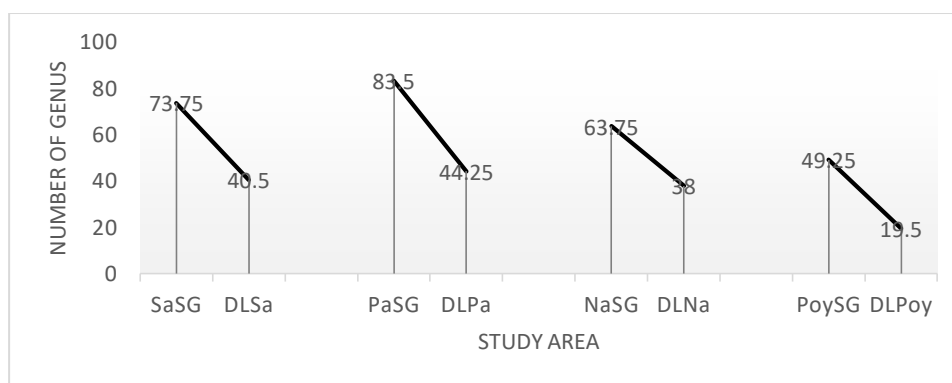


Figure B1: Number of plant genus in selected sacred groves and disturbed non-sacred grove lands at different study sites

Table B100: Details of plant species in sacred groves and disturbed non-sacred grove lands at different study sites

Mean value and SD of number of plant species/sampling unit								
Study area	Sacred groves				Disturbed non-sacred grove lands			
	SaSG	PaSG	NaSG	PoySG	DLSa	DLPa	DLNa	DLPoy
Mean	78.75	89.25	66.25	49.50	45.75	49.25	41.50	19.50
SD ±	9.91	4.57	5.44	2.38	6.70	3.59	4.04	1.29
The 't' value and significant level of number of plant species obtained from comparison								
Comparison between study area	SaSG X DLSa	PaSG X DLPa	NaSG X DLNa	PoySG X DLPoy	SaSG X PaSG	SaSG X NaSG	SaSG X PoySG	
't' value	5.52	13.75	7.31	22.2	-1.92	2.21	5.74	
Sig. level	P<0.001	P<0.001	P<0.001	P<0.001	NS*	P<0.05	P<0.001	

*NS- No significance

SaSG- Sankulangara sacred grove, PaSG- Palliyana sacred grove, NaSG- Nambiyath sacred grove and PoySG- Poyyara sacred grove DLSa- Disturbed land Sankulangara, DLPa- Disturbed land Palliyana, DLNa- Disturbed land Nambiyath and DLPoy- Disturbed land Poyyara

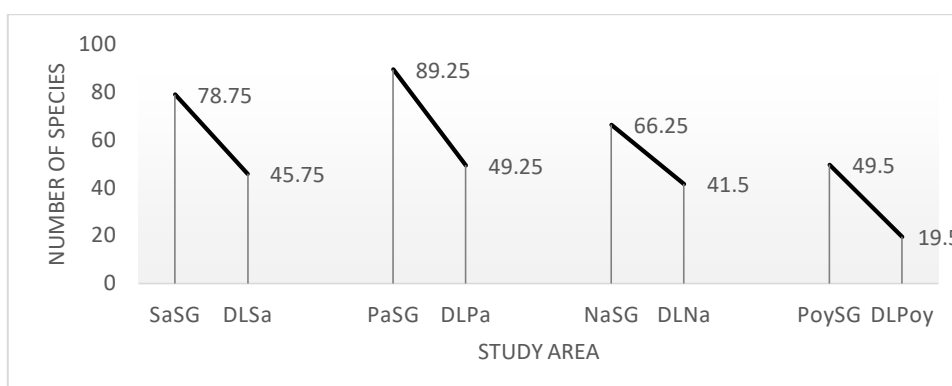


Figure B2: Number of plant species in selected sacred groves and disturbed non-sacred grove lands at different study sites

The study therefore clearly revealed the diversity in the plant genus and species are comparatively very high in the selected sacred groves over the selected disturbed lands of

similar extents. Further, higher representation of plant genus and species from diverse plant groups such as trees, climbers, lianas, shrubs and herbs in the groves- a typical characteristics of undisturbed and mixed type of tropical forest vegetation. The higher species diversity, density and frequency of plants in the groves indicate the existence of better stability and ecosystem balance (Nisha et al., 2016). These inference in the study can be attributed to the absence of anthropogenic pressures on sacred groves as they are protected under the religious grounds. Such protection oriented establishment of sustainable microclimatic and soil factors which favour the natural regeneration of diverse plant species might be the reason for better ecological stability and more or less even distribution of plant groups and plant species in sacred groves. However in the disturbed non-sacred grove lands, the majority of the plant species that are typical to unstressed natural forest vegetation such as liana species and many species of climbers and trees are absent. But, instead many invasive herbaceous and shrubby plant species are found dominating - a typical characteristics of highly disturbed degraded forest vegetation. Total absence of lianas and significant reduction in the diversity, density and frequency of many trees and climbers in the disturbed lands can be attributed to poor regeneration of these plant species due to severe stress environment existing in the area induced by anthropogenic activities (Nepolion et al., 2014).

With respect to the number of families under which plants are distributed, this is found ranged from 38 to 54 in the grove regions over 16 to 30 families in the disturbed regions and this constituted an overall average reduction of 48.15% in disturbed regions. The comparative analysis in the distribution and proportion of different plant groups such as trees, shrubs, herbs, climbers and lianas revealed the occurrence of more plant groups and their more or less even distribution in the selected sacred groves compared to that of corresponding adjacent disturbed non-sacred grove lands. The highest proportion of plants in the total population is occupied by climbers in Sankulangara (43.45%), Palliyana (36.01%) and Poyyara sacred groves (43.89%) while the plant group shrubs in Nambiyath sacred grove (23.71%). These proportions are immediately followed by trees (21.07%) and then shrubs (16.97%) in Sankulangara; shrubs (21.33%) and then trees (19.87%) in Palliyana; trees (19.54%) and then herbs (18.63%) in Nambiyath and shrubs (26.85%) and then herbs (12.54%) in Poyyara sacred groves. However in the selected disturbed non-sacred grove lands, the proportion of plant groups showed different pattern. The majority of the proportion in the total population of all the study sites of disturbed lands are occupied by the plant group herbs. These are 99.88% at Sankulangara, 99.83% at Palliyana, 99.66% at Nambiyath and

98.67% at Poyyara. These are immediately followed by shrubs (0.072%) and then trees (0.026%) in Sankulangara disturbed land while shrubs and then climber in Palliyana (0.108% & 0.035% respectively), Nambiyath (0.172% & 0.115% respectively) and Poyyara disturbed lands (0.731% & 0.455% respectively).

The major plant species which are found to record comparatively higher values of D & RD and F & RF in the selected sacred groves include the trees like *Caryota urens*, *Artocarpus hirsutus*, *Quassia indica*, *Hopea ponga*, *Hydnocarpus pentandrus*, *Aphanamixis polystachya*, *Holigarna arnottiana*, *Sterculia guttata*, *Persea macrantha*, *Vitex altissima*, *Pongamia pinnata*, *Mimusops elengi*, *Pterygota alata*; the climbers like *Smilax zeylanica*, *Pothos scandens*, *Cayratia japonica*, *Tiliacora racemosa*, *Ichnocarpus frutescens*, *Tinospora cordifolia*, *Strychnos minor*, *Dioscorea bulbifera*, *Abrus precatorius*, *Cayratia pedata*, *Asparagus racemosus*, *Cyclea peltata*, *Mukia maderaspatana*; the lianas such as *Gnetum ula*, *Uvaria narum*, *Salacia fruticosa*, *Sarcostigma kleinii*, *Connarus monocarpus*, *Rourea minor* and the shrubs like *Chassalia curviflora*, *Ixora coccinea*; *Briedelia stipularis*, *Hibiscus rosa-sinensis*, *Clerodendrum paniculatum*, *Breynia vitis-idaea*, *Coffea travancorensis*, *Leea indica*, *Polyalthia korintii* and *Grewia nervosa*. However in the selected disturbed non-sacred grove lands, the majority of the plant species which are recorded comparatively higher values of D & RD and F & RF are belonging to the plant group herbs and shrubs. This includes species of herbs like *Cynodon dactylon*, *Desmodium triflorum*, *Commelina diffusa*, *Murdannia pauciflora*, *Mitracarpus hirtus*, *Mimosa pudica*, *Eragrostis amabilis*, *Eragrostis unioides*, *Digitaria ciliaris*, *Aerva lanata*, *Phyllanthus amarus*, *Phyllanthus urinaria*, *Justicia procumbens*, *Cyathula prostrata*, *Achyranthes aspera*, *Andrographis paniculata*, *Alloteropsis cimicina*, *Brachiaria subquadripara*, *Anisomeles indica*, *Cyperus rotundus* and *Leucas aspera*. Similarly the major species of shrubs includes *Triumfetta rhomboidea*, *Hyptis suaveolens*, *Sida rhombifolia*, *Chromolaena odorata*, *Clerodendrum infortunatum*, *Urena lobata*. Only few species of trees such as *Areca catechu* and *Cocos nucifera* and climbers such as *Mikania micrantha* and *Tiliacora racemosa* are found recorded comparatively higher values.

The analysis in the average density of plant species in different plant groups such as trees, shrubs, climbers and lianas generally showed significantly higher values in sacred groves compared to their corresponding disturbed non-sacred grove lands, with an exception of climbers in Nambiyath grove showing a significantly lower value (table B101 to B108 and Figure B3 to B6).

Table B101: Details of average density of a tree species in different sacred groves and disturbed non-sacred grove lands at various study sites

Mean value and SD of average density of a tree species								
Study area	Sacred groves				Disturbed non-sacred grove lands			
	SaSG	PaSG	NaSG	PoySG	DLSa	DLPa	DLNa	DLPoy
Mean	3.11	2.44	1.50	0.75	0.79	0.96	0.51	0.56
SD $\pm$	1.13	0.23	0.17	0.13	0.64	0.66	0.16	0.24
The 't' value and significant level of average density of a tree species obtained from comparison								
Comparison between study area	SaSG X DLSa	PaSG X DLPa	NaSG X DLNa	PoySG X DLPoy	SaSG X PaSG	SaSG X NaSG	SaSG X PoySG	
't' value	3.57	4.24	8.59	1.38	1.17	2.83	4.16	
Sig. level	P<0.05	P<0.001	P<0.001	NS*	NS*	P<0.05	P<0.001	

*NS- No significance

SaSG- Sankulangara sacred grove, PaSG- Palliyana sacred grove, NaSG- Nambiyath sacred grove and PoySG- Poyyara sacred grove DLSa- Disturbed land Sankulangara, DLPa- Disturbed land Palliyana, DLNa- Disturbed land Nambiyath and DLPoy- Disturbed land Poyyara

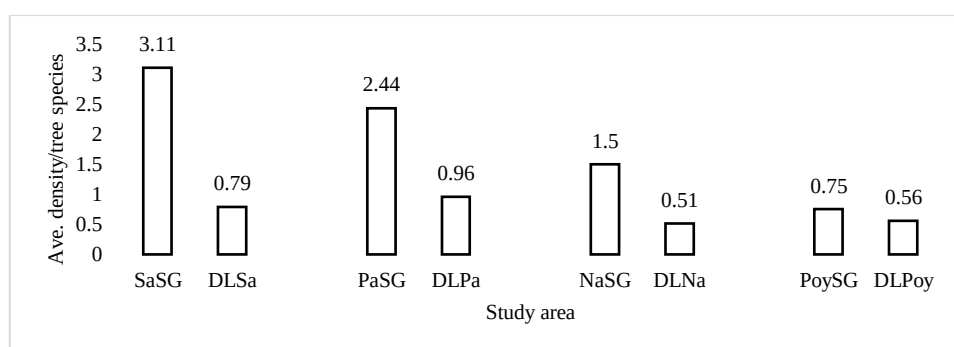


Figure B3: Average density of a tree species in different sacred groves and disturbed non-sacred grove lands at various study sites

Table B102: Details of average density of a shrub species in different sacred groves and disturbed non-sacred grove lands at various study sites

Mean value and SD of average density of a shrub species								
Study area	Sacred groves				Disturbed non-sacred grove lands			
	SaSG	PaSG	NaSG	PoySG	DLSa	DLPa	DLNa	DLPoy
Mean	5.30	3.82	3.20	2.98	3.31	2.21	1.65	1.61
SD $\pm$	1.52	0.36	0.07	0.35	1.27	0.57	0.26	0.34
The 't' value and significant level of average density of a shrub species obtained from comparison								
Comparison between study area	SaSG X DLSa	PaSG X DLPa	NaSG X DLNa	PoySG X DLPoy	SaSG X PaSG	SaSG X NaSG	SaSG X PoySG	
't' value	1.10	4.78	11.559	5.610	1.895	2.754	2.965	
Sig. level	P<0.05	P<0.001	P<0.001	P<0.001	NS*	P<0.05	P<0.05	

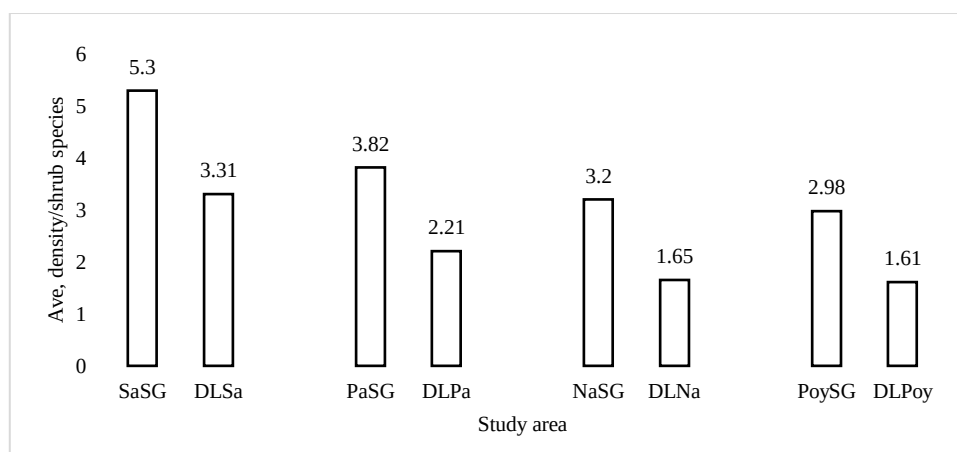


Figure B4: Average density of a shrub species in different sacred groves and disturbed non-sacred grove lands at various study sites

Table B103: Details of average density of a climber species in different sacred groves and disturbed non-sacred grove lands at various study sites

Mean value and SD of average density of a climber species								
Study area	Sacred groves				Disturbed non-sacred grove lands			
	SaSG	PaSG	NaSG	PoySG	DLSa	DLPa	DLNa	DLPoy
Mean	9.23	8.13	2.87	6.21	3.06	2.42	3.59	3.50
SD ±	5.98	0.15	0.55	0.66	0.63	0.74	0.38	0.71
The 't' value and significant level of average density of a climber species obtained from comparison								
Comparison between study area	SaSG X DLSa	PaSG X DLPa	NaSG X DLNa	PoySG X DLPoy	SaSG X PaSG	SaSG X NaSG	SaSG X PoySG	
't' value	2.05	15.15	-2.17	5.58	0.37	2.118	1.01	
Sig. level	P<0.05	P<0.001	P<0.05	P<0.001	NS*	P<0.05	NS*	

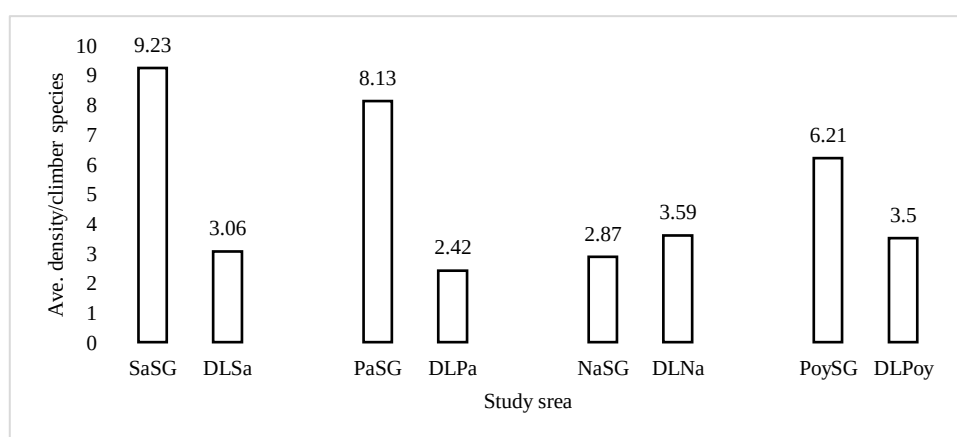


Figure B5: Average density of a climber species in different sacred groves and disturbed non-sacred grove lands at various study sites

Table B104: Details of average density of a liana species in different sacred groves and disturbed non-sacred grove lands at various study sites

Mean value and SD of average density of a liana species								
Study area	Sacred groves				Disturbed non-sacred grove lands			
	SaSG	PaSG	NaSG	PoySG	DLSa	DLPa	DLNa	DLPoy
Mean	5.69	4.39	8.27	2.17	0.0	0.0	0.0	0.0
SD $\pm$	2.59	0.74	1.42	0.70	0.0	0.0	0.0	0.0
The 't' value and significant level of average density of a liana species obtained from comparison								
Comparison between study area	SaSG X DLSa	PaSG X DLPa	NaSG X DLNa	PoySG X DLPoy	SaSG X PaSG	SaSG X NaSG	SaSG X PoySG	
't' value	4.389	9.321	11.622	6.232	1.669	-1.746	2.625	
Sig. level	P<0.001	P<0.001	P<0.001	P<0.001	NS*	NS*	P<0.05	

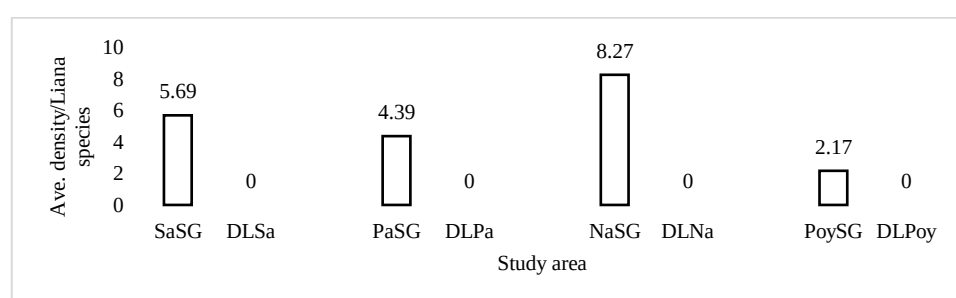


Figure B6: Average density of a liana species in different sacred groves and disturbed non-sacred grove lands at various study sites

However, the average density of herbaceous plant species is found too much higher and significant in all the disturbed non-sacred grove lands compared to average density of herbaceous plant species in all the corresponding selected sacred groves (table B105 & Figure B7). This has resulted in significantly higher average density for a plant species in disturbed lands when all the plant groups including herbs are considered together, although majority of the plant groups in sacred groves are recorded higher average density for plant species (table B106 & B8).

Table B105: Details of average density of herbaceous species in different sacred groves and disturbed non-sacred grove lands at various study sites

Mean value and SD of average density of a herb species								
Study area	Sacred groves				Disturbed non-sacred grove lands			
	SaSG	PaSG	NaSG	PoySG	DLSa	DLPa	DLNa	DLPoy
Mean	3.40	4.68	2.68	1.95	2130.75	1077.75	473.00	116.75
SD $\pm$	0.97	0.51	0.61	0.13	487.99	247.23	13.27	12.66
The 't' value and significant level of average density of a herb species obtained from comparison								
Comparison between study area	SaSG X DLSa	PaSG X DLPa	NaSG X DLNa	PoySG X DLPoy	SaSG X PaSG	SaSG X NaSG	SaSG X PoySG	
't' value	-8.719	-8.681	-70.828	-18.136	-2.352	1.254	2.971	
Sig. level	P<0.001	P<0.001	P<0.001	P<0.001	P<0.05	NS*	P<0.05	

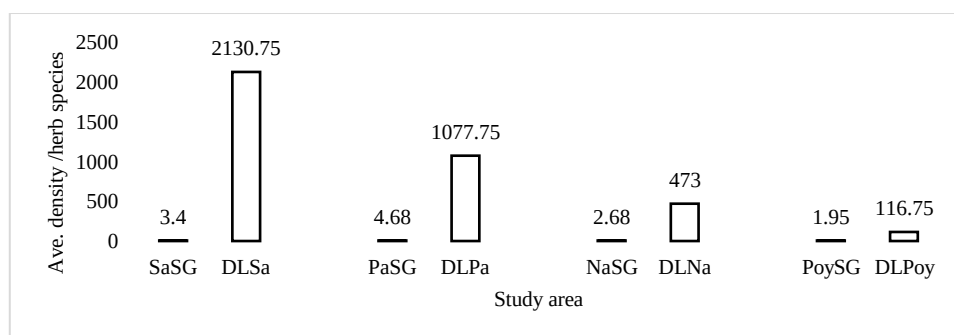


Figure B7: Average density of herbaceous species in different sacred groves and disturbed non-sacred grove lands at various study sites

Table B106: Details of average density of a plant species in different sacred groves and disturbed non-sacred grove lands at various study sites

Mean value and SD of average density of plant species								
Study area	Sacred groves				Disturbed non-sacred grove lands			
	SaSG	PaSG	NaSG	PoySG	DLSa	DLPa	DLNa	DLPoy
Mean	5.25	4.25	2.83	2.64	924.30	539.80	230.33	59.16
SD ±	2.35	.21	0.27	0.14	211.59	53.82	14.70	6.45
The 't' value and significant level of average density of a plant species obtained from comparison								
Comparison between study area	SaSG	PaSG	NaSG	PoySG	SaSG	SaSG	SaSG	
	X	X	X	X	X	X	X	
	DLSa	DLPa	DLNa	DLPoy	PaSG	NaSG	PoySG	
't' value	-8.69	-19.90	-30.95	-17.51	0.85	2.04	2.22	
Sig. level	P<0.001	P<0.001	P<0.001	P<0.001	NS*	P<0.05	P<0.05	

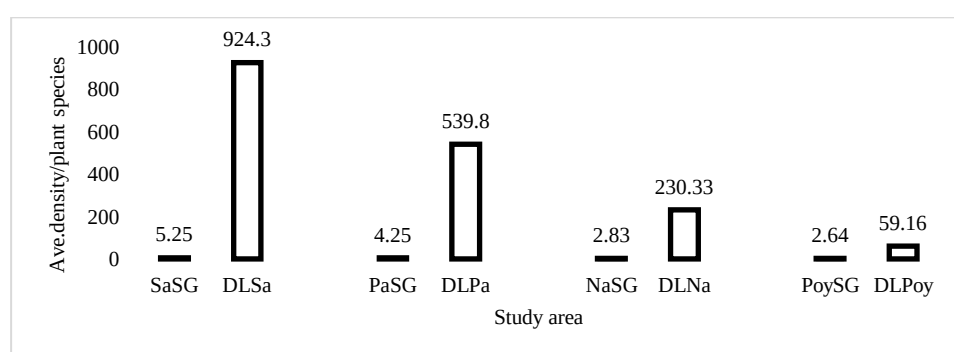


Figure B8: Average density of a plant species in different sacred groves and disturbed non-sacred grove lands at various study sites

The analysis in the average frequency of tree species indicated higher values in all the selected groves where significantly higher values in Nambiyath site in comparison to disturbed lands (table B107 & figure B9). With respect to the shrub species, Palliyana and poyyara groves exhibit significantly higher values, but insignificantly higher values in Nambiyath and significantly lower values in Sankulangara groves (table B108 & figure B10).

In the case of average frequency of climbers, Palliyana grove showed significantly higher value whereas Sankulangara and Nambiyath groves show lower values than disturbed lands while, the Poyyara grove has the same average frequency as its corresponding disturbed land (table B109 & figure B11). Significantly higher average values for liana species in all the sacred groves as total absence of liana species recorded in all the disturbed lands (table B110 & figure B12). The average frequency of herb shows significantly higher values in Poyyara and Palliyana groves, insignificantly higher values in Nambiyath and significantly lower values in Sankulangara groves (table B111 & figure B13). However, the analysis in the average frequency of plant species as a whole by considering all the plant groups together showed comparatively higher frequency values in all the selected sacred groves compared to disturbed lands, but all are insignificant (table B112 & figure B14).

Table B107: Details of average frequency of a tree species in different sacred groves and disturbed non-sacred grove lands at various study sites

Mean value and SD of average frequency of a tree species								
Study area	Sacred groves				Disturbed non-sacred grove lands			
	SaSG	PaSG	NaSG	PoySG	DLSa	DLPa	DLNa	DLPoy
Mean	35.76	40.00	36.55	46.67	25.00	25.00	22.92	28.13
SD $\pm$	3.66	6.06	3.18	25.03	11.79	17.68	6.48	11.97
The 't' value and significant level of average frequency of a tree species obtained from comparison								
Comparison between study area	SaSG	PaSG	NaSG	PoySG	SaSG	SaSG	SaSG	SaSG
	X	X	X	X	X	X	X	X
	DLSa	DLPa	DLNa	DLPoy	PaSG	NaSG	PoySG	
't' value	1.74	1.61	3.78	1.34	-1.20	-0.33	-0.86	
Sig. level	NS*	NS*	P<0.05	NS*	NS*	NS*	NS*	NS*

*NS- No significance

SaSG- Sankulangara sacred grove, PaSG- Palliyana sacred grove, NaSG- Nambiyath sacred grove and PoySG- Poyyara sacred grove DLSa- Disturbed land Sankulangara, DLPa- Disturbed land Palliyana, DLNa- Disturbed land Nambiyath and DLPoy- Disturbed land Poyyara

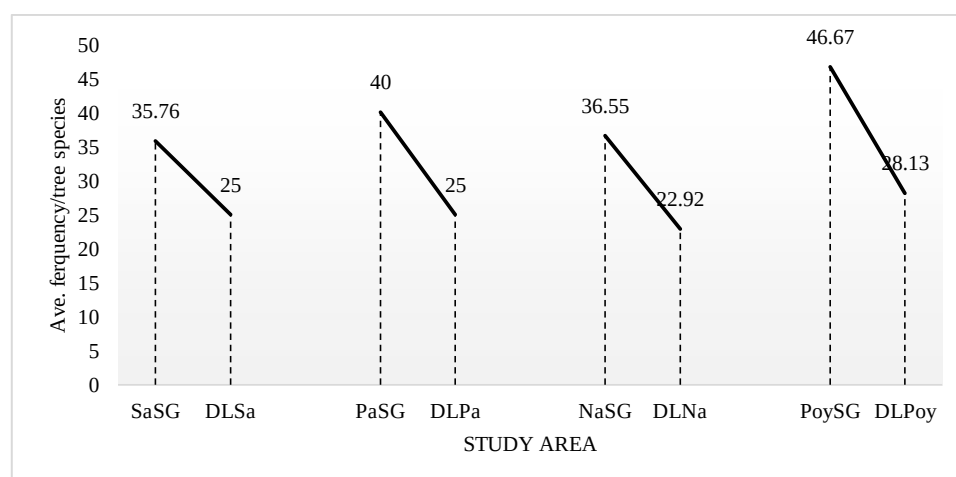


Figure B9: Average frequency of tree species in different sacred groves and disturbed non-sacred grove lands at various study sites

Table B108: Details of average frequency of a shrub species in different sacred groves and disturbed non-sacred grove lands at various study sites

Mean value and SD of average frequency of a shrub species								
Study area	Sacred groves				Disturbed non-sacred grove lands			
	SaSG	PaSG	NaSG	PoySG	DLSa	DLPa	DLNa	DLPoy
Mean	42.65	43.75	44.49	47.32	65.63	35.00	38.77	41.07
SD $\pm$	3.80	2.95	5.42	1.79	20.52	3.54	5.49	3.58
The 't' value and significant level of average frequency of a shrub species obtained from comparison								
Comparison between study area	SaSG X DLSa	PaSG X DLPa	NaSG X DLNa	PoySG X DLPoy	SaSG X PaSG	SaSG X NaSG	SaSG X PoySG	
't' value	-2.20	3.80	1.48	3.13	-0.46	-0.56	-2.23	
Sig. level	P<0.05	P<0.05	NS*	P<0.05	NS*	NS*	P<0.05	

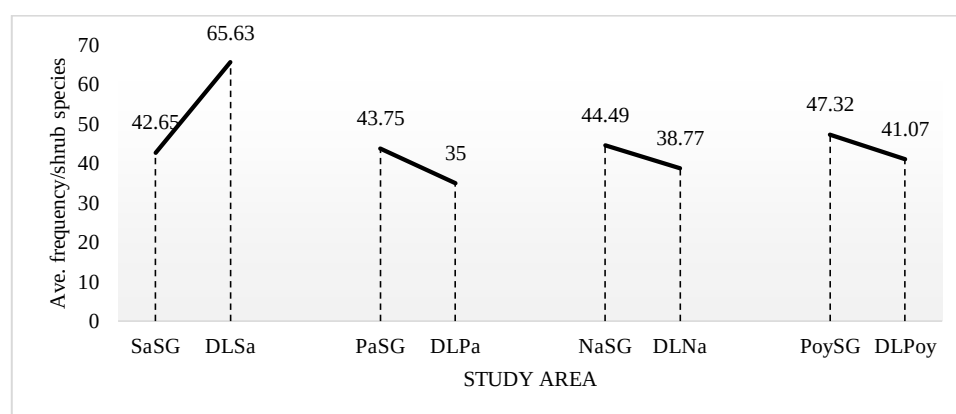


Figure B10: Average frequency of a shrub species in different sacred groves and disturbed non-sacred grove lands at various study sites

Table B109: Details of average frequency of climber species in different sacred groves and disturbed non-sacred grove lands at various study sites

Mean value and SD of average frequency of climber species								
Study area	Sacred groves				Disturbed non-sacred grove lands			
	SaSG	PaSG	NaSG	PoySG	DLSa	DLPa	DLNa	DLPoy
Mean	40.50	49.34	42.66	50.00	50.00	37.50	50.41	50.00
SD $\pm$	8.54	1.32	7.08	1.85	17.68	4.82	7.22	5.10
The 't' value and significant level of average frequency of climber species obtained from comparison								
Comparison between study area	SaSG X DLSa	PaSG X DLPa	NaSG X DLNa	PoySG X DLPoy	SaSG X PaSG	SaSG X NaSG	SaSG X PoySG	
't' value	-0.97	4.75	-1.53	0.00	-2.05	-0.39	-2.17	
Sig. level	NS*	P<0.001	NS*	NS*	P<0.05	NS*	P<0.05	

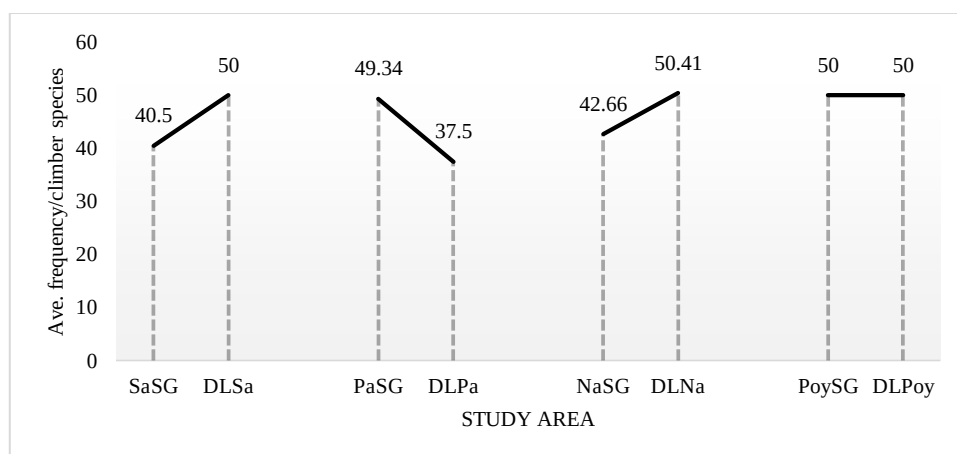


Figure B11: Average frequency of climber species in different sacred groves and disturbed non-sacred grove lands at various study sites

Table B110: Details of average frequency of liana species in different sacred groves and disturbed non-sacred grove lands at various study sites

Mean value and SD of average frequency of liana species								
Study area	Sacred groves				Disturbed non-sacred grove lands			
	SaSG	PaSG	NaSG	PoySG	DLSa	DLPa	DLNa	DLPoy
Mean	37.50	48.44	50.43	50.00	0.00	0.00	0.00	0.00
SD ±	5.10	3.13	2.89	2.55	0.00	0.00	0.00	0.00
The 't' value and significant level of average frequency of liana species obtained from comparison								
Comparison between study area	SaSG X DLSa	PaSG X DLPa	NaSG X DLNa	PoySG X DLPoy	SaSG X PaSG	SaSG X NaSG	SaSG X PoySG	
't' value	14.70	31.00	34.94	39.19	-3.66	-4.41	-4.38	
Sig. level	P<0.001	P<0.001	P<0.001	P<0.001	P<0.05	P<0.001	P<0.001	

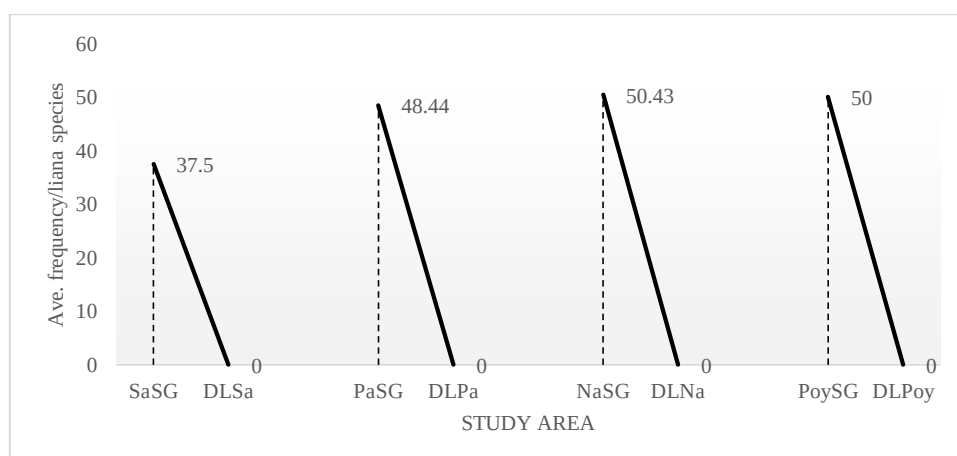


Figure B12: Average frequency of a liana species in different sacred groves and disturbed non-sacred grove lands at various study sites

Table B111: Details of average frequency of herb species in different sacred groves and disturbed non-sacred grove lands at various study sites

Mean value and SD of average frequency of herb species								
Study area	Sacred groves				Disturbed non-sacred grove lands			
	SaSG	PaSG	NaSG	PoySG	DLSa	DLPa	DLNa	DLPoy
Mean	40.84	45.84	46.48	42.50	87.02	32.56	43.63	36.54
SD $\pm$	6.87	1.67	3.96	2.89	15.01	4.61	2.50	3.85
The 't' value and significant level of average frequency of herb species obtained from comparison								
Comparison between study area	SaSG	PaSG	NaSG	PoySG	SaSG	SaSG	SaSG	
	X	X	X	X	X	X	X	
	DLSa	DLPa	DLNa	DLPoy	PaSG	NaSG	PoySG	
't' value	-5.60	5.42	1.21	2.48	-1.41	-1.42	-0.45	
Sig. level	P<0.001	P<0.001	NS*	P<0.05	NS*	NS*	NS*	

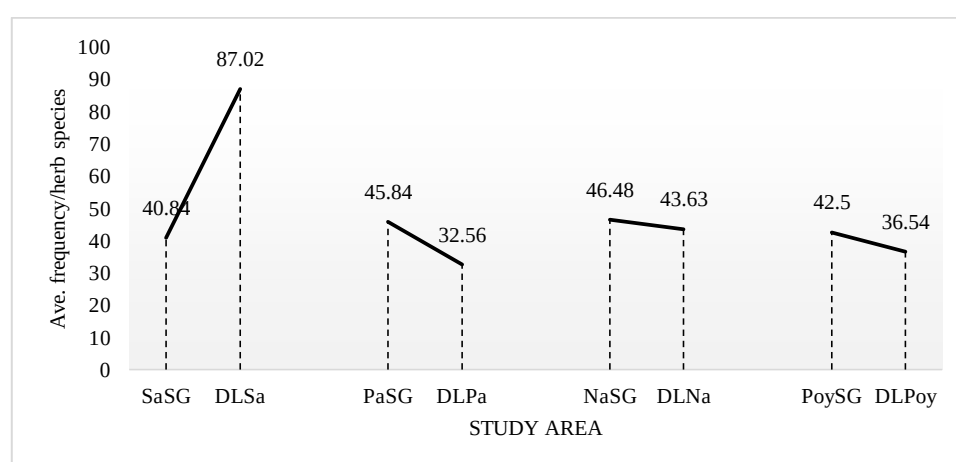


Figure B13: Average frequency of herb species in different sacred groves and disturbed non-sacred grove lands at various study sites

Table B112: Details of average frequency of a plant species in different sacred groves and disturbed non-sacred grove lands at various study sites

Mean value and SD of average frequency of a plant species								
Study area	Sacred groves				Disturbed non-sacred grove lands			
	SaSG	PaSG	NaSG	PoySG	DLSa	DLPa	DLNa	DLPoy
Mean	61.88	60.65	63.02	59.75	60.63	55.10	57.89	56.25
SD $\pm$	14.56	4.58	6.53	5.11	13.87	5.44	8.18	5.74
The 't' value and significant level of average frequency of a plant species obtained from comparison								
Comparison between study area	SaSG	PaSG	NaSG	PoySG	SaSG	SaSG	SaSG	
	X	X	X	X	X	X	X	
	DLSa	DLPa	DLNa	DLPoy	PaSG	NaSG	PoySG	
't' value	0.13	1.56	0.98	0.91	0.16	-0.14	0.28	
Sig. level	NS*	NS*	NS*	NS*	NS*	NS*	NS*	

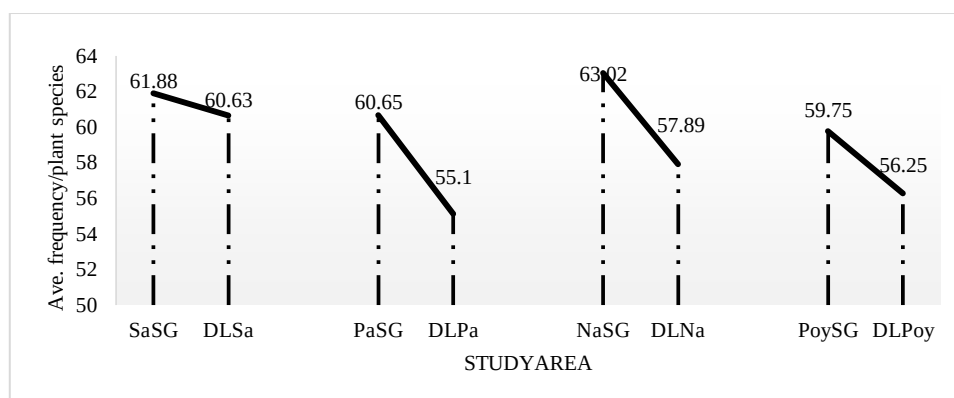


Figure B14: Average frequency of a plant species in selected sacred groves and disturbed non-sacred grove lands at various study sites

The analysis of total population count of different plant groups revealed that, with the exception of plant group herbs, most of the plant groups such as trees, shrubs, climbers and lianas recorded significantly higher count in all the selected sacred groves compared to the selected disturbed non-sacred grove lands of similar extents and the plants in these groups are found occurred in more or less even proportion and distribution. However, the total population of plant group herbs recorded remarkably higher and significant count in the disturbed lands over the count of herbs in the sacred groves. Although, the majority of the plant groups in selected disturbed non-sacred grove lands recorded lower population count and species diversity, including total absence of plant group lianas when compared to the sacred groves of similar extents, the overall total plant population count showed significantly higher values. The total population of disturbed land is found ranging from 6153 to 221848 individuals compared to the range of 622 to 2122 individuals in the selected sacred groves. This recorded an increase of 99.04%, 98.95%, 98.15% and 89.89% higher population count in the disturbed lands over the groves respectively at Sankulangara, Palliyana, Nambiyath and Poyyara. This inference in the study is due to the fact the major proportion of total plant population in the disturbed lands are belonging to the plant group herbs with significantly higher species diversity, density and much higher individual population.

Significant reduction in herbaceous plant population in sacred groves compared to disturbed lands can be attributed to the unfavorable environment in the grove area for the seeds of herbaceous plants to get germinate, emerge and establish. This could be due to the accumulation of litter particularly from trees which usually form a thick layer over the floor area in the groves. This interpretation in the study is in agreement with the observations recorded by Alejandro et al. (2014) who found the tree litter acts as a mechanical barrier to

the establishment of herbaceous seedlings, in their study conducted in the forest–grassland ecotones at Lahn-Dill highlands, Germany. Similar observation was also reported by Xiong and Nilsson (1999) who found the tree litter has strong negative effect on grassland vegetation. Further, the reduction in the diversity and population of herbaceous plants in the groves may also be due to the lack of availability of sunlight to the herbaceous plants as the sunlight fail to penetrate and reach ground area due to thick canopy layer formed particularly by trees and lianas. However in the disturbed lands, the remarkably higher population count and diversity of herbaceous plants may be due to the absence of above said barriers together with comparatively less competition from other groups of plants. Whereas, more or less uniform distribution and better diversity of plant species from diverse groups of plants in the studied groves can be attributed to comparative low human interference and better environmental conditions such as the physical and chemical properties of soil and microclimate.

The comparative analysis in the distribution frequency range of total plant species between the selected sacred groves and disturbed non-sacred grove lands revealed the percentage proportion of plant species distributed in majority of the frequency ranges are more or less similar lines. However, the comparison of total number of plant species distributed in different frequency range showed the sacred groves have comparatively higher number of plant species in majority of the frequency ranges. Further, the study revealed the majority of the plant species in different frequency ranges in the disturbed lands are dominated by herbs and shrubs while in the groves, the species representations from diverse groups such as trees, climbers, lianas, shrubs and herbs in more or less equal proportions. The distribution frequency range of different plant groups trees, climbers and lianas in sacred groves showed that with certain exceptions in the case of trees in Poyyara grove and climbers in Nambiyath grove, the major percentage of species proportion are found distributed in the good to fairly good frequency range (61% – 100%). However in the disturbed lands, total absence of plant group lianas and with certain exceptions in the case of climbers, the major proportion of trees and climbers are belonging to mostly poor and poor frequency range (1% – 40%). But the climbers in Nambiyath and poyyara disturbed lands showed good to fairly good frequency range. The comparative analysis in the distribution of actual number of species of trees, climbers and lianas in different frequency range indicated considerably higher number of species diversity in sacred groves compared to disturbed lands. With respect to the distribution frequency range of plant group herbs and shrubs revealed that the major

percentage of species proportion in groves and disturbed non-sacred grove lands are distributed in moderate to good frequency range (41% – 100%). However, the comparative analysis of total number of species distribution revealed considerably higher number of herbaceous species in disturbed lands while higher number of shrubby species in sacred groves. Therefore, the comparative analysis in the distribution frequency range of plant species clearly revealed higher and more wider distribution of plant species belong to plant group trees, shrubs, climbers and lianas in sacred groves while higher and more wider distribution of herbaceous plant species in disturbed non-sacred grove lands.

The plant community relationships studies between sacred groves and disturbed non-sacred grove lands of similar extent in the investigation revealed significantly lower similarity index values. Higher species diversity recorded in all the selected sacred groves compared to all the selected disturbed non-sacred grove lands of similar extent. This can be attributed to the lack of human interferences in the sacred groves under the fear of social and traditional religious believes (Gadgil & Vartak, 1975). Meanwhile in the non-sacred grove lands, the erosion of many local plant species which are characterises of natural undisturbed forests occurred due to various anthropogenic pressures like developmental activities, clearance for agriculture, harvesting of timber and non-timber forest products. This could be the factors which contributed towards the reduction in plant species diversity and lower similarity index compared to sacred groves (Mishra et al., 2004; Laloo et al., 2006).

The analysis on the influence of difference in extent of the selected groves on various parameters reveals certain trends. The number of genus and species in the Nambiyath and Poyyara groves of smaller extents are noted to decrease along with the reduction in extent compared to Sankulangara and Palliyana groves of larger extents. Here, the difference in the number of genus is significant between Sankulanagara and Poyyara groves whereas, the difference in the number of species is significant not only between Sankulangara and Poyyara but also between Sankulangara and Nambiyath groves. With respect to the number of families, a gradual decrease with decrease in extents is noted among the groves. The same trend is also observed in the case of average density of plants where, the differences are significant when Sankulangara of largest extent compared with Nambiyath and Poyyara groves of smaller extents. The average frequency of plants in the selected groves are found not influenced by the difference in extents. The investigation further observed progressive reduction in overall total plant population as extent of the study area is decreased irrespective of groves as well as disturbed non-sacred grove lands. However, the reductions are

significantly higher in the disturbed lands than the groves. A reduction of 19.13% recorded in the total population of Palliyana grove over the Sankulangara grove of largest extent while the reduction is 26.03% in the disturbed lands at Palliyana site over the disturbed land at Sankulangara site. The reduction is found further increased to 57.07% in the Nambiyath grove over Sankulangara grove while the reduction is increased to 77.76% in the disturbed lands at Nambiyath over Sankulanagara. The highest reduction of 70.69% recorded in the total population of Poyyara grove of smallest extent compared to the Sankulangara grove of largest extent whereas, with respect to the reduction in the disturbed non-sacred grove land of smallest extent at Poyyara site is increased to 97.23% over the total population of largest extent at Sankulangara site. Almost similar trend is also inferred with certain exceptions, when the total population of various plant groups are compared. The exceptions include the plant group shrubs and herbs in the grove and shrubs alone in the disturbed land at Palliyana site and also the plant group lianas in the Nambiyath grove. The total population of these plant groups are found exceeded to the total population of their immediate higher extent.

The progressive reduction in total population observed in the investigation with the decrease in extent of the study area can be attributed to the corresponding reduction in habitat for plant species to regenerate and establish. The inferences obtained from the analysis of density, frequency and similarity index values in the study are supportive of this attribution. The influence of difference in size of study area generally indicates that the reduction in plant density is according to the decrease in size of the selected study area to a greater extent, irrespective of groves and disturbed lands, but with certain exceptions. The similarity studies between the selected sites of different extent revealed progressive reduction in the similarity index values and the number of common plant species shared, as the difference in extent of the study sites under comparison are increased (Sorenson, 1948). However, the study observed that difference in SI values are comparatively less when sacred groves of different extents are compared over the values of same between disturbed lands of different extents. All these observations can be attributed to the difference in specific environmental conditions prevailing in various study sites of different extent and their difference in capacity to accommodate the types of plant species and their population size to the area. The highest reduction in similarity index observed between the largest and smallest extent selected in the study, irrespective of sacred groves and disturbed non-sacred grove lands. The study noticed that, while comparing the similarity either between the sacred groves of different extents or between the disturbed lands of different extents, the overall similarity index values

contributed by majority of the plant groups are having more or less even SI values (table B73 and table B74). However, the analysis of similarity between sacred groves and disturbed lands showed, the total SI values contributed by majority of the plant groups are having highly variable SI values (table B72). Therefore, the present investigation revealed the similarity index values between the selected areas under comparison are found inversely proportional to the difference in extent as well as the rate of anthropogenic disturbances between the areas.

An area of natural forest vegetation free from anthropogenic disturbances are usually having a healthy and sustainable microclimatic conditions which are favorable for the accommodation, natural regeneration and establishment of more diverse types of plant groups and plant species in the area than the disturbed. As we know, the sacred groves are nothing but patches of natural forest vegetation which are protected from anthropogenic disturbances under the religious believes and cultural activities. This could be the reason for increasing trend in the total population and plant diversity along with increase in extent of the grove area. However in the disturbed non-sacred grove lands, although the total population is also increasing along with increasing extent of the study area as in the case of groves, the total absence of plant group lianas and considerable reduction in the diversity of many plant species and population count of plant groups like trees and climbers recorded. The major plant groups which are found dominating in the disturbed lands are herbs and shrubs. This trend can be attributed to the lack of ecological stability in the area induced by anthropogenic pressures. The anthropogenic stress oriented development of unfavorable environmental conditions in the disturbed lands are found restricting the regeneration of many plant species of trees, lianas and climbers which are characteristics of unstressed natural forest vegetation. However, the same time the disturbed lands are found favourable for the enormous establishment of certain indigenous and invasive species of herbs and shrubs of comparatively higher resistance in the area. This might be the reason for increase in the total plant population count but reduction in plant diversity compared to sacred groves along with increase in extent of the study area.

Table 113: Summery of plant distribution in the selected sacred groves and disturbed non-sacred grove lands

Details of Study area		Sacred groves and disturbed non-sacred groves lands of different extents							
		Sankulangara (0.636ha)		Palliyana (0.364ha)		Nambiyath (0.1214ha)		Poyyara (0.0404ha)	
		SaSG	DLSa	PaSG	DLPa	NaSG	DLNa	PoySG	DLPoy
	Genus	30	17	33	12	29	11	19	4

Trees	Species	36	18	35	12	30	11	20	4
	Family	21	14	21	8	20	7	16	3
	Population per sampling unit	111.75 ±35.16	14.25 ±9.98	85.25 ±7.08	11.5 ±6.84	44.5 ±4.39	5.5 ±1.5	15.0 ±2.24	2.25 ±0.83
	Grove population	447 ±140.64	57 ±39.94	341 ±28.34	46 ±27.35	178 ±17.55	22 ±5.99	60 ±8.94	9 ±3.32
	Population per hectare basis	702.83 ±221.13	89.63 ±62.79	936.82 ±77.85	126.38 ±75.13	1463.75 ±144.56	180.93 ±49.35	1485.15 ±221.39	222.77 ±82.10
Shrubs	Genus	16	10	22	17	15	10	14	7
	Species	17	12	24	20	17	13	14	7
	Family	10	9	16	12	10	6	11	5
	Population per sampling unit	90.0 ±22.35	39.75 ±13.27	91.5 ±7.53	44.25 ±9.81	54.0 ±1.0	21.25 ±2.86	41.75 ±4.26	11.25 ±2.05
	Grove population	360 ±89.40	159 ±53.09	366 ±30.13	177 ±39.23	216 ±4.0	84.86 ±11.43	167 ±17.06	45 ±8.19
	Population per hectare basis	566.04 ±140.56	250.0 ±83.48	998.63 ±90.98	486.26 ±107.77	1776.32 ±32.91	699.03 ±94.11	4133.67 ±422.25	1113.86 ±202.61
Herbs	Genus	15	23	15	36	16	25	10	13
	Species	15	26	15	38	16	26	10	13
	Family	12	12	11	15	12	9	9	9
	Population per sampling unit	51.0 ±12.55	55395.75 ±10992	70.25 ±6.65	40955.73 ±8136	42.5 ±8.41	12292.78 ±455	19.5 ±1.12	1517.75 ±143
	Grove population	204 ±50.20	221583 ±43968	281 ±26.59	163822.9 ±32543.26	169.72 ±33.59	49171 ±1818.17	78 ±4.47	6070.99 ±572.37
	Population per hectare basis	320.76 ±78.93	348400.94 ±69132.11	771.98 ±73.05	450062.92 ±89404.56	1398.02 ±276.7	404367.61 ±14976.68	1930.7 ±110.7	150272.03 ±14167.69
Climbers	Genus	24	4	18	6	13	4	11	2
	Species	25	4	19	6	13	4	11	2
	Family	17	4	15	5	10	4	10	2
	Population per sampling unit	230.5 ±129.06	12.25 ±2.17	154.5 ±2.5	14.5 ±3.84	37.0 ±6.12	14.25 ±1.30	68.25 ±6.34	7.0 ±1.22
	Grove population	922 ±516.22	49 ±8.66	618 ±10	58 ±15.36	147.76 ±24.45	56.90 ±5.19	273 ±25.36	28 ±4.9
	Population per hectare basis	1449.69 ±811.67	77.04 ±13.62	1697.8 ±27.47	159.34 ±42.20	1217.09 ±201.41	468.72 ±42.74	6757.42 ±627.66	693.07 ±121.26
Lianas	Genus	8	0	8	0	5	0	4	0
	Species	8	0	8	0	5	0	4	0
	Family	7	0	7	0	5	0	4	0
	Population per sampling unit	45.5 ±17.95	0	27.5 ±5.12	0	34.25 ±8.80	0	11.0 ±1.87	0
	Grove population	182 ±71.81	0	110 ±20.49	0	163.78 ±24.49	0	44 ±7.48	0
	Population per hectare basis	286.06 ±112.91	0	302.20 ±56.3	0	1349.08 ±201.69	0	1089.11 ±185.23	0
Grand total	Genus	89	53	91	67	77	50	57	26
	Species	101	60	101	76	81	54	59	26
	Family	53	30	53	30	44	22	38	16
	Population per sampling	530.5 ±205.85	55461 ±10991	429 ±18.32	41026 ±3541	229.5 ±18.32	12437.5 ±681	155.5 ±7.30	1538.25 ±145

	unit								
	Grove population	2122 ±823	221848 ±43965	1716 ±73.27	164104 ±14165	918 ±73.17	49750 ±2720	622 ±29.19	6153 ±581
	Population per hectare basis	3336.48 ±1294.67	348716.82 ±68984	4714.29 ±201.28	450835.38 ±38915	7491.83 ±602.76	411157.02 ±22403	15396.04 ±722.50	152301.49 ±14390

SaSG- Sankulangara sacred grove, PaSG- Palliyana sacred grove, NaSG- Nambiyath sacred grove and PoySG- Poyyara sacred grove DLSa- Disturbed land Sankulangara, DLPa- Disturbed land Palliyana, DLNa- Disturbed land Nambiyath and DLPoy- Disturbed land Poyyara

Species diversity index (SDI) and Species richness index (SRI)

The present investigation revealed that the species diversity index (SDI) and the species richness index (SRI) of total plants as well as the plant group trees alone are higher and significant in sacred groves compared to their corresponding disturbed non-sacred grove lands selected for the study. The diversity index values of total plant species in the selected sacred groves at Sankulangara, Palliyana, Nambiyath and Poyyara sites are 71.28%, 70.75%, 70.12% and 70.63% higher respectively over the disturbed lands of similar extents (table B114 & figure B15). The increase in the SDI values of plant group trees alone in sacred groves are found 47.96%, 55.56%, 46.38% and 71.34% higher over the values of trees in the disturbed lands in the respective order (table B115 & figure B16). The similar trend is also inferred with respect to species richness index (SRI) in the study. The hike in the SRI values of plants in sacred groves over the values of disturbed lands are 94.21%, 92.32%, 90.93% and 86.12% for total plants (table B116 & figure B17) and 24.84%, 42.57%, 49.27% and 63.90% for the plant group trees alone respectively at Sankulangara, Palliyana, Nambiyath and Poyyara study sites (table B117 & figure B18).

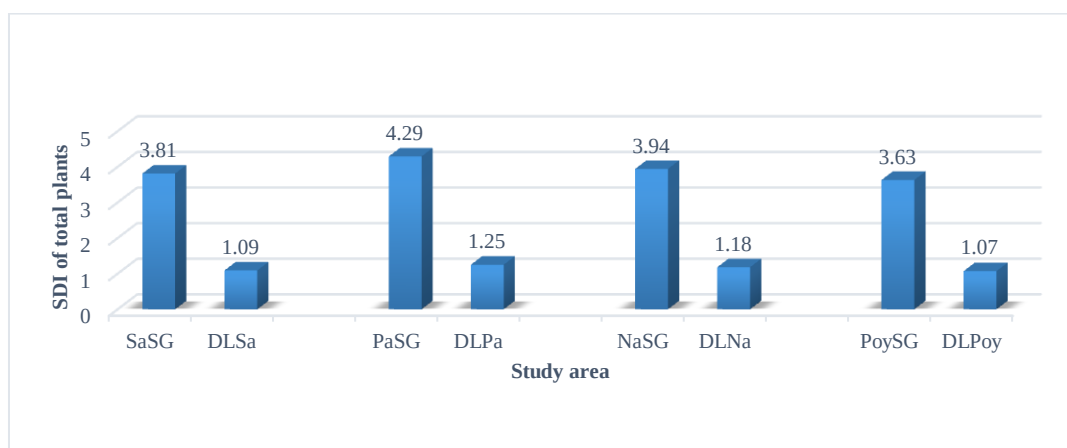


Figure B15: Species diversity index (SDI) of total plants in selected sacred groves and disturbed non-sacred grove lands at various study sites

Table 114: The ‘t’ value and significant level in the SDI of total plants obtained from the comparison between groves and disturbed non-sacred grove lands of similar extents and between sacred groves of different extents

Comparison between study area	SaSG X DLSa	PaSG X DLPa	NaSG X DLNa	PoySG X DLPoy	SaSG X PaSG	SaSG X NaSG	SaSG X PoySG
‘t’ value	17.43	52.22	27.67	54.79	-3.01	-0.67	1.16
Sig. level	P<0.001	P<0.001	P<0.001	P<0.001	P<0.05	NS*	NS*

*NS- No significance

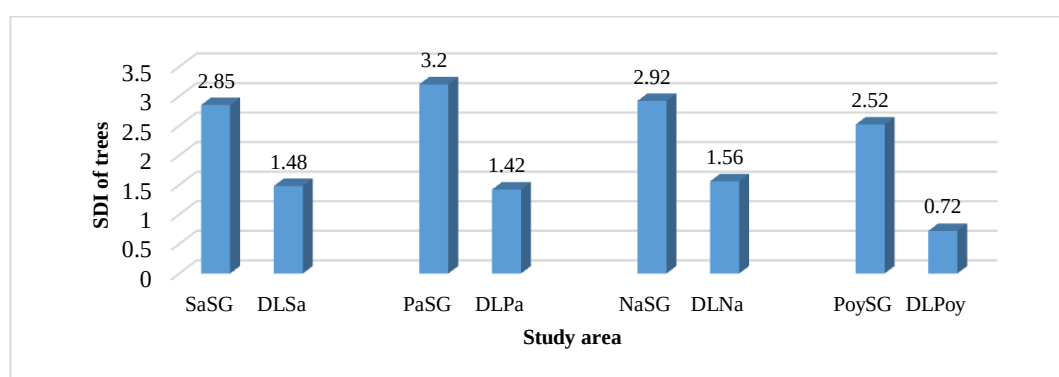


Figure B16: Species diversity index (SDI) trees alone in selected sacred groves and disturbed non-sacred grove lands at various study sites

Table 115: The ‘t’ value and significant level in the SDI of trees obtained from the comparison between groves and disturbed non-sacred grove lands of similar extents and between sacred groves of different extents

Comparison between study area	SaSG X DLSa	PaSG X DLPa	NaSG X DLNa	PoySG X DLPoy	SaSG X PaSG	SaSG X NaSG	SaSG X PoySG
‘t’ value	2.90	5.08	9.55	6.80	-3.44	-0.821	4.004
Sig. level	P<0.05	P<0.05	P<0.001	P<0.001	P<0.05	NS*	P<0.05

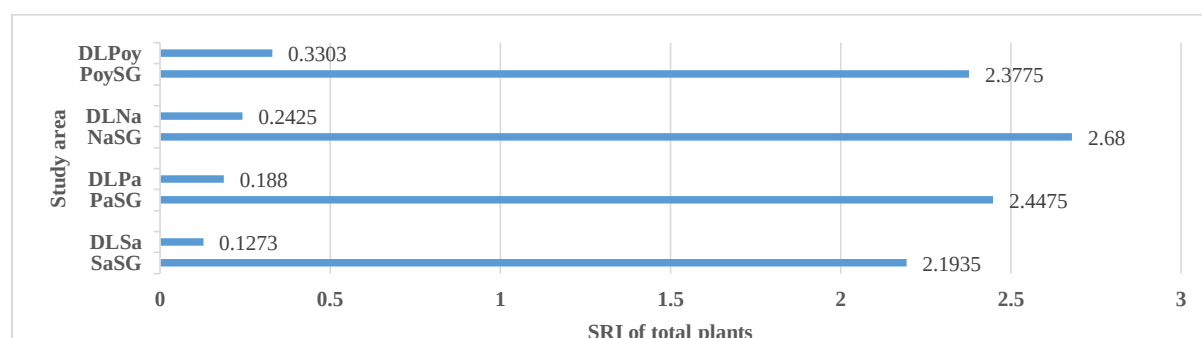


Figure B17: Species richness index (SDI) of total plants in selected sacred groves and disturbed non-sacred grove lands at various study sites

Table 116: The ‘t’ value and significant level in the SRI of total plants obtained from the comparison between groves and disturbed non-sacred grove lands of similar extents and between sacred groves of different extents

Comparison between study area	SaSG X DLSa	PaSG X DLPa	NaSG X DLNa	PoySG X DLPoy	SaSG X PaSG	SaSG X NaSG	SaSG X PoySG
‘t’ value	10.53	63.65	40.18	46.04	-1.28	-2.37	-0.92
Sig. level	P<0.001	P<0.001	P<0.001	P<0.001	NS*	P<0.05	NS*

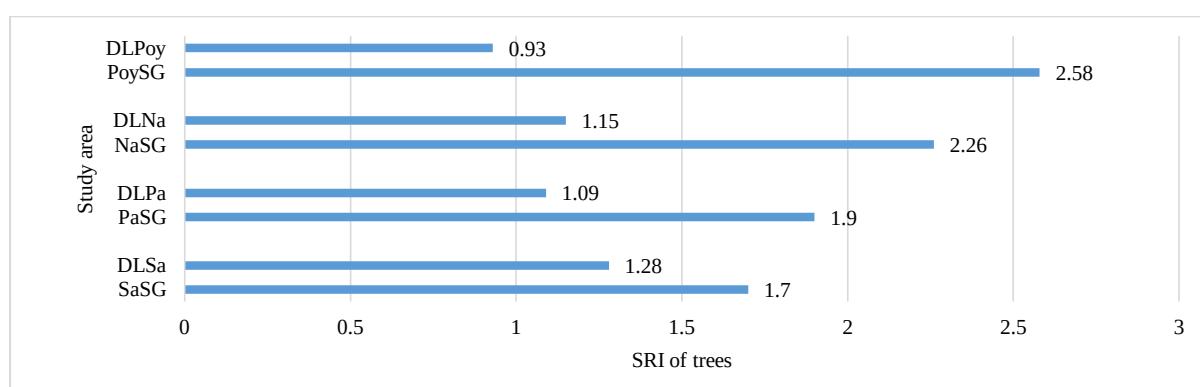


Figure B18: Species richness index (SRI) of trees in selected sacred groves and disturbed non-sacred grove lands at various study sites

Table 117: The ‘t’ value and significant level in the SRI of trees obtained from the comparison between groves and disturbed non-sacred grove lands of similar extents and between sacred groves of different extents

Comparison between study area	SaSG X DLSa	PaSG X DLPa	NaSG X DLNa	PoySG X DLPoy	SaSG X PaSG	SaSG X NaSG	SaSG X PoySG
‘t’ value	3.26	9.79	6.69	12.14	-1.67	-4.30	-5.968
Sig. level	P<0.05	P<0.001	P<0.001	P<0.001	NS*	P<0.05	P<0.001

The higher SDI and SRI values of plants in the selected sacred groves compared to selected disturbed non-sacred grove lands of similar extent can be attributed to the occurrence of higher number of plant species and their population. This may be due to the absence of anthropogenic stresses and better environmental conditions prevailing in the grove areas. However, the lower values of SDI and SRI recorded in the disturbed non-sacred groves lands can be attributed to the reduction in establishment and growth of plant species, particularly tree species. This could be due to population expansion oriented anthropogenic activities and habitat loss that occurred in the past and present in these areas. The tremendous pressure from

human disturbances on the vegetation in the non-sacred grove regions, the majority of the ground area are exposed to direct sunlight. Hence this may cause difficulty in the establishment and growth of plant species other than light-demanding and light tolerant species and this could be the reason for lower diversity index and species richness compared to sacred groves. Therefore the present investigation revealed the existence of a negative correlation between the values of SDI & SRI with degree of anthropogenic disturbances. The present study inferences are in agreement with the report of Pickett and White (1985); Noble and Dirzo (1997); Goudie (2005) and Abadie et al. (2011), who generally reported that the decline in plant diversity and richness is the result of human disturbances.

The influence of difference in the extent of study area on species diversity index (SDI) and species richness index (SRI) are analysed. The SDI values for the total plants as well as for the plant group trees generally exhibited an increasing trend along with increase in the extent of study area but with certain exceptions. The exceptions include lower SDI value for total plants in grove and disturbed non-sacred grove lands at Sankulangara site of largest extent compared to Palliyana and Nambiyath sites. Similarly, lower SDI value recorded for the trees in Sankulangara grove and higher SDI value for the trees in disturbed land at Nambiyath site. The increase in the SDI values are found more prominent and higher in the groves compared to disturbed lands. As the extent of the grove area is increased, the environmental heterogeneity conditions in the grove area may also improve due to the openings of canopy. This allows the sunlight to reach the ground area and which in turn favours co-existence of diverse types of plant species such as light-demanding & shade-loving species and light tolerant & shade tolerant species (Connell, 1978; Loreau & Mouquet, 1999; Fredericksen & Mostacedo, 2000). The better environmental heterogeneity conditions together with low disturbances and the improvements in species composition could be the reason for higher SDI value in sacred groves over the disturbed lands along with increase in the extent.

However, SRI values for the total plants in both sacred groves and disturbed non-sacred grove lands and for the plant group trees alone in the groves are found tend to decrease gradually along with increase in the extent of the study area. These decrease can be attributed to the gradual increase in total population and the dominance of one or few plant species over other remaining species along with increase in extent of the study area (Chandrashekara & Sankar, 1998). The dominance of certain species over other species may be due to more adaptive features such as high reproductive vigour and faster colonizing capacity and further

supported by the more favourable microclimatic conditions existing in the area for growth and establishment of these species than other species. The lower SRI values of total plants in Poyyara grove and irregular order in the values of trees alone in the non-sacred grove lands can be attributed to the differences in species diversity and the dominance of species. Therefore, the present investigation opined that, the SDI and SRI values are mainly depending on the total number of plant species, plant population and the ratio in the dominance of plant species based on their individual population size. These facts are purely based on the level of anthropogenic disturbances and environmental conditions prevailing in the area. The observations in the investigation are in conformity with reports of Connell and Lowman (1989); Pickett and White (1985); Chaneton and Facelli (1991); Dumbrell et al. (2008) and Bongers et al. (2009).

Dominance of family, genera and species

The dominance of family, genera and species are analysed in the selected sacred groves and corresponding disturbed non-sacred grove lands of similar extents. The different aspects considered for the dominance of families in the present investigation are total plant population, diversity in genera and species and total tree population alone in the families. The families which are identified as most dominant in one or more selected sacred groves in one or more aspects considered for the dominance are Dipterocarpaceae, Rubiaceae, Menispermaceae, Leguminosae, Smilacaceae, Lauraceae, Moraceae and Sterculiaceae. The other dominant families in the grove includes Gnetaceae, Apocynaceae, Arecaceae, Anacardiaceae, Araceae, Verbenaceae and Meliaceae. However in the disturbed lands, the most dominant families are Poaceae, Asteraceae and Arecaceae and the other dominant families include Amaranthaceae, Malvaceae Commelinaceae, Leguminosae, Euphorbiaceae, Moraceae, Apocynaceae, Acanthaceae, Anacardiaceae, Verbanaceae, Lamiaceae and Ulmaceae. The most dominant and other dominant families and their level of dominance identified in the groves are characteristics of natural forest vegetation and this dominance level of families still in sacred groves clearly indicates the existence of typical unstressed forest vegetation. However, the most dominant and other dominant families and their level of dominance identified in the disturbed lands revealed greater anthropogenic disturbances indicating the characteristics of degraded and highly degraded forest vegetation (table B118 to table B121).

The plant genera as well as the plant species which are found most dominant in one or more selected sacred groves in the study includes *Artocarpus hirsutus*, *Vitex altissima*, *Hopea ponga*, *Smilax zeylanica*, *Tiliacora racemosa* and *Gnetum ula*. Other dominant plants identified includes trees such as *Caryota urens*, *Vateria indica*, *Aphanamixis polystachya*, *Hydnocarpus pentandrus*, *Pterygota alata* and *Sterculia guttata*, the climbers such as *Chassalia curviflora*, *Ichnocarpus frutescens*, *Pothos scandens*, *Strychnos minor* and the lianas such as *Uvaria narum*, *Sarcostigma kleinii* etc. The majority of these plants are found common in occurrence in the Kerala forest habitat. Whereas in the non-sacred grove lands, the plant genera as well as the plant species identified as most dominant are *Cocos nucifera*, *Areca catechu*, *Trema orientalis*, *Cynodon dactylon*, *Justicia procumbens*, *Aerva lanata* and *Brachiaria remota*. Other dominant plants includes trees such as *Tabernaemontana alternifolia*, *Gliricidia sepium*, *Anacardium occidentale* and *Mangifera indica* and the herbs like *Desmodium triflorum*, *Commelina diffusa*, *Cyathula prostrata*, *Achyranthes aspera*, *Cyperus rotundus*, *Phyllanthus amarus*, *Anisomeles indica*, *Leucas aspera*. The majority of these plants identified as dominant in the non-sacred grove lands are of common occurrence in the degraded forest habitat. The dominance of many herbaceous plants in the non-sacred grove lands indicate greater anthropogenic disturbances while in sacred groves, all the dominant plants are belonging to either climbers, lianas or trees (table B118 to table B121), which indicate natural forest vegetation free from human interferences (Mishra et al., 2008).

Table B118: Dominant families, genera and species at Sankulangara study site

Criteria	Study area					
	Sankulangara sacred grove			Disturbed non-sacred grove		
Dominant families (Based on total no. of plants and distribution %)	Smilacaceae	Rubiaceae	Dipterocarpaceae	Poaceae	Leguminosae	Commelinaceae
	318 (14.99%)	248 (11.69%)	132 (6.22%)	76245 (34.37%)	34555 (15.58%)	31372 (14.14%)
Dominant families (Based on total no. of genus and species)	Leguminosae	Rubiaceae	Apocynaceae	Poaceae	Euphorbiaceae	Asteraceae
	8 genus and 8 species	6 genus and 7 species	4 genus and 4 species	5 genus and 6 species	4 genus and 6 species	4 genus and 4 species
Dominant genera and species (Based on total no. of representation and RD value)	<i>Smilax zeylanica</i>	<i>Chassalia curviflora</i>	<i>Hopea ponga</i>	<i>Cynodon dactylon</i>	<i>Desmodium triflorum</i>	<i>Commelina diffusa</i>
	318 (14.99%)	130 (6.13%)	101(4.76%)	30180 (13.60%)	24620 (11.08%)	20649 (9.31%)

Table B119: Major families, genera and species at Palliyana study site

Criteria	Study area					
	Palliyana sacred grove			Disturbed non-sacred grove		
Dominant families (Based on total no. of plants and distribution %)	Menispermaceae	Rubiaceae	Poaceae	Poaceae	Asteraceae	Acanthaceae
	198 (11.54%)	162 (9.44%)	102 (5.94%)	31161 (18.99%)	22282 (13.58%)	21379 (13.03%)
Dominant families (Based on total no. of genus and species)	Leguminosae	Rubiaceae	Poaceae	Asteraceae	Leguminosae	Poaceae
	7 genus and 7 species	6 genus and 7 species	5 genus and 6 species	8 genus and 8 species	7 genus and 8 species	5 genus and 5 species
Dominant genera and species (Based on total no. of representation and RD value)	<i>Tiliacora racemosa</i>	<i>Ichnocarpus frutescens</i>	<i>Pothos scandens</i>	<i>Justicia procumbens</i>	<i>Cynodon dactylon</i>	<i>Cyathula prostrata</i>
	65 (3.79%)	59 (3.44%)	50 (2.91%)	8903 (5.43%)	8013 (4.88%)	8013 (4.88%)

Table B120: Major families, genera and species at Nambiyath study site

Criteria	Study area					
	Nambiyath sacred grove			Disturbed non-sacred grove		
Dominant families (Based on total no. of plants and distribution %)	Rubiaceae	Poaceae	Gnetaceae	Poaceae	Amaranthaceae	Acanthaceae
	96 (10.54%)	58 (6.37%)	55 (6.04%)	11538 (23.39%)	10016 (20.30%)	5461 (11.07%)
Dominant families (Based on total no. of genus and species)	Rubiaceae	Apocynaceae	Asteraceae, Menispermaceae and Poaceae	Poaceae	Leguminosae, Verbanaceae	Asteraceae
	6 genus and 7 species	5 genus and 6 species	4 genus and 4 species	6 genus and 6 species	5 genus and 5 species each	5 genus and 5 species
Dominant genera and species (Based on total no. of representation and RD value)	<i>Gnetum ula</i>	<i>Uvaria narum</i>	<i>Sarcostigma kleinii</i>	<i>Aerva lanata</i>	<i>Cynodon dactylon</i>	<i>Achyranthes</i>
	55 (6.04%)	35 (3.84%)	32 (3.51%)	3339 (6.77%)	2732 (5.54% each)	2732 (5.54% each)

Table B121: Major families, genera and species at Poyyara study site

Criteria	Study area					
	Poyyara sacred grove			Disturbed non-sacred grove		
Dominant families (Based on total no. of plants and distribution %)	Menispermaceae	Rubiaceae	Araceae	Poaceae	Amaranthaceae	Lamiaceae
	65 (10.45%)	60 (9.65%)	44 (7.07%)	1113 (18.09%)	1012 (16.45%)	1012 (16.45%)
Dominant families (Based on no. of genus and species)	Leguminosae	Rubiaceae	Apocynaceae	Asteraceae	Amaranthaceae, Arecaceae, Euphorbiaceae, Leguminosae, Lamiaceae, Malvaceae, Poaceae	Verbenaceae
	5 genus and 5	4 genus and 4	3 genus and 4	3 genus and 3	2 genus and 2	2 genus and 2

	species	species	species	species	species	species
Dominant genera and species (Based on total no. of representation and RD value)	<i>Tiliacora racemosa</i>	<i>Pothos scandens</i>	<i>Strychnos minor</i>	<i>Brachiaria subquadrifera</i>	<i>Achyranthes aspera</i> , <i>Aerva lanata</i> , <i>Cyperus rotundus</i> , <i>Phyllanthus amarus</i> , <i>Anisomeles indica</i> , <i>Leucas aspera</i> , <i>Cynodon dactylon</i>	<i>Cynodon dactylon</i>
	47 (7.56%)	44 (7.07%)	41(6.59%)	607 (87%)	506 (8.22%) each	506 (8.22%)

Basal area of trees

The cross sectional area of main bole of trees at 4½ feet above ground which are usually used to calculate the percent stocking levels of trees in a given area is called basal area of trees. The analysis of total basal area (TBA) of trees obtained from various study sites revealed significantly higher values in sacred groves when compared to TBA values of trees obtained from their corresponding disturbed non-sacred grove lands of similar extent (figure B19). The TBA of trees in groves are 91.30%, 82.59%, 80.15% and 74.14% higher than the corresponding disturbed lands at Sankulangara, Palliyana, Nambiyath and Poyyara study sites respectively. This can be attributed to much better physico-chemical properties of soil and favorable microclimatic conditions prevailing in the grove area, which support the vigorous growth of vegetation particularly the tree group. The investigation observed the relatively higher basal area recorded by tree species in the selected sacred groves include *Hopea ponga*, *Artocarpus hirsutus*, *Alstonia scholaris*, *Terminalia bellirica*, *Syzygium cumini*, *Hydnocarpus pentandrus*, *Garcinia gummi-gutta* and *Vateria indica*. These are typical tree species representing the repositories of original forest vegetation. However, the disturbed non-sacred grove lands showed the tree species which recorded relatively higher basal area are mainly by humanly cultivated tree species as part of agriculture such as *Cocos nucifera*, *Mangifera indica*, *Anacardium occidentale* and *Artocarpus heterophyllus*. These observations in the study clearly indicates, the original vegetation in the non-sacred grove regions are under high human interferences and severe reduction occurred to the TBA of trees. The recurring logging and other anthropogenic activities and influence of open unfavorable climatic and soil factors might have caused the reduction in tree density and species diversity in the disturbed area (Cakir et al., 2010; Behjou & Mollabashi, 2013). Similar negative correlation of basal area of trees with disturbance index is reported by Nepolion et al. (2014) due to extensive extraction of trees from undisturbed forest sites. However in the sacred

grove regions, the original forest vegetation is still more or less preserved in intact condition based on religious and cultural ground (Chandrashekara & Sankar, 1998).

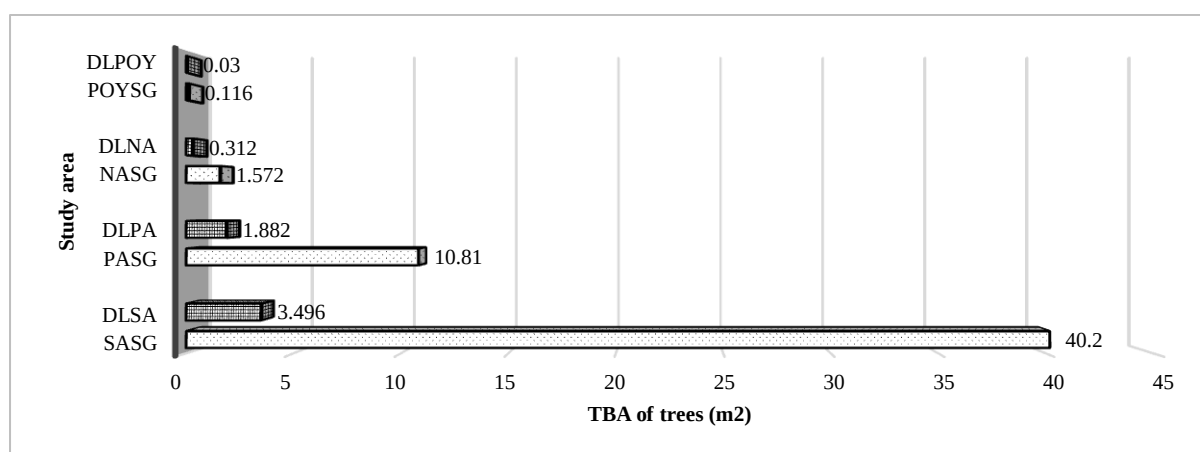


Figure B19: Total basal area (TBA) of tree species in selected sacred groves and disturbed non-sacred grove lands

The lowland and mid-elevation evergreen forests of the Western Ghats of India are reported to have the basal area ranging from $37.37\text{m}^2\text{ha}^{-1}$ to $83.83\text{m}^2\text{ha}^{-1}$ (Pascal, 1988; Chandrashekara & Ramakrishnan, 1994) and similarly the basal area ranging from $7\text{m}^2\text{ha}^{-1}$ to $23\text{m}^2\text{ha}^{-1}$ in certain dry forest communities in India (Jha & Singh, 1990) while, $10.79\text{m}^2\text{ha}^{-1}$ to $20.44\text{m}^2\text{ha}^{-1}$ in the tropical dry evergreen forests of southern India (Parthasarathy & Sethi, 1997). In the present study, while considering the total basal are of trees in the selected sacred groves in per hectare basis, the values of TBA are $63.21\text{m}^2\text{ha}^{-1}$, $29.7\text{m}^2\text{ha}^{-1}$, $12.95\text{m}^2\text{ha}^{-1}$ and $2.87\text{m}^2\text{ha}^{-1}$ respectively for Sankulangara grove, Palliyana grove, Nambiyath grove and Poyyara grove. Similarly, the TBA values for the selected disturbed non-sacred grove lands at Sankulangara, Palliyana, Nambiyath and Poyyara study sites are $5.5\text{m}^2\text{ha}^{-1}$, $5.17\text{m}^2\text{ha}^{-1}$, $2.57\text{m}^2\text{ha}^{-1}$ and $0.74\text{m}^2\text{ha}^{-1}$ respectively. The basal area value obtained for Sankulangara grove indicates the value is within the range of $37.37\text{m}^2\text{ha}^{-1}$ to $83.83\text{m}^2\text{ha}^{-1}$ and hence in harmony with the lowland and mid-elevation evergreen forests of the Western Ghats of India. The basal area value obtained in the Nambiyath grove is found comparable with values of dry forest communities in India or tropical dry evergreen forests of southern India. The Palliyana grove is found occupying a position in between the evergreen forests of the Western Ghats and dry forest or tropical dry evergreen forests communities of India. The lowest TBA value is recorded in the Poyyara sacred grove of smallest extent and the value is found below the

range of dry forest communities in India. However, the TBA values of trees recorded in all the selected non-sacred grove lands which are under human disturbances are found belonging to the range below the dry forest communities of India. The differences in the basal area of tree layers among different study sites may also be due to differences in altitude, species composition, the extent of area and the age of trees, disturbances and successional strategies of the stands.

The data shows drastic and progressive reduction in the TBA of trees as extent of the groves as well as the disturbed lands are decreased. This indicates direct correlation between the TBA of trees and extents of the area under study. However, the investigation revealed the volume of reduction is considerably higher in sacred groves compared to disturbed non-sacred grove lands. When the area of sacred grove at Palliyana site is decreased to 0.364ha compared to 0.636ha at Sankulangara site, a reduction of 29.39 m² (73.11%) in the TBA is recorded in the Palliyana grove over the Sankulangara grove of largest extent. The reductions are found further increased to 38.63m² (96.02%) and 40.08m² (99.70%) respectively in the TBA of trees in Nambiyath grove (0.1214ha) and Poyyara grove (0.0404ha). However the same time, the comparison between corresponding disturbed lands recorded only a reduction of 1.62m² at Palliyana site, 3.19m² at Nambiyath site and 3.47m² at Poyyara site over the TBA of trees in the disturbed land of largest extent at Sankulangara site. The progressive reduction in tree diversity and their population size as the size of the study area decreased might be the reason that contributed to the decrease in TBA of trees. This trend is found more prominent with respect to sacred groves compared to disturbed non-sacred grove lands. This may be due to reduction in tree size, density and diversity along with increasing space constraints and competition among similar and different tree species for various resources. However in the disturbed lands, extent of the area is found not a major limiting factor at present for tree diversity and density as in the case of groves. But failure in proper regeneration and concentration in the biomass of tree species due to severe anthropogenic disturbances like recurrent tree logging and the resulting poor soil, environment and vegetation characteristics are the major factors (Ripu & Shiv, 2004; Sagar, 2006).

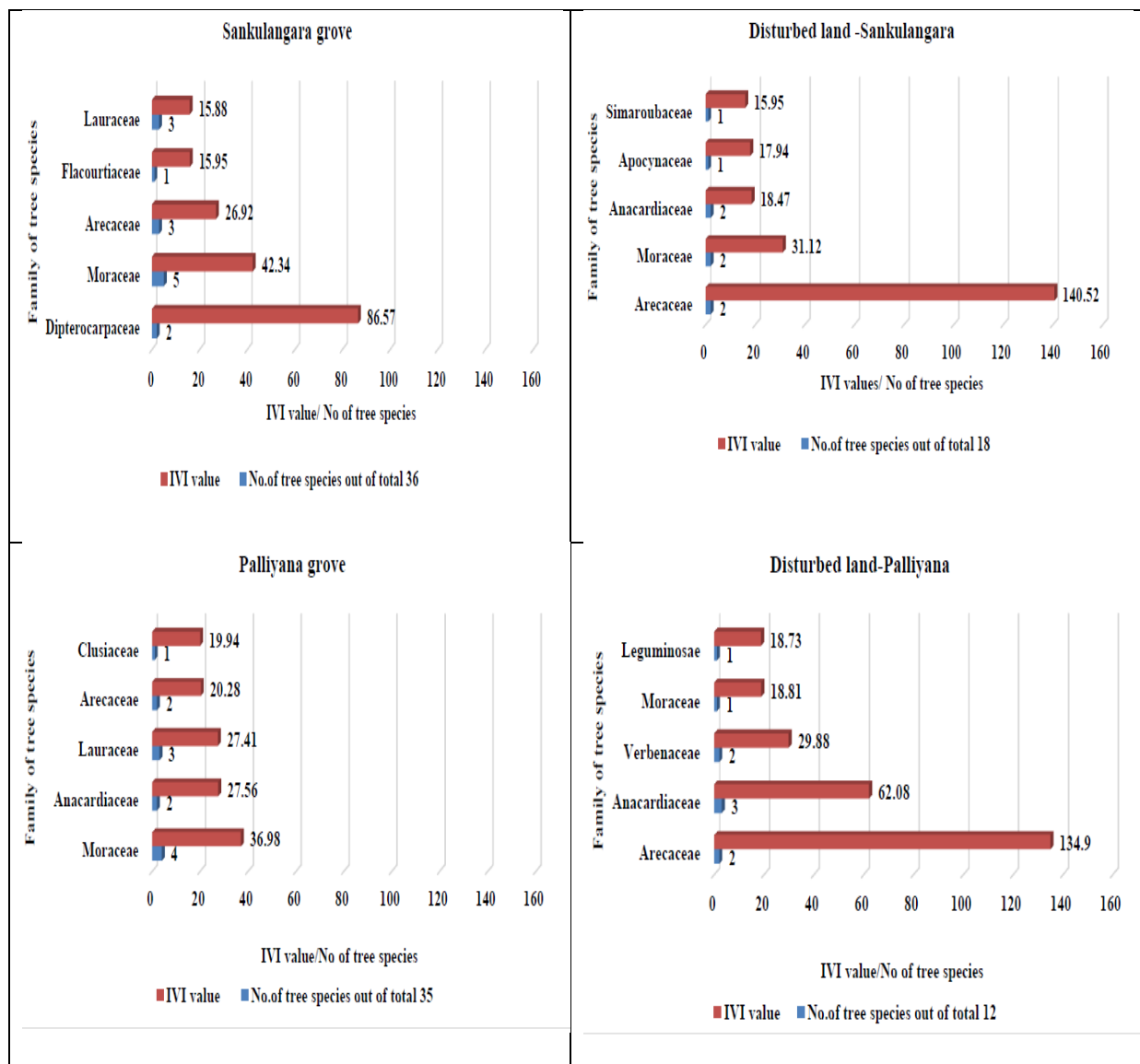
Importance value index (IVI)

The vegetation status as well as the importance of plant species and families in an area can be assessed by comparing the importance value index (IVI) of the plant species and families in the area. The IVI of a species is the sum of relative frequency, relative density, and relative

basal area of the species (Curtis & McIntosh, 1950). The diversity of tree species and the density, frequency and basal area of majority of the tree species in the selected groves are found significantly higher than the values of trees in the disturbed lands.

The major tree species identified having comparatively higher IVI values in one or more selected sacred groves in the study includes *Artocarpus hirsutus*, *Aphanamixis polystachya*, *Hopea ponga*, *Hydnocarpus pentandrus*, *Holigarna arnottiana*, *Syzygium cumini*, *Caryota urens*, *Quassia indica*, *Garcinia gummi-gutta*, *Vitex altissima*, *Alstonia scholaris*, *Ficus amplissima*, *Sterculia guttata*, *Pterygota alata* and *Pongamia pinnata*. However in the selected disturbed non-sacred grove lands, the tree species of similar kind identified includes *Cocos nucifera*, *Areca catechu*, *Artocarpus hirsutus*, *Anacardium occidentale*, *Mangifera indica*, *Artocarpus heterophyllus*, *Ailanthus triphysa*, *Hydnocarpus pentandrus*, *Garcinia gummi-gutta*, *Tectona grandis*, *Gliricidia sepium* and *Dalbergia latifolia*. The higher IVI values recorded by these tree species of groves and non-sacred grove lands are due to substantial dominance of these tree species in terms of basal area or stand density or due to both. Similarly, the analysis of IVI value scored by different families in the groves revealed moraceae, dipterocarpaceae, flacourtiaceae, arecaceae, anacardiaceae, myrtaceae, meliaceae, lauraceae, simaroubaceae, sapotaceae, leguminosae, sterculiaceae, apocynaceae, clusiaceae and verbenaceae are the major families which recorded comparatively higher IVI values in one or more selected groves. The families having comparatively higher IVI values in the non-sacred grove lands are arecaceae, anacardiaceae, verbenaceae, moraceae, flacourtiaceae, clusiaceae, leguminosae, simaroubaceae and apocynaceae. These observations clearly indicate higher diversity for tree species and family and better tree vegetation characteristics in the groves and they are the representations of natural forest vegetation which are still protected and preserved by the people under the religious ground. But in the non-sacred grove lands, the diversity of tree species and family are lower and comparatively dominant tree species with higher IVI values particularly *Cocos nucifera*, *Areca catechu*, *Anacardium occidentale* and *Mangifera indica* indicate high human interference and manmade vegetation in these areas. However, certain tree species like *Cocos nucifera*, *Areca catechu*, *Anacardium occidentale* and families like arecaceae, anacardiaceae, ulmaceae in the disturbed lands are found recorded comparatively higher IVI values compared that of those tree species and families with higher IVI values in the groves. This is nothing but due to higher values of RD, RF and RBA of these tree species in the disturbed lands. This is due to significantly higher density, basal area and frequency of these tree species compared to other tree species together

with significantly lower diversity for tree species and families in the disturbed lands, in comparison to sacred groves. The lack of any kind of restrictions and easy accesses to non-sacred grove lands might be the fact that contributed towards the decline in tree diversity and poor tree stand characteristics in non-sacred grove lands. With respect to the influence of difference in extent of the grove area on the diversity of tree species and the families of tree species, the study generally observed a direct correlation. As the size of the grove area is decreased from Sankulangara site of largest extent towards Poyyara site of smallest extent, a progressive reduction is recorded in the diversity of tree species and in the density and basal area of trees (figure B20 and B21). The increase in space constraints oriented limitations and competitions among trees might be the factor limiting the diversity and size of the tree species.



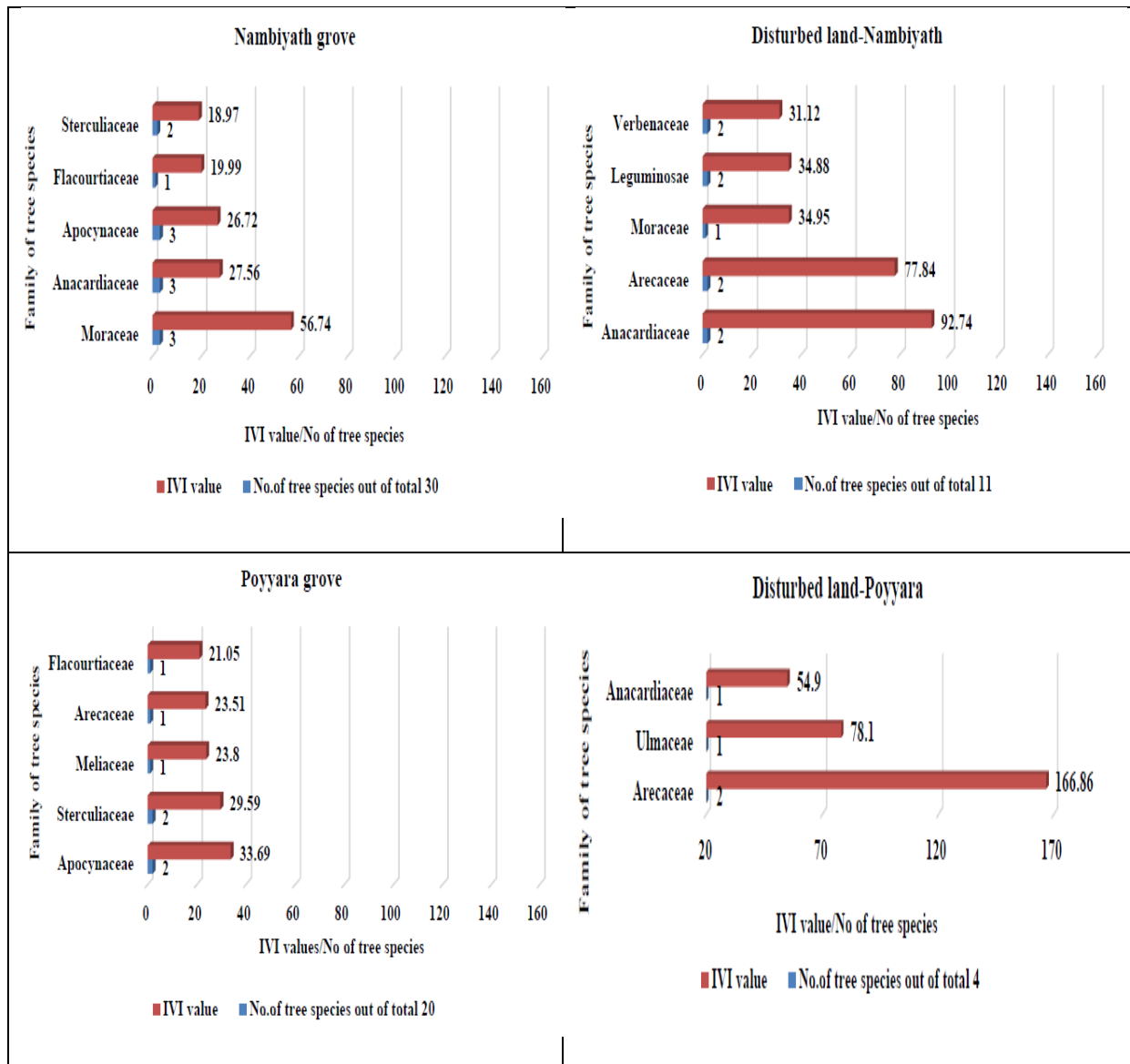
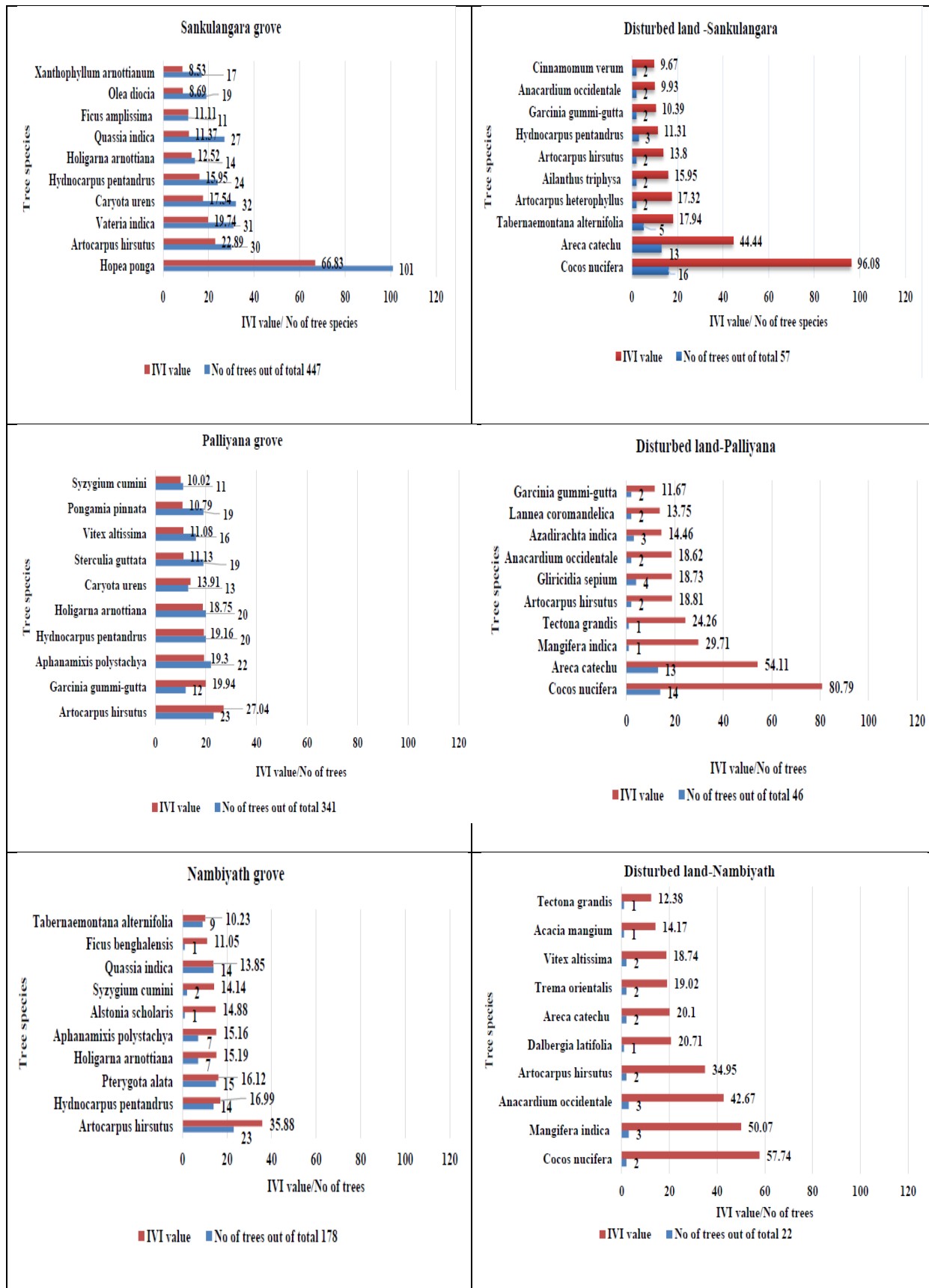


Figure B20: Top five families in selected sacred groves and disturbed non-sacred grove lands showing IVI values and diversity of tree species



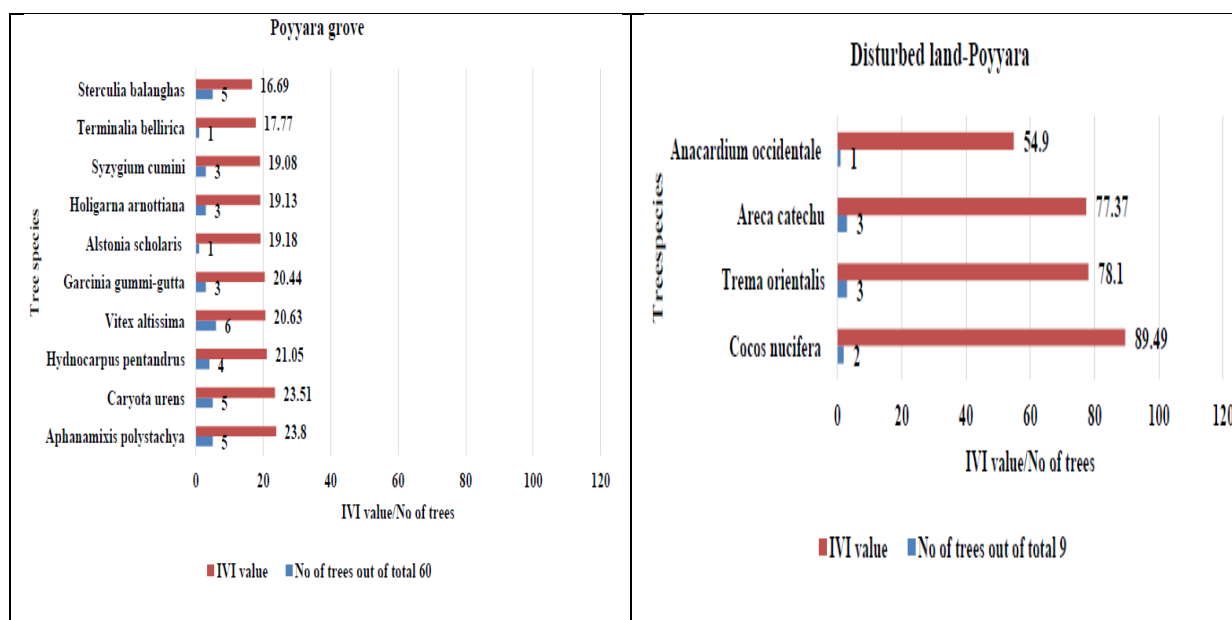


Figure B21: Top ten tree species in selected sacred groves and disturbed non-sacred grove lands showing IVI values and number of tree representation

Endemic and IUCN red listed plants in the selected study sites.

The analysis of plant species in the Sankulanagara sacred grove revealed the occurrence of 15 plant species as endemic. This includes one endangered (*Hopea ponga*); three vulnerable (*Ixora malabarica*, *Saraca asoca* & *Vateria indica*) and one near threatened plant species (*Tabernaemontana alternifolia*) as listed by IUCN red list of plants. The analysis done in the Palliyana sacred grove showed the existence of 12 endemic plant species which also include one endangered (*Syzygium caryophyllatum*); three vulnerable (*Ixora malabarica*, *Saraca asoca* & *Nothapodytes nimmoniana*) and one near threatened plant species (*Tabernaemontana alternifolia*). The Nambiyath sacred grove showed the existence of 8 endemic plant species while it is only 7 plant species in Poyyara sacred grove. As per the IUCN red list of plants, two vulnerable (*Ixora malabarica* & *Saraca asoca*) and one near threatened plant species (*Tabernaemontana alternifolia*) are identified in the Nambiyath grove while in the Poyyara sacred grove one endangered (*Hopea ponga*); one vulnerable (*Nothapodytes nimmoniana*) and one near threatened plant species (*Tabernaemontana alternifolia*) are identified. However the analysis of plant species in the disturbed non-sacred grove land of similar extents corresponding to each sacred groves selected in the study showed the occurrence 2 plant species as endemic at Sankulangara site and this include one plant species as near threatened (*Tabernaemontana alternifolia*). Whereas, the analysis of plant species in all other disturbed non-sacred grove lands revealed the absence of endemic

plant species as well as the absence recorded for endangered, vulnerable, near threatened or rare plant species from IUCN red list of plants. The details of endemic plant species and the plant species identified as listed in the IUCN red list of plants in different study sites are depicted in table B122 to table B126. The analysis clearly indicated significant reductions have occurred for endemic plant species in all the non-sacred grove regions selected in all the study sites and clearly revealed severe anthropogenic disturbances and damage to natural vegetation in comparison to selected sacred groves.

Table B122: Endemic and IUCN red listed plants species in the Sankulangara sacred grove

Sl. No	Plant Name	IUCN Status				
		Endemic	Endangered	Vulnerable	Threatened	Rare
1	<i>Bridelia stipularis</i>	Peninsular India				
2	<i>Canthium rheedei</i>	Peninsular India				
3	<i>Dalbergia horrida</i>	Southern Western Ghats				
4	<i>Holigarna arnottiana</i>	Southern Western Ghats				
5	<i>Hopea ponga</i>	Western Ghats- South and Central Sahyadris	Endangered			
6	<i>Hydnocarpus pentandrus</i>	Western Ghats				
7	<i>Ixora malabarica</i>	Southern Western Ghats		Vulnerable		
8	<i>Kamettia caryophyllata</i>	Southern Western Ghats				
9	<i>Mussaenda frondosa</i>	Peninsular India				
10	<i>Pinanga dicksonii</i>	Western Ghats				
11	<i>Polyalthia korintii</i>	South Asia				
12	<i>Saraca asoca</i>			Vulnerable		
13	<i>Tabernaemontana alternifolia</i>	Southern Western Ghats			Near Threatened	
14	<i>Torenia bicolor</i>	Western Ghats				
15	<i>Vateria indica</i>	Western Ghats		Vulnerable		
16	<i>Xanthophyllum arnottianum</i>	Western Ghats				

Table B123: Endemic and IUCN red listed plants species in the disturbed non-sacred grove land at Sankulangara site

Sl. No	Plant Name	IUCN Status				
		Endemic	Endangered	Vulnerable	Threatened	Rare
1	<i>Hydnocarpus pentandrus</i>	Western Ghats				
2	<i>Tabernaemontana alternifolia</i>	Southern Western Ghats			Near Threatened	

Table B124: Endemic and IUCN red listed plants species in the Palliyana sacred grove

Sl. No	Plant Name	IUCN Status				
		Endemic	Endangered	Vulnerable	Threatened	Rare
1	<i>Bridelia stipularis</i>	Peninsular India				
2	<i>Canthium rheedei</i>	Peninsular India				
3	<i>Holigarna arnottiana</i>	Southern Western Ghats				
4	<i>Hydnocarpus pentandrus</i>	Western Ghats				
5	<i>Ixora malabarica</i>	Southern Western Ghats		Vulnerable		
6	<i>Litsea coriacea</i>	Peninsular India				
7	<i>Mussaenda frondosa</i>	Peninsular India				
8	<i>Nothapodytes nimmoniana</i>			Vulnerable		
9	<i>Salacia fruticosa</i>	Western Ghats				
10	<i>Saraca asoca</i>			Vulnerable		

11	<i>Syzygium caryophyllatum</i>	Western Ghats	Endangered			
12	<i>Tabernaemontana alternifolia</i>	Southern Western Ghats			Near Threatened	
13	<i>Vateria indica</i>	Western Ghats				
14	<i>Xanthophyllum arnottianum</i>	Western Ghats				

Table B125: Endemic and IUCN red listed plants species in the Nambiyath sacred grove

Sl. No	Plant Name	IUCN Status				
		Endemic	Endangered	Vulnerable	Threatened	Rare
1	<i>Bridelia stipularis</i>	Peninsular India				
2	<i>Holigarna arnottiana</i>	Southern Western Ghats				
3	<i>Hydnocarpus pentandrus</i>	Western Ghats				
4	<i>Ixora malabarica</i>	Southern Western Ghats		Vulnerable		
5	<i>Kamettia caryophyllata</i>	Southern Western Ghats				
6	<i>Mussaenda frondosa</i>	Peninsular India				
7	<i>Pinanga dicksonii</i>	Western Ghats				
8	<i>Saraca asoca</i>			Vulnerable		
9	<i>Tabernaemontana alternifolia</i>	Southern Western Ghats			Near Threatened	

Table B126: Endemic and IUCN red listed plants species in the Poyyara sacred grove

Sl. No	Plant Name	IUCN Status				
		Endemic	Endangered	Vulnerable	Threatened	Rare
1	<i>Bridelia stipularis</i>	Peninsular India				
2	<i>Holigarna arnottiana</i>	Southern Western Ghats				
3	<i>Hopea ponga</i>	Western Ghats- South and Central Sahyadris	Endangered			
4	<i>Hydnocarpus pentandrus</i>	Western Ghats				
5	<i>Mussaenda frondosa</i>	Peninsular India				
6	<i>Nothapodytes nimmoniana</i>			Vulnerable		
7	<i>Polyalthia korintii</i>	South Asia				
8	<i>Tabernaemontana alternifolia</i>	Southern Western Ghats			Near Threatened	

(Sasidharan, 2003, 2011; Ariyan & Arumugam, 2016).

Plants of common occurrence

(Occurrence of plants either in one or more selected sacred groves and in one or more selected disturbed non-sacred grove lands)

SL NO	Family : Acanthaceae		
1	 <i>Andrographis paniculata</i> *(SaSG, DLPa, DLNa, DLPoy)		
2	 <i>Justicia procumbens</i> *(PaSG, DLPa)		
	Family : Amaranthaceae		
3	 <i>Aerva lanata</i> *(NaSG, PoySG, DLSa, DLPa, DLNa, DLPoy)		

4	 <i>Cyathula prostrata</i> *(PaSG, NaSG, PoySG, DLSa, DLPa)		
Family: Anacardiaceae			
5	 <i>Anacardium occidentale</i> *(PaSG, NaSG, DLSa, DLPa, DLNa, DLPoy)		
6	 <i>Lannea coromandelica</i> *(NaSG, DLPa)		
Family: Apocynaceae			
7	 <i>Tabernaemontana alternifolia</i> *(SaSG, PaSG, NaSG, PoySG, DLSa)		

8	   <i>Ichnocarpus frutescens</i> *(SaSG, PaSG, NaSG, PoySG, DLSa, DLPa, DLNa)
Family: Arecaceae	
9	   <i>Areca catechu</i> *(SaSG, PaSG, DLSa, D LPa, DLNa, DLPoy)
Family: Asteraceae	
10	   <i>Grangea maderaspatana</i> *(NaSG, DLPa)
11	   <i>Synedrella nodiflora</i> *(PaSG, DLSa, DLPa, DLNa)

12	 <i>Mikania micrantha</i> *(SaSG, PaSG, NaSG, DLSa, DLPa, DLNa, DLPoy)		
Family: Clusiaceae			
13	 <i>Garcinia gummi-gutta</i> *(SaSG, PaSG, NaSG, PoySG, DLSa, DLPa)		
Family: Combretaceae			
14	 <i>Terminalia catappa</i> *(SaSG, DLSa, DLPa)		
Family: Cyperaceae			
15	 <i>Cyperus rotundus</i> *(PaSG, NaSG, PoySG, DLSa, DLNa, DLPoy)		

	Family: Euphorbiaceae		
16	 <i>Bridelia retusa</i> *(PaSG, DLSa)		
17	 <i>Euphorbia hirta</i> *(NaSG, PoySG, DLSa, DLPa, DLNa, DLPoy)		
	Family: Leguminosae		
18	 <i>Abrus precatorius</i> *(SaSG, PaSG, NaSG, PoySG, DLPa, DLNa, DLPoy)		
	Family: Flacourtiaceae		
19	 <i>Hydnocarpus pentandrus</i> *(SaSG, PaSG, NaSG, PoySG, DLSa)		

	Family: Lamiaceae		
20	 <i>Anisomeles indica</i> *(SaSG, DLPa, DLNa, DLPoy)		
	Family: Leeaceae		
21	 <i>Leea indica</i> *(SaSG, PaSG, NaSG, PoySG, DLSa, DLPa, DLNa, DLPoy)		
	Family: Menispermaceae		
22	 <i>Tiliacora racemosa</i> *(SaSG, PaSG, NaSG, PoySG, DLSa, DLPa, DLNa)		

	Family: Moraceae		
23	 <i>Artocarpus hirsutus</i> *(SaSG, PaSG, NaSG, DLSa, DLPa, DLNa)		
	Family: Nyctaginaceae		
24	 <i>Boerhavia diffusa</i> *(NaSG, PoySG, DLPa, DLNa, DLPoy)		
	Family: Oxalidaceae		
25	 <i>Biophytum reinwardtii</i> *(SaSG, PaSG, NaSG, PoySG, DLSa)		

	Family: Poaceae		
26	 <i>Bambusa bambos</i> *(PaSG, NaSG, PoySG, DLNa)		
27	 <i>Brachiaria remota</i> *(SaSG, PaSG, DLSa, DLPa, DLNa, DLPoy)		
28	 <i>Brachiaria subquadriflora</i> *(NaSG, DLSa)		
29	 <i>Eragrostis unioides</i> *(PaSG, DLSa)		

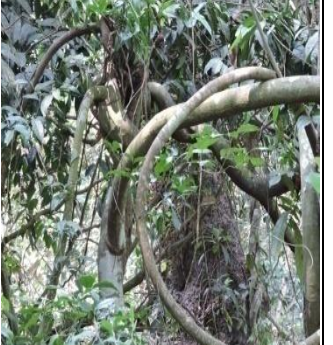
	Family: Rhizophoraceae		
30	 <i>Carallia brachiata</i> *(SaSG, NaSG, DLSa)		
	Family: Rubiaceae		
31	 <i>Mitracarpus hirtus</i> *(SaSG, PaSG, NaSG, DLSa, DLNa)		
	Family: Simaroubaceae		
32	 <i>Quassia indica</i> *(SaSG, PaSG, NaSG, PoySG, DLNa)		
	Family: Tiliaceae		
33	 <i>Grewia nervosa</i> *(SaSG, PaSG, NaSG, PoySG, DLPa, DLNa, DLPoy)		

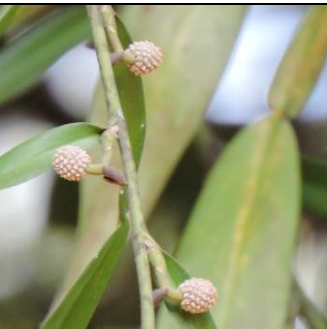
	Family: Ulmaceae		
34	 <i>Trema orientalis</i> * (NaSG, DLNa, DLPoy)		
	Family: Urticaceae		
35	 <i>Laportea interrupta</i> * (SaSG, PaSG, NaSG, DLSa, DLPoy)		
	Family: Verbenaceae		
36	 <i>Vitex altissima</i> * (SaSG, PaSG, NaSG, PoySG, DLSa, DLPa, DLNa)		

Plants of occurrence only in the selected groves

SL NO	Family: Acanthaceae		
1	 <i>Justicia gendarussa</i> *(PaSG)		
	Family: Anacardiaceae		
2	 <i>Holigarna arnottiana</i> *(SaSG, PaSG, NaSG, PoySG)		
	Family: Annonaceae		
3	 <i>Polyalthia longifolia</i> *(PaSG, NaSG)		

4	 <i>Polyalthia korintii</i> *(SaSG, PaSG, PoySG)		
5	 <i>Uvaria narum</i> *(SaSG, PaSG, NaSG, PoySG)		
Family: Apiaceae			
6	 <i>Centella asiatica</i> *(SaSG)		
Family: Apocynaceae			
7	 <i>Alstonia scholaris</i> *(PaSG, NaSG, PoySG)		

8	 <i>Plumeria rubra</i> *(NaSG)		
9	 <i>Tabernaemontana divaricata</i> *(PaSG, NaSG, PoySG)		
10	 <i>Rauvolfia serpentina</i> *(PaSG)		
11	 <i>Anodendron paniculatum</i> *(PaSG)		
12	 <i>Kamettia caryophyllata</i> *(SaSG, NaSG)		

	Family: Araceae		
13	 <i>Pothos scandens</i> *(SaSG, PaSG, PoySG)		
	Family: Arecaceae		
14	 <i>Caryota urens</i> *(SaSG, PaSG, NaSG, PoySG)		
15	 <i>Pinanga dicksonii</i> *(SaSG, PaSG, NaSG)		
	Family: Aristolochiaceae		
16	 <i>Aristolochia indica</i> *(SaSG, PaSG)		

Family: Asclepiadaceae			
17	 <i>Dregea volubilis</i> *(SaSG)		
18	 <i>Gymnema sylvestre</i> *(PaSG)		
Family: Asteraceae			
19	 <i>Cyanthillium cinereum</i> *(PaSG, NaSG)		

20	   <i>Elephantopus scaber</i> *(SaSG)
21	   <i>Emilia sonchifolia</i> *(SaSG, PaSG, NaSG, PoySG)
Family: Combretaceae	
22	   <i>Terminalia bellirica</i> *(SaSG, PaSG, NaSG, PoySG)
23	   <i>Combretum latifolium</i> *(NaSG, PoySG)

	Family: Connaraceae		
24	 <i>Connarus monocarpus</i> *(SaSG, PaSG, NaSG)		
25	 <i>Rourea minor</i> *(SaSG, PaSG, PoySG)		
	Family: Convolvulaceae		
26	 <i>Erycibe paniculata</i> *(SaSG)		
	Family: Costaceae		
27	 <i>Cheilocostus speciosus</i> *(SaSG)		

	Family: Cucurbitaceae		
28	 <i>Mukia maderaspatana</i> *(SaSG, PaSG, NaSG, PoySG)		
	Family: Dioscoreaceae		
29	 <i>Dioscorea bulbifera</i> *(SaSG, PaSG, NaSG, PoySG)		
	Family: Dracaenaceae		
30	 <i>Dracaena terniflora</i> *(NaSG)		
	Family: Dipterocarpaceae		
31	 <i>Hopea ponga</i> *(SaSG, PoySG)		

32	 <i>Vateria indica</i> *(SaSG, PaSG)		
Family: Ebenaceae			
33	 <i>Diospyros malabarica</i> *(PaSG, NaSG)		
Family: Euphorbiaceae			
34	 <i>Aporosa cardiosperma</i> *(SaSG, PaSG)		
35	 <i>Breynia vitis-idaea</i> *(NaSG, PoySG)		

36	 <i>Bridelia stipularis</i> *(SaSG, PaSG, NaSG, PoySG)	 
Family: Leguminosae		
37	 <i>Adenanthera pavonina</i> *(SaSG, PaSG, NaSG, PoySG)	 
38	 <i>Pongamia pinnata</i> *(PaSG, PoySG)	 
39	 <i>Saraca asoca</i> *(SaSG, PaSG, NaSG)	 

40	 <i>Bauhinia acuminata</i> *(PaSG, PoySG)		
41	 <i>Desmodium gangeticum</i> *(SaSG, PaSG, NaSG, PoySG)		
42	 <i>Clitoria ternatea</i> *(SaSG)		
43	 <i>Vigna umbellata</i> *(SaSG)		
44	 <i>Dalbergia horrida</i> *(SaSG)		

45	 <i>Dalbergia volubilis</i> *(SaSG)		
46	 <i>Derris scandens</i> *(PaSG)		
Family: Gnetaceae			
47	 <i>Gnetum ula</i> *(SaSG, PaSG, NaSG, PoySG)		
Family: Hippocrateaceae			
48	 <i>Salacia fruticosa</i> *(PaSG)		

	Family: Hypoxidaceae		
49	 <i>Curculigo orchioides</i> *(PaSG, NaSG)		
	Family: Icacinaceae		
50	 <i>Nothapodytes nimmoniana</i> *(PaSG, PoySG)		
51	 <i>Sarcostigma kleinii</i> *(PaSG, NaSG, PoySG)		
	Family: Lamiaceae		
52	 <i>Hyptis capitata</i> *(SaSG)		

53	 <i>Ocimum basilicum</i> *(SaSG, PaSG)		
54	 <i>Ocimum tenuiflorum</i> *(SaSG, PaSG)		
Family: Lauraceae			
55	 <i>Cinnamomum malabattrum</i> *(SaSG, PaSG, NaSG)		
56	 <i>Litsea coriacea</i> *(SaSG, PaSG)		
57	 <i>Persea macrantha</i> *(SaSG, PaSG)		

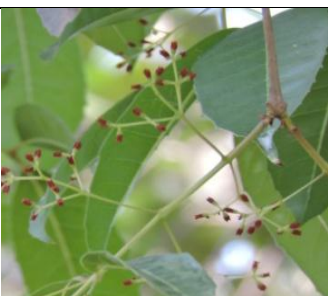
	Family: Liliaceae		
58	 <i>Asparagus racemosus</i> *(SaSG, PaSG, NaSG, PoySG)		
59	 <i>Gloriosa superba</i> *(SaSG)		
	Family: Loganiaceae		
60	 <i>Strychnos nux-vomica</i> *(SaSG, PaSG, NaSG)		
61	 <i>Strychnos minor</i> *(SaSG, PaSG, PoySG)		

	Family: Malvaceae		
62	 <i>Hibiscus rosa-sinensis</i> *(SaSG, PaSG, NaSG)		
	Family: Melastomataceae		
63	 <i>Memecylon depressum</i> *(PaSG)		
64	 <i>Memecylon grande</i> *(SaSG)		
	Family: Meliaceae		
65	 <i>Aphanamixis polystachya</i> *(SaSG, PaSG, NaSG, PoySG)		

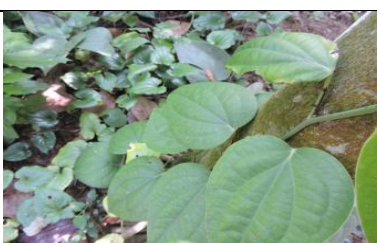
66	 <i>Naregamia alata</i> *(NaSG)		
Family: Menispermaceae			
67	 <i>Anamirta cocculus</i> *(PaSG)		
68	 <i>Cyclea peltata</i> *(SaSG, PaSG, NaSG, PoySG)		
69	 <i>Coscinium fenestratum</i> *(NaSG)		

70	 <i>Tinospora cordifolia</i> *(PaSG, NaSG)		
71	 <i>Tinospora sinensis</i> *(PaSG)		
Family: Moraceae			
72	 <i>Ficus amplissima</i> *(SaSG, NaSG, PoySG)		
73	 <i>Ficus benghalensis</i> *(SaSG, PaSG, NaSG, PoySG)		

74	 <i>Ficus drupacea</i> *(SaSG)		
75	 <i>Ficus religiosa</i> *(SaSG, PaSG)		
76	 <i>Streblus asper</i> *(PaSG)		
Family: Myrtaceae			
77	 <i>Syzygium cumini</i> *(PaSG, NaSG, PoySG)		
78	 <i>Syzygium hemisphericum</i> *(SaSG)		

79	 <i>Syzygium lanceolatum</i> *(SaSG)		
80	 <i>Syzygium caryophyllatum</i> *(PaSG)		
81	 <i>Syzygium zeylanicum</i> *(SaSG)		
Family: Oleaceae			
82	 <i>Olea dioica</i> *(SaSG, PaSG)		

83	 <i>Myxopyrum smilacifolium</i> *(SaSG)		
84	 <i>Jasminum angustifolium</i> *(SaSG)		
85	 <i>Jasminum multiflorum</i> *(NaSG)		
Family: Opiliaceae			
86	 <i>Cansjera rheedii</i> *(SaSG)		

	Family: Pandanaceae		
87	 <i>Pandanus kaida</i> *(SaSG, PaSG, NaSG)		
	Family: Periplocaceae		
88	 <i>Hemidesmus indicus</i> *(SaSG)		
	Family: Piperaceae		
89	 <i>Piper nigrum</i> *(SaSG, PaSG)		
	Family: Poaceae		
90	 <i>Bambusa vulgaris</i> *(PaSG, NaSG)		

91	 <i>Panicum notatum</i> *(SaSG, PaSG, NaSG, PoySG)		
	Family: Polygalaceae		
92	 <i>Xanthophyllum arnottianum</i> *(SaSG, PaSG)		
	Family: Ranunculaceae		
93	 <i>Naravelia zeylanica</i> *(PaSG)		
	Family: Rubiaceae		
94	 <i>Mussaenda frondosa</i> *(SaSG, PaSG, NaSG, PoySG)		

95	 <i>Pavetta indica</i> L *(PaSG, NaSG)		
96	 <i>Chassalia curviflora</i> *(SaSG, PaSG, PoySG)		
97	 <i>Gardenia jasminoides</i> *(NaSG)		
98	 <i>Canthium rheedei</i> *(SaSG, PaSG)		
99	 <i>Ixora coccinea</i> *(SaSG, PaSG, NaSG, PoySG)		

100	 <i>Ixora malabarica</i> *(SaSG, PaSG, NaSG)		
101	 <i>Coffea travancorensis</i> *(SaSG, PaSG, NaSG)		
102	 <i>Spermacoce articularis</i> *(PoySG)		
Family: Rutaceae			
103	 <i>Aegle marmelos</i> *(PoySG)		

104			
	Family: Sapotaceae		
105			
106			
107			

	Family: Scrophulariaceae		
108	 <i>Torenia bicolor</i> *(SaSG)		
	Family: Smilacaceae		
109	 <i>Smilax zeylanica</i> *(SaSG, PaSG)		
	Family: Sterculiaceae		
110	 <i>Pterygota alata</i> *(NaSG, PoySG)		
111	 <i>Sterculia balanghas</i> *(NaSG, PoySG)		

112	 <i>Sterculia guttata</i> *(SaSG, PaSG)		
Family: Verbenaceae			
113	 <i>Vitex pinnata</i> *(SaSG)		
114	 <i>Clerodendrum paniculatum</i> *(SaSG, PaSG, NaSG, PoySG)		
Family: Vitaceae			
115	 <i>Cayratia japonica</i> *(SaSG)		

116	 <i>Cayratia pedata</i> *(SaSG, PaSG)		
117	 <i>Cissus latifolia</i> *(NaSG)		
118	 <i>Cyphostemma trilobata</i> *(PoySG)		
119	 <i>Tetrastigma leucostaphylum</i> *(SaSG)		

Plants of occurrence only in the selected disturbed non-sacred grove lands

SL NO	Family: Acanthaceae		
1	 <i>Barleria cristata</i> *(DLPa)		
2	 <i>Dicliptera paniculata</i> *(DLPa, DLNa)		
3	 <i>Andrographis echinoides</i> *(DLPa, DLNa)		
	Family: Amaranthaceae		
4	 <i>Achyranthes aspera</i> * (DLNa, DLPoy)		

5	 <i>Allmania nodiflora</i> *(DLPa, DLNa)		
6	 <i>Alternanthera brasiliana</i> * (DLPa, DLNa)		
Family: Anacardiaceae			
7	 <i>Mangifera indica</i> * (DLSa, DLPa, DLNa)		
Family: Annonaceae			
8	 <i>Annona squamosa</i> *(DLSa)		

	Family: Arecaceae		
9	 <i>Cocos nucifera</i> *(DLSa, DLPa, DLNa, DLPoy)		
	Family: Asclepiadaceae		
10	 <i>Calotropis gigantea</i> *(DLPa)		
	Family: Asteraceae		
11	 <i>Chromolaena odorata</i> *(DLSa, DLPa, DLNa, DLPoy)		
12	 <i>Ageratum conyzoides</i> *(DLPa, DLNa)		

13	 <i>Eleutheranthera ruderalis</i> *(DLSa, DLPa)		
14	 <i>Acmella ciliata</i> *(DLPa)		
15	 <i>Tridax procumbens</i> *(DLPa, DLNa, DLPoy)		
Family: Capparaceae			
16	 <i>Cleome rutidosperma</i> *(DLPa)		

17	 <i>Cleome viscosa</i> *(DLPa)		
Family: Commelinaceae			
18	 <i>Chromolaena odorata</i> *(DLSa)		
19	 <i>Murdannia pauciflora</i> *(DLSa)		
Family: Convolvulaceae			
20	 <i>Hewittia malabarica</i> *(DLSa, DLPa)		

21	 <i>Merremia umbellata</i> *(DLPa)		
	Family: Euphorbiaceae		
22	 <i>Phyllanthus reticulatus</i> *(DLSa, DLPa)		
23	 <i>Phyllanthus amarus</i> *(DLSa, DLPa, DLNa, DLPoy)		
24	 <i>Phyllanthus urinaria</i> *(DLSa, DLPa)		

25	 <i>Euphorbia thymifolia</i> *(DLSa, DLPa)		
	Family: Leguminosae		
26	 <i>Acacia mangium</i> *(DLNa)		
27	 <i>Dalbergia latifolia</i> *(DLNa)		
28	 <i>Gliricidia sepium</i> *(DLPa)		
29	 <i>Crotalaria pallida</i> *(DLSa, DLPa)		

30	 <i>Senna occidentalis</i> *(DLPa)		
31	 <i>Chamaecrista absus</i> *(DLPa)		
32	 <i>Chamaecrista mimosoides</i> *(DLPa, DLNa)		
33	 <i>Indigofera hirsuta</i> *(DLPa)		

34	 <i>Mimosa pudica</i> * (DLSa, DLPa, DLNa, DLPoy)		
35	 <i>Desmodium triflorum</i> *(DLSa)		
Family: Lamiaceae			
36	 <i>Hyptis suaveolens</i> *(DLSa, DLPa)		
37	 <i>Leucas aspera</i> *(DLSa, DLPa, DLNa, DLPoy)		

	Family: Lauraceae		
38	 <i>Cinnamomum verum</i> *(DLSa)		
	Family: Lythraceae		
39	 <i>Lawsonia inermis</i> *(DLPa)		
	Family: Malvaceae		
40	 <i>Hibiscus hispidissimus</i> *(DLPa, DLNa)		
41	 <i>Hibiscus surattensis</i> *(DLSa, DLNa)		

42	 <i>Sida acuta</i> *(DLSa, DLPa)		
43	 <i>Sida cordifolia</i> *(DLSa, DLPa, DLNa, DLPoy)		
44	 <i>Sida rhombifolia</i> *(DLSa, DLPa, DLNa)		
45	 <i>Sida mysorensis</i> *(DLPa, DLNa)		

46			
	<i>Urena lobata</i> *(DLPa, DLNa, DLPoy)		
	Family: Meliaceae		
47			
	<i>Azadirachta indica</i> *(DLPa)		
48			
	<i>Swietenia macrophylla</i> *(DLSa)		
	Family: Moraceae		
49			
	<i>Artocarpus heterophyllus</i> *(DLSa)		
	Family: Onagraceae		

50	 <i>Ludwigia hyssopifolia</i> *(DLSa, DLPa)		
Family: Pedaliaceae			
51	 <i>Pedalium murex</i> *(DLPa)		
Family: Poaceae			
52	 <i>Alloteropsis cimicina</i> *(DLSa)		
53	 <i>Alloteropsis semialata</i> *(DLSa, DLPa, DLNa)		

54	 <i>Cynodon dactylon</i> *(DLSa, DLPa, DLNa, DLPoy)		
55	 <i>Digitaria ciliaris</i> *(DLSa, DLPa, DLNa)		
56	 <i>Eragrostis amabilis</i> *(DLSa, DLPa, DLNa)		
Family: Rubiaceae			
57	 <i>Oldenlandia corymbosa</i> *(DLSa, DLPa, DLNa)		

	Family: Scrophulariaceae		
58	 <i>Scoparia dulcis</i> *(DLPa, DLNa)		
	Family: Simaroubaceae		
59	 <i>Ailanthus triphysa</i> *(DLSa)		
	Family: Solanaceae		
60	 <i>Datura stramonium</i> *(DLPa)		
61	 <i>Physalis angulata</i> *(DLPa)		

	Family: Tiliaceae		
62	 <i>Triumfetta rhomboidea</i> *(DLSa, DLPa)		
	Family: Urticaceae		
63	 <i>Pouzolzia zeylanica</i> *(DLSa)		
	Family: Verbenaceae		
64	 <i>Tectona grandis</i> L.f. *(DLSa,DLPa,DLNa)		
65	 <i>Clerodendrum infortunatum</i> *(DLSa, DLPa, DLNa, DLPoy)		

66	   <i>Lantana camara</i> *(DLPa, DLNa, DLPoy)
67	   <i>Stachytarpheta jamaicensis</i> *(DLNa)

***mark and letters in parenthesis indicate occurrence of plant species in study areas**

*SaSG- Sankulangara sacred grove, PaSG- Palliyana sacred grove, NaSG- Nambiyath sacred grove and PoySG- Poyyara sacred grove

DLSa- Disturbed land Sankulangara, DLPa- Disturbed land Palliyana, DLNa- Disturbed land Nambiyath and DLPoy- Disturbed land Poyyara

Conclusion

The floristic and phytosociological analysis revealed considerable degradation in the selected non-sacred grove lands compared to their corresponding sacred grove lands of similar extent. The significant reduction in species diversity index and species richness index of plants in the non-sacred groves lands clearly indicated unsustainable over exploitation of forest plants had occurred during the past. This may have created unstable and unfavourable habitat and environmental conditions in the disturbed lands for the regeneration and establishment of many local plant species of natural forest. This kind of tremendous pressure by human disturbances in the disturbed lands may be the major factor responsible for the decline in plant diversity and richness. Total absence of plant group lianas and comparatively lower diversity and population of climbers and trees while higher diversity and population of plant group herbs and shrubs in the selected non-sacred grove lands revealed the characteristics of highly disturbed degraded forest vegetation. Whereas in the selected sacred groves, higher diversity, density and more or less even distribution of different plant group's trees, climbers, lianas and shrubs clearly indicated the existence of similar pattern of natural forest vegetation and ecosystem stability. The higher IVI values of significantly large number of diverse tree species in the selected groves contributed by their higher basal area and density clearly indicate sacred groves are surviving patches of natural forest vegetation with least disturbances while, the lower values of these parameters in the disturbed lands confirm the occurrence of severe anthropogenic disturbances and poor stand characteristics. The study further found the values of most of the parameters selected are directly correlated to the difference in extent of the area, irrespective of sacred grove and non-sacred grove lands. However, the differences are found more prominent with respect to sacred groves as they are significantly higher in diversity and density of plant species much compared to disturbed non-sacred grove lands.

The investigation concludes that diversity and richness of plant species particularly endemic tree species and importance value index of trees and families are the most important criteria for evaluation of an ecosystem and also for understanding the relationship between the ecological process and community. The study further conclude that analysis of plant richness, diversity and the count of endemic plant species in area can be useful in getting an idea regarding the impacts of anthropogenic disturbances and its level on plant community. The dominance of many families, genera and species of plants that are characteristics to native

forest vegetation in the selected sacred groves compared to non-sacred grove lands might be as they have been traditionally protected and conserved from human interference on the grounds of spiritual and religious faith. However, the growing human population rate and their demands for space and forest resources are expected to increase further in the future and there is also chances of disturbing the vegetation in the existing remnants of natural forest, the so called sacred groves. Therefore appropriate conservation strategies are to be taken to ensure the long term sustainability of existing groves which are essential for the maintenance of ecological environment at least to certain extent in the future.

References

- Abadie, J.C., Machon, N., Muratet, A., & Porcher, E. (2011). Landscape disturbance causes small-scale functional homogenization, but limited taxonomic homogenization, in plant communities. *Journal of Ecology*, 99(5), 1134–1142.
- Akter, A., & Zuberi, M.I. (2009). Invasive alien species in Northern Bangladesh: identification, inventory and impacts. *Journal of Biodiversity and Conservation*, 1(5), 129–134.
- Alejandro Loydi., Kerstin Lohse., Annette Otte., Tobias Donath., & Lutz Eckstein. (2014). Distribution and effects of tree leaf litter on vegetation composition and biomass in a forest–grassland ecotone. *Journal of Plant Ecology*, 7 (3), 264–275.
- Andrew, N. (1998). *Conservation of Sacred groves: Participatory strategy for the Future*. Proceedings of the National conferences on conservation of sacred groves and Ecological Heritage Sites, C. P. R. Environment Education Centre, Chennai. 12–16.
- Ariyan Sarvalingam., & Arumugam Rajendran. (2016). Rare, endangered and threatened (RET) climbers of Southern Western Ghats, India, *Journal of Revista Chilena de Historia Natural*, 89(9), 2–5.
- Balasubramanyan, K., Swarupanandan, K., & Sasidharan, N. (1985). *A field key to the identification of indigenous arborescent species of Kerala forests*. Research Report, No.33, KFRI. Peechi.
- Balasubramanyam, K., & Induchoodan, N. C. (1996). Plant diversity in sacred groves of Kerala. *Evergreen*, 36, 3–4.
- Behjou, F.K., & Mollabashi, O.G. (2013). A practical sampling strategy for assessing woody debris in Fandoghlu forest, Iran. *Journal of Environmental Science*, 8, 83–87.
- Bentham, G., & Hooker, J. D. (1862-1883). *Genera Plantarum Ad Exemplaria Imprimis in Herbariis Kewensibus Servata Definita*, (3 Vols.), London: L Reeve & Co.
- Bhuyan, P., Khan, M. L., & Tripathi, R. S. (2003). Tree diversity and population structure in undisturbed and human - impacted stands of tropical wet evergreen forest in Arunachal Pradesh, Eastern Himalayas, India. *Biodiversity and Conservation*, 12(8), 1753–1773.
- Bisht, A.P.S. (1989). *Microsite mosaic and under canopy vegetation dynamics of Sal communities in East and West Dehradun forest division*. D. Phil. Thesis, Garhwal University, Srinagar, India. pp187.

- Bongers, F., Poorter, L., Hawthorne, W.D., & Sheil, D. (2009). The intermediate disturbance hypothesis applies to tropical forests, but disturbance contributes little to tree diversity. *Ecology Letters*, 12(8), 798–805.
- Borah, N., & Garkoti, S.C. (2011). Tree species composition, diversity and regeneration patterns in undisturbed and disturbed forests of Barak Valley, South Assam, India. *International Journal of Ecology and Environmental Sciences*, 37(3), 131–141.
- Cakir, M., Makineci, E., & Kumbasli, A. (2010). Comparative study on soil properties in a picnic and undisturbed area of Belgrad forest, Istanbul. *Journal of Environmental Biology*, 31, 125–128.
- Chandrasekhara, U.M., & Ramakrishnan, P.S. (1994). Successional patterns and gap phase dynamics of a humid tropical forest of the Western Ghats of Kerala, India: ground vegetation, biomass, productivity and nutrient cycling. *Forest Ecology and Management*, 70, 23–40.
- Chandrashekara, U.M., & Sankar, S. (1998). Ecology and management of sacred groves in Kerala, India. *Forest Ecology and Management*, 112(2), 165–177.
- Chaneton, E.J., & Facelli, J.M. (1991). Disturbance effects on plant community diversity: spatial scales and dominance hierarchies. *Plant Ecology*, 93(2), 143–155.
- Chapin, F.S., Moilanen, L., & Kielland, K. (1993). Preferential use of organic nitrogen for growth by a non-mycorrhizal arctic sedge. *Nature*, 361, 150–153.
- Connell, J.H., & Lowman, M.D. (1989). Low-diversity tropical rain forests: some possible mechanisms for their existence. *The American Naturalist*, 134(1), 89–119.
- Connell, J.H. (1978). Diversity in tropical rain forests and coral reefs. *Science*, 199(4335), 1302–1310.
- Curtis, J.T., & McIntosh, R.P. (1950). The interrelations of certain analytic and synthetic phytosociological characters. *Ecology*, 31(3), 434–455.
- Dansereau, P. (1960). *Biogeography-An Ecological Perspective*. The Ronald Press Co. New York.
- Dumbrell, A.J., Clark, E.J., Frost, G.A., Randell, T.E., Pitchford, J.W., & Hill, J.K. (2008). Changes in species diversity following habitat disturbance are dependent on spatial scale: theoretical and empirical evidence. *Journal of Applied Ecology*, 45(5), 1531–1539.
- Felfili, J.M. (1995). Diversity, structure and dynamics of a gallery forest in central Brazil. *Vegetatio*, 117(1), 1–15.

- Fredericksen, T.S., & Mostacedo, B. (2000). Regeneration of Timber species following selection logging in a Bolivian tropical dry forest. *Forest Ecology Management*, 131(1), 47–55.
- Fosberg, F.R., & Sachet, M.H. (1965). Manual for Tropical Herbaria. International Bureau for Plant Taxonomy and Nomenclature, Utrecht. *Regnum Vegetabile*, 39, 132.
- Gadgil, M., & Chandran, S. (1989). *Environmental impact of forest based industries on the evergreen forests of Uttar Kannada District- A case study*. Final report Submitted to Development of Ecology and Environment, Government of Karnataka.
- Gadgil, M., & Vartak, V.D. (1975). Sacred groves of India - A plea for continued conservation. *Journal of Bombay Natural History Society*, 72(2), 314–321.
- Gamble, J. S., & Fischer, C. E. C. (1915-1936). *Flora of the Presidency of Madras*. 11 parts. Adlard & Sons Ltd, London.
- Goudie, A.S. (2005). *The Human Impact on the Natural Environment: Past, Present, and Future*. London (UK), Wiley-Blackwell.
- Hart, S.P. (1990). Effects of altering the grain content of sorghum silage on its nutritive value. *Journal The Journal of Animal Science*, 68(11), 3832–3842.
- Husch, B., Beers, T.W., & Kershaw Jr, J.A. (2002). *Forest Mensuration*. New York (NY): John Wiley & Sons.
- Indrajit Majumdar., Maksym Polyakov., Lawrence, D. Teeter., & Brett, J. Butler. (2009). Effect of population pressure on forest land use change in Alabama: A nested logit approach. *Journal of Ecological Economics & Statistics*, 14(9), 78–87.
- Induchoodan, N. C. (1998). *Ecological Studies on the Sacred Groves of Kerala*. Ph. D Thesis, Pondicherry University, Pondicherry. pp156.
- Induchoodan, N. C., & Balasubramanyan, K. (1991). Sacred Groves - Savior of Endemics. In: Proc. Sem. *Rare, Endemic and Endangered Plants of Western Ghats, Kerala*. Forest Department, Thiruvananthapuram, Kerala. 348–353.
- Jayarajan, M. (2004). Sacred Groves of North Malabar. Discussion paper No 92. Kerala Research Programme on Local Level Development.1–84.
- Jha, C.S., & Singh, J.S. (1990). Composition and dynamics of dry tropical forest in relation to soil texture. *Journal of Vegetation Science*, 1(5), 609–614.
- Kharkwal, G., & Rawat, Y.S. (2010). Structure and composition of vegetation in subtropical forest of Kumaun Himalaya. *African Journal of Plant Science*, 4 (4), 116–121.

- Laloo, R.C., Kharlukhi, L., Jeeva, S., & Mishra, B.P. (2006). Status of medicinal plants in the disturbed and the undisturbed sacred forests of Meghalaya, northeast India: population structure and regeneration efficacy of important tree species. *Current Science*, 90(2), 225–232.
- Lawes, M.J., Joubert, R., Griffiths, M.E., Boudreau, S., & Chapman, C.A. (2007). The effect of the spatial scale of recruitment on tree diversity in Afromontane forest fragments. *Biological Conservation*, 139(5), 447–456.
- Loreau, M., & Mouquet, N. (1999). Immigration and the maintenance of local species diversity. *The American Naturalist*, 154(4), 427–440.
- Margalef, R. (1958). Temporal succession and spatial heterogeneity in phytoplankton. In: *Perspectives in Marine biology*, Buzzati-Traverso (ed.), Univ. Calif. Press, Berkeley, pp. 323–347.
- Martijena, N.E., & Bullock, S.H. (1994). Monospecific dominance of a tropical deciduous forest in Mexico. *Journal of Biogeography*, 21(1), 63–74.
- McKinney, M.L. (2002). Urbanization, biodiversity, and conservation the impacts of urbanization on native species are poorly studied, but educating a highly urbanized human population about these impacts can greatly improve species conservation in all ecosystems. *Bioscience*, 52(10), 883–890.
- Meher-Homji, V.M. (1973). A phytosociological study of the *Albizia amara* Boiv. community of India. *Phytocoenologia*, 1(1), 114–129.
- Mishra, R.K., Upadhyay, V.P., & Mohanty, R.C. (2008). Vegetation ecology of the Similipal biosphere reserve, Orissa, India. *Applied Ecology and Environmental Research*, 6(2), 89–99.
- Mishra, B.P., Tripathi, O.P., Tripathi, R.S., & Pandey, H.N. (2004). Effect of anthropogenic disturbance on plant diversity and community structure of a sacred grove in Meghalaya, northeast India. *Biodiversity and Conservation*, 13(2), 421–436.
- Misra, R., & Puri, G.S. (1954). *Indian Manual of Plant Ecology*. English Book Depot, Dehradun.
- Misra, R. (1968). *Ecology Work Book*, Oxford and IBH Publications Co, New Delhi, 244.
- Misra, R. (1969). *Ecology Work Book*, Oxford and IBH, Calcutta.
- Mueller-Dombois, D., & Ellenberg, H. (1974). *Aims and methods of vegetation science*. John Wiley & Sons, New York.
- Nepolion Borah., Florida Devi Athokpam., Garkoti, S.C., Ashesh Kumar Das., & Hore, D.K. (2014). Structural and compositional variations in undisturbed and disturbed tropical

- forests of Bhuban hills in south Assam, India. *International Journal of Biodiversity Science, Ecosystem Services & Management*, 10(1), 9–19.
- Nisha, S.A., Jaishanker, R., Sooraj, N.P., & Saroj Kumar, K. (2016). Monitoring pollution using diversity indices, density and biomass of tree species from Kavil Shree Maheswarashramam (Sacred grove) from Nedumangad, Thiruvananthapuram. *Journal of Advances in Biological Science*, 3(1&2), 18–20.
- Noble, I.R., & Dirzo, R. (1997). Forest as human-dominated ecosystems. *Science*, 277(5325), 522–525.
- Oliveira-Filho, A.T., & Ratter, J.A. (1995). A study of the origin of central Brazilian forests by the analysis of plant species distribution patterns. *Edinburgh Journal of Botany*, 52(2), 141–94.
- Pande, P.K. (1999). Comparative vegetation analysis and sal (*Shorea robusta*) regeneration in relation to their disturbance magnitude in some sal forests. *Tropical Ecology*, 40(7), 51.
- Parthasarathy, N., & Karthikeyan, R. (1997). Plant biodiversity inventory and conservation of two tropical dry evergreen forests on the Coromandel Coast, South India. *Biodiversity and Conservation*, 6, 1063–1083.
- Parthasarathy, N., Kinhal, U., & Praveen Kumar, L. (1992). Plant species diversity and human impact in tropical wet evergreen forests of South Western Ghats. Indo French workshop on tropical forest system: Natural functioning and Anthropogenic impact, French Institute, Pondicherry, 165–176.
- Parthasarathy, N., & Sethi, P. (1997). Trees and liana species diversity and population structure in a tropical dry evergreen forest in south India. *Tropical Ecology*, 38(1), 19–30.
- Pascal, J. P. (1988). Wet evergreen forests of the Western Ghats of India: Ecology, structure, floristic composition and succession. French Institute of Pondicherry, Pondicherry.
- Pickett, S.T.A., & White, P.S. (1985). *The Ecology of Natural Disturbance and Patch dynamics*. Orlando (FL), Academic Press.
- Prasad Ram., & Pandey, R.K. (1992). An observation on plant diversity of Sal and teak forest in relation to intensity of biotic impact of various distances from habitation in Madhya Pradesh, A case study. *Journal of Tropical Forestry*, 8(1), 62–83.
- Putman, R.J. (1994). *Community Ecology*. Chapman & Hall, London.

- Rahman, M., Nishat, A., & Vacik, H. (2009). Anthropogenic disturbances and plant diversity of the Madhupur Sal forests (*Shorea robusta* CF Gaertn) of Bangladesh. *International Journal of Biodiversity and Management*, 5(3), 162–173.
- Rajendra Prasad, M. (1995). *The floristic, structural and functional analysis of sacred groves of Kerala*. Ph.D Thesis. TBGRI, Palode, Trivandrum.
- Rajendraprasad, M., Krishnan, P. N., & Pushpangadan, P. (1996). Floristic variations in the sacred groves of Kerala: A case study in five agro climatically divergent sacred groves. Natn. Sem. on Sacred Groves, Hyderabad.
- Ramachandran, K.K., & Mohanan, C.N. (1991). *Studies of Sacred Groves of Kerala*. Final Report submitted to Ministry of Environment and Forests, Government of India.
- Raunkiaer, (1934). *The Life Forms of Plants and Statistical Plant Geography*. Oxford University Press.
- Ripu, M. Kumar., & Shiv, P. Sharma. (2004). Quantitative analysis of tree species in two community Forests of Dolpa district, mid-west Nepal. *Himalayan Journal of Sciences*, 2(3), 23–28.
- Sagar, R. (2006). Tree density, basal area and species diversity in a disturbed dry tropical forest of northern India: Implications for conservation. *Environmental Conservation*, 33(3), 256–262.
- Sasidharan, N. (2011). Flowering Plants of Kerala.ver.2.0,KFRI, Peechi.
- Sasidharan, N.(2003). Red Listed Threatened Tree Species in Kerala: A Review. Ecologically Fragile Lands, KFRI, Peechi.
- Saxena, A. K., & Singh, J. S. (1982). A phytosociological analysis of woody species in forest communities of a part of Kumaun Himalaya; *Vegetatio*, 50, 3–32.
- Shannon, C. E., & Wiener, W. (1949). *The Mathematical Theory of Communication*. Urbana, University of Illinois Press, pp 177.
- Singh, L., Sharma, B., Agrawal, R., & Puri, S. (2005). Diversity and dominance of Sal dominated tropical moist deciduous forest in Achanakmar Wildlife Sanctuary. *Bulletin of the National Institute of Ecology*, 15, 1–9.
- Singh, S.P., Rawat, Y.S., & Garkoti, S.C. (1997). Failure of brown oak (*Quercus leucotrichophora*) to regenerate in Central Himalaya a case of environmental semisurprise. *Current Science*, 73, 371–374.
- Singh, S. P., & Singh, J. S. (1986). Structure and function of Central Himalayan oak forest; *Proc. Indian Academy of Sciences*, 96, 159–189.

- Slobodkin, L.B., & Sanders, H.L. (1969). On the contribution of environmental predictability to species diversity. *Brookhaven Symposia in Biology*, 22, 82–95.
- Sorenson, T. (1948). A method of establishing groups of equal amplitude in plant sociology based on similarity of species content and its application to analyses of the vegetation on Danish commons. *Kongelige Danske Videnskabernes Selskab, Biologiske Skrifter*, 5, 1–34.
- Sujana, K.A., & Sivaperuman, C. (2008). Preliminary studies on flora of Kole wetlands, Thrissur, Kerala. *Indian Forester*, 134(8), 1079–1086.
- Sundriyal, R., & Sharma, E. (1996). Anthropogenic pressure on tree structure and biomass in the temperate forest of Mamlay watershed in Sikkim. *Forest and Ecology Management*, 81, 113–134.
- The Plant List, (2013). Version 1. Published on the Internet; <http://www.theplantlist.org/> (accessed 1st January).
- Unnikrishnan, E. (1995). *Sacred Groves of North Kerala: An Eco-folklore Study*. Jeeva Rekha Publications, Thrissur, Kerala, pp. 229.
- Upadhaya, K., Pandey, H.N., Law, P.S., & Tripathi, R.S. (2003). Tree diversity in sacred groves of the Jaintia hills in Jaintia hills in Meghalaya, north east India. *Biodiversity and Conservation*, 12(3), 583–597.
- Vartak, V. D., Kumbhojkar, M. S., & Dabadghao, V. (1986). *Sacred groves – A sanctuary for lofty trees and Lianas*. Proc. Seminar on Eco-development of Western Ghats, 55–59.
- Verghese, A.O., & Menon, A.R.R. (1998). Vegetation characteristics of southern secondary moist mixed deciduous forests of Agasthyamalai region of Kerala. *Indian Journal of Forestry*, 21(4), 639–644.
- Visalakshi, K. (1995). Vegetation analysis of two tropical dry evergreen forests in South India. *Tropical ecology*, 36(1), 117–127.
- Werger, M.J.A. (1974). On concepts and techniques applied to Zurich-Montpellier method in vegetation analysis. *Bothalia*, 1 (3), 309–323.
- Whitmore, T. C. (1975). *Tropical Rain Forests of the Far East*. Clarendon Press, Oxford and London.
- Xiong, S., & Nilsson, C. (1999). The effects of plant litter on vegetation: a meta-analysis. *Journal of Ecology*, 87(6), 984–994.

CHAPTER- 4

Brief account of other plant groups or forms identified in the study areas

Introduction

The environmental conditions in sacred groves are favourable for the shelter and growth of diverse forms of plants besides the major forms of plants like trees, shrubs, herbs, climbers and lianas. The other major forms identified in the study include pteridophytes, bryophytes, lichen, macro fungi and algae. The favourable temperature, humidity, high litter fall and thick canopy are the major factors which favours the growth of these lower forms in the groves. During the wet periods, the high water content in the substrate, suitable temperature and occasional sunlight in the atmosphere are favourable for the growth of algae, macro fungi, bryophytes and pteridophytes in sacred groves. The rich leaf litter and decaying wood in the sacred groves provide the necessary substrate and developmental support for macro fungi, particularly the basidiomycetes. Abundant presence of lichen in the grove indicates the quality of the atmosphere because lichens need clean and fresh air to survive. Epiphytic plants and bryophytes attached to their host plants hold water, create a cooler environment in the host canopy and reducing water loss through transpiration. Sacred groves are also abode different types of epiphytes and parasites.

Review of Literature

In the past, numerous studies were carried out to determine the angiosperm plant diversity, but less focus was laid on the lower group or forms of plants. The pteridophytes are the earliest vascular plants which first colonised on land characterised by the absence of flower/seeds and have independent gametophytic generations. The earliest account of the plant wealth of Kerala is in van Rheede's (1678-1693) classical work *Hortus Indicus Malabaricus*, in which 15 Pteridophytes were illustrated and described (Madhusoodanan & Rajani, 1994). Kunze (1851), who recorded and described 82 ferns and 12 fern allies from the Nilgiris Hills and Beddome (1864) recorded 38 species from Kerala. Bryophytes, the amphibians of the plant kingdom growing preferably in aquatic and wet habitats are the second largest group of plants. Around 30,000 species of bryophytes are distributed world over, out of which around 4500 species are reported from India and about 700 species from Kerala (Manju, 2010). Manju et al. (2008) reported 465 species from whole of Kerala. This report is thus significant that only the Northern part of Kerala holds 333 species. Fungi constitute the third essential functional component after flora and fauna as decomposers, symbionts and pathogens representing highest global diversity between 1.5 and 3 million species (Hawksworth, 2012). The Macrofungi particularly mushrooms are representing up to 41,000 species, of which about 850 species are recorded from different parts of India especially in Himalayan and Western Ghat region (Manoharachary et al., 2006). Thirteen species of macro fungi belonging to Bolbitiaceae are reported Western Ghats of Kerala by Thomas et al. (2001). Natarajan et al. (2005) reported approximately 195 species of agarics have been reported from the Nilgiri Biosphere Reserve of Tamil Nadu and 28 species of agarics from Kerala region.

Lichens are a unique group of plants composed of a photobiont and a mycobiont associated in a symbiotic manner. They form one of the important constituents of the Indian flora. Recently, throughout the world, studies on lichens as bio-monitoring agents and bioindicators of environmental contamination have gained importance. Muktesh Kumar (2000) reported 254 species of macro lichens under 43 genera belonging to 18 families in the Western Ghats of Kerala part. Macrolichens constitute an important component in the flora of the tropical forest as they play varying role in the pioneer, transition and climax ecosystems.

Morphologically the thallus of lichens shows variation in its structure like crustose, squamulose, foliose and fruiticose forms. Epiphytes are ones which rely on other plants for mechanical support yet are not parasitic to their host, are a diverse group, representing approximately 9% of global vascular plant species (Zotz, 2013). The epiphytes constitute an important component in the ecology of the tropical forests due to their diverse habits and habitats. About 225 species of vascular epiphytes have been enumerated from the Tropical forests of Western Ghats of Kerala, among them 159 species belonging to 54 genera representing 12 families are angiosperms and 66 species belonging to 29 genera representing 12 families are pteridophytes (Kumar, 1998). Parasitic plants are angiospermic flowering plants that directly attaches to another plant via a haustorium- a specialized structure that forms a morphological and physiological link between the parasite and host (Yoshida et al., 2016). They can be classified based on where they attach to the host, the degree of nutritional dependence upon the host, or whether they require a host to complete their life cycle and in terms of location on the host, two basic types can be distinguished: stem parasites and root parasites (Nickrent et al., 2004).

Materials and Methods

The exploration and identification of plant groups or forms- epiphytes, parasites, pteridophytes, bryophytes, algae, lichen and macro fungi are carried out in all the selected sacred groves and disturbed non-sacred grove lands by visiting frequently in all the seasons during the period of June 2015 to June 2017. The details of plants identified such as scientific name (either genus level or both genus and species level), family, brief description and photograph are recorded.

Epiphytes and parasites: The identification of epiphytes and parasites are done with the help of the Flora of Presidency of madras (Gamble & Fischer, 1957), using field keys (Balasubramanyan et al., 1985) and other relevant Floras, Manuals, Revisions etc. The identifications were further confirmed by consulting experts.

Pteridophytes: The identification of pteridophytes are done with the help of standard floras, manuals, monographs and other literature available (Beddome, 1892; Blatter & Almeida, 1992; Manickam & Irudayaraj, 1992; Rajagopal & Bhat, 1998; Madhusoodanan & Nampy, 1998; Fraser-Jenkins, 2008). The experts were also consulted for the identification.

Bryophytes: The identification of bryophytes are done by scrapped out the plants from the substrate with the help of a sharp knife. Fresh, dried and preserved specimens are used for identification. Liverworts and mosses were kept in 70% alcohol or 4% formalin to preserve for further analysis and identification. The dried specimens are stored in brown paper packets of 5"x 4"(Manju, 2005). Before analysis dried specimens are soaked in cold water to regain its original shape. The external features of the specimens were studied using a stereo dissection microscope and the internal features studied using a compound microscope. The collected samples are identified by referring the relevant literature (Jan, 2013; Manju et al., 2008). The experts were also consulted for the identification.

Algae: Algal specimens are collected from ponds, soil, barks and leaves of trees from the study sites. Terrestrial algal specimens and specimens collected from surface water of ponds are preserved in 3% neutralized formaldehyde solution or Lugols iodine. Nikon Eclipse Ci-L Trinocular Phase contrast microscope is used for identification and photos. Identification of

microalgae using standard keys and books (Allen & Cupp, 1935; Philipose, 1967; Desikachary et al., 1987; Tomas, 1997; Bellinger & Sigee, 2015). The experts were also consulted for the identification.

Lichen: The identification of collected lichens are carried out by analysing the morphological and anatomical features and by performing microchemical colour tests. The data obtained are compared with the keys and descriptions available in the published floras and monographs of lichen genera (Awasthi, 1991). The experts were also consulted for the identification.

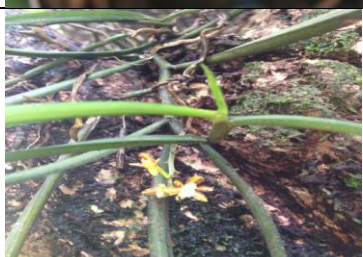
Morphological features were studied with the help of dissection binocular microscope. Anatomical features were studied by cutting thin dry sections using a cutting knife or a razor blade and mounted in 5% aqueous potassium hydroxide solution. Squash preparations were also used for observing the ascus and spores. All these anatomical details were observed under the standard compound microscope. The experts are also consulted for the identification. Pictures are taken using Labomed Luxeo 4D stereo zoom microscope.

Macro fungi: Total of 40 macro fungal samples are collected during the monsoon and winter seasons (June-September and December-early February, 2015- 2017). The tree-dwelling macro fungi are sampled by cutting off the basidiomata from the trees without disturbing the spore surfaces present below. All collected samples are carefully wrapped in aluminium foil, placed in an air tight zip lock bag separately and labelled (Valsan et al., 2015). Specimens are dried using oven at temperature of 40 - 45°C. Dried specimens are kept in refrigerator (Hosaka & Uno, 2011). Both fresh and dried specimens are used for the identification. The experts were consulted for the identification.

Results

The occurrence of other forms or groups of plants such as epiphyte, parasite, pteridophyte, bryophyte, algae, lichen and macro fungi identified in the selected sacred groves and disturbed non-sacred grove lands and the diversity in the representation of plants in each case with their scientific name, systematic position and short description are depicted in the following tables (table C1 to table C7)

Table C1: Epiphytes

Sl. No.	Scientific name & Systematic Position	Brief description	
1	<i>Acampe praemorsa</i> (Roxb.) Blatt. & McCann Class : Monocotyledonae Order : Asparagales Family: Orchidaceae * (PaSG, NaSG, PoySG)	Epiphyte with stout stem, vermiform roots from basal nodes, leaves distichous, sheathing at the base, inflorescence compact with numerous flowers, flowers thick, fleshy and creamy yellow with reddish-brown bands, capsule long & cylindrical.	
2	<i>Bulbophyllum sterile</i> (Lam.) Suresh Class : Monocotyledonae Order : Asparagales Family: Orchidaceae * (SaSG, PaSG)	Epiphyte with yellowish-green fleshy pseudo-bulb carrying a single, apical, sessile, erect, obtuse leaf, rhizome creeping, racemes lateral, sheathing at base, flowers brownish in colour.	
3	<i>Drynaria quercifolia</i> (L.) J. Sm. Class: Polypodiopsida Order: Polypodiales Family: Polypodiaceae * (SaSG, NaSG, PaSG, PoySG, DLSa, DLPa, DLNa)	Epiphyte with deeply pinnatifid fertile fronds and sterile nest fronds which look like oak leaf- known as oakleaf fern, sori are scattered or arranged in two regular rows.	
4	<i>Hoya ovalifolia</i> Wight & Arn. Class : Dicotyledonae Order : Gentianales Family: Asclepiadaceae * (SaSG)	Epiphyte with shortly pendulous stem, glabrous, terete, elliptic or rhomboid, apex acute or obtuse, base acute, margins undulate, flowers are axillary peduncled umbel, pedicels slender, corona lobes stellate, stigma head short and 4 apiculate.	
5	<i>Luisia tristis</i> (G.Forst.) Hook.f. Class : Monocotyledonae Order : Asparagales Family: Orchidaceae * (SaSG)	Erect, tufted epiphyte, leaves long, acute at apex, fleshy, sheathing at base, inflorescence condensed racemes, flowers greenish-yellow with purple tinge, petals similar to sepals, trilobed with dark maroon horizontal bands, fruits oblong.	

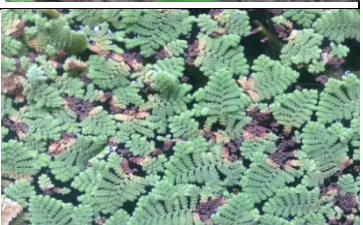
***mark and letters in parenthesis indicate occurrence of plant species in study areas**

SaSG- Sankulangara sacred grove, PaSG- Palliyana sacred grove, NaSG- Nambiyath sacred grove and PoySG- Poyyara sacred grove
DLSa- Disturbed land Sankulangara, DLPa- Disturbed land Palliyana, DLNa- Disturbed land Nambiyath and DLPoy- Disturbed land Poyyara

Table C2: Parasites

SL NO	Scientific name & Systematic Position	Brief description	
1	<i>Cuscuta chinensis</i> Lam. Class : Dicotyledonae Order : Solanales Family: Convolvulaceae * (SaSG, DLPa)	Stems yellow, thin, Inflorescences lateral, compact cymose glomerules, few to many flowered, subsessile; bracts and bracteoles scalelike ,corolla white,ovary subglobose,seeds pale brown, ovoid.	
2	<i>Dendrophthoe falcata</i> (L.f.) Ettingsh. Class : Dicotyledonae Order : Santalales Family: Loranthaceae * (NaSG, DLs, DLPa, DLpoy)	Stem woody, branches are swollen from the base,opposite leaves, inflorescence axillary and lateral, curved racemes,flower long, pinkish white,stamens protrude out of the flower, green style is slender and is longer than the stamens.	
3	<i>Helicanthes elastica</i> (Desr.) Danser Class : Dicotyledonae Order : Santalales Family: Loranthaceae * (NaSG, DLs, DLNa)	Dichotomously branched subshrubs, semi parasitic, branchlets woody, swollen at nodes and glabrous, leaves opposite, flowers aggregated in short axillary fascicles, corolla white with green stripes, stamens exserted, filaments crimson.	

Table C3: Pteridophytes

SL NO	Scientific name & Systematic Position	Brief description	
1	<i>Adiantum lunulatum</i> Burm. f. Class: Pteridopsida Order: Polypodiales Family: Pteridaceae * (SaSG, PaSG, NaSG, PoySG)	Commonly known as walking fern (maiden hair fern), black stipes with bright green delicately cut leaves, grows on humus rich, moist and shady places.	
2	<i>Azolla pinnata</i> R. Br. Class: Pteridopsida Order: Salviniales Family: Salviniaceae * (SaSG, PaSG, DLPa)	Commonly known as mosquito fern or water velvet, aquatic small fern, green or blue green in colour with a triangular frond which is floating on the surface of the water, grows in stagnant or slow moving water.	
3	<i>Christella dentata</i> (Forssk.) Brownsey & Jermy Class: Polypodiopsida Order: Polypodiales Family: Thelypteridaceae * (SaSG)	Commonly seen in the margins of rain forest, wide spread distribution, creeping short stem, leaves dimorphic evergreen, hairy scales, circular shaped sori present and plant used as medicinal.	

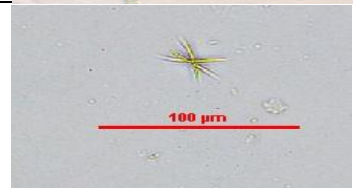
4	<i>Drynaria quercifolia</i> (L.) J. Sm. Class: Polypodiopsida Order: Polypodiales Family: Polypodiaceae * (SaSG, PaSG, PoySG, DLSa, DLPa, DLNa)	Commonly known as the oak leaf fern, epiphytic, plant with deeply pinnatifid fertile fronds and sterile nest fronds which look like oak leaf, sori are scattered or arranged in two regular rows.	
5	<i>Lycopodioides apoda</i> (L.) Kuntze Class: Isoetopsida Order: Selaginellales Family: Selaginellaceae * (SaSG, PaSG)	Commonly called as meadow spikemoss, creeping plant with dichotomous branching growing on wet fields. Stems have two rows of smaller leaves and two rows of larger leaves.	
6	<i>Marsilea quadrifolia</i> L. Class: Polypodiopsida Order: Salviniales Family: Marsileaceae * (DLSa)	Aquatic fern seen in shallow water, roots both at the nodes and internodes of the rhizome, petiole slender-glabrous, leaves look like a four-leaf clover, leaflets are triangular obovate, peduncles bearing the dark brown sporocarps-oval to elliptical in shape.	
7	<i>Nephrolepis cordifolia</i> (L.) Presl. Class: Pteridopsida Order: Polypodiales Family: Nephrolepidaceae * (NaSG)	Commonly known as the sword fern, fronds are upright at early stages then become pendulous or archy, numerous round sori are produced underside of the margins of the pinnae.	
8	<i>Phymatosorus scolopendria</i> (Burm. f.) Pic. Serm. Class: Polypodiopsida Order: Polypodiales Family: Polypodiaceae * (SaSG)	Commonly known as monarch fern, musk fern or wart fern, pinnately lobed leaves with deeply sunken sori on underside of the frond which look like warts on upperside of the frond.	
9	<i>Pteris vittata</i> L. Class: Pteridopsida Order: Polypodiales Family: Pteridaceae * (NaSG)	Commonly called as ladder brake, widespread, living on cracks and concrete structures, pinnae linear, shortly stalked and tapering at the apex, sori continuous and linear.	
10	<i>Salvinia adnata</i> Desv. Class: Polypodiopsida Order: Salviniales Family: Salviniaceae * (SaSG, DLSa, DLPa)	Aquatic, buoyant on the surface of water bodies, two pairs of fronds with a third root like frond which hangs into the water, grows as weed.	

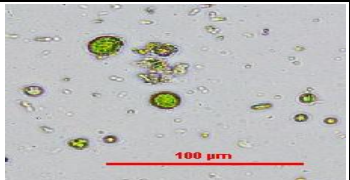
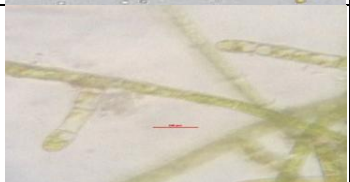
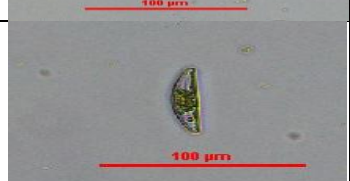
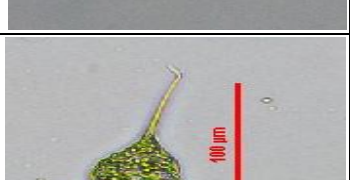
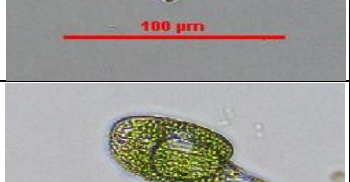
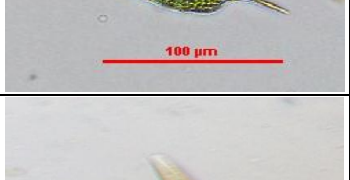
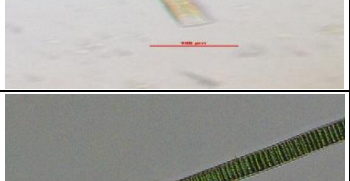
Table C4: Bryophytes

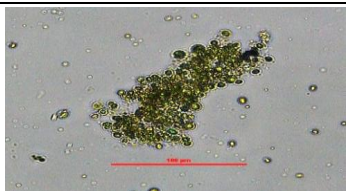
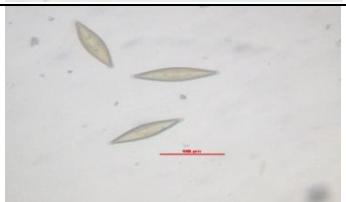
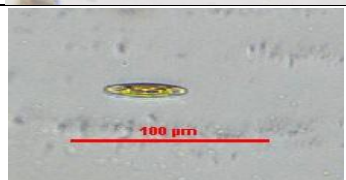
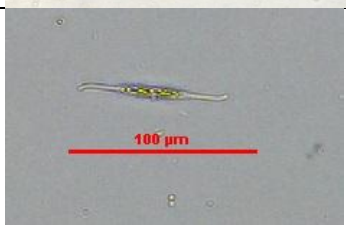
SL NO	Scientific name & Systematic Position	Brief description	
1	<i>Anthoceros</i> sp. Class:Anthocerotopsida Order:Anthocerotales Family:Anthocerotaceae * (SaSG)	Thallus green, dichotomous, scales simple, horn shaped sporophytes, seta absent.	
2	<i>Atrichum undulatum</i> (Hedw.) P. Beauv. Class:Polytrichopdida Order:Polytrichales Family:Polytrichaceae * (SaSG, NaSG, DLSa)	Green, upright small moss, growing on nutrient-poor soils. Sporophytes with shiny, cylindrical maroon capsules, growing in shades or gets partial sun exposures.	
3	<i>Bryum coronatum</i> Schwägr. Class: Bryopsida Order:Bryales Family:Bryaceae * (SaSG, PaSG, NaSG, PoySG, DLSa, DLPa, DLNa, DLPoy)	Plant is bright greenish, densely tufted tomentose at base, stem erect, leaves lanceolate, spreads in the presence of moisture, capsule cup shaped and pendulous with reddish peristome.	
4	<i>Bryum retusifolium</i> Cardot & P. de la Varde var.heterophyllum Cardot Class: Bryopsida Order:Bryales Family:Bryaceae * (SaSG)	Plants small, dense tuft yellowish green above and brown tomentose below, stems slender with subfloral innovations, leaves erect and dentate at apex.	
5	<i>Cyathodium cavernarum</i> Kunze Class:Marchantiopsida Order:Marchantiales Family:Targioniaceae * (SaSG, PaSG, PoySG)	Thallus flourescent green, delicate and thin, usually dichotomously branched, densely overlapping smooth rhizoids, pores present on the dorsal surface.	
6	<i>Entodon plicatus</i> Müll. Hal. Class: Bryopsida Order:Hypnales Family:Entodontaceae * (SaSG, PaSG, NaSG, DLSa, DLPa, DLPoy)	Plants are delicate and shiny, creeping, yellowish-green in colour with opposite branches which are irregularly to sub-pinnately branched, capsules erect and cylindrical.	
7	<i>Hyophila involuta</i> (Hook.) A. Jaeger Class: Bryopsida Order:Pottiales Family:Pottiaceae * (DLSa, DLPa, DLNa)	Commonly known as star moss or cement moss, lawn forming moss, upright stem with dense spirally arranged leaves, rosulate group of leaves on the shoot tip gives star like appearance.	
8	<i>Lejeunea cocoes</i> Mitt. Class:Jungermanniopsida Order:Jungermanniales Family:Lejeuneaceae * (DLSa, DLNa)	Delicate, pale green shoot, leaf apex rounded, broad ovate base and lobule sometimes reduced, growing on tree bark.	

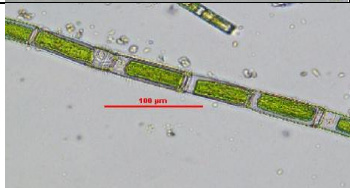
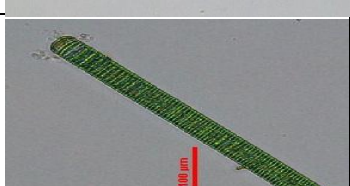
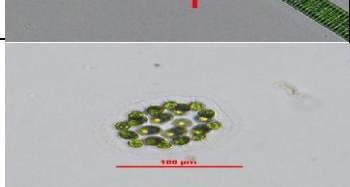
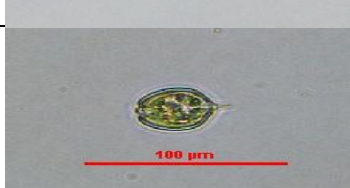
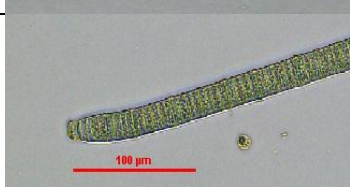
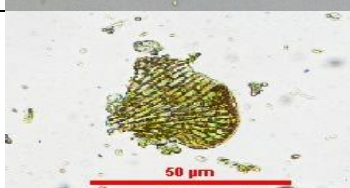
9	<i>Mastigolejeunea humilis</i> (Gottsche) Schiffner Class: Jungermanniopsida Order: Jungermanniales Family: Lejeuneaceae * (NaSG, PoySG)	Convolute leaves, elongate cells, cordate trigones, segmented oil bodies, gynoecia with 1–2 lejeunoid innovations, a non-articulate seta, entire and 3-keeled perianth.	
10	<i>Octoblepharum albidum</i> Hedw. Class: Bryopsida Order: Dicranales Family: Octoblepharaceae * (SaSG, PaSG, PoySG)	Whitish green plants, erect short stem with crowded leaves, seta straight and erect, capsule ovoid in shape.	
11	<i>Phaeoceros laevis</i> (L.) Prosk. Class: Anthocerotopsida Order: Anthocerotales Family: Anthocerotaceae * (PaSG)	Thallus flat dark green, horn shaped sporophytes, slender green capsules produced in large numbers.	
12	<i>Philonotis hastata</i> (Duby) Wijk & Margad. Class: Bryopsida Order: Bryales Family: Bartramiaceae * (SaSG)	Plants greenish, erect stem, spongy in appearance.	
13	<i>Riccia</i> sp. Class: Marchantiopsida Order: Marchantiales Family: Ricciaceae * (PaSG, NaSG)	The plant body is small, thallus with dichotomous branches and may form rosettes.	

Table C5: Algae

SL NO	Scientific Name & Systematic Position	Brief description	
1	<i>Anabaena</i> sp. Class: Hormogoneae Order: Nostocales Family: Nostocaceae * (DLPa)	Filamentous cyanobacteria, found as plankton, nitrogen fixing abilities, symbiotic relationships with other plants, produce neurotoxins.	
2	<i>Ankistrodesmus</i> sp. Class: Chlorophyceae Order: Sphaeropleales Family: Selenastraceae * (DLSa)	Unicellular or colonial chlorophyte, curved long needle like cells tapering at both ends, seen as individually or clustered, parietal chloroplasts have pyrenoids and cells lack mucilage.	

3	<i>Chlorella</i> sp. Class: Trebouxiophyceae Order: Chlorellales Family: Chlorellaceae * (SaSG, PoySG, DLNa, DLPoy)	Unicellular green algae, cup shaped chloroplast, numerous starch grains, flagella absent, asexual reproduction by non-motile reproductive cells, used as nutritional supplement.	
4	<i>Cladophora</i> sp. Class: Ulvophyceae Order: Cladophorales Family: Cladophoraceae * (DLPa)	Branched filamentous green algae, found in both fresh and marine waters, grows primarily on rocky substrates then detached and forming large, cell walls harder, foul-smelling.	
5	<i>Closterium ehrenbergii</i> Meneghini ex Ralfs Class: Zygnematophyceae Order: Desmidiaceae Family: Closteriaceae * (NaSG)	Unicellular, crescent-shaped with curved tapered ends, isogamous, charophycean, asexual reproduction by binary fission.	
6	<i>Cymbella</i> sp. Class: Bacillariophyceae Order: Cymbellales Family: Cybellaceae * (PaSG)	Unicellular, valves asymmetrical around apical axis and symmetrical to the transapical axis, mostly single H-shaped chloroplast, and a central pyrenoid located towards the dorsal margin.	
7	<i>Euglena</i> sp. Class: Euglenophyceae Order: Euglenales Family: Euglenaceae * (DLSa, DLPa)	Single celled, flagellate, found in fresh and salt waters, photosynthesizing Chloroplasts, autotrophic or heterotrophic.	
8	<i>Halamphora coffeaeformis</i> (Agardh) Levkov Class: Bacillariophyceae Order: Thalassiosiphales Family: Catenulaceae * (PaSG)	Valves are semi-lanceolate or semi-elliptical, dorsiventral, dorsal margin smooth and arched, ends are protracted, ventral margin slightly concave.	
9	<i>Lepocinclis</i> sp. Class: Euglenophyceae Order: Euglenales Family: Euglenaceae * (DLPa)	Freshwater swimming euglenoid with plastids, single emergent flagellum, rigid with longitudinal ridges, stigma is present.	
10	<i>Licmophora</i> sp. Class: Bacillariophyceae Order: Licmophorales Family: Licmophoraceae * (DLSa, DLPa)	Epiphytic diatom, found in low numbers in shallow or turbid environments, both marine and freshwater, triangular or Fan-shaped cells, grow on a common stalk that is attached to rocks.	
11	<i>Lyngbya</i> sp. Class: Cyanophyceae Order: Oscillatoriales Family: Oscillatoriaceae * (SaSG, PaSG, DLSa)	Unicellular, autotrophic cyanobacteria, unbranched filaments inside a rigid mucilaginous sheath, reproduce asexually by breaking filaments.	

12	<i>Microcystis</i> sp. Class: Cyanophyceae Order: Chroococcales Family: Microcystaceae * (DLPa)	Freshwater cyanobacteria, spherical shape, organized into colonies, thick mucilage around colonies, cause algal blooms.	
13	<i>Mougeotia</i> sp. Class: Zygnemophyceae Order: Zygnematales Family: Zygnemataceae * (PaSG)	Green alga, unbranched filaments, long cylindrical cells, cells with single chloroplast in the form of axial plate or ribbon with several pyrenoids, seen in slow flowing waters.	
14	<i>Navicula cinta</i> (Ehrenberg) Ralfs in Pritchard Class: Bacillariophyceae Order: Naviculales Family: Naviculaceae * (SaSG, DLPa)	Valves are linear-lanceolate, no protracted apices, axial area is narrow and widens gradually into the central area, raphe is filiform, straight with proximal ends.	
15	<i>Navicula gottlandica</i> Grunow Class: Bacillariophyceae Order: Naviculales Family: Naviculaceae * (DLPa)	Aquatic, single celled, eukaryotic, photosynthetic, produce oxygen, keystone species in the food chain of many environments.	
16	<i>Navicula microspora</i> Kant & Gupta Class: Bacillariophyceae Order: Naviculales Family: Naviculaceae * (DLPa)	Frustules elliptical lanceolate, rostrate apices, capitae, pseudoraphe at the centre, axial area broad, it is a keystone species in the food chain of many environments.	
17	<i>Navicula mutica</i> Kützinger Class: Bacillariophyceae Order: Naviculales Family: Naviculaceae * (SaSG, DLPa)	Frustules elliptical lanceolate, axial area broad, striation not visible in fresh material, keystone species in the food chain of many environments.	
18	<i>Navicula</i> sp. Class: Bacillariophyceae Order: Naviculales Family: Naviculaceae * (SaSG, PaSG)	Aquatic, eukaryotic, unicellular diatom photosynthetic, keystone species in aquatic food chain.	
19	<i>Nitzschia palea</i> (Kützinger) W. Smith Class: Bacillariophyceae Order: Bacillariales Family: Bacillariaceae * (SaSG, DLPa)	Cells solitary, frustules isopolar, bilaterally symmetrical, usually linear, poles shortly rostrate or subcapitate, central portion of the valve has parallel or very slightly convex, but never concave margins.	
20	<i>Nitzschia reversa</i> W. Smith Class: Bacillariophyceae Order: Bacillariales Family: Bacillariaceae * (SaSG, PaSG)	Aquatic, valves are spindle shaped, with parallel margins and abruptly tapering apices with the ends turned in opposite directions, fibulae are small.	

21	<i>Nitzschia sigma</i> (Kützting) W.Smith Class: Bacillariophyceae Order: Bacillariales Family: Bacillariaceae * (NaSG, DLPa)	Valves linear with the ends slightly curved in opposite directions, apices are capitated, and keel of the raphe is strongly excentric.	
22	<i>Nietzsche tabellaria</i> (Grunow) Grunow in Cleve & Grunow Class: Bacillariophyceae Order: Bacillariales Family: Bacillariaceae * (SaSG, PaSG, DLSa)	Valves are lanceolate and swollen at the centre with apices nearly capitated to round, fibulae of the raphe are distinct, elongate. Striae are distinctly punctate and radiate, central nodule is absent.	
23	<i>Nostoc</i> sp. Class: Nostocophyceae Order: Nostocales Family: Nostocaceae * (SaSG, NaSG, DLPa)	Filamentous cyanobacteria, colonies in gelatinous sheath, grow symbiotically in the tissues of plants, nitrogen fixing heterocysts.	
24	<i>Oedogonium</i> sp. Class: Chlorophyceae Order: Oedogoniales Family: Oedogoniaceae * (PaSG, NaSG, DLSa)	Unbranched filamentous free floating green algae, fresh water habitat, usually attached to aquatic plants by a holdfast.	
25	<i>Oscillatoria</i> sp. Class: Cyanophyceae Order: Oscillatoriales Family: Oscillatoriaceae * (SaSG, PaSG, NaSG, PoySG, DLSa, DLNa, DLPoy)	Dark blue green filamentous Cyanobacterium, cells are broader than long, vegetative reproduction by fragmentation and hormogonia, mature straight trichome.	
26	<i>Pandorina</i> sp. Class: Chlorophyceae Order: Volvocales Family: Volvocaceae * (SaSG, PaSG)	Green algae, composed of 8- 32 celled globular colony surrounded by mucilage, each ovoid cell has two flagella with two contractile vacuoles at their base, an eyespot, and a large cup shaped chloroplast with one pyrenoid.	
27	<i>Phacus</i> sp. Class: Euglenophyceae Order: Euglenales Family: Euglenaceae * (PaSG, NaSG, DLSa)	Unicellular, fresh water, green algae, flat, leaf shaped with rigid cytoskeleton-pellicle, many small discoid chloroplasts present, single flagellum.	
28	<i>Phormidium</i> sp. Class: Cyanophyceae Order: Oscillatoriales Family: Phormidiaceae * (PaSG, DLSa)	Unbranched filaments dark brown or green or blue-green algae, short cylindrical cells in a fine sheath, end cells often pointed or tapered with a calyptra on the terminal cell.	
29	<i>Phycopeltis</i> sp. Class: Ulvophyceae Order: Trentepohliales Family: Trentepohliaceae * (SaSG, PaSG, NaSG, PoySG)	Dichotomously branched filaments forming openly-branched to pseudoparenchymatously discoidal thalli, golden-brown, supracuticular epiphytes of leaves, fruits and stems of vascular plants.	

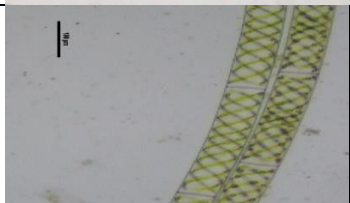
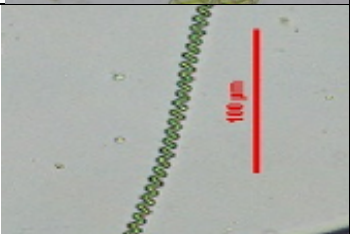
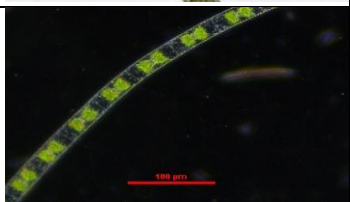
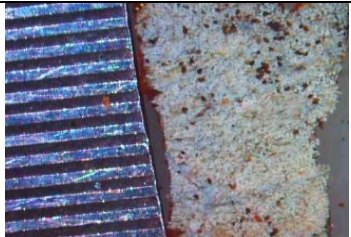
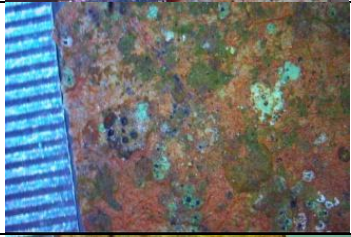
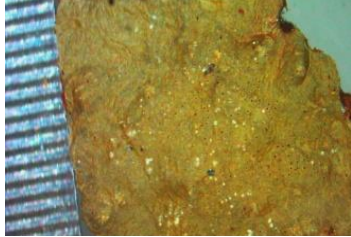
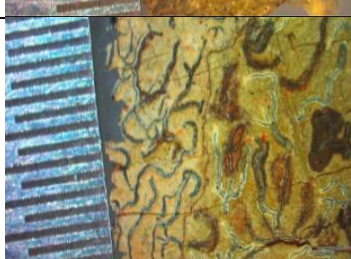
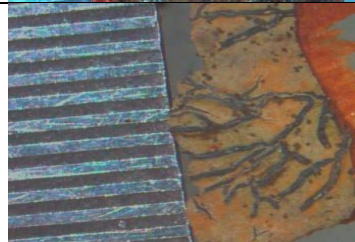
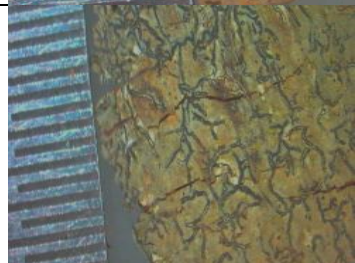
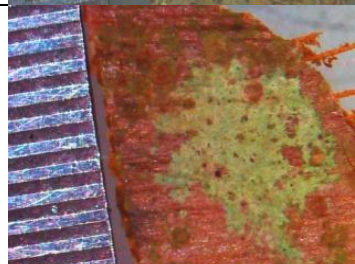
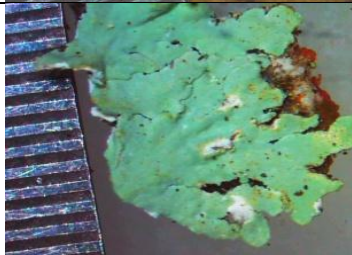
30	<i>Pithophora</i> sp. Class: Ulvophyceae Order: Cladophorales Family: Cladophoraceae * (SaSG)	Branched filamentous green algae, green to a dark greenish brown in colour, growing on the bottom or in dense mats on the surface of ponds.	
31	<i>Spirogyra</i> sp. Class: Zygnematophyceae Order: Zygnematales Family: Zygnemataceae * (SaSG)	Filamentous green algae, known as water silk or blanket weed, seen in freshwater, chloroplasts helical or spirally arranged.	
32	<i>Spirulina</i> sp. Class: Cyanophyceae Order: Spirulinales Family: Spirulinaceae * (PaSG)	Aquatic, helical form which is typically inhabiting freshwater, mesophilic and able to survive over a wide range of temperatures, used as a dietary supplement as well as a whole food.	
33	<i>Synedra acicularis</i> Kutz. Class: Bacillariophyceae Order: Fragilariales Family: Fragilariaceae * (PaSG, DLSa)	Cells rectangular, long and thin, attached by mucilage, two long plastids lying against the girdles and overlapping into the valve face.	
34	<i>Trentepohlia</i> sp. Class: Ulvophyceae Order: Trentepohliales Family: Trentepohliaceae * (SaSG, NaSG, PoySG, DLSa, DLPa, DLNa, DLPoy)	Filamentous green algae, living on tree trunks and wet rocks or symbiotically in lichens, presence of large quantities of carotenoid pigments which mask the green chlorophyll.	
35	<i>Ulothrix</i> sp. Class: Ulvophyceae Order: Ulotrichales Family: Ulotrichaceae * (SaSG)	Eukaryotic filamentous green algae, present in fresh and marine water, broader cells, attached to surfaces by holdfast cell for attachment to the surface.	
36	<i>Zygnema</i> sp. Class: Zygnematophyceae Order: Zygnematales Family: Zygnemataceae * (PaSG, NaSG)	Freshwater filamentous yellow-green coloured alga, free-floating, cells are elongate barrel shaped and each with two star-shaped chloroplasts.	

Table C6: Lichens

SL NO	Scientific Name & Systematic Position	Systematic Position	Brief description
1	<i>Arthothelium</i> sp. Class: Arthoniomycetes Order: Arthoniales Family: Arthoniaceae * (SaSG, PaSG, PoySG, DLSa)	Crustose, thallus is whitish or grey-brown, immersed in the substrate, often bordered by a brown line, apothecia irregularly rounded.	
2	<i>Byssoloma</i> sp. Class: Lecanoromycetes Order: Lecanorales Family: Pilocarpaceae * (SaSG, PaSG, PoySG)	Crustose, thallus pale greenish grey in colour and almost round shape, surface uneven, verrucose, prothallus absent, apothecia round in shape.	
3	<i>Cryptothecia</i> sp. Class: Arthoniomycetes Order: Arthoniales Family: Arthoniaceae * (SaSG, NaSG)	Crustose, thallus white to greenish in colour, grow on bark or leaves, conspicuous prothallus that develops around its periphery.	
4	<i>Dirinaria</i> sp. Class: Lecanoromycetes Order: Teloschistales Family: Physciaceae * (PaSG, DLSa, DLPa)	Foliose, thallus continuous, lobate, lobes irregular to radiating, upper surface white or grey-white colour, hypothecium brown, grow on bark or rocks.	
5	<i>Fissurina</i> sp. Class: Lecanoromycetes Order: Ostropales Family: Graphidaceae * (SaSG, PaSG, PoySG, DLPa)	Crustose, thallus looks like cracks with white ridges, without soralia or Pisidia, cortex well developed, consisting of periclinal hyphae, medulla often with large calcium oxalate crystals.	
6	<i>Graphis ajarekarii</i> Patw. & C.R. Kulk. Class: Lecanoromycetes Order: Ostropales Family: Graphidaceae * (SaSG, PaSG, PoyDSG, DLSa, DLPa)	Crustose, thallus continuous to slightly rugose and white-grey in colour with calcium oxalate crystals, cortex compact, slightly shiny exterior, apothecia raised from the thallus.	
7	<i>Graphis capillaceae</i> Stirt. Class: Lecanoromycetes Order: Ostropales Family: Graphidaceae * (SaSG, PaSG, NaSG, PoySG, DLSa, DLNa, DLPoy)	Crustose, exciple indistinctly closed, black, labia convergent, entire to crenate, partially covered by thalline margin, ascospores eight.	

8	<i>Graphis cincta</i> (Pers.) Aptroot Class: Lecanoromycetes Order: Ostropales Family: Graphidaceae * (SaSG, PaSG)	Crustose, white to pale grey thallus which is uneven often slightly cracked, without soralia or isidia, white medulla, often with large crystals, exciple carbonized, asci 1-8 spored.	
9	<i>Graphis japonica</i> (Müll. Arg.) A.W. Archer & Lückin Class: Lecanoromycetes Order: Ostropales Family: Graphidaceae * (SaSG, PaSG)	Crustose, thallus corticolous, continuous, bulging, shiny, grey green or yellowish green, ascomata lirelliform.	
10	<i>Graphis</i> sp. Class: Lecanoromycetes Order: Ostropales Family: Graphidaceae * (SaSG, NaSG, DLNa)	Crustose, thallus continuous to slightly rugose and white-grey in colour with calcium oxalate crystals, cortex compact, apothecia raised from the thallus.	
11	<i>Graphis subducta</i> Vain. Class: Lecanoromycetes Order: Ostropales Family: Graphidaceae * (SaSG, PaSG, NaSG, DLNa)	Crustose, corticolous, finely cracked, grayish, flaking, smooth to rough, hypothallus black, ascomata is lirelline, simple, curved and emergent.	
12	<i>Mazosia</i> sp. Class: Arthoniomycetes Order: Arthoniales Family: Roccellaceae * (SaSGK, PaSG, NaSG, PoySG)	Crustose, thallus grew as discrete and round patches.	
13	<i>Opegrapha</i> sp. Class: Arthoniomycetes Order: Arthoniales Family: Opegraphaceae * (PaSG, PoySG, DLSa, DLPoy)	Crustose, branched and anastomosing paraphysis, one asco spore with cylindrical lumina, distinct perispore.	
14	<i>Pertusaria</i> sp. Class: Lecanoromycetes Order: Pertusariales Family: Pertusariaceae * (SaSG, PaSG, NaSG)	Crustose, commonly known as wart lichen, apothecia immersed in warts on the thallus with tiny holes to emerge spores.	

15	<i>Phaeographis</i> sp. Class: Lecanoromycetes Order: Ostropales Family: Graphidaceae * (SaSG, PaSG, NaSG)	Crustose, thallus pale greyish white, corticolous, thin, surface slightly cracked, smooth and dull, apothecia is lirelliform, black, conspicuous, numerous.	
16	<i>Physcia</i> sp. Class: Lecanoromycetes Order: Teloschistales Family: Physciaceae * (SaSG, PaSG, NaSG, DLPa, DLNa, DLPoy)	Foliose, wide spread lichen, small grey lobes fringed with black or dark grey cilia, indicators of nitrogen enrichment.	
17	<i>Porina</i> sp. Class: Lecanoromycetes Order: Ostropales Family: Trichotheliaceae * (SaSG, PaSG, DLPa)	Crustose, thallus superficial or immersed, surrounded by prothallus, inconspicuous upper surface, whitish grey in colour, true exciple, ascospore eight.	
18	<i>Pyrenula</i> sp. Class: Eurotiomycetes Order: Pyrenulales Family: Pyrenulaceae * (SaSG, PaSG, DLPa)	Crustose, pale olive green or yellowish green, immersed thallus, clusters of perithecia present.	
19	<i>Pyxine cocoes</i> (Sw.) Nyl. Class: Lecanoromycetes Order: Teloschistales Family: Physciaceae * (DLSa, DLPa, DLNa, DLPoy)	Foliose, thallus firmly appressed, flat lobes, upper surface grey or white, soredia granular, apothecia cocoes type and laminal.	
20	<i>Strigula</i> sp. Class: Ascomycetes Order: Sphaeriales Family: Strigulaceae * (SaSG, NaSG, PoySG)	Crustose, occur as epiphylls, thallus immersed in the substrate, ascomata perithecial, globose, exciple dark, ascospores ellipsoid.	
21	<i>Tapellaria</i> sp. Class: Lecanoromycetes Order: Lecanorales Family: Ectolechiaceae * (SaSG, NaSG, DLSa)	Crustose, folicolous lichen, pale green, smooth thallus dispersed in patches, apothecia black and rounded.	

22	<i>Thelenella</i> sp. Class: Lecanoromycetes Order: Lecanorales Family: Thelenellaceae * (SaSG, PaSG, NaSG)	Crustose, thallus superficial to partially immersed, ascomata appearing as warts, brownish globose, ascospores muriform.	
23	<i>Trichothelium</i> sp. Class: Lecanoromycetes Order: Ostropales Family: Trichotheliaceae * (SaSG, PaSG, NaSG)	Crustose, well developed perithecia, silvery white, black crown of setae, ascospores 7 septate and bacillar.	

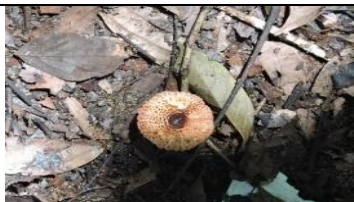
(Scale used- millimeter scale)

Table C7: Macro fungi

SL NO	Scientific Name	Brief description	
1	<i>Auricularia auricula-judae</i> (Bull.) J. Schrot. Class: Agaricomycetes Order: Auriculariales Family: Auriculariaceae * (NaSG)	It is commonly known as wood ear or jelly ear, wide spread, edible, jelly brownish fungus, grows upon on elder living and decaying logs.	
2	<i>Auricularia polytricha</i> (Mont.) Sacc. Class: Agaricomycetes Order: Auriculariales Family: Auriculariaceae * (PaSG, DLPa)	It is commonly known as cloud ear, wide spread, edible, jelly brownish fungus, growing on rotting branches and decaying logs.	
3	<i>Auriculocypha</i> sp. Class: Agaricomycetes Order: Auriculariales Family: Auriculariaceae * (DLSa)	It is a monotypic genus, in the order of auriculariales, gelatinous basidiocarps.	
4	<i>Calocera</i> sp. Class: Dacrymycetes Order: Dacrymycetales Family: Dacrymycetaceae * (SaSG)	Commonly called as the yellow stagshorn, bright orange or yellow coloured and gelatinous in texture, non-poisonous.	

5	<i>Calvatia craniiformis</i> (Schwein.) Fr.ex De Toni. Class: Agaricomycetes Order: Agaricales Family: Agaricaceae * (SaSG, PoySG)	Commonly known as brain puffball, edible, grows on ground, used in the traditional medicine.	
6	<i>Clitocybe infundibuliformis</i> Quel. Class: Agaricomycetes Order: Agaricales Family: Tricholomataceae * (SaSG, PoySG)	It is the common funnel mushroom, hardwood-loving, cap vase-shaped, gills run down to the stem, edible.	
7	<i>Collybia aurea</i> (Beeli) Pegler Class: Agaricomycetes Order: Agaricales Family: Tricholomataceae * (SaSG, PaSG, DLSa)	Fleshy agaric with small fruit body, cap is creamish-white, white gills, stipe brownish, edible.	
8	<i>Cookeina</i> sp. Class: Ascomycota Order: Pezizales Family: Sarcoscyphaceae * (NaSG)	It is a cup fungi, wide spread distribution, growing on fallen branches of trees.	
9	<i>Daldinia concentrica</i> (Bolton) Cesati&de Notaris Class: Sordariomycetes Order: Xylariales Family: Xylariaceae * (SaSG, PaSG)	Known as cramp balls or coal fungus, grows on dead and decaying wood, wild spread saprotroph.	
10	<i>Daldinia vernicosa</i> (Schw.) Ces. &De Not. Class: Sordariomycetes Order: Xylariales Family: Xylariaceae * (PaSG, NaSG)	Grows on dead and decaying wood but usually seen in burnt places, worldwide distribution.	
11	<i>Ganoderma applanatum</i> (Pers.) Pat. Class: Agaricomycetes Order: Polyporales Family: Ganodermataceae * (SaSG, PaSG, NaSG, PoySG)	Commonly known as bracket fungi, grows on living and dead trees, hard woody and inedible.	
12	<i>Ganoderma lucidum</i> (Curtis) P.Karst. Class: Agaricomycetes Order: Polyporales Family: Ganodermataceae * (SaSG, PaSG, NaSG, PoySG)	Lingzhi mushroom or reishi mushroom, it is hard and used in folklore medicine.	

13	<i>Geastrum saccatum</i> Fr. Class: Agaricomycetes Order: Geastrales Family: Geastraceae * (SaSG, DLSa, DLNa)	It is known as the rounded earthstar, worldwide distribution, growing on decaying wood. It is inedible.	
14	<i>Hexagonia tenuis</i> (Hook.)Fr. Class: Agaricomycetes Order: Polyporales Family: Polyporaceae * (SaSG)	Poroid fungi widespread distribution, it is inedible.	
15	<i>Lentinus polychrous</i> Lev. Class: Agaricomycetes Order: Polyporales Family: Polyporaceae * (SaSG)	Widely distributed, poroid fungi, edible.	
16	<i>Lenzites acuta</i> Berk. Class: Agaricomycetes Order: Polyporales Family: Polyporaceae * (SaSG, PaSG, NaSG, PoySG)	It grows as small groups or single, it has hard flesh, white to cream colour, forking gills.	
17	<i>Lycoperdon pyriforme</i> Schaeff. Class: Agaricomycetes Order: Agaricales Family: Agaricaceae * (SaSG, PaSG, NaSG, DLNa)	It is pear-shaped puffball or stump puffball, it is a saprobic fungus, living on decaying logs and edible.	
18	<i>Microporus xanthopus</i> (Fr.) Kuntze Class: Agaricomycetes Order: Polyporales Family: Polyporaceae * (SaSG, PaSG, NaSG, PoySG, DLSa, DLPa, DLPoy)	Widespread distribution, growing on fallen twigs, logs. It is funnel shaped paper thin polypore.	
19	<i>Mycena inclinata</i> (Fr.) Quel. Class: Agaricomycetes Order: Agaricales Family: Mycenaceae * (PaSG)	Commonly called as clustered bonnet, worldwide distribution, saprobic, inedible.	
20	<i>Phallus indusiatus</i> Vent. Class: Agaricomycetes Order: Phallales Family: Phallaceae * (PaSG, NaSG, DLPoy)	Commonly called the bamboo fungus veiled lady, worldwide distribution, grows in well-rotted wood rich soil, edible.	
21	<i>Pleurotus ostreatus</i> (Jacq.ex Fr.) P.Kumm. Class: Agaricomycetes Order: Agaricales Family: Pleurotaceae * (SaSG)	Commonly known as oyster mushroom, oyster-shaped cap, worldwide distribution, edible.	

22	<i>Polyporus arcularius</i> (Batsch) Fries. Class: Agaricomycetes Order: Polyporales Family: Polyporaceae * (SaSG, NaSG)	It is saprobic, inedible, solitary or in groups, growing on decaying wood.	
23	<i>Polyporus gramocephalus</i> Berk. Class: Agaricomycetes Order: Polyporales Family: Polyporaceae * (SaSG, NaSG, PoySG, DLSa, DLNa)	Grows on rotting wood, centrally-placed stipes and pores underside of the fruiting body.	
24	<i>Psilocybe sylvatica</i> (Peck.)Singer&A.H Sm. Class: Agaricomycetes Order: Agaricales Family: Strophariaceae * (SaSG, PaSG, NaSG)	It has world wide distribution, little brown mushroom, sharp conical cap, growing in groups on ground.	
25	<i>Ramariopsis kunzei</i> (Fr.) Corner. Class: Agaricomycetes Order: Agaricales Family: Clavariaceae * (SaSG)	Commonly known as white coral fungi, widely distributed, branched smooth fruit bodies on short stem, edible.	
26	<i>Rigidoporus lineatus</i> (Pers.) Ryvar den. Class: Agaricomycetes Order: Polyporales Family: Meripilaceae * (SaSG)	It is a widespread fungi, growing in groups and pathogenic.	
27	<i>Russula fragilis</i> (Pers.)Fr. Class: Agaricomycetes Order: Russulales Family: Russulaceae * (SaSG)	It is commonly known as fragile brittle gill. It is an ectomycorrhizal mushroom and inedible.	
28	<i>Termitomyces clypeatus</i> R.Heim. Class: Agaricomycetes Order: Agaricales Family: Lyophyllaceae * (SaSG, PaSG, DLSa)	It is grows on termites excreta with woody fragments, edible.	
29	<i>Termitomyces microcarpus</i> (Berk&Broome) R.Heim. Class: Agaricomycetes Order: Agaricales Family: Lyophyllaceae * (NaSG)	World wide distribution, grows in groups, seen near the roots of bamboo plants, edible.	

30	<i>Termitomyces striatus</i> (Beeli.)R.Heim. Class: Agaricomycetes Order: Agaricales Family: Lyophyllaceae * (SaSG)	It has a greyish brown cap and grows on termites excreta with woody fragments, edible.	
31	<i>Trametes versicolor</i> (L.)Lloyd. Class: Agaricomycetes Order: Polyporales Family: Polyporaceae * (SaSG)	Commonly known as turkey tail, worldwide distribution, the flesh has leathery texture.	
32	<i>Tremella fuciformis</i> Berk. Class: Tremellomycetes Order: Tremellales Family: Tremellaceae * (PaSG, PoySG)	It is commonly known as snow fungus or white jelly mushroom, frond-like, white gelatinous basidiocarps, wide spread, edible, growing on dead branches of trees.	
33	<i>Xylaria hypoxylon</i> (L.)Grev. Class: Sordariomycetes Order: Xylariales Family: Xylariaceae * (SaSG, PoySG, DLSa, DLPa)	Commonly known as candle stick or candle snuff fungus. The fruit bodies are erect, elongated and black, grow in clusters on rotting hardwood.	
34	<i>Xylaria polymorpha</i> (Pers.) Grev. Class: Sordariomycetes Order: Xylariales Family: Xylariaceae * (SaSG, PaSG, DLPa, DLPoy)	Commonly known as dead man's fingers, cosmopolitan distribution, saprobic, growing on the bases of rotting wood, inedible.	

***mark and letters in parenthesis indicate occurrence of plant species in study areas**

SaSG- Sankulangara sacred grove, PaSG- Palliyana sacred grove, NaSG- Nambiyath sacred grove and PoySG- Poyyara sacred grove

DLSa- Disturbed land Sankulangara, DLPa- Disturbed land Palliyana, DLNa- Disturbed land Nambiyath and DLPoy- Disturbed land Poyyara

Discussion

The plant groups or forms such as epiphytes, parasites, pteridophytes, bryophytes, lichens, algae and macro fungi considered for the study have found their occurrence in both sacred groves and disturbed non-sacred grove lands. However, considerable differences in plant members and their distribution in each group or form found recorded in selected sacred groves and disturbed lands. The differences include the representation of a particular plant species or their absence either in one or more sacred groves or in one or more disturbed non-sacred grove lands or both. Overall 109 plant species in sacred groves and 59 plant species in non-sacred grove lands recorded inclusive of all the plant group's epiphytes, parasites, pteridophytes, bryophytes, lichens, algae and macro fungi. The highest proportion of 30.28% (33 species) of total plant species in sacred groves occupied by the plant group macro fungi and this followed immediately by 23.85% algae (26 species), 20.18% lichens (22 species), 10.09% bryophytes (11 species), 8.26% pteridophytes (9 species), 4.59% epiphytes (5 species) and the lowest proportion of 2.75% (3 species) occupied by parasites. However in the non-sacred grove lands, the highest proportion occupied by the plant group algae (38.98% - 23 species), followed immediately by 22.03% lichens (12 species), 18.64% macro fungi (11 species), 8.47% bryophytes (5 species), 6.78% pteridophytes (4 species), 5.08% parasites (3 species) and the lowest proportion of 1.69% (1 species) occupied by epiphytes.

Overall 45 plant species recorded as common plant species which include epiphytes, parasites, pteridophytes, bryophytes, lichens, algae and macro fungi among the selected groves and non-sacred grove lands. The similarity index (SI index) analysis revealed an overall 53.57% similarity. The highest SI value recorded by parasites (100%), followed by lichens (68.57%), macro fungi (58.82%), algae (54.17%), pteridophytes (46.15%), bryophytes (37.5%) and the lowest value recorded by epiphytes (33.33%).

Conclusion

The study revealed considerable degradation have occurred in the diversity and distribution of most of the lower forms of plants such as pteridophytes, bryophytes, lichens and macro fungi in the selected disturbed non-sacred grove lands, compared to sacred groves. The lack of restrictions to human interventions in the non-sacred grove regions leading to severe damage to natural vegetation particularly tree population is the major reason. Many tree members of natural existence are essential for providing favourable habitat and environment for the development and establishment of many lower forms of plants and microbes of ecological significance.

References

- Allen, W. E., & Cup, E. F. (1935). Plankton diatoms of the Java Seas. *Annales du Jardin botanique de Buitenzorg*, 44(2), 101–174.
- Balasubramanyan, K., Swarupanandan, K., & Sasidharan, N. (1985). A field key to the Identification of Indigenous Arborescent species of Kerala Forests. Research reports, No.33, KFRI. Peechi.
- Beddome, R. H. (1864). *The Ferns of Southern India*. pp. 271.
- Beddome, R. H. (1892). *Supplement to the Ferns of British India, Ceylon, and Malay Peninsula*. Thacker Spink and Co, Calcutta (Reprint ed. 1976). Today and tomorrow's Printers, New Delhi.
- Bellinger, E. G., & Sigee, D. C. (2015). *Fresh water Algae Identification, Enumeration and use as Bioindicators*. Second Edition, John Wiley and Sons Ltd, West Sussex, UK, 1–275.
- Blatter, E., & d'Almeida, J. F. R. (1922). *The Ferns of Bombay*. D.B. Taroporevala Sons and Co, Bombay, Fort, 190.
- Desikachary, T. V., Gowtham, S., & Latha, Y. (1987). *Diatom Flora of Some Sediments from the India*. Ocean region Fasc.II, Madras Science Foundation, Madras.
- Fraser-Jenkins, C. R. (2008). *Taxonomic Revision of Three Hundred Indian sub continental Pteridophytes with a Revised Census-list - A new picture of fern-taxonomy and nomenclature in the Indian subcontinent*. 1–685, t. 1–255. Bishen Singh Mahendra Pal Singh, Dehra Dun, India.
- Gamble, J. S., & Fischer, C. E. C. (1957). *Flora of the Presidency of Madras*. Vols.1–3. Botanical Survey of India, Calcutta.
- Hawksworth, D. L. (2012). Global species numbers of fungi: Are tropical studies and molecular approaches contributing to a more robust estimate? *Biodiversity and Conservation*, 21(9), 2425–2433.

- Hosaka, K., & Uno, K. (2011). Assessment of the DNA quality in mushroom specimens: effect of drying temperature. *Bulletin of the National Museum of Nature and Science*, 37(3), 101–111.
- Jan Peter Frahm. (2013). *Mosses and liverworts of Western Ghats, India - A picture book*. Archieve for Bryology, special volume No.14, 2nd.revised ed. ISSN 9045–3466.
- Kumar, M. & S. Sequiera. (1998). Diversity, systematics, distribution and taxonomy of epiphytic Pteridophytes of Kerala part of Western Ghats, South India. *Indian fern Journal*, 15(1-2), 106–130.
- Kunze, G. (1851). *Die Farrankrauter von Schkuhra Farrukrauter*. suppl, 2: 1-98, t.101-140. 1848–1851.
- Madhusoodanan, P. V., & Nampy, S. (1998). Biodiversity of the ferns and fern allies of Kerala. *Journal of Economic and Taxonomic Botany*, 22(1), 183–189.
- Madhusoodanan P.V. & Rajani, A. (1994). Reinvestigation of the present status of the ferns and fern allies of Hortus Malabaricus. *Indian Fern Journal*, 11, 12–19.
- Manickam, V. S., & Irudayaraj, V. (1992). *Pteridophytic Flora of the Western Ghats, South India*, BI Publication Pvt. Ltd, New Delhi.
- Manju, C. Nair. (2005). *Eco-systematic studies on Bryophytes of Wayanad, Kerala*. Thesis. Department of Botany, University of Calicut, 2005.
- Manju, C. Nair. (2010). Systematic studies on Bryophytes of Northern Western Ghats in Kerala. Council order no. (T) 155/WSC/2010/KSCSTE, Malabar Botanical Garden Kozhikode, Kerala, India.
- Manju, C. N., Rajesh, K. P., & Madhusoodanan, P. V. (2008). *Checklist of the Bryophytes of Kerala*. India.Tropical Bryology Reserch Reports, 7, 1–24.
- Manoharachary, C., Sridhar, K. R., Singh, R., Adholeya, A., Suryanarayanan, T. S., Rawat, S. and Johri, B. N. (2006). Fungal biodiversity: Distribution, conservation and prospecting of fungi from India. *Current Science*, 89(1), 58–71.
- Muktesh Kumar, M.S. (2000). *Lichen (macrolichen) Flora of Kerala part of Western Ghats*. KFRI Research Report 194, Kerala Forest Research Institute, Peechi, Thrissur.

- Natarajan, K., Narayanan, K., Ravindran, C. & Kumaresan, V. (2005). Biodiversity of agarics from Nilgiri Biosphere Reserve, Western Ghats, India. *Current Science*, 88(12), 1890–1893.
- Nickrent, D. L. & Musselman, L. J. (2004). Introduction to parasitic flowering plants. *The Plant Health Instructor*. DOI: 10.1094/PHI-I-2004-0330-01
- Philipose, M.T. (1967). *Chlorococcales*. Indian Council of Agricultural Research.
- Rajagopal, P. K., & Bhat, K. G. (1998). Pteridophytic flora of Karnataka state, India. *Indian Fern Journal*. 15, 1–28.
- Thomas, K. A., Hausknecht, A. and Manimohan, P. (2001). Balbitiaceae of Kerala State, India: New species and new and noteworthy records. *Österreichische Zeitschrift für Pilzkunde*, 10, 87–114.
- Tomas. (1997). *Identifying Marine diatoms and Dinoflagellates*. Academic Press, New York, 1–886.
- Valsan, A. E., Priyamvada, H., Ravikrishna, R., Despre's, V. R., Biju, C.V., Sahu, L. K. (2015). Morphological characteristics of bioaerosols from contrasting locations in southern tropical India- A case study. *Atmospheric Environment*, 122(1), 321–31.
- Yoshida, S., Cui, S., Ichihashi, Y., and Shirasu, K. (2016). The haustorium, a specialized invasive organ in parasitic plants. *Annual Review of Plant Biology*, 67(1), 643–667.
- Zotz, G. (2013). The systematic distribution of vascular epiphytes - a critical update. *Botanical Journal of the Linnean Society*, 171(3), 453–481.

CHAPTER- 5

Regeneration pattern of trees in sacred groves and disturbed non-sacred grove lands

Introduction

The richness, health and sustainability of natural forest mainly depend on the diversity, distribution and regeneration pattern of trees than any other plant groups in the ecosystem. However, during the course of time, different man made disturbances and activities like over exploitation of forest resources particularly for timber and the deforestation practices for various developmental activities have resulted in the degradation of majority of the forest area. Be the forest area large or small as patches, trees form the major structural and functional basis in maintaining the ecosystem balance in the area and they can serve as indicators of changes and disturbance pressures affecting landscape (Jayakumar & Nair, 2013). Evaluating the regeneration pattern of trees, their diversity and distribution in the area would be useful in understanding the stability and richness of vegetation. This study was undertaken to assess the regeneration status of trees in view of degree of protection and disturbance in the selected sacred groves and non-sacred grove lands to predict what would be the status of tree species composition in future and why it should be so.

Review of Literature

The impact of different environmental pressures and other disturbances on characteristics, germination, growths and population dynamics of seeds in the innate forest vegetation of India has been studied by many researchers (Saxena & Singh, 1984). A satisfactory regeneration characteristics of trees is implied upon in a vegetation if its population structure has the presence of adequate number of seedlings, saplings along with further growth stages, whereas a lower number of the same point towards poor regeneration status (Nazir et al., 2013). A prediction on the future composition of tree species can be done based on the ratio of seedling, sapling and mature plants of tree species existing at present. A forest is said to be sustainable and healthy when the plant species particularly trees has proper regeneration which in turn depends on anthropogenic interferences and the process in the internal community (Barker & Patrick, 1994). Khan et al. (1986, 1987) reported that the interaction between the biotic and abiotic factors are playing very important role in the regeneration process of tree species. A possibility of change in the composition of tree species in an ecosystem in future is noticed where there is wide variation between the existing the adult and new regenerating species and similarly in cases where there are large number of adult trees but with no regeneration while reappearance of other tree species (Devi & Shwetha, 2015).

A characteristic that typically marks the tropical forests is its tendency of having a decreased density with an increased GBH value which result in a reversed J- shaped curve. This feature is indicative of a sustainable regeneration and such similar curves are observed in the evergreen, dry and deciduous forests of Chittoor, Andhra Pradesh (Rao et al., 2011) as well as in the Swer grove of Meghalaya (Mishra, 2004). Induchoodan in 1998 and Uma Shankar in 2001 have reported that the evaluation of regeneration of the tree species can be done with reference to the different growth stages and density of various species of trees in the area.

According to Chauhan et al. (2010), the adult density of a species is unaccountable for its regenerative ability. This implies that the relation that the seedling density shares with the adult density is not linear. A reverse J-shape curve in the regeneration pattern of tree species in a forest ecosystem denotes sustainability. This trend of the curve means the highest count

for seedlings (class I) and the lowest count for adult trees (class IV). Reverse J-shape regeneration pattern have been reported by Prasad & Nageeb in 2012 in the eight Dipterocarp forests along the Western Ghats of Karnataka. A similar J-shaped curve has also been reported in the reserve and disturbed groves of Kodagu (Boraiah et al., 2003).

The germination as well as existence of seedlings are dependent on the characteristics and the Micro-environment of local canopy (Khan et al., 1986). According to the observation of Welden et al. in 1991, the process of regeneration is affected by various environmental factors like fire and light, density of canopy, moisture and nutrients of soil and anthropogenic activities like grazing. Seedling density ranging from 11.36 to 18.74 seedlings/100 m² and sapling density ranging from 8.84 to 15.2 saplings/100 m² recorded in the Garhwal Himalaya sacred grove suggest that the reduced opening of canopy and minimum formation of canopy gap has led to decreased density of seedling and sapling (Nazir et al., 2013). Nagamtsu et al. (2002) observed that the openness of a canopy influences the rate of survival of the seedlings. The reason for the presence of trees only in the adult stage with considerably low representation of seedling and sapling in the Manipur sacred grove may be due to scarcity in seed set and germination and their poor survival (Nagamtsu et al., 2002). The lower light penetration in a forest ecosystem due to a close canopy may be the reason for reduced number of seedling and sapling (Devi & Shwetha, 2016). It is generally observed that in community forest, the population of tree sapling is poor even in the presence of higher number of seedlings and this can be due the buffalo and cattle trampling which indicate further degradation of the forest in the future (Kuba & Khan, 1998). Canopy opening in forest ecosystem due to the removal of over story trees result in more penetration of sunlight in to the ground area favouring increased surface temperature and decreased competition for light, both contributing to better germination and establishment of seedling (Oliver, 1981; Tripathi & Khan, 1992; Barik et al., 1996; Rao et al., 1997).

Materials and Methods

Regeneration studies of trees in sacred groves and adjacent disturbed non-sacred grove lands are carried out based on the method followed by Induchoodan (1998) and Uma Shankar (2001) with some modifications. All the selected study areas are divided into approximately four equal divisions and all the tree species having girth at breast height (GBH) less than 10 cm in each division are considered for the study. The regeneration status of each tree species is analysed through enumeration and their classification according to the height growth stage as follows

1. Seedling stage

Tree growth height class 1 - less than 20 cm in height

Tree growth height class 2 - 20 to 40 cm in height

2. Sapling stage

Tree growth height class 3 - 41 to 100 cm in height

Tree growth height class 4 - greater than 100 cm in height

The height growth class 1 and 2 are considered as early seedling stage and late seedling stage respectively while height growth class 3 and 4 are considered as early sapling stage and late sapling stage respectively. Regeneration studies are carried out during the period of years 2015-2016.

Results

A) Sankulangara sacred grove and disturbed non-sacred grove land

The data on regeneration pattern of different tree species in the Sankulangara sacred grove is shown in the table D1. The tree species like *Aphanamixis polystachya*, *Cinnamomum malabathrum*, *Hopea ponga*, *Vateria indica*, *Artocarpus hirsutus*, *Hydnocarpus pentandrus*, *Mimusops elengi*, *Olea dioica*, *Persea macrantha*, *Caryota urens*, *Holigarna arnottiana*, *Tabernaemontana alternifolia*, *Quassia indica* and *Vitex altissima* exhibited normal conventional regeneration pattern. In these species, the representation of tree in early seedling growth stage is comparatively higher and progressive reduction in regenerate density towards the late sapling growth stage. The tree species such as *Adenanthera pavonina*, *Aporosa cardiosperma*, *Areca catechu*, *Carallia branchiata*, *Garcinia gummi-gutta*, *Litsea coriaceae*, *Pinanga dicksonii* and *Sterculia guttata* showed irregular regeneration pattern. In these cases, the tree species representation is not following either an ascending or descending order in the regenerate density from first to last height growth class. Instead, it is observed that the pattern is not consistently increasing or decreasing. Another regeneration pattern observed in the study is incomplete or discontinuous regeneration pattern. This includes representation of tree either in seedling stage or in the sapling stage or both but lack of representation in one or more height growth class. The tree species found belonging to such category include *Pouteria campechiana* (upto 20cm height class-seedling stage), *Ficus amplissima*, *Ficus benghalensis*, *Ficus drupaceae*, *Saraca asoca*, *Syzygium hemisphericum* & *Terminalia catappa* (upto 40cm height classes -seedling stage), *Chrysophyllum cainito* & *Syzygium lanceolatum* (above 40cm-100cm height growth class-sapling stage) and *Xanthophyllum arnottianum* (above 100cm height growth class-sapling stage). Besides all these, the trees such as *Ficus religiosa*, *Strychnos nux-vomica*, *Terminalia bellirica* and *Vitex pinnata* showed no regeneration, not even a single seedling represented in any of the height growth classes considered for the study.

Table D1: Regeneration pattern of trees in Sankulangara sacred grove

SI NO	NAME OF SPECIES	FAMILY	TREE GROWTH CLASSES				
			Seedling stage		Sapling stage		Adult trees
			<20cm	20-40 cm	41-100 cm	>100 cm <10cm GBH	>10cm GBH
1	<i>Adenanthera pavonina</i>	Leguminosae	3	4	3	3	3
2	<i>Aphanamixis polystachya</i>	Meliaceae	28	12	8	6	12
3	<i>Aporosa cardiosperma</i>	Euphorbiaceae	9	8	7	9	16
4	<i>Areca catechu</i>	Arecaceae	3	4	3	3	4
5	<i>Artocarpus hirsutus</i>	Moraceae	72	42	24	21	30
6	<i>Carallia branchiata</i>	Rhizophoraceae	3	4	2	3	3
7	<i>Caryota urens</i>	Arecaceae	43	22	8	6	32
8	<i>Chrysophyllum cainito</i>	Sapotaceae	0	0	2	4	4
9	<i>Cinnamomum malabattrum</i>	Lauraceae	18	9	8	4	14
10	<i>Ficus amplissima</i>	Moraceae	8	3	0	0	11
11	<i>Ficus benghalensis</i>	Moraceae	12	4	0	0	1
12	<i>Ficus drupaceae</i>	Moraceae	5	3	0	0	4
13	<i>Ficus religiosa</i>	Moraceae	0	0	0	0	1
14	<i>Garcinia gummi-gutta</i>	Clusiaceae	6	6	7	5	9
15	<i>Holigarna arnottiana</i>	Anacardiaceae	26	19	11	9	14
16	<i>Hopea ponga</i>	Dipterocarpaceae	93	50	38	31	101
17	<i>Hydnocarpus pentandrus</i>	Flacourtiaceae	40	29	18	13	24
18	<i>Litsea coriacea</i>	Lauraceae	3	2	4	2	5
19	<i>Mimusops elengi</i>	Sapotaceae	28	21	13	11	12
20	<i>Olea dioica</i>	Oleaceae	25	17	7	3	19
21	<i>Persea macrantha</i>	Lauraceae	22	9	8	2	6
22	<i>Pinanga dicksonii</i>	Arecaceae	9	5	5	8	9
23	<i>Pouteria campechiana</i>	Sapotaceae	16	0	0	0	1
24	<i>Quassia indica</i>	Simaroubaceae	34	20	7	5	27
25	<i>Saraca asoca</i>	Leguminosae	3	1	0	0	2
26	<i>Sterculia guttata</i>	Sterculiaceae	6	5	2	5	4
27	<i>Strychnos nux-vomica</i>	Loganiaceae	0	0	0	0	1
28	<i>Syzygium hemisphericum</i>	Myrtaceae	6	2	0	0	2
29	<i>Syzygium lanceolatum</i>	Myrtaceae	0	0	2	6	4
30	<i>Tabernaemontana alternifolia</i>	Apocynaceae	22	11	6	3	12
31	<i>Terminalia bellirica</i>	Combretaceae	0	0	0	0	1
32	<i>Terminalia catappa</i>	Combretaceae	10	3	0	0	1
33	<i>Vateria indica</i>	Dipterocarpaceae	42	35	20	18	31
34	<i>Vitex altissima</i>	verbenaceae	21	18	8	4	8
35	<i>Vitex pinnata</i>	Verbenaceae	0	0	0	0	2
36	<i>Xanthophyllum arnottianum</i>	Polygalaceae	0	0	0	4	17
Total (Height class wise)			616	368	221	188	447

The result of the tree regeneration study conducted in the disturbed non-sacred grove land at S.N.Puram is shown in the table D2. The regeneration pattern exhibited by majority of the tree members is mostly incomplete in nature. Tree species like *Briedelia retusa*, *Carallia branchiata* (40cm-100cm), *Ailanthus triphysa*, *Anacardium occidentale*, *Artocarpus heterophyllus*, *Cinnamomum verum*, *Garcinia gummi-gutta*, *Mangifera indica*, *Terminalia catappa*, *Vitex altissima* (40cm-above 100cm), *Areca catechu*, *Swietenia macrophylla*, *Tectona grandis* (above 100cm) are belonging to this kind of regeneration pattern. *Tabernaemontana alternifolia* is the only tree species which exhibited the normal regeneration pattern. Tree species like *Artocarpus hirsutus* and *Hydnocarpus pentandrus*

exhibit complete but irregular regeneration pattern. The tree species *Cocos nucifera* and *Annona squamosa* showed no regeneration.

Table D2: Regeneration pattern of trees in the disturbed non-sacred grove land

SI NO	NAME OF SPECIES	FAMILY	TREE GROWTH CLASSES				
			Seedling stage		Sapling stage		Adult trees
			<20cm	20-40 cm	41-100 Cm	>100 cm <10cm GBH	>10cm GBH
1	<i>Ailanthus triphysa</i>	Simaroubaceae	0	0	1	1	2
2	<i>Anacardium occidentale</i>	Anacardiaceae	0	0	2	2	2
3	<i>Annona squamosa</i>	Annonaceae	0	0	0	0	1
4	<i>Areca catechu</i>	Arecaceae	0	0	0	2	13
5	<i>Artocarpus heterophyllus</i>	Moraceae	0	0	3	2	2
6	<i>Artocarpus hirsutus</i>	Moraceae	2	3	1	2	2
7	<i>Briedelia retusa</i>	Euphorbiaceae	0	0	2	0	1
8	<i>Carallia branchiata</i>	Rhizophoraceae	0	0	1	0	1
9	<i>Cinnamomum verum</i>	Lauraceae	0	0	1	4	2
10	<i>Cocos nucifera</i>	Arecaceae	0	0	0	0	16
11	<i>Garcinia gummi-gutta</i>	Clusiaceae	0	0	1	2	2
12	<i>Hydnocarpus pentandrus</i>	Flacourtiaceae	9	4	4	7	3
13	<i>Mangifera indica</i>	Anacardiaceae	0	0	1	2	1
14	<i>Swietenia macrophylla</i>	Meliaceae	0	0	0	1	1
15	<i>Tabernaemontana alternifolia</i>	Apocynaceae	12	9	5	2	5
16	<i>Tectona grandis</i>	Verbenaceae	0	0	0	2	1
17	<i>Terminalia catappa</i>	Combretaceae	0	0	1	3	1
18	<i>Vitex altissima</i>	Verbenaceae	0	0	2	2	1
Total (Height class wise)			23	16	25	34	57

B) Palliyana sacred grove and disturbed non-sacred grove land

The details of regeneration pattern of tree species in the Palliyana sacred grove is given in the table D3. The tree species like *Aphanamixis polystachya*, *Artocarpus hirsutus*, *Cinnamomum malabattrum*, *Hydnocarpus pentandrus*, *Holigarna arnottiana*, *Persea macrantha*, *Pongamia pinnata*, *Vitex altissima*, *Caryota urens*, *Mimusops elengi*, *Olea diocia*, *Sterculia guttata*, *Tabernaemontana alternifolia* and *Quassia indica* exhibited normal regeneration pattern. The data indicates large number of tree species such as *Adenanthera pavonina*, *Aporosa cardiosperma*, *Areca catechu*, *Anacardium occidentale*, *Briedelia retusa*, *Diospyros malabarica*, *Garcinia gummi-gutta*, *Streblus asper*, *Litsea coriacea*, *Syzygium cumini* and *Vateria indica* exhibited irregular order in the regeneration pattern. The incomplete regeneration pattern is exhibited by tree species like *Alstonia scholaris*, *Ficus benghalensis*, *Saraca asoca* (upto 40cm height), *Strychnos nux-vomica*, *Syzygium caryophyllatum*, *Xanthophyllum arnottianum* (40cm-above 100cm height) and *Polyalthia longifolia* (upto 100cm height) *Chrysophyllum cainito* (21cm-above 100cm height). The tree species *Ficus religiosa* and *Terminalia bellirica* showed no representation of seedling in any of the height growth classes (no regeneration).

Table D3: Regeneration pattern of trees in Palliyana sacred grove

SI NO	NAME OF SPECIES	FAMILY	TREE GROWTH CLASSES				
			Seedling stage		Sapling stage		Adult trees
			<20cm	20-40 cm	41-100 cm	>100 cm <10cm GBH	>10cm GBH
1	<i>Adenanthera pavonina</i>	Leguminosae	6	3	5	3	8
2	<i>Alstonia scholaris</i>	Apocynaceae	9	1	0	0	1
3	<i>Anacardium occidentale</i>	Anacardiaceae	2	3	1	4	7
4	<i>Aphanamixis polystachya</i>	Meliaceae	28	13	9	3	22
5	<i>Aporosa cardiosperma</i>	Euphorbiaceae	5	1	4	3	10
6	<i>Areca catechu</i>	Arecaceae	4	2	3	2	9
7	<i>Artocarpus hirsutus</i>	Moraceae	34	15	8	7	23
8	<i>Briedelia retusa</i>	Euphorbiaceae	3	1	3	2	4
9	<i>Caryota urens</i>	Arecaceae	26	11	6	3	13
10	<i>Chrysophyllum cainito</i>	Sapotaceae	0	2	8	12	10
11	<i>Cinnamomum malabattrum</i>	Lauraceae	17	12	4	3	15
12	<i>Diospyros malabarica</i>	Ebenaceae	4	6	3	5	2
13	<i>Ficus benghalensis</i>	Moraceae	3	1	0	0	1
14	<i>Ficus religiosa</i>	Moraceae	0	0	0	0	1
15	<i>Garcinia gummi-gutta</i>	Clusiaceae	7	3	5	9	12
16	<i>Holigarna arnottiana</i>	Anacardiaceae	32	18	9	5	20
17	<i>Hydnocarpus pentandrus</i>	Flacourtiaceae	28	17	11	8	20
18	<i>Litsea coriacea</i>	Lauraceae	3	7	3	4	12
19	<i>Mimusops elengi</i>	Sapotaceae	28	9	5	4	13
20	<i>Olea diocia</i>	Oleaceae	18	14	8	4	10
21	<i>Persea macrantha</i>	Lauraceae	25	15	9	5	16
22	<i>Polyalthia longifolia</i>	Annonaceae	9	5	1	0	3
23	<i>Pongamia pinnata</i>	Leguminosae	17	11	7	3	19
24	<i>Quassia indica</i>	Simaroubaceae	31	13	9	7	14
25	<i>Saraca asoca</i>	Leguminosae	5	1	0	0	1
26	<i>Sterculia guttata</i>	Sterculiaceae	15	12	8	5	19
27	<i>Streblus asper</i>	Moraceae	5	7	4	6	4
28	<i>Strychnos nux-vomica</i>	Loganiaceae	0	0	0	2	3
29	<i>Syzygium caryophyllatum</i>	Myrtaceae	0	0	1	3	5
30	<i>Syzygium cumini</i>	Myrtaceae	9	2	5	3	11
31	<i>Tabernaemontana alternifolia</i>	Apocynaceae	10	6	5	2	4
32	<i>Terminalia bellirica</i>	Combretaceae	0	0	0	0	2
33	<i>Vateria indica</i>	Dipterocarpaceae	9	3	5	4	3
34	<i>Vitex altissima</i>	Verbenaceae	27	11	7	5	16
35	<i>Xanthophyllum arnottianum</i>	Polygalaceae	0	0	1	2	8
Total (Height class wise)			419	225	157	128	341

The tree regeneration study conducted in the disturbed land at Palliyana site showed *Gliricidia sepium* and *Garcinia gummi-gutta* are the two tree species which exhibited a normal pattern of regeneration (table D4). The tree species *Anacardium occidentale*, *Artocarpus hirsutus* and *Lannea coromandelica* followed irregular order in the regeneration pattern. The majority of the tree species in the disturbed land exhibited incomplete or discontinuous regeneration pattern. This includes *Terminalia catappa*, *Vitex altissima* (40cm-above 100cm), *Mangifera indica* (upto 20cm and above 100cm), *Cocos nucifera*, *Areca catechu*, *Azadirachta indica* (above 100cm). Representation of tree species in any of the height growth classes is not recorded by *Tectona grandis*.

Table D4: Regeneration pattern of trees in the disturbed non-sacred grove land

SI NO	NAME OF SPECIES	FAMILY	TREE GROWTH CLASSES				
			Seedling stage		Sapling stage		Adult trees
			<20cm	20-40 cm	41-100 cm	>100 cm <10cm GBH	>10cm GBH
1	<i>Anacardium occidentale</i>	Anacardiaceae	4	2	1	3	2
2	<i>Areca catechu</i>	Arecaceae	0	0	0	3	13
3	<i>Artocarpus hirsutus</i>	Moraceae	5	1	2	6	2
4	<i>Azadirachta indica</i>	Meliaceae	0	0	0	2	3
5	<i>Cocos nucifera</i>	Arecaceae	0	0	0	7	14
6	<i>Garcinia gummi-gutta</i>	Clusiaceae	9	5	3	2	2
7	<i>Gliricidia sepium</i>	Leguminosae	15	7	3	2	4
8	<i>Lannea coromandelica</i>	Anacardiaceae	7	1	3	4	2
9	<i>Mangifera indica</i>	Anacardiaceae	1	0	0	3	1
10	<i>Tectona grandis</i>	Verbenaceae	0	0	0	0	1
11	<i>Terminalia catappa</i>	Combretaceae	0	0	5	2	1
12	<i>Vitex altissima</i>	verbenaceae	0	0	3	2	1
Total (Height class wise)			41	16	20	36	46

C) Nambiyath sacred grove and disturbed non-sacred grove land

The regeneration pattern of tree species in the Nambiyath sacred grove is given in the table D5. The tree species *Quassia indica*, *Holigarna arnottiana*, *Vitex altissima*, *Mimusops elengi*, *Aphanamixis polystachya*, *Caryota urens*, *Cinnamomum malabattrum*, *Hydnocarpus pentandrus*, *Pterygota alata*, *Artocarpus hirsutus*, and *Tabernaemontana alternifolia* exhibited a normal pattern of regeneration. The tree species such as *Adenanthera pavonina*, *Carallia branchiata*, *Diospyros malabarica*, *Garcinia gummi-gutta*, *Lannea coromandelica*, *Pinanga dicksonii*, *Polyalthia longifolia*, *Sterculia balanghas*, *Syzygium cumini* and *Trema orientalis* exhibited irregular order in the regeneration pattern. The incomplete regeneration pattern is exhibited by tree species *Alstonia scholaris*, *Chrysophyllum cainito*, *Ficus benghalensis*, *Ficus amplissima*, *Plumeria rubra*, *Saraca asoca* (upto 40cm height), *Anacardium occidentale* (20cm – above 100cm height). The tree species *Strychnos nux-vomica* and *Terminalia bellirica* showed no regeneration.

Table D5: Regeneration pattern of trees in Nambiyath sacred grove

SI NO	NAME OF SPECIES	FAMILY	TREE GROWTH CLASSES				
			Seedling stage		Sapling stage		Adult trees
			<20cm	20-40 cm	41-100 cm	>100 cm <10cm GBH	>10cm GBH
1	<i>Adenanthera pavonina</i>	Leguminosae	8	4	2	5	4
2	<i>Alstonia scholaris</i>	Apocynaceae	8	3	0	0	1
3	<i>Anacardium occidentale</i>	Anacardiaceae	0	2	1	3	4
4	<i>Aphanamixis polystachya</i>	Meliaceae	13	9	7	4	7
5	<i>Artocarpus hirsutus</i>	Moraceae	15	12	8	6	23
6	<i>Carallia branchiata</i>	Rhizophoraceae	7	2	4	3	2
7	<i>Caryota urens</i>	Arecaceae	8	7	3	1	3
8	<i>Chrysophyllum cainito</i>	Sapotaceae	0	0	5	3	8

9	<i>Cinnamomum malabattrum</i>	Lauraceae	11	9	5	3	7
10	<i>Diospyros malabarica</i>	Ebenaceae	2	1	2	3	5
11	<i>Ficus amplissima</i>	Moraceae	3	1	0	0	4
12	<i>Ficus benghalensis</i>	Moraceae	5	1	0	0	1
13	<i>Garcinia gummi-gutta</i>	Clusiaceae	2	6	6	4	3
14	<i>Holigarna arnottiana</i>	Anacardiaceae	19	13	8	5	7
15	<i>Hydnocarpus pentandrus</i>	Flacourtiaceae	11	10	5	4	14
16	<i>Lannea coromandelica</i>	Anacardiaceae	5	2	3	2	5
17	<i>Mimusops elengi</i>	Sapotaceae	16	11	6	4	5
18	<i>Pinanga dicksonii</i>	Arecaceae	2	5	3	6	6
19	<i>Plumeria rubra</i>	Apocynaceae	7	2	0	0	1
20	<i>Polyalthia longifolia</i>	Annonaceae	4	7	1	4	4
31	<i>Pterygota alata</i>	Sterculiaceae	21	12	7	5	15
22	<i>Quassia indica</i>	Simaroubaceae	19	11	9	7	14
23	<i>Saraca asoca</i>	Leguminosae	3	1	0	0	2
24	<i>Sterculia balanghas</i>	Sterculiaceae	3	1	3	7	2
25	<i>Strychnos nux-vomica</i>	Loganiaceae	0	0	0	0	3
26	<i>Syzygium cumini</i>	Myrtaceae	3	1	1	2	2
27	<i>Tabernaemontana alternifolia</i>	Apocynaceae	12	9	7	4	9
28	<i>Terminalia bellirica</i>	Combretaceae	0	0	0	0	2
29	<i>Trema orientalis</i>	Ulmaceae	13	4	8	3	9
30	<i>Vitex altissima</i>	Verbenaceae	11	10	4	2	6
Total (Height class wise)			231	156	108	90	178

The selected disturbed land at Nambiyath site showed, none of the tree species exhibited normal regeneration pattern. The majority of the tree species followed incomplete or discontinuous regeneration pattern (table D6). This includes representation of trees upto 40cm height growth classes (*Acacia mangium* and *Quassia indica*), representation from 40cm - above 100cm (*Mangifera indica* and *Vitex altissima*) and representation of trees above 100cm height (*Dalbergia latifolia*). *Cocos nucifera*, *Areca catechu* and *Tectona grandis* showed no regeneration. However, tree species such as *Artocarpus hirsutus*, *Anacardium occidentale* and *Trema orientalis* showed representation in all the height growth classes but exhibited irregular regeneration pattern.

Table D6: Regeneration pattern of trees in the disturbed non-sacred grove land

SI NO	NAME OF SPECIES	FAMILY	TREE GROWTH CLASSES				
			Seedling stage		Sapling stage		Adult trees
			<20cm	20-40 cm	41-100 Cm	>100 cm	>10cm GBH
1	<i>Acacia mangium</i>	Leguminosae	4	2	0	0	1
2	<i>Anacardium occidentale</i>	Anacardiaceae	2	1	3	4	3
3	<i>Areca catechu</i>	Arecaceae	0	0	0	0	2
4	<i>Artocarpus hirsutus</i>	Moraceae	1	4	2	6	2
5	<i>Cocos nucifera</i>	Arecaceae	0	0	0	0	4
6	<i>Dalbergia latifolia</i>	Leguminosae	0	0	0	2	1
7	<i>Mangifera indica</i>	Anacardiaceae	0	0	3	5	3
8	<i>Quassia indica</i>	Simaroubaceae	6	1	0	0	1
9	<i>Tectona grandis</i>	Verbenaceae	0	0	0	0	1
10	<i>Trema orientalis</i>	Ulmaceae	5	2	3	3	2
11	<i>Vitex altissima</i>	Verbenaceae	0	0	1	5	2
Total (Height class wise)			18	10	12	25	22

D) Poyyara sacred grove and disturbed non-sacred grove land

The details of tree regeneration pattern in the Poyyara sacred grove is shown in the table D7. The tree species like *Aphanamixis polystachya*, *Caryota urens*, *Vitex altissima*, *Pterygota alata*, *Holigarna arnottiana*, *Hydnocarpus pentandrus*, *Mimusops elengi*, *Quassia indica* and *Tabernaemontana alternifolia* exhibited normal pattern of regeneration while tree species *Adenanthera pavonina*, *Garcinia gummi-gutta*, *Sterculia balanghas* and *Syzygium cumini* showed irregular regeneration pattern. The incomplete regeneration pattern is represented by *Alstonia scholaris*, *Ficus amplissima*, *Pongamia pinnata* (upto 40cm height growth), *Aegle marmelos*, and *Hopea ponga* (above 40cm height growth). The tree species that have no representation in any of the height growth classes include *Ficus benghalensis* and *Terminalia bellirica*.

Table D7: Regeneration pattern of trees in Poyyara sacred grove

SI NO	NAME OF SPECIES	FAMILY	TREE GROWTH CLASSES				
			Seedling stage		Sapling stage		Adult trees
			<20cm	20-40 cm	41-100 cm	>100 cm <10cm GBH	>10cm GBH
1	<i>Adenanthera pavonina</i>	Leguminosae	6	4	5	3	4
2	<i>Aegle marmelos</i>	Rutaceae	0	0	2	1	1
3	<i>Alstonia scholaris</i>	Apocynaceae	5	1	0	0	1
4	<i>Aphanamixis polystachya</i>	Meliaceae	11	9	4	3	5
5	<i>Caryota urens</i>	Arecaceae	17	11	4	3	5
6	<i>Ficus amplissima</i>	Moraceae	1	2	0	0	3
7	<i>Ficus benghalensis</i>	Moraceae	0	0	0	0	1
8	<i>Garcinia gummi-gutta</i>	Clusiaceae	11	4	4	5	3
9	<i>Holigarna arnottiana</i>	Anacardiaceae	12	7	3	2	3
10	<i>Hopea ponga</i>	Dipterocarpaceae	0	0	1	3	1
11	<i>Hydnocarpus pentandrus</i>	Flacourtiaceae	16	11	7	3	4
12	<i>Mimusops elengi</i>	Sapotaceae	18	9	3	2	2
13	<i>Pongamia pinnata</i>	Leguminosae	13	3	0	0	1
14	<i>Pterygota alata</i>	Sterculiaceae	11	6	5	2	4
15	<i>Quassia indica</i>	Simaroubaceae	9	7	2	1	3
16	<i>Sterculia balanghas</i>	Sterculiaceae	12	2	8	3	5
17	<i>Syzygium cumini</i>	Myrtaceae	5	2	3	6	3
18	<i>Tabernaemontana alternifolia</i>	Apocynaceae	10	5	3	2	4
19	<i>Terminalia bellirica</i>	Combretaceae	0	0	0	0	1
20	<i>Vitex altissima</i>	Verbenaceae	14	13	5	3	6
Total (Height class wise)			171	96	59	42	60

The regeneration pattern of tree species in the disturbed land at Poyyara showed no tree species in the area exhibited normal regeneration pattern (table D8). *Trema orientalis* is the only tree species which succeeded to represent regeneration in all the height growth classes considered for the study but it is irregular regeneration pattern. The tree species *Anacardium occidentale* and *Areca catechu* exhibited incomplete or discontinuous regeneration pattern where, lack of representation of seedlings in 20cm-40cm height growth class with respect to *Anacardium occidentale* while upto 40cm height growth classes with respect to *Areca*

catechu is noticed. *Cocos nucifera* showed not even a single regenerate representation in any of the height classes (no regeneration).

Table D8: Regeneration pattern of trees in the disturbed non-sacred grove land

SI NO	NAME OF SPECIES	FAMILY	TREE GROWTH CLASSES				
			Seedling stage		Sapling stage		Adult trees
			<20cm	20-40 cm	41-100 cm	>100 cm	>10cm GBH
1	<i>Anacardium occidentale</i>	Anacardiaceae	2	0	2	3	1
2	<i>Areca catechu</i>	Arecaceae	0	0	0	2	3
3	<i>Cocos nucifera</i>	Arecaceae	0	0	0	0	2
4	<i>Trema orientalis</i>	Ulmaceae	9	3	1	6	3
Total (Height class wise)			11	3	4	13	9

Discussion

The tree species having higher regenerate density in the initial height growth class and then progressively decreasing towards higher height growth classes are considered as good, sustainable and normal regeneration pattern of trees (Rao et al., 2011). Considerable number of tree species in all the selected sacred groves is found to have normal regeneration pattern. The highest number of 14 tree species each recorded normal regeneration pattern in both Sankulangara and Palliyana sacred grove, followed by 11 tree species in Nambiyath grove and the lowest number of 9 tree species are recorded in Poyyara sacred grove. This accounted for a proportion of 38.89%, 40%, 36.67% and 45% out of total number of tree species represented respectively in Sankulangara, Palliyana, Nambiyath and Poyyara sacred groves. This clearly revealed that the proportion of tree species having normal regeneration pattern is not following a direct relationship with the size of the grove area. However, the number of tree species with normal regeneration pattern is found to have some what gradual increase with increase in size of the groves. These tree species with normal regeneration pattern are also found to have more or less dominating position in the grove area. All these facts are justified by the phytosociological data like diversity, relative frequency and relative density of adult trees (Chapter 3). Chauhan et al. (2008 & 2010) opined that, there is no linear relationship between seedling density and adult density of a species and the regeneration of a species does not account for its adult density in an area. However, the inference obtained from the present investigation revealed; there exist linear relationship between the densities of adult trees species with its regenerate density. The present investigation is of the opinion that, this observation may not be true for those tree species which exhibited linear relationship between adult density and regenerate density in the past but facing disturbances in the regeneration process during the recent years. The common tree species which are found to follow sustainable and normal regeneration pattern in all the selected sacred groves in the study include *Aphanamixis polystachya*, *Caryota urens*, *Holigarna arnottiana*, *Hydnocarpus pentandrus*, *Mimusops elengi*, *Quassia indica*, *Tabernaemontana alternifolia* and *Vitex altissima*. The better adaptability of these tree species in the present microclimatic conditions of the groves may be the reason for their normal regeneration pattern and dominance.

Another major pattern observed in the grove area is irregular but fairly good regeneration pattern. In this case, the regenerate density recorded by the tree species is not following either

ascending or descending order but showed more or less similar density of regeneration in various height growth classes. Although, the phytosociological data of many such species in the study are found not supporting to consider them as dominant tree species, their trend in regeneration pattern indicates the present ecological conditions of the groves is favorable for better regeneration of these species and hence they may become dominant tree species of the groves in the future. The irregular regeneration pattern was recorded by 8 tree species in Sankulangara sacred grove, 11 tree species in Palliyana, 10 tree species in Nambiyath and 4 tree species in Poyyara sacred grove. This is accounted for a proportion of 22.22%, 31.43%, 33.33% and 20% of the total number of tree species represented respectively in Sankulangara, Palliyana, Nambiyath and Poyyara sacred groves. The tree species which are found common and exhibiting irregular regeneration pattern in all the selected sacred groves include *Adenanthera pavonina* and *Garcinia gummi-gutta*.

The incomplete or discontinuous regeneration pattern of trees recorded in the study can be attributed to some internal community process or due to some exogenic disturbances in the groves which disturb or block the establishment and survival of tree regenerates at seedlings or saplings stage (Barker & Patrick, 1994). The absence of sapling representation in certain tree species, in spite of number of seedlings representation, may be attributed to grazing and trampling by buffaloes and other cattle. Similarly, the absence of seedling representation in certain tree species, in spite of number of saplings representation, may be attributed to the thick canopy cover developed in the grove area in the recent years, which block the falling of sunlight on the ground which is essential for certain kind of seeds to get germinated or essential for certain seedlings to survive. Further, competition among regenerates of different tree species and anthropogenic activities such as selective harvesting of seedling or saplings of certain tree species by the local people in the area can also accelerate these problems. This kind of disturbances may cause gradual disappearance of certain tree species in the area. The incomplete regeneration pattern was exhibited by 10 tree species in Sankulangara sacred grove, 8 tree species each in Palliyana and Nambiyath and 5 tree species in Poyyara grove. This accounts for a proportion of 27.78%, 22.86%, 23.33% and 25% of the total tree species represented respectively in Sankulangara, Palliyana, Nambiyath and Poyyara groves. Besides the incomplete regeneration pattern, total absence of tree regenerate representation was recorded by certain tree species. This situation can be attributed to the phytotoxic effects of certain plant species recently established in the grove and can also be attributed to the thick litter cover over the soil surface of the grove, which prevents seed germination or

establishment of seedlings of certain tree species. Tree species *Ficus religiosa*, *Strychnos nux-vomica*, *Terminalia bellirica* and *Vitex pinnata* in Sankulangara sacred grove; *Ficus religiosa* and *Terminalia bellirica* in Palliyana; *Strychnos nux-vomica* and *Terminalia bellirica* in Nambiyath and *Ficus benghalensis* and *Terminalia bellirica* in Poyyara sacred grove are seen to have not recorded tree regenerates in any of the height growth classes. This accounted for a proportion of 11.11%, 5.71%, 6.67% and 10% of the total tree species representation respectively in Sankulangara, Palliyana, Nambiyath and Poyyara sacred groves.

The overall observation done in the regeneration status of trees in the investigation revealed, majority of the tree species in all the selected sacred groves, irrespective of the size, are following good (normal and complete) or fairly good (irregular but complete) regeneration pattern. About 61.11% of total tree species in Sankulangara, 71.43% in Palliyana, 70% in Nambiyath and 65% tree species in Poyyara sacred grove are following these patterns of regeneration. In all the selected sacred groves, significantly higher regenerate density is recorded in the seedling stage, particularly in the height growth class up to 20cm and found progressively decreasing towards the sapling stage above 100cm height growth. This kind of decrease in the regenerate density with increasing GBH or height growth classes are resulting in a reverse J-shaped curve which is an indication of sustainable regeneration and typical characteristic of tropical forests ecosystem (Devi & Shwetha, 2016). Similar observations have also been reported by other workers in this field. This includes, the reverse J shaped curve in the regeneration pattern of Swer sacred grove in Meghalaya (Mishra, 2004) and evergreen dry deciduous forests of Chittoor in Andhra Pradesh (Rao et al., 2011). Based on these observations and reports it can be said that the ecological balance in the studied groves are still more or less stable due to comparatively low human interferences and existence of better microclimatic conditions. The study believes, the present tree species composition in selected groves shall remain almost same in the near future also and the vegetation will be mostly dominated by those tree species following good or fairly good regeneration pattern at present. However, at the same time the study further expects gradual but certain possible change in the tree species composition in long term future. This is because about 28.58% to 38.89% of the tree species in the groves include tree species with no regenerates and incomplete regeneration status (Devi & Shwetha, 2015).

The analysis of regeneration pattern of tree species in the selected disturbed non-sacred grove lands revealed, majority of the tree species showed incomplete regeneration pattern. This is about 72.22%, 50%, 63.64% and 50% of total tree species in the disturbed lands respectively at Sankulangara, Palliyana, Nambiyath and Poyyara study sites. Tree species with no regenerate representation in all the height growth classes are 11.11% in Sankulangara, 8.33% in Palliyana, 9.09% in Nambiyath and 25% in Poyyara. However, good or fairly good regeneration pattern are followed by only 16.67% of tree species in the disturbed land at Sankulangara, 41.67% at Palliyana, 27.27% at Nambiyath and 25% tree species at Poyyara. The tree species *Tabernaemontana alternifolia* at Sankulangara and *Garcinia gummi-gutta* and *Gliricidia sepium* at Palliyana site are the only species which exhibited normal regeneration pattern while no tree species at Nambiyath and Poyyara sites. The analysis of sum total of regenerate density from height growth class1 to height growth class 4 in disturbed lands revealed comparatively higher regenerate density recorded either in the later growth stage of sapling (class 4) or in the early growth stage of seedling (class 1) and lower regenerate density recorded in between these two classes. This indicates non-sustainable regeneration pattern exist in disturbed non-sacred grove lands and clearly revealed high anthropogenic disturbances.

The observations done in the selected sacred grove lands revealed those tree species with good or fairly good regeneration pattern are generally the dominant tree species in the area. Considering this trend, the tree species which exhibited comparatively better regeneration status as recorded by *Tabernaemontana alternifolia*, *Hydnocarpus pentandrus*, *Artocarpus hirsutus* etc in the disturbed non-sacred grove lands at Sankulangara site would be expected to be the dominant tree species. Similarly, the tree species *Gliricidia sepium*, *Garcinia gummi-gutta*, *Artocarpus hirsutus*, *Anacardium occidentale*, *Lannea coromandelica* at Palliyana; tree species *Anacardium occidentale*, *Artocarpus hirsutus*, *Trema orientalis* etc at Nambiyath and *Trema orientalis* at Poyyara disturbed lands are also expected to be the dominant tree species. However, the phytosociological data of tree species analysed in the above said disturbed lands revealed, *Cocos nucifera* and *Areca catechu* are the dominant tree species, though their regeneration status is very poor or not even represented a single regenerate in any of the height growth classes. This clearly revealed high human interference in the area and comparatively higher values of phytosociological data of these tree species in the disturbed land which may be the result of human cultivation as part of agriculture.

The influence of difference in extend of the study area on the regeneration status of tree species indicated that, the sum total of regenerate density generally tended to increase in all the height growth classes as extend of area increased, irrespective of the grove or disturbed non-sacred grove area. However, the rate of increase is considerably higher in the sacred grove regions compared to disturbed non-sacred grove regions. The less anthropogenic disturbances and better microclimatic conditions prevailing in the grove regions are usually more favorable for the germination and survival of seedlings of more diverse tree species and this might be the factor contributing towards the enhanced density of regenerates.

Conclusion

The tree regeneration analysis done in the selected sacred groves revealed that greater seedling and sapling densities with reverse J-shaped curve exhibited by good proportion of the total tree species. This implies satisfactory regeneration behavior of these tree species. However, considerable reduction in the seedlings and saplings density in the selected non-sacred grove lands with incomplete regeneration or even total absence of regenerate representation is exhibited by majority of the tree species. This indicates poor regeneration status. The higher regenerate density with good regeneration status of majority of the tree species recorded in the studied sacred groves is due to protection and conservation of these groves by the local communities based on their religious beliefs. However, the opposite situation in the regeneration process observed in the selected non-sacred grove lands is due to the lack of protection and high anthropogenic disturbances. The study suggests it is necessary to continue the protection of such groves by providing additional support from government bodies and NGOs for joint management to address the conservation activities very efficiently to be sustainable for the future.

References

- Barik, S. K., Tripathi, R. S., Pandey, H. N., & Rao, P. (1996). Tree regeneration in a subtropical humid forest effect of cultural disturbance on seed production, dispersal and germination. *Journal of Applied Ecology*, 33(3), 1551–1560.
- Barker, P. C. J., & Patrik, L. B. K. (1994). *Phyllocladus asplenifolius*: Variability in the population structure of the regeneration niche and dispersion pattern in Tasmanian forest. *Australian Journal of Botany*, 42(2), 163–190.
- Boraiah, K. T., Vasudeva, R., Shonil, A. B., & Kushalapa, C. G. (2003). Do informally managed sacred groves have higher richness and regeneration of medicinal plants than state managed reserve forests. *Current Science*, 84(6), 804–808.
- Chauhan, D. S., Bhupendra Singh., Shashi Chauhan., Dhanai, C. S., Todaria, N. P. (2010). Regeneration and plant diversity of natural and planted Sal (*Shorea robusta* Gaertn.F.). Forests in the Terai-Bhabhar of Sohagibarwa Wildlife Sanctuary, India. *Journal of American Science*, 6(3), 32–45.
- Chauhan, D. S., Dhanai, C. S., Bhupendra Singh., Shashi Chauhan., Todaria, N. P., & Khalid, M. A. (2008). Regeneration and tree diversity in natural and planted forests in a Terai - Bhabhar forest in Katarniaghat Wildlife Sanctuary, India. *Tropical Ecology*, 49(1), 53.
- Devi Prasad., & Shwetha Bharathi. (2015). Regeneration status of tree composition in the sacred groves of Mercara, Central Western Ghats. *European Journal of Experimental Biology*, 5(10), 29–40.
- Devi Prasad., & Shwetha Bharathi. (2016). Tree diversity and their regeneration in the sacred groves of Virajpet, Central Western Ghats, India. *Notulae Scientia Biologicae*, 8(3), 360–369.
- Induchoodan, N. C. (1998). *Ecological Studies on the Sacred Groves of Kerala*. Ph. D Thesis, Pondicherry University, Pondicherry. 156.
- Jayakumar, R., & Nair, K. K. N. (2013). Species diversity and tree regeneration patterns in tropical forests of the Western Ghats, India. ISRN, *Ecology*, ID890862.
- Khan, M. L., Rai, J. P. N., & Tripathi, R. S. (1987). Population structure of some tree species in disturbed and protected sub-tropical forests of north-east India. *Acta Ecologica. Applied Ecology and Environmental Research*, 8, 247–255.

- Khan, M. L., Rai, J. P. N., & Tripathi, R. S. (1986). Regeneration and survival of tree seedlings and sprouts in tropical deciduous and sub-tropical forest of Meghalaya, India. *Forest Ecology and Management*, 14(4), 293–304.
- Kuba Maram, M., & Khan, M. L. (1998). Regeneration status of trees in various categories of forests in Manipur. *Journal of Hill Research*, 11(2), 178–182.
- Mishra, B. P., Tripathi, O. P., Tripathi, R. S., & Pandey, H. N. (2004). Effects of anthropogenic disturbance on plant diversity and community structure of a sacred grove in Meghalaya, northeast India. *Biodiversity and Conservation*, 13(2), 421–436.
- Nagamastu, D., Seiwa, K., & Sakai, A. (2002). Seedling establishment of deciduous trees in various topographic positions. *Journal of Vegetation Science*, 13(1), 35–44.
- Nazir, A. P., Negi, A. K., Yogesh Gokhale., & Todaria, N. P. (2013). Tree regeneration status of sacred and protected landscapes in Garhwal Himalaya, India. *Journal of Sustainable Forestry*, 32(3), 230–246.
- Oliver, C. D. (1981). Forest development in North America following major disturbances. *Forest Ecology and Management*, 3, 153–168.
- Prasad, A. G. D., & Nageeb, A. A. (2012). Floristic diversity of regenerated tree species in Dipterocarp forests in Western Ghats of Karnataka, India. *Journal of Environmental Biology*, 33(4), 791–797.
- Rao, B. R. P., Suresh Babu, M. V., Sridhar Reddy, M., Madhusudhana Reddy, A., Srinivasa Rao, V., Sunitha, S., & Ganeshaiah, K. N. (2011). Sacred groves in Southern Eastern Ghats, India: Are they better managed than forest reserves? *Tropical Ecology*, 52(1), 78–79.
- Rao, P., Barik, S. K., Pandey, H. N., & Tripathi, R. S. (1997). Tree seed germination and seedling establishment in tree fall gaps and understorey in a subtropical forest of north east India. *Australian Journal of Ecology*, 22, 136–145.
- Saxena, A. K., & Singh, J. S. (1984). Tree population structure of certain Himalayan forest associations and implications concerning their future composition. *Vegetation*, 58(2), 61–69.
- Tripathi, R. S., & Khan, M. L. (1992). Regeneration pattern and population structure of trees in subtropical forests of north east India. In: *Tropical ecosystems, Ecology and Management*. Singh K. P. & Singh J. S. (eds.). Wiley Eastern, New Delhi, pp. 431–441.

- Uma Shankar. (2001). A case of high tree diversity in a sal (*Shorea robusta*)-dominated lowland forest of Eastern Himalaya: Floristic composition, regeneration and conservation. *Current Science*, 81(7), 775–776.
- Welden, C. W., Hewett, S. W., Hubbell, S. P., & Foster, R. B. (1991). Sapling survival, growth and recruitment: Relationship to canopy height in a Neotropical forest. *Ecology*, 72, 35–50.

CHAPTER-6

Population analysis of major soil microbes in the selected sacred groves and adjacent disturbed non-sacred grove lands

Introduction

The research work in connection with sacred groves mostly concentrated on the analysis of plant and animal species, their diversity and other phytosociological aspects. What is often given less attention is the importance of unseen soil microorganisms and their active participation in different process like decomposition, chemical transformation and mineralization which are essential for the proper functioning of an ecosystem. The vegetation cover in an area is mainly dependent on the health and quality of soil which in turn is decided by the microbial diversity and frequency. Similarly, the vegetation cover particularly of tree community in the area can also influence the microbial compositions and diversity which can further contribute to the physicochemical properties of soil in the area. The sacred groves are patches of original forest with abundant plant diversity and plant dead organic matter which have been the result of recurrent accumulation of litter fall, thereby forming an important source of mineral nutrients in the grove soil (Kourtev et al., 2002; Bird et al., 2011). However, the disturbance of soil and changes in the natural vegetation cover by anthropogenic pressures may negatively affect the diversity and population size of microbes causing a reduction in their decomposition rate on organic matter. This kind of reduction in microbes will adversely affect the biogeochemical cycles responsible for the recycling of mineral nutrients which are essential for the sustainable plant growth.

Liu et al. (2000) reported that anthropogenic disturbances can cause an unfavorable effect on the diversity of soil microbes and their activity. Therefore knowing the microbial population and their count in the soil is very important to understand the soil health. There are several factors which are positively or negatively correlated with microbes and their activity in a particular soil environment which in turn influence the soil properties. The information on the changes in soil microbial biomass following the removal of vegetation is highly valuable as several studies have revealed their role in organic matter decomposition and nutrient cycling. The microbiological data collected pertaining to an area may be useful to relate it to the vegetation stand, chemical composition and soil fertility and thereby the health of the soil

(Waksman, 1927). Therefore, the objective of the present research work is to analyze and evaluate the population count of major microbes in the soil samples collected from traditionally maintained sacred grove regions and the soil samples collected from nearby disturbed non-sacred grove regions for correlating these parameters with chemical properties and vegetation characteristics of the study areas.

Review of Literature

The microbiological analysis of soil in an area can be used to ascertain the bacterial population, fungi, actinomycetes and other groups of microbes as well as the chemical properties of the soil as inferred by Waksman (1927). The diversity and activity of microorganism in soil decides its ability to be productive and sustainable – when the diversity and activity are higher, higher is the productivity and sustainability. A fundamental necessity for better soil quality is the enhanced level of microbial diversity and activity, which directly influences the stability and fertility of an ecosystem (Moussa & Abdel, 2008). The soil microorganisms carry and transport the organic matter through biochemical process which enables the cycling nutrients (Lima et al., 1996; Jordan et al., 1999; Garau et al., 2007). Bacteria and fungi are the two major groups of microorganisms which vigorously participate in the decomposition activities of dead organic matter as they are found to have greater biomass and respiratory metabolism (Persson et al., 1980). The bacterial community is recorded to have higher biomass in summer as the air temperature increases (Chhonkar & Tarafdar, 1984). Pennanen et al. (1999) observed a reduction in the fungal population with increased soil fertility whereas an increment in the bacterial population was recorded.

The study carried out in various forests in India revealed that soil bacterial population was on the higher side in the month of September while it lowered in July which may be due to the changes rain and temperature (Jha et al., 1992). The breakdown of dead organic matter depends on soil parameters such as physicochemical properties, the kind of organisms participating in decomposition as well as the quality and amount of litter (Swift et al., 1979). Taylor and Parkinson in 1988 has recorded that various factors like type of soil, moisture content and temperature of air are found to affect the decomposition rate of organic matter, which is noticed to be greater in tropical regions in comparison with temperate regions. A suitable and better habitat for microbial diversity is usually supported by the vegetation stand, amount of litter and the extent rhizosphere when compared to a barren and rocky grassland (Purabi & Santa, 2012).

The microbial population of soil in area is greatly influenced by plant diversity and richness which in turn occurs due higher plant production (Liu et al., 2007). The soil microbial population and its diversity is altered by anthropogenic pressures and as well as the variation

in the composition of plant community (Carney & Matson, 2006). Generally the natural forest experience higher enzymatic activity of microbes in comparison to reconstructed forests and this is attributed to the vegetation diversity, high litter fall and soil nutrient richness (Barbhuiya et al., 2004).

Karam et al. (2012) reported that the breakdown of dead organic matter as well as the cycling of mineral nutrients by the enzymatic activity of microbes are the key factor in soil biological processes. For the better growth of microorganisms, dead organic matter is the ideal substrate (Beare et al., 1997; Banning et al., 2008). The mineral nutrient content of the soil is found correlated to the enzymatic activities of microorganisms which enhance decomposition of litter (Kourtev et al., 2002; Li et al., 2004). According to Barbhuiya et al. (2004), there exist a strong positive relationship between the density of plants and population of bacteria and fungi in the soil, which can influence the vegetation stand characteristics of the area. Further, they have inferred that higher litter fall and rhizosphere found improved the microbial biomass and revealed a positive correlation between them. The increased rhizosphere area, enhanced root exudates and enzyme activity in the soil is found to stimulate the population growth of bacteria and fungi (Clarholm, 1985).

The organic matter content, availability of moisture, temperature, aeration and similarly the season and the rate of decomposition activity are the major ecological factors which decide the distribution as well as the population of microbes in soil (Mishra, 1966). The analysis seasonal variation and its influence on the population of bacteria and fungi in the soil have high relevance with respect to biodiversity (Kennedy & Smith, 1995) and in regulating the ecosystem processes as well as the biomass of various organisms in the area (Reid, 1994). The decrease in the biomass of different fungal, bacterial and other microorganisms in the soil during the winter season may be due to unsuitable climates together with reduction in decomposition rate which led to the gradual decrease in mineral nutrient content (Berg et al., 1998; Kayang, 2006).

According to Shukla et al. (1989), the reduction in the population of microbes in the disturbed as well as in the undisturbed lands during the monsoon period may be due to washing off organic matter combined with microbial propagules which in turn the result of heavy rainfall. The reduction in the availability of mineral nutrients due to their higher intake by peak vegetation growth during the monsoon season may limit their availability to

microbes which generally result in the reduction of microbial population during the rainy season (Sarathchandra et al., 1984). The investigation done by Purabi and Santa (2012) revealed that the growth of microbes and their biomass in the soil is highly depended on the availability of moisture content, suitable temperature and organic matter content. The higher soil compaction and decreased soil porosity leading to lesser availability of aeration, moisture content and organic matter for decomposition and release of nutrients might be an important reason for reduction in microbial population in soil (Hakansson & Lipiec, 2000; Bouwman & Arts, 2000; Xiao et al., 2005).

Materials and Methods

Population analysis of major microbial groups

Soil samples in triplicates from core region of Sankulangara sacred grove, transition region (the region which buffer between the grove and disturbed land) and disturbed non-sacred land are collected at a depth of 30cm from the surface, using the core type soil auger to get comparatively less disturbed pedon of soil. Soil samples are collected and analyzed during the pre-monsoon period (April-May) and post-monsoon period (October-November) from previously marked regions in all the study sites in the consecutive years from 2015-2017. The following microbial parameters are analyzed and counted in the soil samples for the present investigation.

- a) Total bacteria
- b) Total fungi
- c) Total actinomycetes
- d) Total cellulose degrading bacteria
- e) Total lignin degrading bacteria
- f) Total nitrogen fixing bacteria
- g) Phosphorus solubilizing bacteria
- h) Total mycorrhizal spore count

The soil samples are analyzed and data recorded by following the methods of Cappuccino and Sherman (1992) while, the total mycorrhizal spores is counted by following the method of Gerdemann and Nicolson (1963).

Principle

Soil contains myriads of microorganisms including bacteria, fungi, actinomycetes, mycorrhizal spores, viruses, protozoa etc. It is essential to bear in mind that the soil environment differs from one location to another and from one period of time to another. Therefore factors such as moisture, PH, temperature, gaseous oxygen content and organic and inorganic composition of soil are crucial in determining the specific microbial flora of a particular sample. The relative number of bacteria, actinomycetes, fungi, nitrogen fixers,

phosphorus solubilising bacteria, cellulose degrading bacteria and lignin degrading bacteria are determined.

Materials

Soil

1gram sample of finely pulverized soil in a flask containing 99 ml sterile water; flask labelled as 1:1:100 dilution (10^{-2})

Media Used

Different media are employed to support the growth of these microorganisms. This includes, nutrient agar for the isolation of bacteria, glycerol yeast agar for the isolation of actinomycetes, sabouraud agar for the isolation of fungi (Sabouraud agar are supplemented with $10\mu\text{g}$ of chlorotetracycline per millimeter of medium to inhibit the growth of bacteria), Carboxy methyl cellulose agar for the isolation of cellulose degrading bacteria, lignin sulphonate medium for the isolation of lignin degrading bacteria, Jenson's agar for the isolation of nitrogen fixers, Pikovskaya's medium for the isolation for Phosphorus solubilising bacteria.

Equipment

Bunsen burner, Quebec colony counter, mechanical hand counter, sterile 1-ml pipettes, mechanical pipetting device, sterile petri dishes and glassware marking pencil.

Procedure

1. With a glassware marking pencil, label each set of four petri dishes as follows:

Nutrient agar: 10^{-5} , 10^{-6} (to be used for the enumeration of bacteria)

Glycerol yeast extract agar: 10^{-3} , 10^{-4} (to be used for the enumeration of actinomycetes)

Sabouraud agar: 10^{-2} , 10^{-3} (to be used for the enumeration of fungi)

Carboxy methyl cellulose agar: 10^{-1} , 10^{-2} (to be used for the enumeration of cellulose degrading bacteria)

Lignin sulphonate medium: 10^{-1} , 10^{-2} (to be used for the enumeration of lignin degrading bacteria)

Jenson's agar: 10^{-3} , 10^{-4} (to be used for the enumeration of nitrogen fixers)

Pikovskaya's medium: 10^{-3} , 10^{-4} (to be used for the enumeration of Phosphorus solubilising bacteria)

2. Label the 99 ml sterile water flasks.
3. Shake the soil sample dilution of $1:100(10^{-2})$ vigorously approximately 30 times, with your elbow resting on the table.
4. Use a sterile 1-ml pipette, transfer 1 ml of the soil sample dilution to flask 2 and shake vigorously as before. The final dilution is $1:10,000 (10^{-4})$.
5. Use another sterile 1- ml pipette, transfer 1 ml of dilution 2 to flask 3 and shake vigorously as before. The final dilution is $1:1,000,000 (10^{-6})$.
6. Using sterile 1- ml pipettes and aseptic technique, distribute the proper amount of each dilution to the approximately labelled plates to effect the final required dilutions as follows:

A) For fungi- in plates labelled sabouraud agar:

1ml of dilution 1 in plate to effect a 10^{-2} dilution.

0.1ml of dilution 1 in plate to effect a 10^{-3} dilution.

B) For actinomycetes – in plates labelled glycerol yeast extract agar:

0.1 ml of dilution 1 in plate to effect a 10^{-3} dilution.

1 ml of dilution 2 in plate to effect a 10^{-4} dilution.

C) For bacteria- in plates labelled nutrient agar:

0.1 ml of dilution 2 in plate to effect a 10^{-5} dilution.

1 ml of dilution 3 in plate to effect a 10^{-6} dilution.

D. For cellulose degrading bacteria:

10 ml of dilution 1 in plate to effect a 10^{-1} dilution.

1 ml of dilution 1 in plate to effect a 10^{-2} dilution.

E. For lignin degrading bacteria:

10 ml of dilution 1 in plate to effect a 10^{-1} dilution.

1 ml of dilution 1 in plate to effect a 10^{-2} dilution.

F. For nitrogen fixers:

0.1ml of dilution 1 in plate to effect a 10^{-3} dilution.

1ml of dilution 2 in plate to effect a 10^{-4} dilution.

G. For Phosphorus solubilizing bacteria:

0.1ml of dilution 1 in plate to effect a 10^{-3} dilution.

1ml of dilution 2 in plate to effect a 10^{-4} dilution.

7. Remove the medium from the water bath and wipe the flask dry with paper towel. Using sterile technique, pour approximately 15 ml of medium into each dilution plate for bacterial enumeration. Rotate each plate gently to ensure uniform distribution of cells in the medium.

8. Repeat step 7 using the molten respective medium for microorganisms mentioned above.

9. Allow the all the plate cultures to solidify.

10. Incubate the plate in an inverted position for three to seven days at 25 °C.

Determination of viable count is calculated by the formula

$$\text{No. of cell/ml} = \frac{\text{Number of colonies}}{\text{Volume of sample}} \times \text{Dilution factor}$$

Analysis of mycorrhizal spore count

Procedure

The spores in 100g soil per samples are determined by wet sieving and decantation method as outlined by Gerdemann and Nicolson (1963).

1. About 100g of soil is collected in a 1000 ml beaker, suspended in 1000 ml of water, stirred well and allowed the heavier particles to settle for a few seconds.
2. Then the suspension is passed through coarse sieve (710 μ) to remove large pieces of debris. Again water is added up to 1000ml, stirred vigorously using glass rod and allowed for few seconds to make the heavier particles to settle down.
3. The suspension is collected and passed through a series of sieves (of sizes 180,106 and 45 μ) arranged descendingly.
4. The sieving from each sieve are collected separately in beakers.
5. This process is repeated 4 to 5 times, till the suspension appeared clear.

6. Each time, the sieving from all the three sieves are collected separately and added to the sieving collected earlier.
7. Finally the sieving are observed under stereoscopic zoom microscope for the presence of spores.

Quantification of the extracted spores:

Fractions from each sieve are collected separately into small beakers and transferred again into the fine sieve (45 μ). The fractions from the 45 μ sieve are collected using a fine jet of water into a griddled filter paper funnel, so as to remove the excess water. The filter paper is griddled at one half of the sheet and it is folded in such a way that the marked portion is the receiving surface during filtration. After filtration, the filter paper is removed gently and spread on a petri plates with spores and other debris and observed under stereo zoom microscope. Presence of spores is counted by moving the petri plate and the total number of spores are calculated in 100 g of soil taken for analysis.

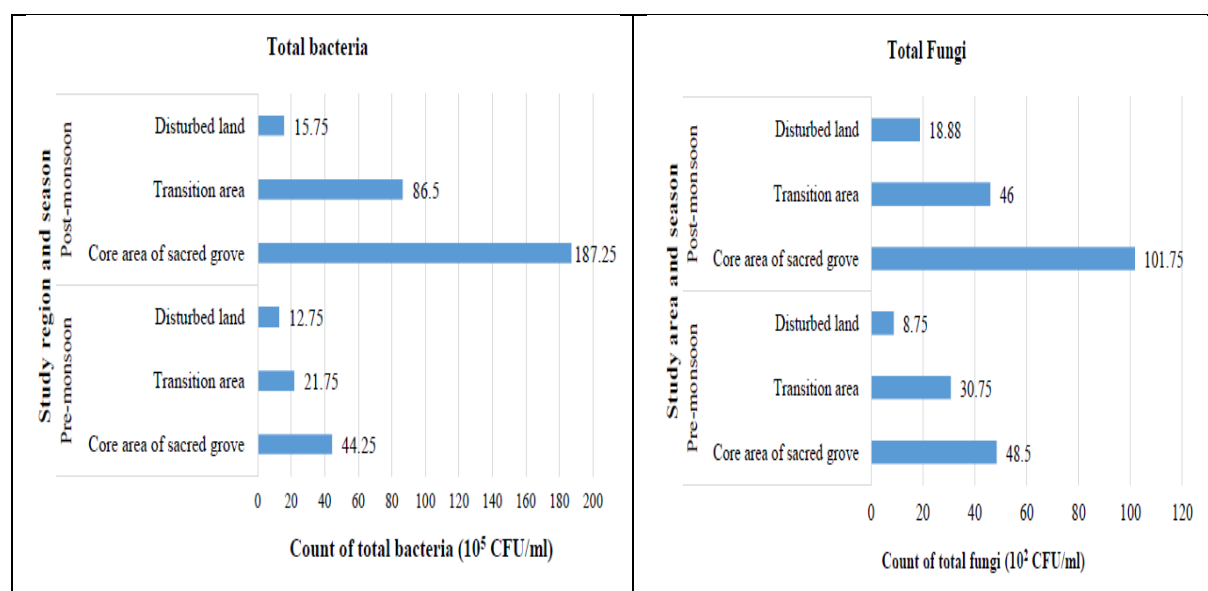
The mean value and standard deviation of different parameters in selected sacred groves and disturbed non-sacred grove lands are determined and compared statistically using 't'test of SPSS statistics 20.

Results

The details of result obtained from the microbiological analysis of soil samples collected from the core region of sacred grove, the transition region and the disturbed non-sacred grove region at each study sites during the pre-monsoon as well as the post-monsoon periods are as follows.

A) Sankulangara study site

The microbiological data obtained from Sankulangara site is depicted in the figure E1. The result shows the core region of sacred grove have higher count for total bacteria, fungi, actinomycetes, phosphorus solubilizing bacteria, cellulose degrading bacteria and total mycorrhizal spore count during the pre-monsoon as well as post-monsoon periods compared to the transition and disturbed non-sacred grove regions. The count of total nitrogen fixers shows slightly higher value in the core region of grove during the pre-monsoon period but during the post-monsoon period, the higher value is recorded by the disturbed region. With respect to the lignin degrading bacteria, very low count is recorded in the core region of grove during both the seasons while other regions recorded no count. The soil samples collected from disturbed land during the pre-monsoon season recorded no count for cellulose degrading bacteria. The data shows with the exception of total mycorrhizal spore count, the total count of most of the selected parameters recorded higher value during the post-monsoon period compared to the pre-monsoon whereas, the former recorded higher count during the pre-monsoon.



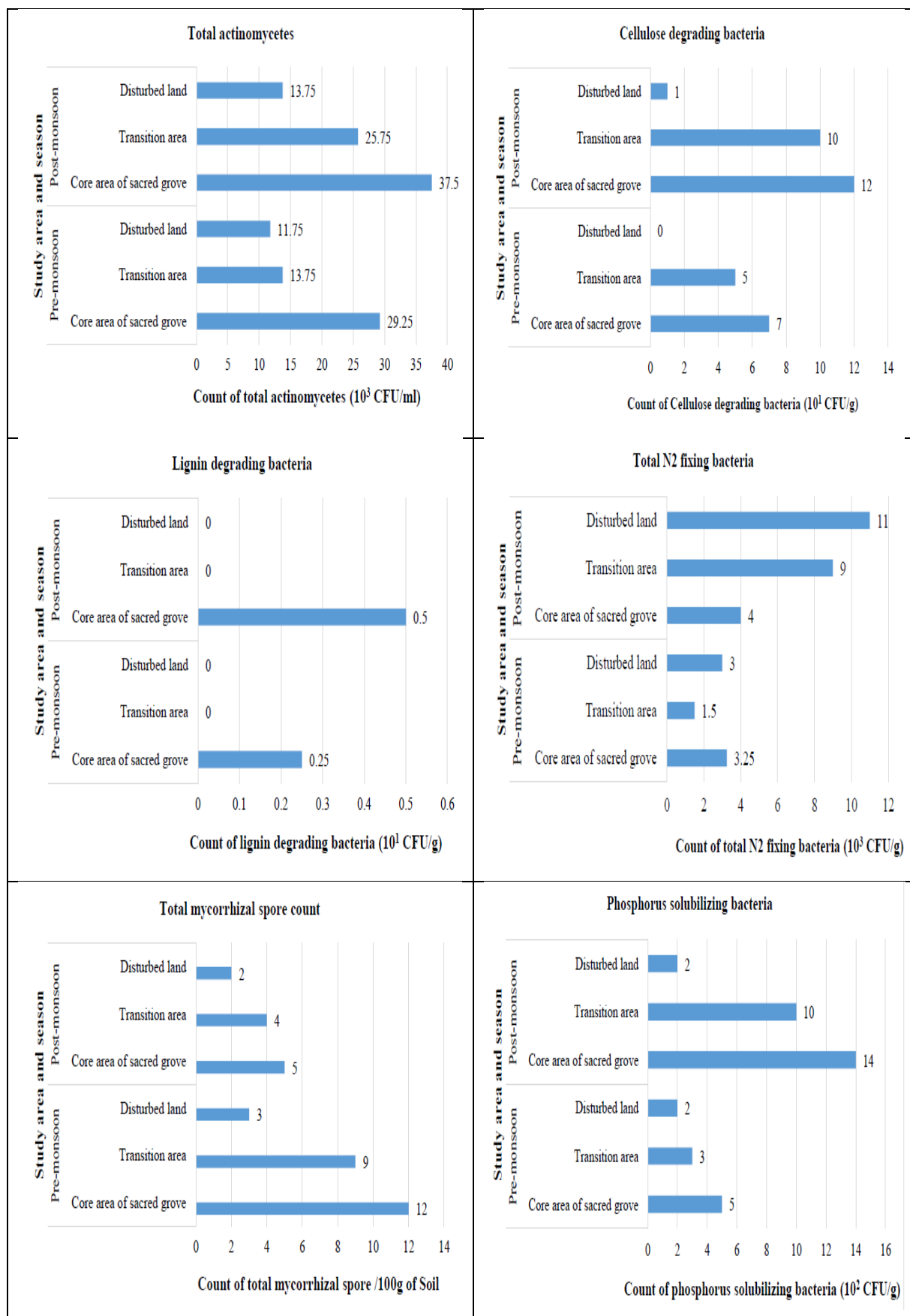
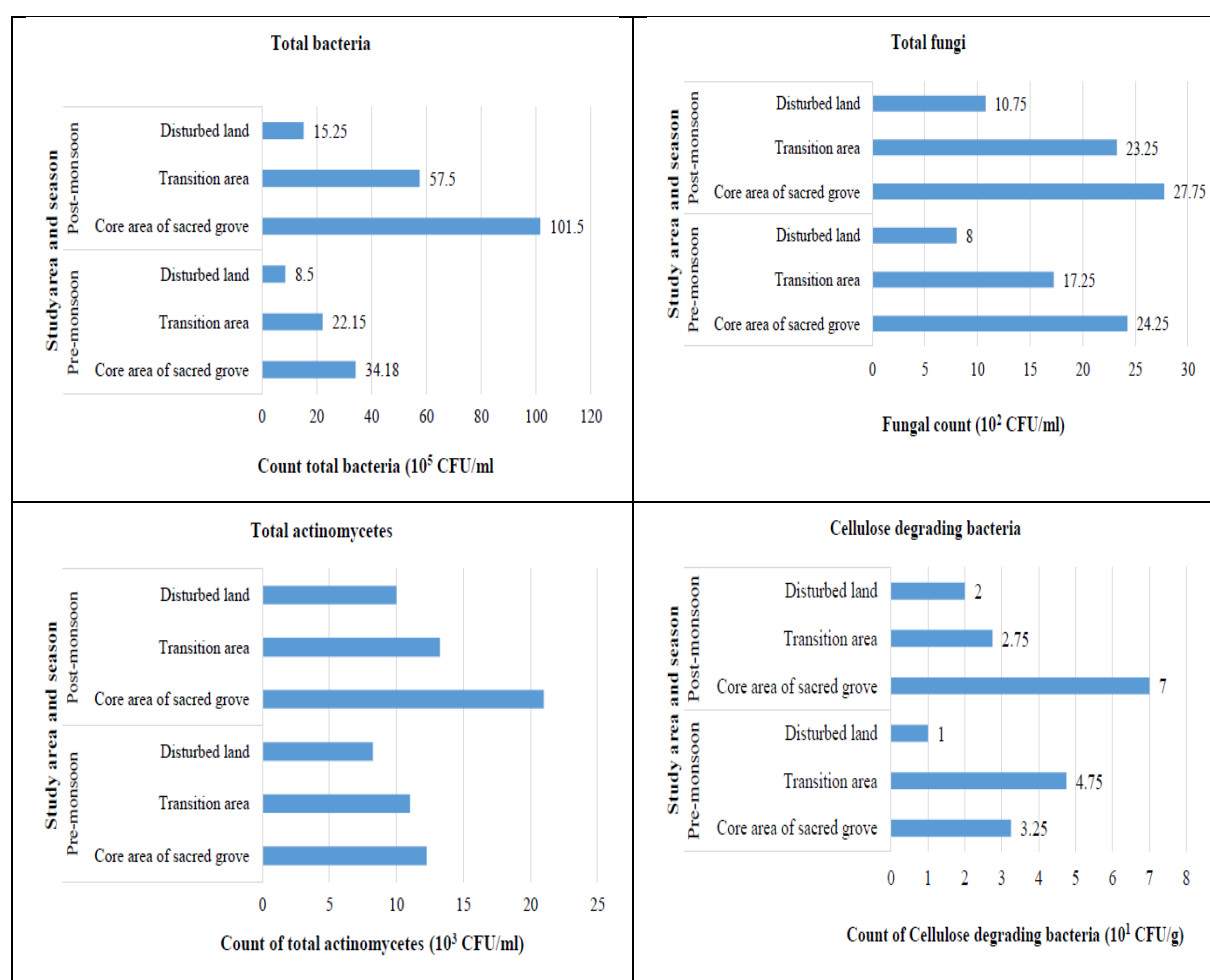


Figure E1: Total population count of selected microbial groups at Sankulangara site

B) Palliyana study site

The soil microbiological data obtained from the Palliyana study site is depicted in the figure E2. With the exception of higher mycorrhizal spore count recorded in the pre-monsoon period, all the selected parameters recorded comparatively higher count in the post-monsoon period compared to the pre-monsoon. The highest population count of bacteria, fungi, actinomycetes, phosphorus solubilizing bacteria and total mycorrhizal spore are recorded in the core region of grove, immediately followed by the transition region and the lowest count in the disturbed non-sacred grove region. With respect to the count of cellulose degrading bacteria, the highest count is observed in the transition region during the pre-monsoon but in the core region during the post-monsoon period. In contradiction, the total count of nitrogen fixers exhibited a different trend where the highest population count is recorded in the disturbed non-sacred grove region and the lowest count in the core region of grove. The lignin degrading bacteria recorded their count only during post-monsoon period in the core region of grove.



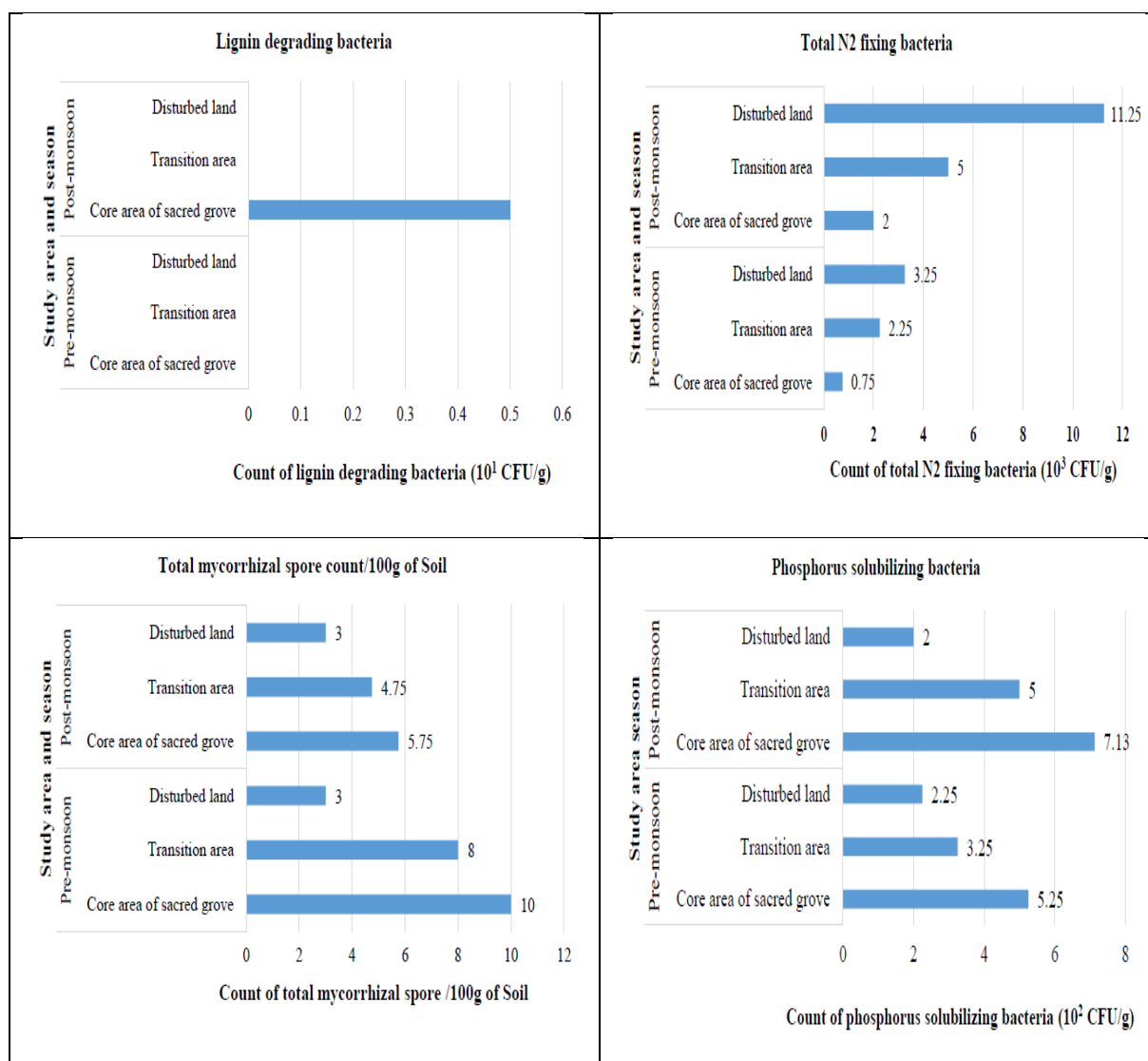
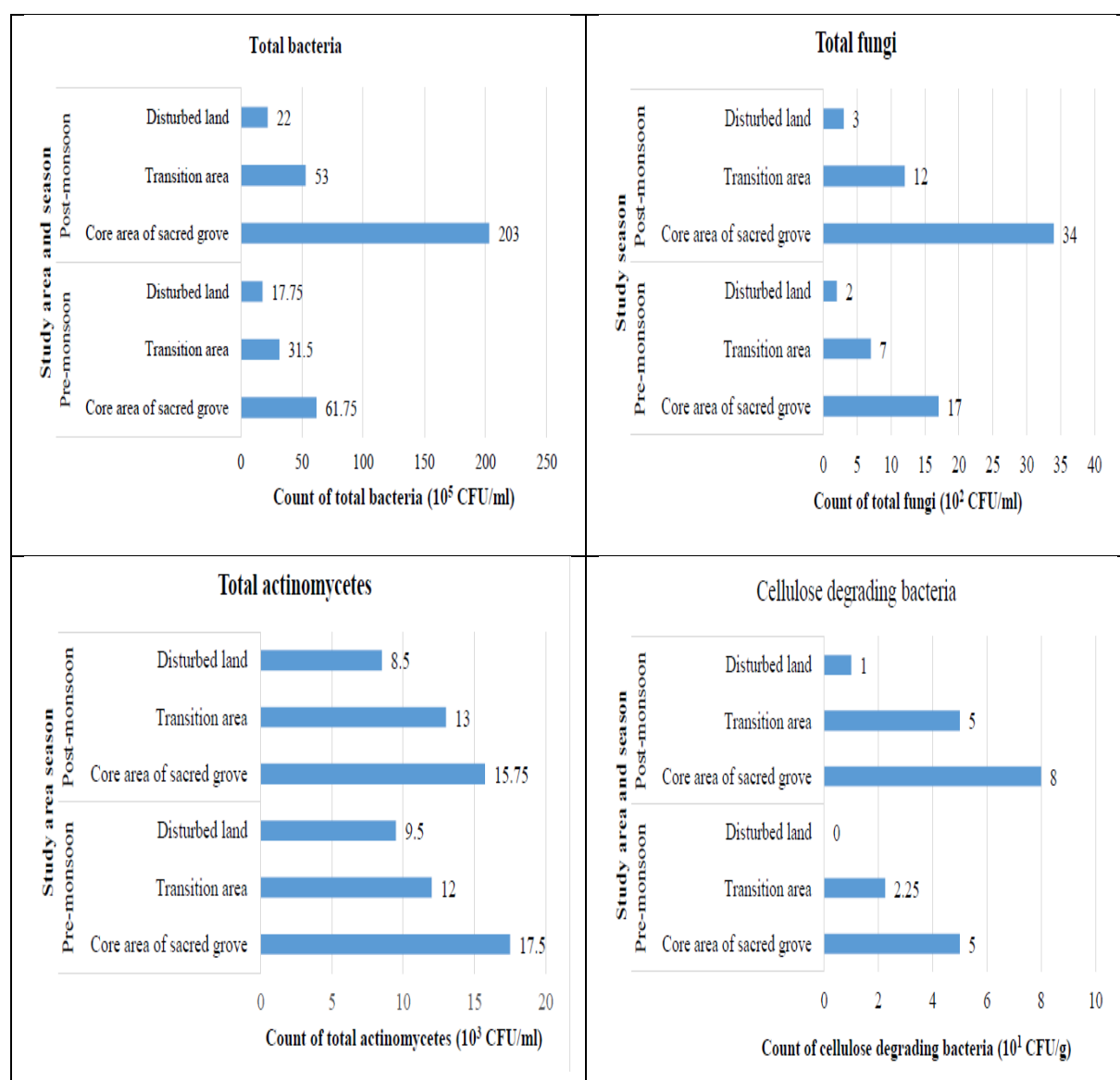


Figure E2: Total population count of selected microbial groups at Palliyana site

C) Nambiyath study site

The highest total population count for bacteria, fungi, actinomycetes, cellulose degrading bacteria and the count of total mycorrhizal spore at Nambiyath site are observed in the core region during the pre-monsoon as well as post-monsoon periods. The core region is immediately followed by the transition region and the lowest count is observed in the disturbed non-sacred grove region, with an exception in the case of total mycorrhizal spore where the core region is immediately followed by disturbed region and the lowest count in the transition region (figure E3). However in the case of phosphorus solubilizing bacteria, the difference is in the pre-monsoon period where the highest count has been observed in the transition region, which is immediately followed by core region and the lowest count in the disturbed region. Whereas in the case of total nitrogen fixers, the highest population count

has been recorded in the disturbed non-sacred grove region, followed immediately by transition region and the lowest count recorded in the core region of grove. No count for lignin degrading bacteria is recorded in all the soil samples collected from the study site. The results obtained from different season showed the total population count of bacteria, fungi, cellulose degrading bacteria, nitrogen fixers and phosphorus solubilizing bacteria are higher during the post-monsoon period compared to pre-monsoon counts in all the soil samples, with an exception in the case of phosphorus solubilizing bacteria in the transition region. However in the case of total mycorrhizal spore count in all the soil samples and actinomycetes count in the core and transition regions of Nambiyath site, higher counts has been recorded during the pre-monsoon period compared to post-monsoon period.



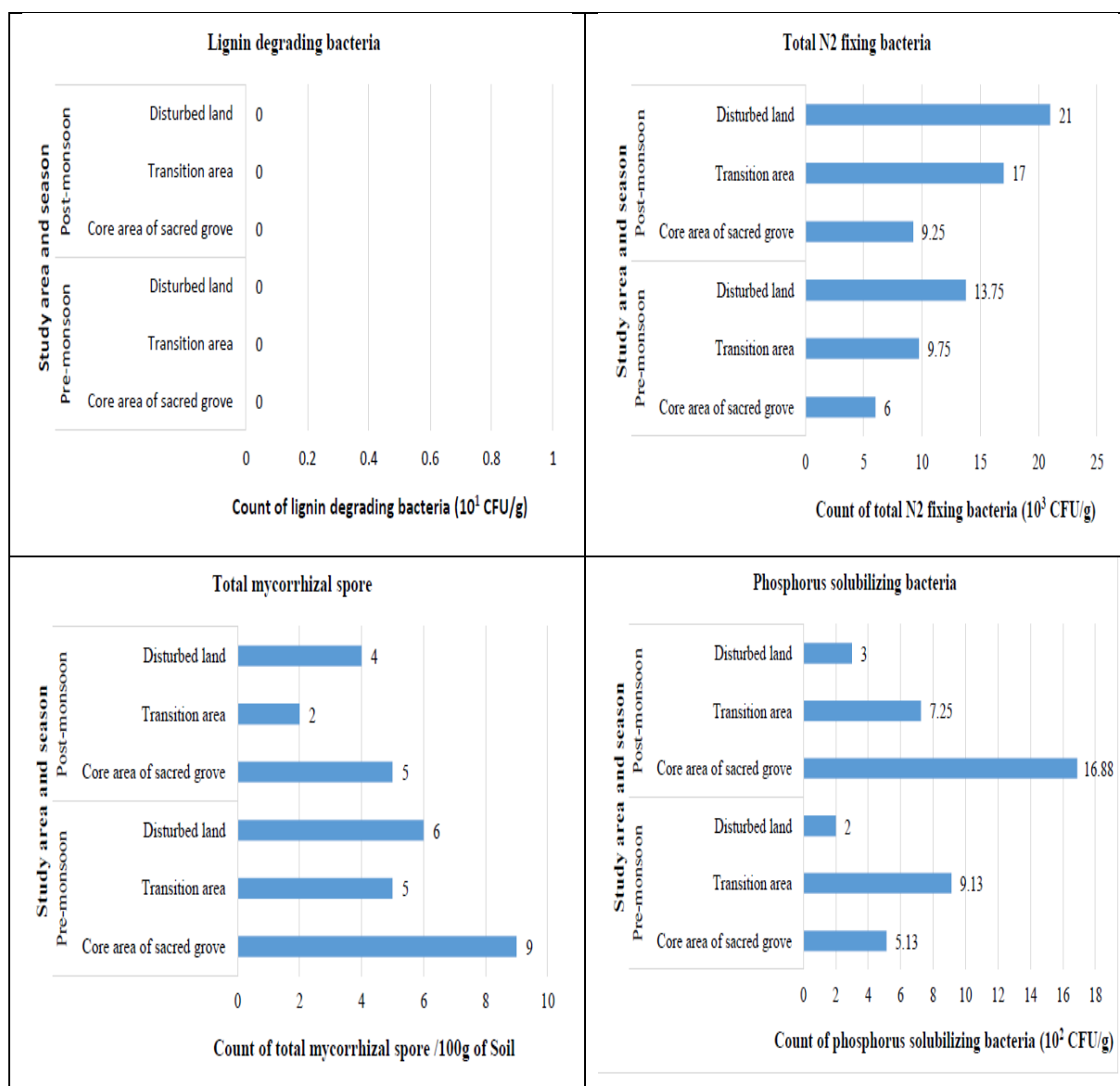
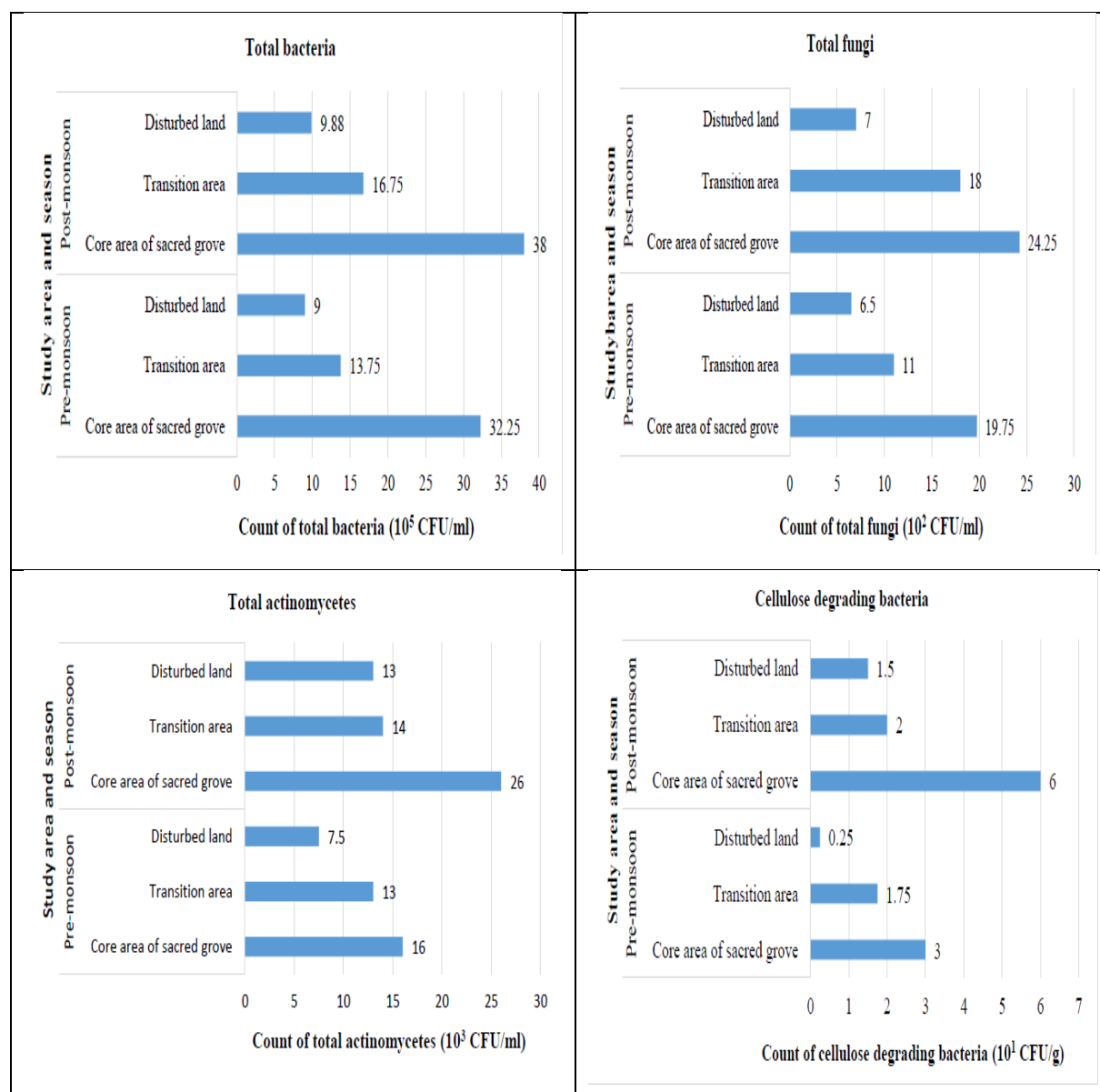


Figure E3: Details of selected soil microbiological parameters at Nambiyath site

D) Poyyara study site

The data collected from the Poyyara study site depicted in the table E4 showed most of the selected microbiological parameters of soil samples with the exception of total nitrogen fixers and lignin degrading bacteria, the highest population count has been recorded in the core region of grove, followed immediately by the transition region and the lowest count in the non-sacred grove region. However, the total count for nitrogen fixers showed a reverse trend while no count is recorded in any of the soil samples for lignin degrading bacteria during the pre-monsoon as well as post-monsoon periods. The comparison of data obtained in different season indicated the total count of bacteria, fungi, actinomycetes, cellulose degrading bacteria, nitrogen fixers and with certain exceptions in the case of phosphorus solubilizing

bacteria, the higher counts are recorded during the post-monsoon period over pre-monsoon. The exceptions in the phosphorus solubilizing bacteria include the count in the transition and disturbed region during the post-monsoon where there is no change in the count in the transition region while the count decreased in the disturbed region over pre-monsoon counts. However, contradictory to the above general observation of various parameters, the total mycorrhizal spore count recorded comparatively higher count during the pre-monsoon period over post-monsoon.



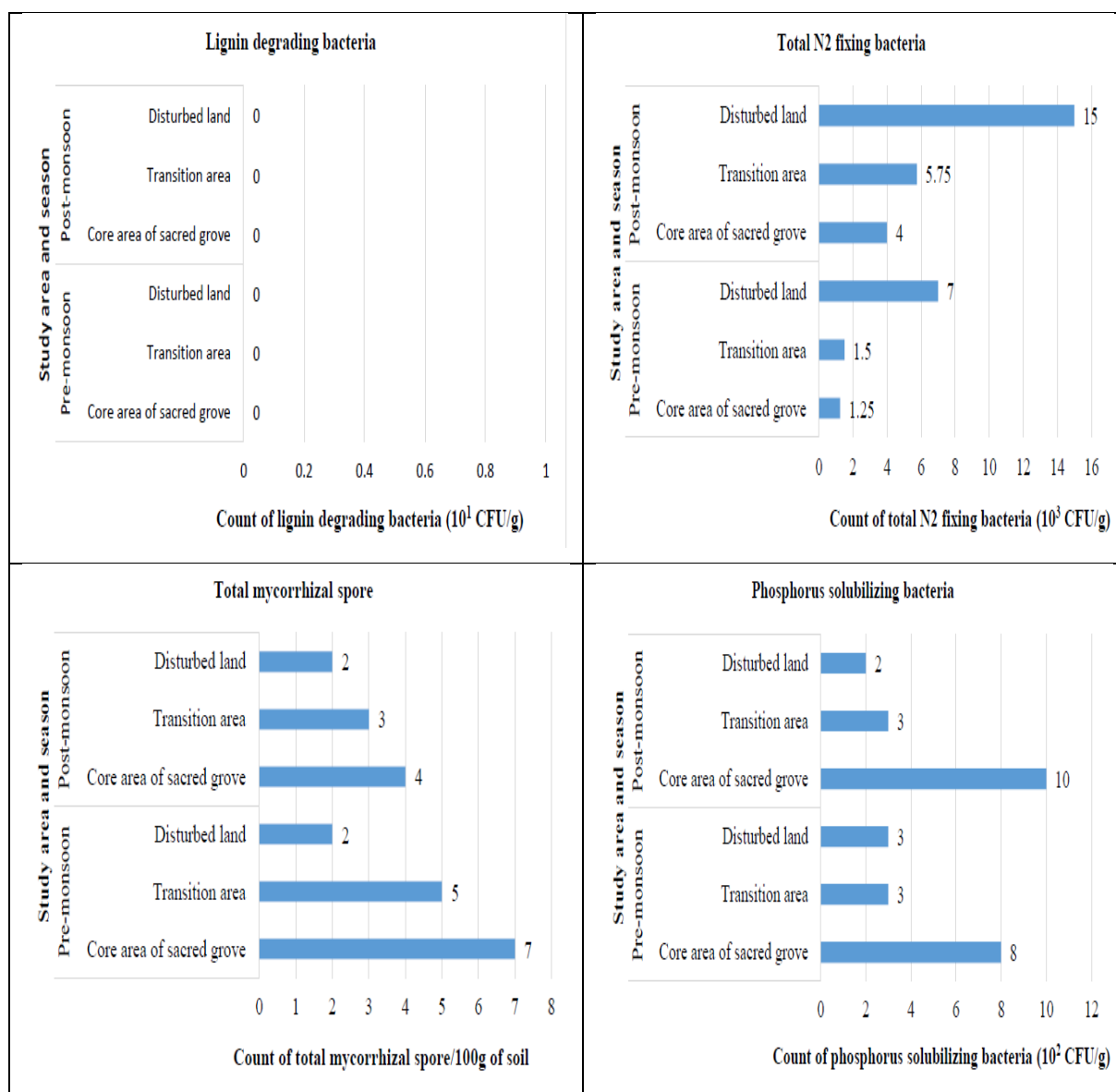
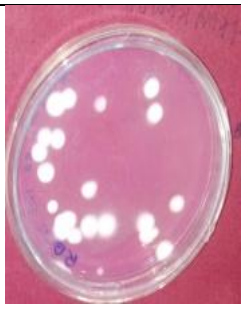
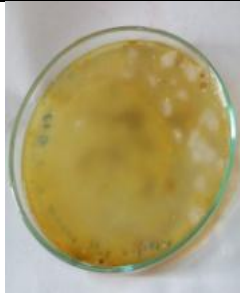
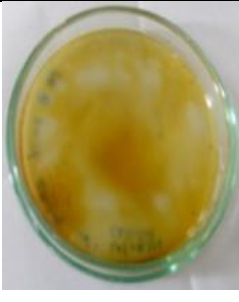


Figure E4: Details of selected soil microbiological parameters at Poyyara site

Microbial group	Sankulangara study site		Poyyara study site	
	Post-monsoon season			
	Core region of grove	Disturbed non-sacred grove region	Core region of grove	Disturbed non-sacred grove region
Bacteria				
Fungi				
Actinomycetes				
Cellulose degrading bacteria				

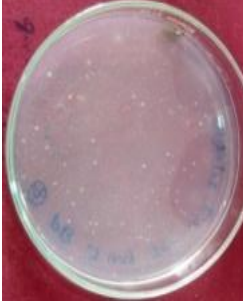
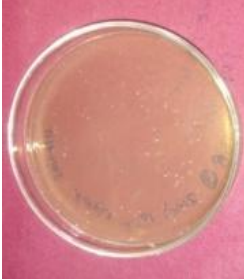
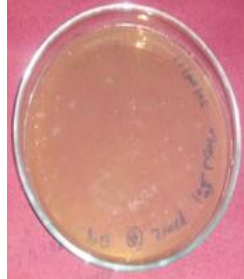
Nitrogen fixers				
Phosphate solubilizing bacteria				
Lignin degrading bacteria				

Figure E5: A comparative view of cultures of various microbial groups from the soil of core region of grove and disturbed non-sacred grove region during the post-monsoon period at Sankulanagara site of largest extent and Poyyara site of smallest extent

Discussion

The analysis of the total population count of various microbial groups selected in the study revealed with few exceptions in certain cases that there is considerable difference in their count in soil samples collected from different regions in all the study sites. The total count of bacteria, fungi, actinomycetes, cellulose degrading bacteria, phosphorus solubilizing bacteria and total mycorrhizal spore are found to generally exhibit a decreasing trend during the pre-monsoon as well as post-monsoon season with the highest count being recorded in the core region of sacred grove, which is followed by the region of transition and finally lowest count recorded in the disturbed non-sacred grove region. The comparative analysis of the total population count of microbial groups obtained from the core region of sacred grove, transition region and the disturbed non-sacred grove regions indicated that the maximum difference is between the core region and disturbed non-sacred grove region. The differences are found statistically significant for majority of the selected parameters in all the study sites during both the pre-monsoon and post-monsoon season but with few exceptions (table E1 to table E8). The exceptions include the difference in the count of N_2 fixers between the core and disturbed region during the pre-monsoon period at Sankulanagara and Palliyana sites and similarly, the difference in the total mycorrhizal spore count during the post-monsoon period between the core and disturbed region at Nambiyath and Poyyara sites, which did not differ significantly.

Significantly higher total population count of many microbial groups in the soil of core region of sacred groves can be attributed to the faster decomposition activity and multiplication rate of microorganisms in this soil favoured by the higher volume of dead organic matter available as litter fall, together with favourable soil temperature and moisture content. Less favourable soil environment and considerable reduction in the availability of litter depositions due to the result of poor floristic composition, poor growth of the root system and reduced rhizosphere in the disturbed land might be the factors responsible for the poor or comparatively lower microbial population growth. The above observations in the present investigation are in agreement with the reports of Purabi and Santa (2012). Mishra (1966) who reported that ecological factors like soil moisture, soil temperature, and substrate availability for microbial activity have been attributed as the most important factors that influence soil microbial growth and population density.

Table E1: Comparison of bacterial population count in selected sacred groves and disturbed non-sacred grove lands during the pre-monsoon and post-monsoon season

Study site	Mean value and SD of bacterial population count (10 ⁵ CFU/ml)					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Sankulangara site	44.25 ±4.11	21.75 ±3.30	12.75 ±4.92	187.25 ±35.58	86.50 ±20.31	15.75 ±5.74
	The 't' value and significant level of average bacterial population count					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	9.819		9.516	-7.984		-0.794
	P<0.001		P<0.001	P<0.001		NS*
Palliyana site	34.18 ±9.59	22.15 ±7.35	8.50 ±3.08	101.50 ±15.69	57.50 ±9.85	15.25 ±4.35
	The 't' value and significant level of average bacterial population count					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	5.096		10.595	-7.322		-2.532
	P<0.05		P<0.001	P<0.001		P<0.05
Nambiyath site	61.75 ±10.63	31.50 ±7.4	17.75 ±2.50	203.0 ±34.86	53.0 ±8.01	22.0 ±3.27
	The 't' value and significant level of average bacterial population count					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	8.061		10.339	-7.751		-2.067
	P<0.001		P<0.001	P<0.001		P<0.05
Poyyara site	32.25 ±3.43	13.75 ±2.50	9.0 ±3.27	38.0 ±4.10	16.75 ±2.5	9.88 ±3.28
	The 't' value and significant level of average bacterial population count					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	9.821		10.714	-2.151		-.378
	P<0.001		P<0.001	P<0.05		NS*

NS* - Not significant

Table E2: Comparison of fungal population count in selected sacred groves and disturbed non-sacred grove lands during the pre-monsoon and post-monsoon season

Study site	Mean value and SD of fungal population count (10 ² CFU/ml)					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Sankulangara site	48.5 ±8.23	30.75 ±6.55	8.75 ±4.11	101.75 ±18.12	46.0 ±37.84	18.88 ±3.28
	The 't' value and significant level of average fungal population count					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	8.644		9.003	-5.352		-3.851
	P<0.001		P<0.001	P<0.05		P<0.05
Palliyana site	24.25 ±4.11	17.25 ±3.30	8.0 ±3.27	27.75 ±3.30	23.25 ±3.86	10.75 ±3.30
	The 't' value and significant level of average fungal population count					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	6.188		7.276	-1.327		-1.184
	P<0.001		P<0.001	NS*		NS*
Nambiyath site	17.0 ±2.94	7.0 ±1.41	2.0 ±1.41	34.0 ±4.16	12.0 ±2.16	3.0 ±1.63
	The 't' value and significant level of average fungal population count					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	9.186		13.864	-6.668		-0.926
	P<0.001		P<0.001	P<0.001		NS*
Poyyara site	19.75 ±4.92	11.0 ±2.94	6.5 ±1.91	24.25 ±4.11	18.0 ±2.83	7.0 ±2.45
	The 't' value and significant level of average fungal population count					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	5.015		7.207	-1.403		-0.322
	P<0.05		P<0.001	NS*		NS*

Table E3: Comparison of actinomycetes population count in selected sacred groves and disturbed non-sacred grove lands during the pre-monsoon and post-monsoon season

Study site	Mean value and SD of actinomycetes population count (10 ³ CFU/ml)					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Sankulangara site	29.25 ±5.74	13.75 ±2.50	11.75 ±5.74	37.5 ±4.20	25.75 ±3.30	13.75 ±4.11
	The 't' value and significant level of average actinomycetes population count					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	4.314		8.077	-2.320		-0.567
	P<0.05		P<0.001	P<0.05		NS*
Paliyanaa site	12.25 ±2.25	11.0 ±1.63	8.25 ±0.87	21.0 ±3.27	13.25 ±2.50	10.0 ±0.82
	The 't' value and significant level of average actinomycetes population count					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	3.312		6.535	-4.410		-2.941
	P<0.05		P<0.001	P<0.05		P<0.05
Nambiyath site	17.50 ±2.89	12.0 ±2.16	9.50 ±2.08	15.75 ±3.30	13.0 ±1.41	8.50 ±1.29
	The 't' value and significant level of average actinomycetes population count					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	4.496		4.088	0.798		0.816
	P<0.05		P<0.05	NS*		NS*
Poyyara site	16.0 ±2.94	13.0 ±2.16	7.5 ±1.29	26.0 ±3.74	14.0 ±2.94	13.0 ±3.27
	The 't' value and significant level of average actinomycetes population count					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	5.288		5.235	-4.201		-3.132
	P<0.05		P<0.05	P<0.05		P<0.05

Table E4: Comparison of cellulose degrading bacterial count in selected sacred groves and disturbed non-sacred grove lands during the pre-monsoon and post-monsoon season

Study site	Mean value and SD of cellulose degrading bacterial count (10 ¹ CFU/g)					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Sankulangara site	7.0 ±1.63	5.0 ±0.82	0.0 ±0.0	12.0 ±2.45	10.0 ±1.63	1.0 ±0.82
	The 't' value and significant level of average cellulose degrading bacterial count					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Core zone of grove	Disturbed non-sacred grove land X Disturbed non-sacred grove land	
	8.573		8.521	-3.397		-2.449
	P<0.001		P<0.001	P<0.05		P<0.05
Palliyana site	3.25 ±0.96	4.75 ±0.96	1.0 ±0.82	7.0 ±1.63	2.75 ±0.96	2.0 ±0.82
	The 't' value and significant level of average cellulose degrading bacterial count					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Core zone of grove	Disturbed non-sacred grove land X Disturbed non-sacred grove land	
	3.576		5.477	-3.962		-1.732
	P<0.05		P<0.05	P<0.05		NS*
Nambiyath site	5.0 ±2.16	2.25 ±0.96	0.0 ±0.0	8.0 ±1.63	5.0 ±1.41	1.0 ±0.82
	The 't' value and significant level of average cellulose degrading bacterial count					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Core zone of grove	Disturbed non-sacred grove land X Disturbed non-sacred grove land	
	4.629		7.668	-2.216		-2.449
	P<0.05		P<0.001	P<0.05		P<0.05
Poyyara site	3.0 ±1.41	1.75 ±0.96	0.25 ±0.50	6.0 ±2.16	2.0 ±0.82	1.5 ±0.58
	The 't' value and significant level of average cellulose degrading bacterial count					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Core zone of grove	Disturbed non-sacred grove land X Disturbed non-sacred grove land	
	3.667		4.025	-2.324		-3.273
	P<0.05		P<0.05	P<0.05		P<0.05

Table E5: Comparison of total N₂ fixers in selected sacred groves and disturbed non-sacred grove lands during the pre-monsoon and post-monsoon season

Study site	Mean value and SD of total N ₂ fixers (10 ³ CFU/g)					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Sankulangara site	3.25 ±1.26	1.50 ±0.58	3.0 ±1.63	4.0 ±0.82	9.0 ±1.63	11.0 ±5.72
	The 't' value and significant level of total N ₂ fixers					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	0.243		-2.425	-1.000		-2.692
	NS*		P<0.05	NS*		P<0.05
Palliyana site	0.75 ±0.50	2.25 ±0.96	3.25 ±2.87	2.0 ±0.82	5.0 ±0.82	11.25 ±2.50
	The 't' value and significant level of total N ₂ fixers					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	-1.715		-7.034	-2.611		-4.202
	NS*		P<0.001	P<0.05		P<0.05
Nambiyath site	6.0 ±2.16	9.75 ±2.50	13.75 ±2.06	9.25 ±2.50	17.0 ±2.16	21.0 ±7.48
	The 't' value and significant level of total N ₂ fixers					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	-5.191		-2.979	-1.967		-1.868
	P<0.05		P<0.05	P<0.05		NS*
Poyyara site	1.25 ±0.96	1.50 ±0.58	7.0 ±1.41	4.0 ±1.41	5.75 ±2.50	15.0 ±2.94
	The 't' value and significant level of total N ₂ fixers					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	-6.734		-6.736	-3.220		-4.899
	P<0.001		P<0.001	P<0.05		P<0.05

Table E6: Comparison of total mycorrhizal spore count in selected sacred groves and disturbed non-sacred grove lands during the pre-monsoon and post-monsoon season

Study site	Mean value and SD of total mycorrhizal spore count (count/100g of Soil)					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Sankulangara site	12.0 ±1.63	9.0 ±2.45	3.0 ±0.82	5.0 ±0.82	4.0 ±1.63	2.0 ±0.82
	The 't' value and significant level of total mycorrhizal spore count					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	9.859		5.196	7.668		1.732
	P<0.001		P<0.05	P<0.001		NS*
Paliyana site	10.0 ±1.63	8.0 ±0.82	3.0 ±1.63	5.75 ±1.71	4.75 ±0.50	3.0 ±0.82
	The 't' value and significant level of total mycorrhizal spore count					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	6.062		2.905	3.597		0.00
	P<0.001		P<0.05	P<0.05		NS*
Nambiyath site	9.0 ±2.16	5.0 ±1.63	6.0 ±2.16	5.0 ±0.82	2.0 ±0.82	4.0 ±0.82
	The 't' value and significant level of total mycorrhizal spore count					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	1.964		1.732	3.464		1.732
	P<0.05		NS*	P<0.05		NS*
Poyyara site	7.0 ±1.63	5.0 ±0.82	2.0 ±0.82	4.0 ±2.16	3.0 ±1.41	2.0 ±0.82
	The 't' value and significant level of total mycorrhizal spore count					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	5.477		1.732	2.216		0.00
	P<0.05		NS*	P<0.05		NS*

Table E7: Comparison of phosphorus solubilizing bacteria count in selected sacred groves and disturbed non-sacred grove lands during the pre-monsoon and post-monsoon season

Study site	Mean value and SD of phosphorus solubilizing bacteria count (10 ² CFU/g)					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Sankulangara site	5.0 ±0.82	3.0 ±0.82	2.0 ±0.82	14.0 ±2.45	10.0 ±1.63	2.0 ±1.63
	The 't' value and significant level of phosphorus solubilizing bacteria count					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	5.196		8.152	-6.971		0.00
	P<0.05		P<0.001	P<0.001		NS*
Palliyana site	5.25 ±0.50	3.25 ±0.50	2.25 ±0.96	7.13 ±1.65	5.0 ±0.82	2.0 ±0.82
	The 't' value and significant level of phosphorus solubilizing bacteria count					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	5.555		5.562	-2.173		0.397
	P<0.001		P<0.001	P<0.05		NS*
Nambiyath site	5.13 ±0.86	9.13 ±1.65	2.0 ±0.82	16.88 ±1.65	7.25 ±1.44	3.0 ±0.82
	The 't' value and significant level of phosphorus solubilizing bacteria count					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	5.290		15.059	-12.637		-1.732
	P<0.05		P<0.001	P<0.001		NS*
Poyyara site	8.0 ±1.41	3.0 ±2.16	3.0 ±1.41	10.0 ±2.94	3.0 ±1.63	2.0 ±0.82
	The 't' value and significant level of phosphorus solubilizing bacteria count					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	5.000		5.237	-1.225		1.225
	P<0.05		P<0.05	NS*		NS*

Table E8: Comparison of lignin degrading bacteria in selected sacred groves and disturbed non-sacred grove lands during the pre-monsoon and post-monsoon season

Study site	Mean value and SD of lignin degrading bacteria (10^1 CFU/g)					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Sankulangara site	0.25 ±0.50	0.0 ±0.0	0.0 ±0.0	0.50 ±0.58	0.0 ±0.0	0.0 ±0.0
	The 't' value and significant level of lignin degrading bacteria					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	1.000		1.732	-0.655		0.0
	NS*		NS*	NS*		-
Palliyana site	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	0.50 ±0.58	0.0 ±0.0	0.0 ±0.0
	The 't' value and significant level of lignin degrading bacteria					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	-		1.732	-1.732		-
	NS*		NS*	NS*		NS*

To understand the health and functionality of a soil ecosystem, it is very necessary to evaluate the factors in the soil which regulate activity, growth and population size of microbes. Soil compaction might be one of the important factors which govern the soil composition and quality. The compaction depends on the availability of organic matter content in the soil which serves as an ideal medium for microbial activity and growth (Beare et al., 1997; Banning et al., 2008). Considerable reduction in the litter volume and their decomposition products can cause unfavourable soil environment such as lower soil porosity, reduced nutrients, moisture and aeration. Barbhuiya et al. (2004) reported a positive correlation between litter accumulation and fine roots with microbial population. Further, another factor which caused reduction in the microbial population count in the soil of disturbed land may be due to higher soil temperature resulting from canopy damage particularly of trees. All these unfavourable factors prevailing in the disturbed land may be the reason for significant

reduction in the population count of various microbes. The present observations are also in agreement with that of Bouwman and Arts (2000), Hakansson and Lipiec (2000), Xiao et al. (2005) who reported a negative correlation between microbial biomass and soil compaction.

The comparison of total population count of selected microbial groups obtained during the pre-monsoon and post-monsoon periods revealed that comparatively lower population count in the soil is recorded for many parameters during the pre-monsoon period over the post-monsoon period but with exceptions. The increase in the population count of majority of the microbial groups in the core region of sacred groves during the post-monsoon period are mostly significant over pre-monsoon. The exceptions include the difference in the total count of fungi obtained during the pre-monsoon and post-monsoon periods at Palliyana and Poyyara site, similarly the count of actinomycetes at Nambiyath site, count of N_2 fixers at Sankulangara site, count of phosphorus solubilizing bacteria at Poyyara site and the count of lignin degrading bacteria at Sankulanagara and Palliyana sites, which did not differ significantly. However, with respect to the difference in population count in the disturbed non-sacred grove regions obtained for majority of the microbial groups during the pre-monsoon and post-monsoon season revealed the differences are mostly not significant (table E1 to table E8). The mycorrhizal spore count at Sankulanagara and Nambiyath study sites, phosphorus solubilizing bacterial count at Palliyana and Poyyara sites and the count of actinomycetes at Nambiyath site obtained during the post-monsoon period in the soil of non-sacred grove region exhibited a decrease over the pre-monsoon counts. The study further observed no differences for the count of mycorrhizal spore at Palliyana and Poyyara sites and phosphorus solubilizing bacteria count at Sankulanagara site in the non-sacred grove region due to the difference in seasonal variation. The reduction in the population count of majority of the microbial groups during the pre-monsoon period compared to post-monsoon period can be attributed to the reduction in favourable soil climatic conditions for microbial activity and growth. The considerable reduction in the rain fall rate together with influence of global warming effect during the pre-monsoon period may cause increased soil temperature and decreased moisture content. This may result in drastic cut down of microbial activity and organic matter decomposition rate which in turn may cause reduction in the multiplication of microbes. The present investigation further observed that, on the whole, there exists a positive correlation between the microbial population counts particularly bacterial, fungal and actinomycetes count, with soil chemical properties and quality (Berg et al., 1998; Kayang, 2006).

The analysis on the influence of difference in the extent of grove area on total population count of selected microbial groups revealed that either a steady continuous increase or decrease is not recorded in the total population count of bacteria, actinomycetes, cellulose degrading bacteria, total N₂ fixers and phosphorus solubilizing bacteria in the soil samples along with increase or decrease in extent of the study area. However, although not significant, a slight decreasing trend is recorded in the count of total fungi, total mycorrhizal spore and lignin degrading bacteria in the soil samples with decrease in the extent of grove area. The highest count for total fungi, actinomycetes, cellulose degrading bacteria, mycorrhizal spore and lignin degrading bacteria are generally recorded in the Sankulangara grove of largest extent while highest count for total bacteria and phosphorus solubilizing bacteria are generally recorded in the Nambiyath grove of comparatively lower extent. The representation of lignin degrading bacteria is detected only in the soil samples collected from the core region of Sankulangara and Palliyana groves of comparatively larger extents while their representation is nil in any of the soil samples collected from the Nambiyath and Poyyara study sites of smaller extents. With certain exceptions, particularly in the total population count of lignin degrading bacteria, phosphorus solubilizing bacteria and in the count of mycorrhizal spore, the differences in the total population count of majority of the microbial groups between sacred groves of different extent are found statistically significant (table E9). Comparatively higher microbial population count of majority of the microbial groups in the soil of sacred groves with larger extents compared to soil in the sacred groves of smaller extents can be attributed to the higher rhizosphere and increased root exudates in the soil of larger extents which stimulate the growth of microbial populations (Barbhuiya et al., 2004).

Table 9: The ‘t’ value and significant level in the population count of various microbial groups between the core zone of selected sacred groves of different extents during the pre-monsoon and post-monsoon periods

Soil parameter	Core zone Sankulangara grove X Core zone Palliyana grove	Core zone Sankulangara grove X Core zone Nambiyath grove	Core zone Sankulangara grove X Core zone Poyyara grove
Population count	Pre-monsoon period		
Bacteria	1.930	-3.072	4.483
	NS*	P<0.05	P<0.05
Fungi	5.274	7.211	5.998
	P<0.05	P<0.001	P<0.001
Actinomycetes	5.516	3.659	4.109
	P<0.001	P<0.05	P<0.05
Cellulose degrading bacteria	3.962	1.477	3.703
	P<0.05	NS*	P<0.05
Lignin degrading bacteria	1.000	1.000	1.000
	NS*	NS*	NS*

N ₂ fixers	3.693	-2.200	2.530
	P<0.05	P<0.05	P<0.05
Mycorrhizal spore	1.732	2.216	4.330
	NS*	P<0.05	P<0.05
Phosphorus solubilizing bacteria	-.522	-.212	-3.674
	NS*	NS*	P<0.05
Population count	Post-monsoon period		
Bacteria	4.410	-.632	8.333
	P<0.05	NS*	P<0.001
Fungi	8.036	7.289	8.343
	P<0.001	P<0.001	P<0.001
Actinomycetes	6.200	8.136	4.087
	P<0.001	P<0.001	P<0.05
Cellulose degrading bacteria	3.397	2.717	3.674
	P<0.05	P<0.05	P<0.05
Lignin degrading bacteria	0.00	1.732	1.732
	NS*	NS*	NS*
N ₂ fixers	3.464	-3.992	0.00
	P<0.05	P<0.05	NS*
Mycorrhizal spore	-0.792	0.00	0.866
	NS*	NS*	NS*
Phosphorus solubilizing bacteria	4.654	-1.946	2.089
	P<0.05	NS*	P<0.05

NS*- Not significant

Conclusion

The vegetation stand in all the ecosystems are generally playing a very important role related to soil organic matter content and microbial community of the area, which are essential for ecosystem functioning. The present investigation revealed considerable variation in the soil microbial population counts between sacred groves and disturbed non-sacred grove lands. The higher floral composition and diversity of tree species in the sacred grove land compared to disturbed land contributed abundant organic matter, higher rhizosphere and adequate moisture content in the soil, which provided a good habitat for microbes. However, the degraded vegetation and poor stand quality induced by anthropogenic disturbances in the non-sacred land failed to provide suitable quantity of organic matter, moisture content and habitat for microbes in the soil for their activity and multiplication. Therefore, the study concludes that there exists direct correlation between the vegetation stand and its quality in an area with microbial population and their performance.

References

- Banning, N. C., Grant, C. D., Jones, D. C., & Murphy, D. V. (2008). Recovery of soil organic matter, organic matter turnover and nitrogen cycling in a post-mining forest rehabilitation chronosequence. *Soil Biology & Biochemistry*, 40(8), 2021–2031.
- Barbhuiya, A. R., Arunachalam, A., Pandey, H. N., & Aruna. (2004). Dynamics of soil microbial biomass C, N and P in disturbed and undisturbed stands of a tropical wet evergreen forest. *European Journal of Soil*, 40(3), 113–121.
- Beare, M. H., Hui, S., Coleman, D. C., & Hendrix, P. F. (1997). Influences of mycelial fungi on soil aggregation and organic matter storage in conventional and no-tillage soils. *Applied Soil Ecology*, 5, 211–219.
- Berg, M. P., Kniese, J. P., & Verhoof, R. A. (1998). Dynamics and stratification of bacteria and fungi in the organic layers of soil pine forest soil. *Biology and Fertility*, 50, 313–322.
- Bird, J. A., Herman, D. J., & Firestone, M. K. (2011). Rhizosphere priming of soil organic matter by bacterial groups in a grassland soil. *Soil Biology & Biochemistry*, 43(4), 718–725.
- Bouwman, L. A., & Arts, W. B. M. (2000). Effects of soil compaction on the relationships between nematodes, grass production and soil physical properties. *Applied Soil Ecology*, 14(3), 213–222.
- Cappuccino, J. C., & Sherman, N. (1992). *Microbiology: A Laboratory Manual*, 3rd Edition Benjamin/Cummings Pub.Co, New York.
- Carney, K. M., & Matson, P. A. (2006). The influence of tropical plant diversity and composition on soil microbial communities. *Microbial Ecology*, 52(2), 226–238.
- Chhonkar, P. K., & Tarafdar, J. C. (1984). Accumulation of phosphatases in soil. *Journal of Indian Society of Soil Science*, 132(2), 266–272.
- Clarholm, M. (1985). *Possible role of roots, bacteria, protozoa and fungi in supplying Nitrogen to plants*. In: Fitter, A.H., Atkinson, D., Read, D.J., & Usher, M.B. (Eds.), *Ecological Interactions in Soils*, Blackwell Scientific Publication, Oxford, UK, 355–365.
- Garau, G., Castaldi, P., Santona, L., Deiana, P., & Melis, P. (2007). Influence of red mud, zeolite and lime on heavy metal immobilization, culturable, heterotrophic microbial populations and enzyme activities in a contaminated soil. *Geoderma*, 142(1-2), 47–27.

- Gerdemann, J. W., & Nicolson, T. H. (1963). Spores of mycorrhizal endogone extracted from soil by wet sieving and decanting. *Transactions of British Mycological Society*, 46(2), 235–244.
- Hakansson, I., & Lipiec, J. (2000). A review of the usefulness of relative bulk density values in studies of soil structure and compaction. *Soil Tillage Research*, 53(2), 71–85.
- Jha, D. K., Sharma, G. D., & Mishra, R. R. (1992). Soil microbial population numbers and enzyme activities in relation to altitude and forest degradation. *Soil Biology & Biochemistry*, 24(8), 761–767.
- Jordan, D., Li, F., Jr, F.P., Berry, E.C., & Hubbard, V.C. (1999). The effects of forest practices on earthworm populations and soil microbial biomass in a hardwood forest in Missouri. *Applied Soil Ecology*, 13(4), 31–38.
- Karam, D. S., Arifin, A., Radziah, O., Shamshuddin, J., & Majid, N. M. (2012). Impact of long-term forest enrichment planting on the biological status of soil in a deforested dipterocarp forest in Perak. Malaysia. *Scientific World Journal*, 12, 1–8.
- Kayang, H. (2006). Soil microbial population numbers in sacred grove forest of Meghalaya. Northeast India. *Asian Journal of Microbiology, Biotechnology & Environmental Sciences*, 8(3), 521– 526.
- Kennedy, A. C., & Smith, K. L. (1995). *Soil Microbial Diversity and the Sustainability of Agricultural Soils*. In: The significance and regulation of soil biodiversity. Kluwer Dordrecht, 75–86.
- Kourtev, P. S., Ehrenfeld, J.G., & Huang, W. Z. (2002). Enzyme activities during litter decomposition of two exotic and two native plant species in hard wood forests of New Jersey. *Soil Biology & Biochemistry*, 34(9), 1207–1218.
- Li, Q., Allen, H. L., & Wollum, A. G. (2004). Microbial biomass and bacterial functional diversity in forest soils: Effects of organic matter removal, compaction and vegetation control. *Soil Biology & Biochemistry*, 36, 571–579.
- Lima, J. A., Nahas, E., & Gomes, A. C. (1996). Microbial populations and activities in sewage sludge and phosphate fertilizer-amended soil. *Applied Soil Ecology*, 4(1), 75–82.
- Liu, X., Lindemann, W. C., Whitford, W. G., & Steiner, R. L. (2000). Microbial diversity and activity of disturbed soil in the northern Chihuahuan desert. *Biology and Fertility of Soils*, 32(3), 243–249.

- Liu, Z., Liu, G., Fu, B., & Zheng, X. (2007). Relationship between plant species diversity and soil microbial functional diversity along a longitudinal gradient in temperate grasslands of Hulunbeir, Inner Mongolia, China. *Ecological Research*, 23(3), 511–518.
- Mishra, R. R. (1966). Influence of soil environment and surface vegetation on soil microflora. *Proc. National Academy of Science*, 36(11), 117–123.
- Moussa, H. R., & Abdel-Aziz, S. M. (2008). Comparative response of drought tolerant and drought sensitive maize genotypes to water stress. *Australian Journal of Crop Science*, 1(1), 31–36.
- Pennanen, T., Liski, J., Bááth, E., Kitunen, V., Uotila, J., Westman, C. J., & Fritze, H. (1999). Structure of the microbial communities in coniferous forest soils in relation to site fertility and stand development stage. *Microbial Ecology*, 38(2), 168–179.
- Persson, T., Baath, E., Clarholm, M., Lundkvist, H., Söderström, B., & Sohlenius, B. (1980). Trophic structure, biomass dynamics and carbon metabolism of soil organisms in a scots pine forest. *Ecological Bulletins*, 32, 419–459.
- Purabi Saikia., & Santa Ram Joshi. (2012). Changes in micro fungal community in Cherrapunji- The wettest patch on earth as influenced by heavy rain and soil degradation. *Advances in Microbiology*, 2(4), 456–464.
- Reid, W. V. (1994). Setting objectives for conservation evaluation. In: Forey, P. L., Humphries, C. J., & Vane-Wright, R. I. (Eds.) *Systematic and Conservation Evaluation*. Systematics Association, 50, 1–13.
- Sarathchandra, S. U., Perrott, K. W., & Upsdell, M. P. (1984). Microbiological and biochemical characteristics of a range of New Zealand soils under established pastures. *Soil Biology & Biochemistry*, 16(2), 177–183.
- Shukla, A. K., Tiwari, B. K., & Mishra, R. R. (1989). Temporal and depth wise distribution of microorganisms, enzymes activities and soil respiration in potato field soil under different agricultural system in north eastern hill region of India. *European Journal of Soil Biology*, 26(3), 249–265.
- Swift, M. J., Heal, O. W., & Anderson, J. M. (1979). *Decomposition in Terrestrial Ecosystems*. Oxford: Blackwell Scientific Publications, 372.
- Taylor, B. R., & Parkinson, D. (1988). Aspen and pine leaf litter decomposition in laboratory microcosms. II. Interactions of temperature and moisture level. *Canadian Journal of Botany*, 66(10), 1966–1973.

- Waksman, S. A. (1927). *Principles of Soil Microbiology*, Baillie're Tindall and Co, London.
- Xiao, T., Scott, X. C., & Richard, K. (2005). Effects of soil compaction and forest floor removal on soil microbial properties and N transformations in a boreal forest long-term soil productivity study. *Forest Ecology and Management*, 217(2), 158–170.

CHAPTER-7

Analysis of physical and chemical properties of soil in the selected sacred groves and disturbed non-sacred grove lands

Introduction

Physical and chemical properties are the two important parameters of soil which are directly or indirectly correlated to its fertility and productivity. The texture and structure of soil system define its physical property and throws light into several parameters like porosity, aeration, moisture content, particle size, water holding capacity and temperature. The above said factors determine the quality of soil which make available water, nutrients and aeration for plants. Therefore, the physical property of a soil has great influence on the natural distribution of diverse plant species including trees, lianas and climbers. However, the chemical properties of a soil is decided by the level of organic matter content and their decomposition rate by microorganisms. Hence, the availability and stability of nutrients in the soil which are essential for plant growth and biomass production is decided by its chemical properties (Osman, 2013). With respect to a natural forest ecosystem, the physical as well as chemical properties are generally healthy and sustainable. However, due to various anthropogenic activities in the forest ecosystem and when pressure is high and prolonged, the existing vegetational characteristics may change and become enough to alter the favourable soil and environmental characteristics existing in the ecosystem. This may affect the survival of many endemic plants particularly of tree species in the ecosystem which are essential for providing favorable environment and habitat for many other plant species of natural existence. This change in vegetation and environmental characteristics may cause further reduction in diversity and richness of plant species in an area. The less diversity and decrease in the vegetation stand can cause reduction in the quantity and quality of organic matter content of the soil. This kind of a situation may lead to decrement in diversity and biomass of microbes in such soil which in turn may affect the decomposition rate of organic matter and may result in poor soil characteristics and quality.

Several reports on the influence of soil physical as well as chemical properties on vegetation stand characteristics and similarly the impact of anthropogenic pressures on forest vegetation and soil characteristics are available (Grogan et al., 2012; Burton et al., 1989; Olanrewaju,

2008; Keenan et al., 1998; Lu et al., 2002; Rasiah & Kay, 1995; Lu et al., 2002; Cavelier et al., 1999; Tisdall & Oades, 1980; Sakai et al., 2008; Osman, 2013; Nelofer et al., 2016). The objective of the present chapter is to analyse the selected physical and chemical properties of soil samples collected from selected sacred groves and disturbed non-sacred grove lands. Based on this objective, the study tries to reveal the influence of difference in vegetational stand on soil property and quality. The study also tries to reveal whether there is any influence on the difference in extent of the selected groves on soil properties.

Review of Literature

In a forest ecosystem, various characteristics like vegetation, water and soil resources as well as microclimate are subjected to substantial impacts by anthropogenic pressures caused due to collection of wood for fuel, animal grazing, shifting of cultivation, extraction of fodder and burning of forest patches to facilitate growth of grass for fodder by communities living inside and nearby the forest reserves (Tilman & Lehman, 2001; Bhat et al., 2001; FAO, 2006). When degradation of a forest ecosystem occurs on account of agricultural practice like slash and burn crop production and clearing of forest for developmental activities, it is mainly the complex soil ecosystem with unique physical and chemical parameters that gets deteriorated (Olanrewaju, 2008). In majority of the tropical areas, the extend of forest area utilised for shifting cultivation has increased considerably and this continuous practice has resulted in the degradation and loss of soil quality and biodiversity and ultimately many such areas are now made unproductive (Grogan et al., 2012).

Cavelier et al. (1999) has reported that the degradation of soil quality occurs due to soil erosion as well as intensive grazing and conventional slash and burn method for agriculture which lead to long term deforestation and this has its effect on the physical and chemical properties of soil. The climate and ecological parameters have varied severely as a result of shifting cultivations which cause destruction of natural forest thereby leading to soil and nutrient loss and subsequently have an impact on the varying patterns of biogeochemical cycles. It is observed that as a result of deforestation and cropping thereafter, the amount of plant-available nutrients have decreased (Keenan et al., 1998; Lu et al., 2002), microbial activity has retarded (Sahani & Behera, 2001), soil erosion, runoff as well as bulk density has enhanced (Rasiah & Kay, 1995), and infiltration, porosity together with water-holding capability has decreased (Lu et al., 2002). Equipment's like felling machines, crawler tractors as well as mechanical processors used for logging and harvesting forest produce can disturb and compact the soil thereby causing soil damage (McMahon et al., 1999). Clearance of forest may lead to reduced biodiversity, restricted natural adaptive vegetation and simplify the structure of ecosystem causing moderate to large scale soil erosion as a result of reducing quantity of organic matter and non-availability of vegetative canopy to obstruct the rainfall in those areas (Zheng, 2005).

Soil disruption and compaction as a result of harvesting may lead to increased seedling mortality and retard the growth of trees, and the after effect of this may often last long for

many years if no corrective measures are taken (Minore & Weatherley, 1990; Wronski & Murphy, 1994). Soil bulk density is dependent on the porosity, content of organic matter available, compaction and soil texture. Bulk density being an index of compaction of soil, it has an impact on productivity of site (Gale & Grigal, 1987) and growth of trees (Froehlich et al., 1986). Due to soil compaction, consolidation of soil happens physically by some applied force which destroys the structure of soil, causes compression of soil volume, enhances bulk density, decreases porosity and restricts movement of air and water (Osman, 2013). Soil moisture content is one among the major factors which affect the level of soil compaction; any change in compaction causes change in the content of soil moisture; resistance to root penetration and bulk density increases with increase in soil compaction and also reduces porosity, rate of infiltration and hydraulic conductivity (Jagdish et al., 2015). Soil compaction that happened due to harvesting may result in reduced content of soil moisture and nutrients in soil (Froehlich & McNabb, 1984; Rockich et al., 2001) that may affect the growth and regeneration of trees in future (Sakai et al., 2008). Richards and Cockcroft (1974) inferred that root respiration in trees was fairly prohibited as the air space in between soil was decreased below 15% and the growth of root as well as the overall tree growth in many analysis which include *Pinus sylvestris*, *Picea abies* (Youngberg, 1970), *Pinus contorta* (Lees, 1972), and citrus (Patt et al., 1966), was observed to be considerably decreased when the content of O₂ in soil lowered to 10%. It is the energy which is released in root respiration that is required for the intake of minerals, new protoplasm synthesis and cell membrane maintenance (Osman, 2013). As bulk density is less, compaction decreases and porosity increases which shows an inverse relationship between soil porosity and bulk density (Amusan et al., 2006). The soil porosity affects the diffusion of oxygen to tree roots as well as the diffusion of unwanted carbon dioxide concentrations to tree roots from nearby areas and hence is a prominent factor in assessing the growth and progressive development of tree root (Kramer, 1949). The germination of seeds and emergence of seedling of trees in forest are affected by bulk density and compaction of soil (Taylor, 1971; Corns, 1988) as well as natural regrowth in forests (Sokolovskaya et al., 1977), due to the reason that compaction increases strength of soil and reduces the macropore numbers, root elongation rate thereby reducing root length which affects productivity. The value of bulk density lowers when the moisture content in forest soil is higher and vice versa and the value of bulk density increases when the organic matter content decreases (Johan, 1998).

Another key physical property that manages the physical, chemical as well as the biological process of soil is the soil temperature. Solar radiation, temperature of air, water in soil, content of organic matter, soil texture, topography of site, surface area covered by litter and plant canopy are the factors which influence the forest soil temperature (Paul et al., 2004). Normally during summer the forest sites are cooler compared to field sites due to the forest vegetation canopy and layers of litter which intercept the solar rays by way of acting as insulator. Spittlehouse and Stathers (1990) identified that highest daily temperature of soil at 1 cm depth in cleared forest area was 50°C above compared to 16°C in the nearby full-grown, hemlock-fir forest in the coastal belt of British Columbia. The microbial changes of nitrogen (Plymale et al., 1987) and sulphur (Strickland & Fitzgerald, 1984) and other various nutrients are regulated by temperature of soil in any forest ecosystem.

The important factors that reign the transformation process of organic matter are quantitative and qualitative components of litter materials, the physical as well as chemical environment and the organisms which are involved in decomposition (Swift et al., 1979). The physical and chemical soil properties may have a direct influence on the microbiological process which support the capacity to hold water, water accessibility, buffering in pH, nutrient cycling and capability of soil for exchange of ions (Nelofer et al., 2016). Liu et al. (2000) has observed that diversity of microbes reduces with disturbance. Carney and Matson (2006) identified evidence for changes in the microbial population and community which occurred in the forest vegetation where the alteration happened in the plant community in the interest of human.

The availability of nutrients to roots of plants, growth of microbes, processes in soil, chemical changes in soil and water stability are explained by the soil solution chemistry in that area (Nelofer et al., 2016). More than 72 mineral elements available in the soil, which are otherwise called as plant nutrients, may be categorized as minor and major. These are essentially required for the growth and development of plants. The important elements are nitrogen, potassium, sulphur, carbon, calcium, phosphorus, copper, magnesium, zinc, molybdenum, manganese and boron (Osman, 2013). Fall of litter is an important biological pathway for transfer of elements from plants to soil which lead to replenishment of OM and cycling of nutrients (Yang et al., 2005; Bhat & Jan, 2010). In case of a forest ecosystem, the depletion of nutrient pool that happens due to uptake of nutrients and leaching is replenished by litter fall (Gosz et al., 1976; Morrison, 1991). The process of accumulation of organic matter in soil, their break down and nutrient release may be influenced by composition and age of vegetation stand, edaphic factors, climate, disturbance history and season (Schlesinger, 1977; Binkley,

1995). Conductive microenvironment and quantity and quality of material primarily determine the decomposition rates (Schlesinger, 1977; Berg et al., 1996).

Soil organic matter (SOM) is an important chemical indicator to assess the quality of soil aggregate stability (Schaetzl & Thompson, 2015; Henderson et al., 2010). It is suggested by many authors that the species of trees and ground vegetation has an impact on the quality and quantity of organic matter in soil (Kaiser et al., 2001; Park et al., 2002). The lower production of litter and speedy decomposition rate may be the reason for low SOM in the disturbed areas (Vitousek & Sanford, 1986). It is noticed that in an agroforestry ecosystem, nitrogen and potassium retained in the trees are low, but calcium, phosphorus and magnesium retention is high which indicates that comparatively higher quantity of N and K are returned to soil by way of litter fall (Bhardwaj & Pankaj, 2005). Soil and vegetation are the factors on which the retention of nutrient depend upon (Vitousek & Reiners, 1975). Out of the assimilated nutrients of trees in forest, only a small portion is utilized for physiological needs and accumulated in biomass whereas a major portion is returned to soil (Alifragis & Papamichos, 1990). The various means of return of nutrients to soil by the existing biomass may be via the different dead organic plant components such as leaves, dead roots etc. (Sollins et al., 1980).

Due to the uninterrupted production of carbon dioxide and many organic acids produced from decomposing litter together with the uptake of bases like calcium, magnesium etc., by trees for storage in the wood tissues, thereby acidifying the soil, may be the reason why forest soils are more acidic compared to grasslands and soils of agricultural areas (Osman, 2013). The pH of soil in an open system is usually found to be lowered by the organic matter which may be the result of hydrogen ions release which are in association with organic anions or it can be the result of nitrification process (Porter et al., 1980).

Materials and methods

Soil sample collection

Soil samples are collected in triplicates from core regions of sacred groves, transition regions (the buffer region between the grove and disturbed land) and disturbed non-sacred grove regions of all the four selected study sites (Sankulangara, Palliyana, Nambiyath and Poyyara sites) at a depth of 30cm from the surface, using the core type soil auger to get comparatively less disturbed pedon of soil. The soil samples are collected for analysis all the times from previously marked area from each regions of study. The soil samples are then carefully transferred to air tight polythene covers and subjected to analysis for physical and chemical properties. The soil analysis is conducted during the pre-monsoon (April-May) and post-monsoon (August-September) period of years 2016-2018.

I) Analysis of soil physical properties

Various soil physical properties analysed for the study include soil moisture content, water holding capacity, bulk density, porosity, pH and electrical conductivity.

1. Moisture content

Soil moisture is estimated using the gravimetric method. Initial weights of fresh soil samples are recorded and the samples are kept in a hot air oven at 105 °C, until a constant weight is attained. After cooling the sample is taken in a desiccators and the final weight is recorded. Soil moisture of the samples is calculated using the formula:

$$\text{Moisture \%} = \frac{I - F}{I} \times 100$$

Where, I is the Initial weight of the soil (g)

F is the Final weight of the soil (g)

2. Water holding capacity, bulk density and porosity

The physical constants like Water holding capacity, bulk density and porosity of the soil samples are determined by Keen Racksowski box method.

Principle:

A known quantity of soil is allowed to fully saturate and equilibrated with water and from the water held in the soil, single value constants namely bulk density, maximum water holding capacity and porosity are determined using Keen Racksowski box.

Procedure:

Fit a suitable filter paper to the perforated base of the box and weigh it in the balance. Pack the box with air dried soil by adding small quantities at a time and tapping the box after each addition to ensure even packing. Continue addition of soil and tapping to pack until the box is nearly full. Level the surface, when the box is completely full. Record the weight of the box with soil. Place the box with soil in a small tray containing water to a depth of half inch and leave it overnight. Remove the box next day and wipe outside with a dry towel and weigh immediately. Using a sharp scalpel remove the expanded wet soil from the box and transfer to a pre-weighed porcelain dish. Weigh the box with residual wet soil. Dry in an oven at 105 °C and weigh to constant weight. In the same way, find out the weight of expanded soil also. From the readings, calculate the physical constants.

Calculations:

Weight of box + filter paper = A g

Weight of box + dry soil = B g

Weight of box + saturated soil = C g

Weight of the box + soil after removing the expanded portion = D g

Weight of the box + soil after drying in oven = E g

Volume of the box $V = \pi r^2 H$

Weight of the soil = E – A g

Water holding capacity =
$$\frac{C-B}{B-A} \times 100$$

Bulk density (g/cm³) =
$$\frac{\text{Weight of the soil}}{\text{Volume of soil with pore space}} = \frac{B-A}{V}$$

Porosity =
$$\frac{D-E}{B-A} \times 100$$

3. pH

To determine pH at the moisture saturation level, 20 g of soil is dissolved in 100 mL of distilled water (1:5) and stirred with a glass rod for an hour at regular intervals. The pH is determined with a pH meter and expressed directly in pH units associated with the specific dilution of the soil suspension.

4. Electrical conductivity (Electrometric method)

Soil suspension is prepared after shaking a mixture of 20 grams of soil in 100 mL de-ionized water for about an hour. Conductivity of the suspension is measured within an hour by using a conductivity meter. The values are expressed in mho/cm at specific dilution of the soil suspension.

II) Analysis of soil chemical properties

Various soil chemical properties analysed for the study include organic carbon, available nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, sodium, and available boron, extractable iron, manganese, zinc and copper.

1. Estimation of organic carbon (OC)- (Walkley & Black, 1934)

Reagents:

Potassium dichromate (1 N); Silver sulphate-sulphuric acid reagent; Ferroin indicator; ferrous sulphate (0.5 N)

Procedure:

10 mL of 1N potassium dichromate solution is added to 1 gram of sieved (0.5 mm mesh), air-dried soil and swirled gently to disperse the soil. 20 mL of silver sulphate-sulphuric acid reagent is added rapidly to the suspension with constant swirling and allowed to stand on an asbestos sheet for 30 minutes. After 30 minutes, 100 mL distilled water is added followed by 3–4 drops of Ferroin indicator. The solution is titrated against 0.5 N ferrous sulphate solutions. At the end point, solution changes from blue to red.

Calculation:

$$\text{Organic Carbon \%} = \frac{(\text{me K}_2\text{Cr}_2\text{O}_7 - \text{me FeSO}_4)}{\text{Gram of air dried soil}} \times 0.003 \times 100 \times f$$

Where, f = Correction factor (1.33); me = Normality of solution $\times$ mL of the solution used;
OC% = % of organic matter in soil (% organic carbon $\times$ 1.729)

2. Estimation of available nitrogen (NH_4^+ , NO_3^-) Alkaline permanganate method (Subbia & Asija, 1956)

Principle: The amount of soil nitrogen released by alkaline permanganate solution is estimated by distillation with sodium hydroxide. The distillate is collected in boric acid containing mixed indicator and titrated against standard acid – H_2SO_4 . The nitrogen so estimated is designated as available nitrogen which is correlated with crop response to nitrogen fertilization.

Reagents:

Liquid paraffin or paraffin wax, potassium permanganate solution, NaOH solution, distilled water, boric acid with mixed indicator, N / 50 sulphuric acid

Procedure:

Weigh 20g of the soil and transfer it to a distillation flask. Add 20 mL of distilled water and 1 mL of liquid paraffin or 1 g of paraffin wax to control frothing. Put a few glass beads to prevent bumping and then add 100 mL of 0.32% potassium permanganate solution and 100 mL of 2.5% NaOH solution. Distill the contents in a steady rate collecting the liberated ammonia in 100 mL conical flask containing 20 mL of 2% boric acid with mixed indicator (0.5 g of bromocresol green, 0.1 g of methyl red in 100 mL of ethyl alcohol). Continue distillation for about half an hour or until 100 mL of distillate is collected in the beaker. Titrate the ammonia collected against N / 50 sulphuric acid.

Calculation:

$$\begin{aligned} 1 \text{ mL of N/50 } \text{H}_2\text{SO}_4 &= 0.0028 \text{ g of Nitrogen} \\ \text{N Kg ha}^{-1} &= \frac{\text{TV} \times 0.0028 \times 1000 \times 2.24 \times 10^6}{1000 \times 20} \end{aligned}$$

3. Estimation of available phosphorus (H_2PO_4) - (Watanabe & Olsen, 1965).

Reagents:

Ammonium fluoride (NH_4F) 1N: Dissolve 37 g of NH_4F in distilled water and dilute the solution to 1 litre. Store the solution in polythene bottle.

Hydrochloric acid (HCl) 0.5 N: Dilute 20.2 mL of concentrated HCl to a volume of 500 mL with distilled water.

Bray No.1: Add 15 mL of 1N ammonium fluoride (NH_4F) and 25 mL of 0.5N Hydrochloric acid (HCl) to 460 mL of distilled water. This solution can be kept in glass for more than one year.

Ammonium paramolybdate ($(\text{NH}_4)_6\text{Mo}_7\text{O}_{24}\cdot 4\text{H}_2\text{O}$): Dissolve 12g of ammonium paramolybdate in 250 mL of distilled water. Dissolve 0.2908 g of potassium antimony tartarate ($\text{KSbO}\cdot\text{C}_4\text{H}_4\text{O}_6$) in 100 mL of distilled water. Add these dissolved reagents to 1 litre of 5N sulphuric acid (H_2SO_4) (141 mL of concentrated H_2SO_4 diluted to 1 litre), mix thoroughly and dilute with distilled water to 2 litre. Store in a Pyrex glass bottle in a dark and cool compartment (Reagent A).

Ascorbic acid: Dissolve 1.056 g of ascorbic acid in 200 mL of reagent A and mix. This ascorbic acid (reagent B) should be prepared as and when required because it cannot be kept for more than 24 hours.

Standard phosphate solution: Dissolve 0.4393 g of oven-dry AR grade potassium dihydrogen phosphate (KH_2PO_4) in distilled water and dilute the solution to 1 L. One millilitre of this solution contains 100 μg of P. From this solution, prepare a secondary standard of 2 $\mu\text{g mL}^{-1}$ by pipetting out 2 mL and diluting to 100 mL with distilled water.

Procedure:

Extraction: Available P in acidic soils is commonly extracted using Bray No.1 (Bray & Kurtz, 1945) which consists of 0.03 N NH_4F and 0.025 N HCl. The combination of HCl and NH_4F is designed to remove easily acid soluble P forms, largely calcium phosphates and a portion of the aluminium and iron phosphates. The NH_4F dissolves aluminium and iron phosphates by its complex ion formation with these metal ions' acid solution.

Weigh out 5 gm of soil into a 100 mL conical flask and add 50 mL of Bray No.1 reagent and shake for exactly 5 minutes. Filter through Whatman No.42 filter paper. To avoid interference of fluoride, 7.5 mL of 0.8 M boric acid (50 g of H_3BO_3 per litre) can be added to 5 mL of the extract if necessary. Estimate phosphorus in the extract by ascorbic acid method (Watanabe & Olsen, 1965).

Estimation by reduced molybdate blue colour method:

Pipette out 5 mL of the extract into a 25 mL volumetric flask and dilute it to approximately 20 mL. Add 4 mL of reagent B. Make up the volume with distilled water and shake the contents well. Read the intensity of colour after 10 minutes at 660 nm. The colour is stable for 24 hours and the maximum intensity develops within 10 minutes. The concentration of P in the sample is computed from the standard curve.

Preparation of standard curve:

Prepare different concentrations of P by taking 1, 2, 3, 4, 5 and 10 mL of G mL⁻¹ P solution in 25 mL volumetric flasks. Add 5 mL of extracting reagent (Bray No.1) and develop colour as described above by adding reagent B. Plot the concentration vs. absorbance curve on a graph paper.

Calculation:

Available P (mg kg⁻¹ soil) = $\mu\text{g P mL}^{-1}$ of aliquot $\times 50/5 \times 25/5$

Available P (mg kg⁻¹ soil) =
$$\frac{\text{Absorbance for sample} \times 50}{\text{Slope of Std. curve}}$$

Available P (kg ha⁻¹ soil) = Available P (mg kg⁻¹ soil) $\times 2.24$

4. Estimation of available potassium (K⁺) - (Jackson, 1973).

Principle:

By definition, exchangeable K is that which is free to exchange with cations of salt solutions added to soils, but the quantity exchanged from the soil depends on the nature of replacing solution. Hence with reference to fertility evaluation exchangeable K is defined more specifically as that which is extracted with neutral one N ammonium acetate minus the water soluble K. In normal soil, as the water soluble K is so small there is no appreciable error even if it is included in the water soluble plus exchangeable K which represents the available pool. The removal of water soluble K before extraction with ammonium acetate is not recommended because as the salt content of soil solution is decreased, the adsorption of divalent cations in solution increases.

Reagents:

Neutral 1 N ammonium acetate solution ($\text{CH}_3\text{COONH}_4$): Dissolve 77.08 gm of ammonium acetate in distilled water and make up to 1 L. Adjust the pH if necessary to 7 with acetic acid or ammonium hydroxides.

Standard K solution: Dissolve 1.908 gm of dried K chloride (KCl) AR grade in distilled water and make up to 1 L so as to get $1000 \mu\text{g mL}^{-1}$ K solution.

Procedure:

Extraction: Available potassium was extracted by shaking with neutral normal ammonium acetate for 5 minutes (Hanway & Heidel, 1952). Shake 5gm of soil with 25 mL neutral normal ammonium acetate for five minutes and filter immediately through a dry Whatman No: 42 to filter paper. First few mL of the filtrate may be discarded. K concentration in the extract is determined using flame photometer after necessary setting and calibration of the instrument (Jackson, 1973).

Standard curve for potassium:

Dilute measured aliquots from the standard solution using ammonium acetate solution to give concentrations of 5 to 20g K. After attaching the appropriate filter and adjusting the gas and air pressure set reading in the flame photometer to zero for the blank (ammonium acetate) at 100 for 20g K. The curve is obtained by plotting the reading against different concentrations (4, 10, 15, 20g) of K. Fluctuation in gas and air pressure does not allow steady reading in the meter and must be taken care of.

Calculation:

Available K (mg kg^{-1} soil) = $\mu\text{g K mL}^{-1}$ of the aliquot $\times 25/5$

Available K (mg kg^{-1} soil) = $\mu\text{g K mL}^{-1}$ of the aliquot $\times 5$

Available K (kg ha^{-1}) = Available K (mg kg^{-1} soil) $\times 2.24$

5. Estimation of available calcium (K^+) and magnesium (Mg^{2+})- (By Atomic Absorption Spectrophotometry)

Principle:

In the absence of excess of $CaCO_3$, the cations Ca^{2+} , Mg^{2+} and Na^+ along with K^+ appear to be completely exchangeable by neutral normal ammonium acetate.

Reagents:

Neutral normal ammonium acetate solution (CH_3COONH_4): Dissolve 77.08 g of ammonium acetate in distilled water and make up to 1L. Adjust the pH if necessary to 7 with acetic acid or ammonium hydroxide.

Procedure:

Extraction of available Calcium and Magnesium: Shake 5 g of soil with 25 mL of neutral normal ammonium acetate for 5 minutes and filter immediately through a dry Whatman No: 42 filter paper. First few mL of the filtrate may be discarded.

Estimation of Calcium and magnesium by Atomic Absorption Spectrophotometry: From the soil extract, Ca and Mg can be estimated by Atomic Absorption Spectroscopy (AAS). The chemical interference, resulting from the formation of stable compounds between Ca and Mg ions and the accompanying anions may reduce the absorption. This interference may be overcome by using a realising agent such as Lanthanum or Strontium.

Calculation

Available Ca/Mg ($mg\ kg^{-1}$ soil) = $\mu g\ Ca/Mg\ mL^{-1}$ of the aliquot $\times 25/5$

Available Ca/Mg ($mg\ kg^{-1}$ soil) = $\mu g\ Ca/Mg\ mL^{-1}$ of the aliquot $\times 5$

6. Estimation of available sulphur (SO_4) by Turbidimetric method (Massoumi & Cornfield, 1963)

Principle:

Different reagents have been proposed for extracting plant available sulphur from the soil. These include water, salt solutions such as 0.15% $CaCl_2$, 500 ppm P as Ca (H_2PO_4)₂ or KH_2PO_4 and acidic solutions such as 0.5 N ammonium acetate plus 0.25 N acetic acid and Bray No.1. Generally phosphate solutions extract more sulphate sulphur from soil than that can

be extracted with water or salt solutions because phosphate ions displace the adsorbed sulphate, which is known to be readily available to plants.

Reagents:

0.15% CaCl_2 solution: Dissolve 1.5 g of Calcium chloride dehydrate ($\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$) in about 500 mL of distilled water and make up the volume to 1L.

Gum acacia solution: Dissolve 0.25 g of chemically pure gum acacia in hot water and filter the hot solution through Whatman No.42 filter paper. Cool the filtrate and dilute to 100 ml.

Barium chloride (BaCl_2): Grind analytical grade BaCl_2 to pass through 1 mm sieve.

Concentrated standard sulphate solution (100 mg S L^{-1}): Dissolve 0.5434 g oven dried AR potassium sulphate (K_2SO_4) in distilled water and make up to 1 litre.

Extraction (Tabatabai, 1982): Shake 10 g of air dried processed soil with 50 mL of 0.15% CaCl_2 solution in a 250 ml conical flask for 30 minutes. Filter the extract through Whatman No.42 filter paper and estimate the sulphate content by turbidimetric procedure.

Preparation of standard curve:

Pipette out 0, 0.25, 0.5, 0.75, 1.0, 1.25 and 2.5 mL of standard sulphate solutions in separate 25 mL volumetric flasks and add 10 ml of extracting solution (0.15% CaCl_2). Prepare fresh standards each time when a batch of sample is analysed.

Add 1 g of BaCl_2 crystals to each flask and swirl to dissolve.

Add 1 ml of 0.25 % gum acacia solution, make up the volume with distilled water and shake well.

Within 5-30 minutes of development of turbidity, read the absorbance at 440 nm on a spectrophotometer.

Draw the standard curve with absorbance on Y axis and concentration on X axis.

Procedure:

Pipette out 10 ml of the soil extract into a 25 mL volumetric flask.

Add 1 g of BaCl_2 crystals and swirl to dissolve.

Add 1 ml of 0.25 % gum acacia solution, make up the volume with distilled water and shake well.

Within 5-30 minutes of development of turbidity, read the absorbance at 440 nm on a spectrophotometer.

Calculation:

$$\text{Amount of Sulphur (mg kg}^{-1}\text{ soil)} = \text{Concentration from the instrument} \times \frac{25}{10} \times \frac{50}{10}$$

$$\text{Amount of sulphur (mg kg}^{-1}\text{ soil)} = \frac{\text{Absorbance for the sample} \times 12.5}{\text{Slope of Std. curve}}$$

7. Estimation of available sodium (Na⁺) by Flame photometry (Skoog et al., 1992)

Apparatus:

- 1) Flame Photometer
- 2) Beaker – 250 mL, 100 ml.
- 3) Volumetric measuring flask – 50 mL capacity
- 4) Measuring flask – 1 litre capacity

Reagents:

1 N Ammonium Acetate - Dissolve 77.08 gm of ammonium acetate in distilled water and make the volume to 1L. Adjust the pH to 7.0 with glacial acetic acid or ammonia solution.

Standard Sodium Solution (0-40 mg/l)

Procedure:

Weigh 5 g of 2 mm sieved soil sample in 250 ml plastic conical flask.

Add 25 ml of the neutral 1N ammonium acetate solution and shake for 30 minutes on mechanical shaker at 110 rpm. Filter through whatman No. 1 filter paper.

Take the readings on flame photometer.

Feed the working standard solution and prepare a standard curve.

Calculation:

$$\text{Na mg/100 g} = \frac{A \times V \times 100}{W \times 10,000}$$

Where,

A = Sodium/ content of soil extract (mg/l)

V = Total volume of the soil extract (ml)

W = Weight of the air dried soil taken for extraction (g)

8. Estimation of extractable Iron (Fe^{2+} , Fe^3), Manganese (Mn^{2+}), Zinc (Zn^{2+}) and Copper (Cu^{2+}) (Lindsay & Norvell, 1978)

Principle:

The major categories of micronutrient extracts presently in use are dilute acids and solutions containing agents such as DTPA or EDTA.

Dilute acids (0.025-0.1 M) have been used as micronutrient extracts for many years, primarily on acidic soils. Their applicability is confirmed to acidic soils because they generally are not sufficiently buffered to extract meaningful levels of micronutrients from calcareous soils. Acidic extractants do not have a particularly sound theoretical basis, but due to their extensive use in field and laboratory studies, a well-developed database exists relating acid extractable levels of micronutrients to crop response. The most commonly used dilute acids are: Mehlich - 1 (dilute double acid, 0.0125 M H_2SO_4 + 0.05 M HCl) (Sims & Johnson, 1991).

Among the chelating agents, DTPA is the most commonly used one. The DTPA soil test, developed for near neutral and calcareous soil (Lindsay & Norvell, 1978) illustrates the evolution of the soil test extractant from theoretical principles. The extracting solution consists of 0.005 M DTPA and 0.01 M $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$, buffered at pH 7.3 by 0.1 M triethanolamine (TEA). The DTPA extractant offered the most favourable combination of stability constants necessary to simultaneously extract four micronutrient cations (Fe, Mn, Cu and Zn). The buffered pH and presence of soluble Ca^{2+} prevent excessive dissolution of calcium carbonate avoiding the release of available micronutrients occluded by this solid phase. At pH 7.3, 70-80 % of the buffering capacity provided by TEA has been consumed. Therefore use of DTPA extractant on acidic soils will result in neutralization of remaining buffer capacity and unpredictable extraction pH.

Reagents:

Hydrochloric acid (HCl), 0.1 N: Add 8.1 mL of concentrated HCl (reagent grade) to approximately 900 mL of distilled water, mix cool to room temperature and make up to 1 litre.

DTPA: Prepare the extractant by dissolving 1.967 g of 14.92 g of TEA and 1.47 g of $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ in 200 mL of distilled water and dilute to approximately 900 ml. Adjust the pH to + or - 0.05 with 1:1 HCl and make up the volume to 1 litre.

Estimation of Fe, Mn, Zn and Cu in acid soils (pH<6.5)

Extraction and estimation:

Shake 2 g of soil with 20 mL of 0.1 M HCl for 5 minutes. Filter through Whatman No.42 filter paper. Collect the filtrate and estimate the contents of Fe, Mn, Zn and Cu using an Atomic Absorption Spectrophotometer.

Calculation

$$\text{Amount of micronutrient (mg kg}^{-1}\text{ soil)} = \text{Concentration from the instrument} \times \frac{20}{2}$$

$$\text{Amount of micronutrient (mg kg}^{-1}\text{ soil)} = \text{Concentration from the instrument} \times 10$$

9. Estimation of available boron (H_3BO_3 , BO_3)- Hot water-soluble boron (Gupta, 1967)

Principle:

Although there are a variety of chemical tests for predicting crop response to boron, the hot water extraction procedure developed by Gupta (1967) is the easiest method.

Reagents:

Buffer solution: Dissolve 250 gm of ammonium acetate and 15 g of EDTA (disodium salt) in 400 mL of distilled water, slowly add 125 mL of glacial acetic acid and mix thoroughly.

Azomethine -H reagent: Dissolve 0.45 g of azomethine-H in 100 mL of 1 % L- ascorbic acid solution. Store in polypropylene bottle in refrigerator. Prepare fresh solution every week.

Boron standard solution: Dissolve 0.114 g of AR grade boric acid (H_3BO_3) in distilled water and make the volume to 1000 ml. Each mL of this solution contains 20 μg of B. Dilute 0.5, 1, 2, 3, 4, 5, 10, 20, 30, 40 and 50 ml of this stock solution to 100 ml with distilled water to have solution concentrations of 0.1, 0.2, 0.4, 0.6, 0.8, 1.0, 2.0, 4.0, 6.0, 8.0 and 10 $\mu\text{g ml}^{-1}$ respectively.

Activated charcoal.

Procedure:

Weigh 20 g of air dried processed soil in a 250 ml quartz or other boron free conical flask and add 40 ml distilled water.

Add 0.5 g of activated charcoal and boil for 5 minutes on a hot plate, filter immediately through Whatman no.42 filter paper.

Cool the contents to room temperature and transfer 1 mL aliquot of blank, diluted boron standard or sample solution into a 10 ml polypropylene tubes.

Add 2 mL of buffer and mix.

Add 2 mL of azomethine-H reagent, mix and after 30 minutes read the absorbance at 420 nm on a spectrophotometer.

Prepare a standard curve plotting boron (B) concentrations (0 to 10 $\mu\text{g B ml}^{-1}$) on X-axis and absorbance on Y-axis.

Calculation

$$\text{Amount of B in soil (mg kg}^{-1}\text{ soil)} = \frac{\text{Absorbance reading}}{\text{Slope from curve}} \times \frac{40}{20}$$

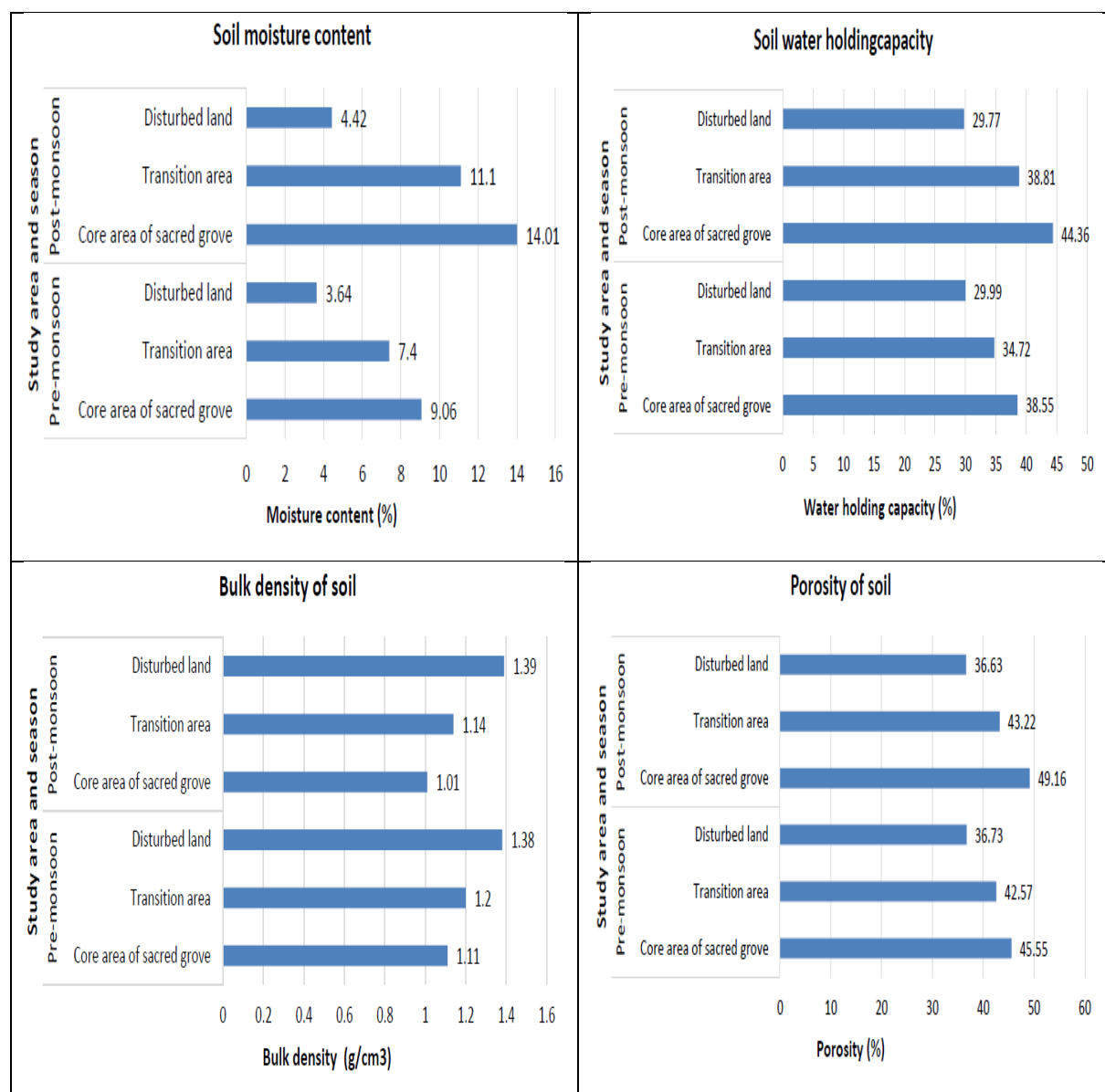
The mean value and standard deviation of different parameters in selected sacred groves and disturbed non-sacred grove lands are determined and compared statistically using 't'test of SPSS statistics 20.

Results

I) Analysis of soil physical properties

A) Sankulangara study site

The details of various physical properties of soil samples collected from the core region, the transition region and the disturbed non-sacred region at Sankulangara study site during the pre-monsoon as well as the post-monsoon season are shown in the figure F1.



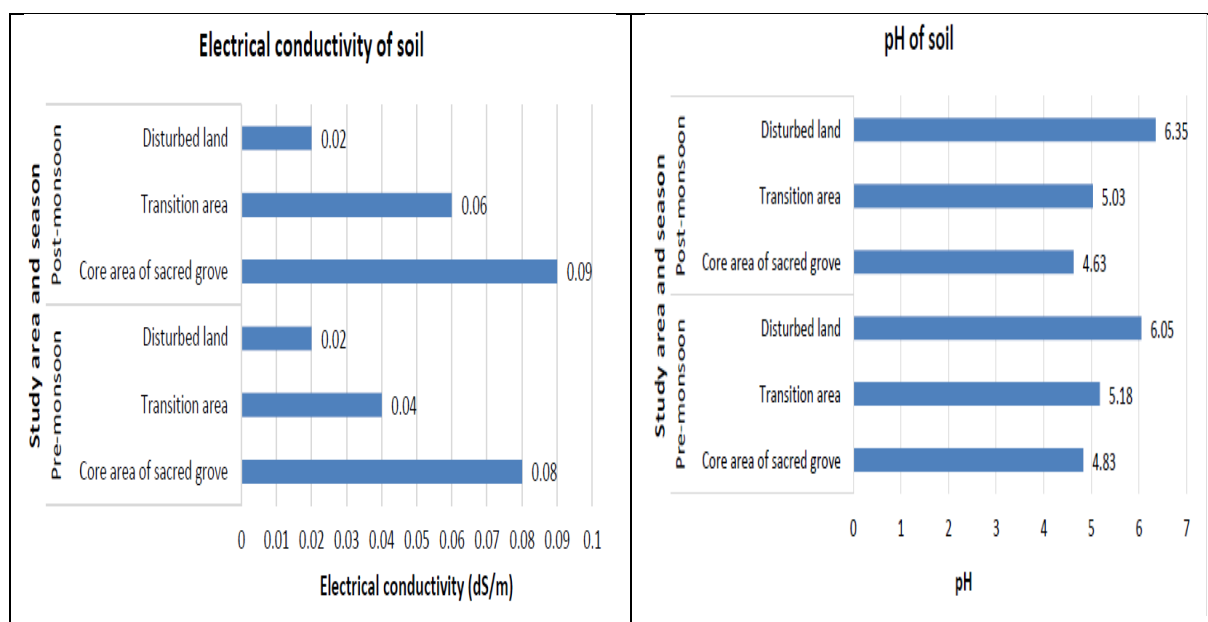


Figure F1: The status of various physical properties of soil samples collected from different regions in different season at Sankulangara study site

The soil moisture content data showed variation among the samples collected. The highest moisture content is obtained in the soil of core region of sacred grove while the lowest in the disturbed non-sacred grove region, irrespective of pre-monsoon and post-monsoon periods. During the pre-monsoon period, an average moisture content of 9.06% is recorded in the core region of sacred grove while an average of 7.4% and 3.64% are recorded in the transition region and disturbed land respectively. In the post-monsoon period, the average moisture content in the core region is 14.01% and is 11.1% and 4.42% respectively in the transition region and disturbed land. The data shows the soil moisture level tend to improve during the post-monsoon period compared to pre-monsoon and the improvements are 35.33%, 33.32% and 17.65% increase respectively in the core, transition and disturbed regions. The maximum difference in soil moisture content is recorded between the core region of sacred grove and the region of disturbed non-sacred grove land. This recorded an increase of 59.82% and 68.45% higher soil moisture content in the core region over the disturbed land during the pre-monsoon and post-monsoon periods respectively. However the difference in soil moisture content between the core and the transition regions are comparatively lower where the core region is 18.32% higher during the pre-monsoon and 20.77% higher during the post-monsoon periods over the transition region. The moisture content in the transition region recorded an increase of 50.81% and 60.19% compared to the disturbed land respectively during the pre-monsoon and post-monsoon periods.

The **soil porosity** values showed the highest porosity in the soil samples collected from the core region of sacred grove and this is followed by the region of transition and the lowest value in the soil of disturbed non-sacred grove land. The average porosity of 45.55%, 42.57% and 36.73% are recorded in the region of core, transition and disturbed land respectively during the pre-monsoon period while during the post-monsoon period, the porosity values are 49.16%, 43.22% and 36.63% respectively. The soil porosity in the core and transition regions are found to increase during the post-monsoon period over the pre-monsoon while in the disturbed non-sacred grove land, the porosity value is found to decrease slightly. This recorded an increase of 7.35% and 1.52% with respect to core and transition region while a decrease of 0.27% is recorded with respect to disturbed land. The highest difference in soil porosity is recorded between the core region of sacred grove and the region of disturbed non-sacred grove land. The differences are 19.37% and 25.50% higher porosity in the core regions over the region of disturbed land during the pre-monsoon and post-monsoon periods respectively. This is followed by the higher porosity difference recorded between the transition region and the disturbed land (an increase of 13.73% during pre-monsoon and 15.26% during post-monsoon in the transition region). The lowest difference in soil porosity is recorded between the core and transition region where an increase of 6.54% during the pre-monsoon and 12.08% during the post-monsoon are recorded in the core region.

The data on **bulk density** indicate differences between soil samples during the pre-monsoon as well as the post-monsoon periods. Comparatively higher bulk density values are obtained in the soil samples collected from the disturbed land, followed by the transition region and lowest values recorded in the core region of sacred grove. In the pre-monsoon period, average bulk density values of 1.11g/cm^3 in the core region, 1.20g/cm^3 in the transition region and 1.38g/cm^3 in the disturbed land are recorded. However, during the post-monsoon period the values decreased to 1.01g/cm^3 and 1.14g/cm^3 respectively for core and transition regions while the values slightly increased to 1.39g/cm^3 with respect to the soil of disturbed land. The highest difference in bulk density values is obtained between the region of disturbed land and core region of sacred grove. An increase of 19.27% and 27.70% are recorded in the soil of disturbed land compared to soil of core region during the pre-monsoon and post-monsoon period respectively. The lowest difference in BD values is recorded between the transition region and the core region where the BD values recorded in the transition region are 7.69% and 11.84% higher over the values of core region.

The highest **water holding capacity (WHC)** is recorded in the soil of core region, followed by the region of transition and the lowest is recorded in the soil of disturbed land, irrespective of the season. The data shows the WHC values of soil in the core and transition regions tend to increase during the post-monsoon period over the pre-monsoon values while in the disturbed land, the WHC slightly tend to exhibit a reverse trend. The enhancement in the WHC which occurred during the post-monsoon period with respect to core and transition region are 13.10% and 10.54% respectively over the pre-monsoon values while, the reduction in WHC values with respect to disturbed land is 0.73%. The highest difference in the WHC is obtained between the soil in the core and disturbed non-sacred grove land. An increase of 22.20% and 32.89% is recorded in the soil of core region over the disturbed land during the pre-monsoon and post-monsoon periods respectively. This is immediately followed by a difference of 13.62% and 23.29% increase respectively in the soil of transition region over the disturbed land while, the lowest difference is recorded between the core and the transition region where an increase of 9.94% and 12.51% recorded in the core over the transition region during the pre-monsoon and post-monsoon periods respectively.

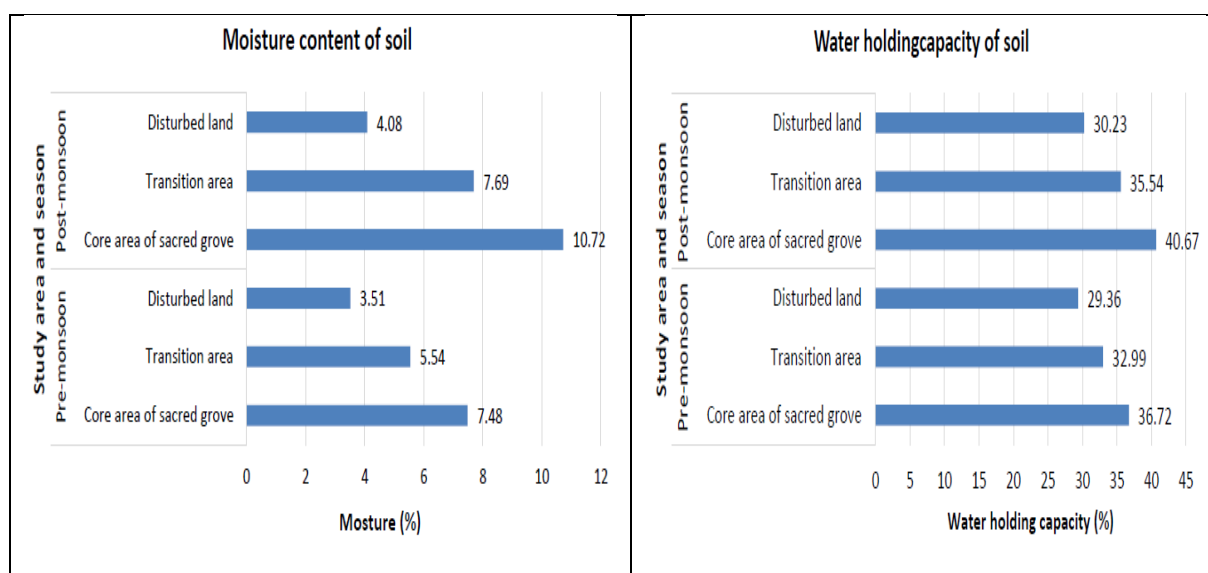
The **soil pH** obtained from various study regions at Sankulangara site shows the values are within the acidic range and this ranged from 4.83 to 6.05 in the pre-monsoon and 4.63 to 6.35 in the post-monsoon periods. Comparatively lower pH values are recorded in the core region of sacred grove and region of transition over the disturbed non-sacred grove land. The data presented in the figure F1 shows an increasing trend in the pH values from core region of grove to transition and then to disturbed non-sacred grove land. The soil pH recorded in different seasons in the core and transition regions indicate the values obtained during the post monsoon period is more or less lower values compared to the pre-monsoon whereas, in the case of disturbed land the higher pH values are recorded in the post-monsoon period than the pre-monsoon. The lowest pH of 4.63 is recorded in the core region of sacred grove and the highest pH of 6.35 in the disturbed land, both the values are recorded during the post-monsoon period.

The electrical conductivity (EC) data shows there are differences in the values in different soil samples collected and indicated a decreasing trend in the EC value from the highest value being recorded in the core region of sacred grove towards the direction of transition region and finally the lowest value in the soil of disturbed non-sacred grove land. The EC values are found to range from 0.02dS/m to 0.08dS/m during the pre-monsoon while this is from 0.02dS/m to 0.09dS/m during the post-monsoon period. The comparison of EC values obtained in the two

study seasons, the core and transition regions recorded relatively higher EC values during the post monsoon period while no change in the EC value is found with respect to the soil of disturbed non-sacred grove land.

B) Palliyana study site

The details of physical properties of soil samples collected from Palliyana study site is shown in figure F2. The values of **soil moisture content** shows variation among soil samples collected from different regions of study site. The highest soil moisture content is obtained in the core region of sacred grove while the lowest in the disturbed non-sacred grove region, during both the study seasons. The soil moisture level tend to enhance during the post-monsoon period over the pre-monsoon period and are 30.22%, 27.96% and 13.97% higher respectively for core region, transition region and disturbed land. The highest difference in soil moisture content is recorded between core and disturbed region where, the core region exhibited an increase of 53.07% during the pre-monsoon and 61.94% during the post-monsoon periods over that in the disturbed land. The lowest difference is recorded between the core and transition region where the core region exhibited an increase of 25.94% and 28.26% during the pre-monsoon and post-monsoon period respectively.



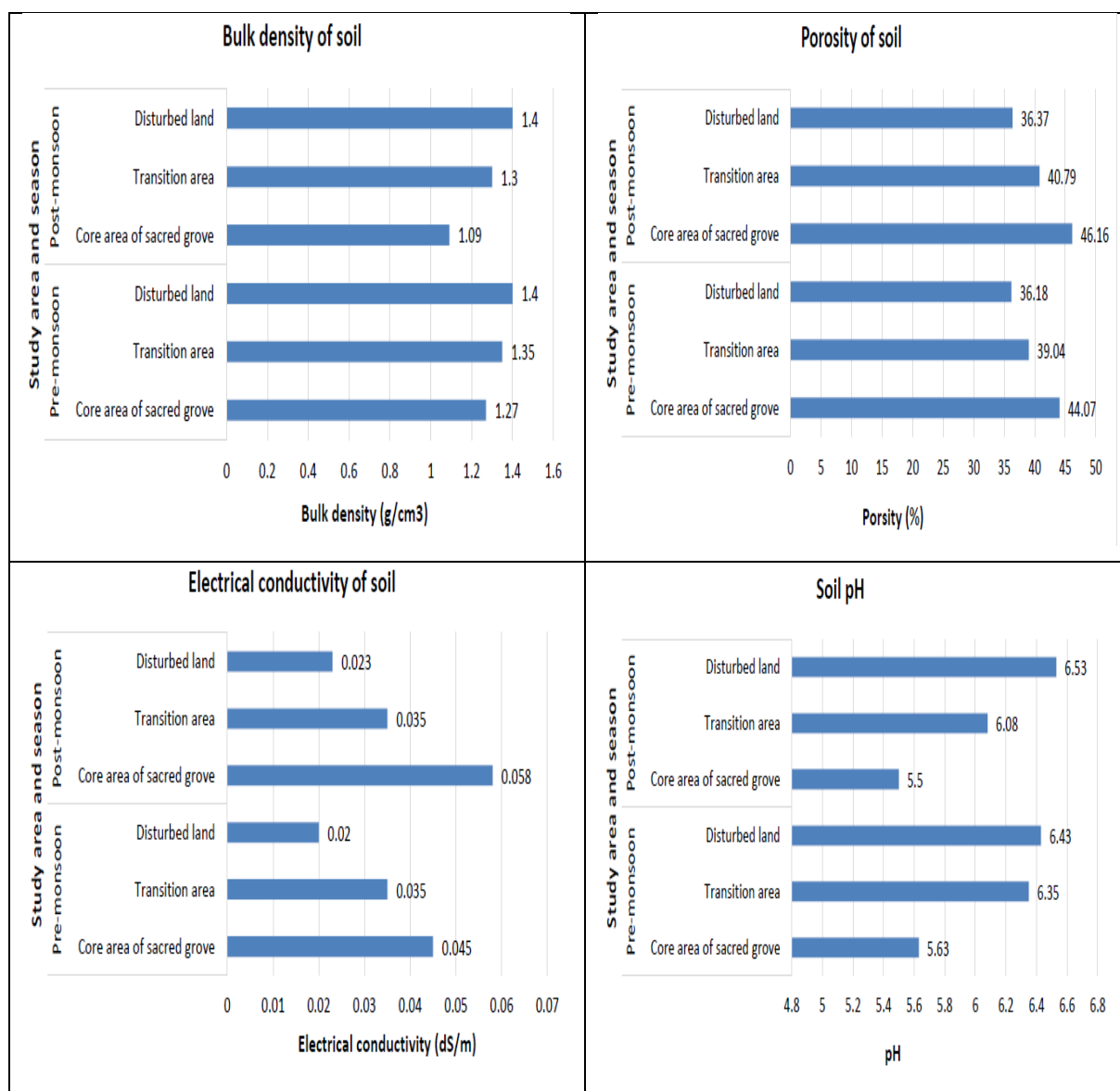


Figure F2: The status of various physical properties of soil samples collected from different regions in different season at Palliyana study site

The **soil porosity** data indicates difference between various soil samples during the pre-monsoon and the post-monsoon periods. The higher soil porosity value is recorded in the core region which is followed by transition region and the lowest value is recorded in the disturbed non-sacred grove land. The comparison of data obtained in two different seasons indicate the soil porosity values in all the study regions of Palliyana site tend to increase during the post-monsoon period over the pre-monsoon values and the increase is 4.53%, 4.28% and 0.51% respectively for core, transition and disturbed regions. The highest difference in soil porosity values of 17.90% and 21.21% is recorded between the core region and the region of disturbed land during the pre-monsoon and post-monsoon periods respectively. This is immediately followed by a difference of 11.41% and 11.63% recorded between core region and transition

region while, the lowest difference of 7.33% and 10.84% is recorded between the transition region and the disturbed region during the pre-monsoon and post-monsoon periods respectively.

The **bulk density** (BD) values shows a decreasing trend from the soil of disturbed non-sacred grove land to region of transition and then the core region of sacred grove, irrespective of the sampling periods (figure F2). In the pre-monsoon period, an average bulk density of 1.27 g/cm^3 is recorded at core region while an average of 1.35 g/cm^3 and 1.40 g/cm^3 are recorded at region of transition and disturbed land respectively. During the post-monsoon period, the average bulk density value of 1.09 g/cm^3 , 1.30 g/cm^3 and 1.40 g/cm^3 are recorded respectively for core, transition and disturbed region. This indicates a reduction in the BD values during the post-monsoon period with respect to core and transition regions however, no change has been found recorded for the disturbed land due to seasonal variation. The reductions are 14.17% and 3.70% in the core and transition regions respectively. The highest difference in bulk density values is found between the core and the disturbed region and is 9.29% during the pre-monsoon and 22.14% during the post-monsoon period. This is immediately followed by the difference of 5.93% and 16.15% between the core and transition regions and the lowest difference of 3.57% and 7.14% is recorded between the transition and disturbed regions during the pre-monsoon and post-monsoon periods respectively.

Variation in soil **water holding capacity (WHC)** is recorded between different regions of study site. The highest WHC is identified in the core region of grove and this is followed by region of transition and the lowest in the disturbed non-sacred grove region. The data showed an enhancement in the soil WHC value for all the study regions during the post-monsoon period over the pre-monsoon period. An enhancement of 9.71%, 7.18% and 2.88% is recorded respectively for core, transition and disturbed regions. The data further shows a maximum difference in the WHC between the soil of core and disturbed regions and this is 20.04% and 25.67% during the pre-monsoon and post-monsoon period respectively. This is immediately followed by the difference of 11.0% and 14.93% respectively between the soil of transition and disturbed regions. The minimum difference is recorded between the core and transition regions and this is 10.16% and 12.62% during the pre-monsoon and post-monsoon period respectively.

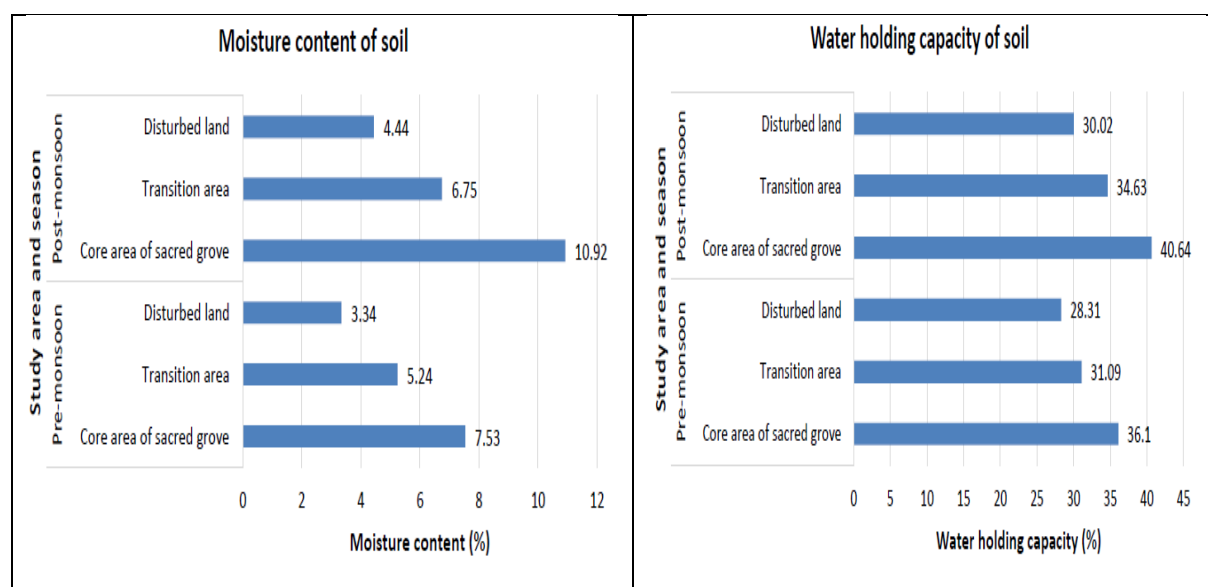
The soil **pH** values obtained from various regions at Palliyana site show differences but all the values are within the acidic range. The lowest pH value of 5.63 and 5.5 is recorded in the core region of sacred grove during the pre-monsoon and post-monsoon period respectively while

highest values of 6.43 and 6.53 recorded respectively in the disturbed land. The values indicate an increasing trend in the soil pH from core to transition and then to disturbed land. The comparison of pH values obtained with respect to core and transition regions in different seasons show more or less lower values during the post-monsoon compared to pre-monsoon whereas, the pH value recorded in the disturbed land is found more or less to be increasing in the post-monsoon period over the pre-monsoon.

Soil electrical conductivity (EC) varies with soil samples collected from core, transition and disturbed land and the values are found to range from 0.02dS/m to 0.045dS/m during the pre-monsoon and from 0.023dS/m to 0.058dS/m during the post-monsoon periods. The results show a decreasing trend in the EC value with the highest value being recorded in the soil of core region and then decrease in the direction of transition region and the lowest value recorded in the disturbed non-sacred grove region. Comparatively higher EC value is recorded in the post monsoon period over the pre-monsoon value with respect to core region while, EC value of soil in the transition region and disturbed region are found unaffected or not much affected by the season.

C) Nambiyath study site

The details of various physical properties of soil samples collected from different regions of Nambiyath study site during the pre-monsoon and the post-monsoon periods are shown in figure F3.



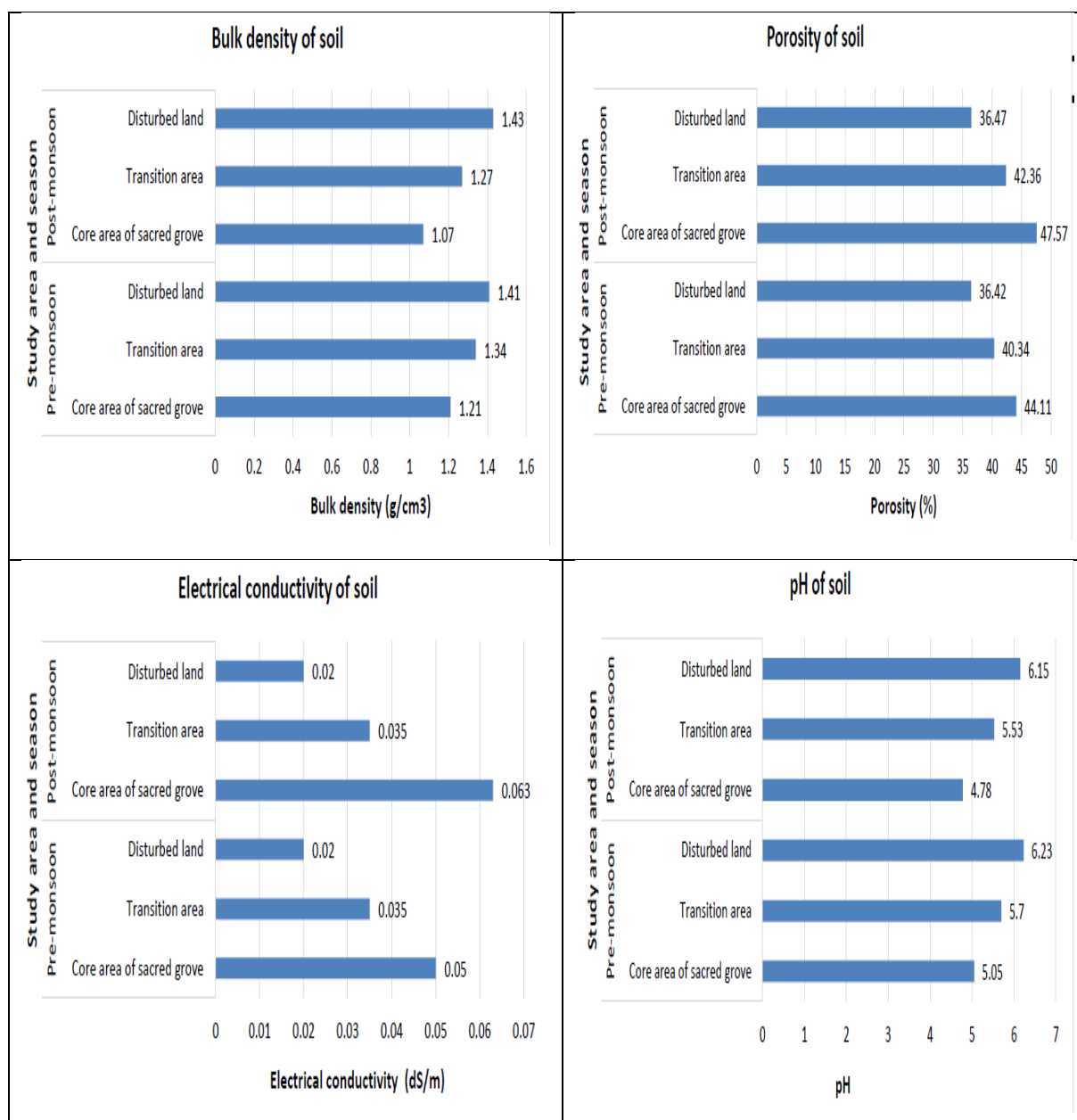


Figure F3: The status of various physical properties of soil samples collected from different regions in different season at Nambiyath study site

The data on **soil moisture content** shows difference between soil samples. The highest soil moisture content is obtained in the core region of sacred grove while, the lowest in the disturbed land, irrespective of the seasonal variation. Comparatively higher moisture content in the soil recorded during the post-monsoon season over the pre-monsoon and the increase are 31.04%, 22.37% and 24.77% respectively for core, transition and disturbed region over their pre-monsoon values. The highest difference is in soil moisture content recorded between core and disturbed region where, the core region is having 55.64% and 59.34% higher moisture content than the soil of disturbed region during the pre-monsoon and post-monsoon period

respectively. This is immediately followed by a difference of 36.26% and 34.22% respectively between the transition region and disturbed region and the lowest difference is recorded between the core and transition region where an increase of 30.41% and 38.19% is recorded by the soil in the core region over the transition region during the pre-monsoon and post-monsoon period respectively.

The **soil porosity** data in the figure F3 shows the highest soil porosity value recorded in the core area of sacred grove, followed by transition area and the lowest value recorded in the disturbed non-sacred grove area. In the pre-monsoon period, average porosity values of 44.11%, 40.34% and 36.42% is obtained in the soil of core, transition and disturbed area respectively while, in the post-monsoon period the average porosity values increased to 47.57%, 42.36% and 36.47% in the core, transition and disturbed area respectively. This recorded an enhancement of 7.27%, 4.76% and 0.13% of soil porosity respectively in the core, transition and disturbed areas during the post-monsoon. The maximum difference in soil porosity value is recorded between the core and disturbed area which is immediately followed by the transition and disturbed area and the minimum difference recorded between core and transition area. This recorded a difference of 17.43% & 23.33% between core and disturbed area, 9.72% & 13.90% between transition and disturbed area and 8.55% & 10.95% between core and transition area respectively during the pre-monsoon and post-monsoon periods.

The highest **bulk density** value is obtained in the soil of disturbed non-sacred grove area and this is followed by transition area and the lowest value recorded in the core area of grove. During the pre-monsoon, an average bulk density of 1.21 g/cm³ and 1.34 g/cm³ are recorded at core and transition region while an average of 1.41 g/cm³ is recorded in the disturbed land. Compared to the pre-monsoon, the values of bulk density during the post-monsoon period are found decreasing with respect to core and transition area while a slight increase is recorded with respect to the disturbed area. The decrease recorded is 1.07g/cm³ and 1.27g/cm³ respectively for core and transition area and the increase is 1.43g/cm³ for disturbed area. This accounts for a reduction of 11.57% and 5.22% respectively in the core and transition area and an enhancement of 1.4% in the disturbed area. The result shows the highest difference in bulk density value obtained between the soil of disturbed land and core region of sacred grove (14.18% and 25.17% in the pre-monsoon and post-monsoon respectively). This is immediately followed by difference between the transition and core regions (9.70% and 15.75% respectively) and the lowest difference is identified between the disturbed land and transition region (4.96% and 11.19% respectively).

The values of **water holding capacity** indicate the highest value in the soil of core region of sacred grove, followed by region of transition and the lowest value in the disturbed non-sacred grove land (figure F3). The WHC of soil tend to enhance in all the study regions during the post-monsoon period over the pre-monsoon. An enhancement of 11.17%, 10.22% and 5.70% respectively for soil in the core, transition and disturbed regions is noticed during the post-monsoon season. The highest difference in the WHC is recorded between the soil of core region and the disturbed land where, the core region shows an increase of 21.58% and 26.13% over the disturbed area during the pre-monsoon and the post-monsoon periods respectively. This is immediately followed by a difference of 8.94% and 13.31% increment in the transition region over the disturbed land. The lowest difference is recorded between the core and the transition region where, an increase of 13.88% and 14.79% recorded in the core region over the transition region during the pre-monsoon and post-monsoon periods respectively.

The **soil pH** obtained from different soil samples shows that the values are within the acidic range and found ranging from 5.05 to 6.23 during the pre-monsoon and 4.78 to 6.15 during the post monsoon. Increasing trend in the pH values is recorded in the direction of core region to transition and then to disturbed land. On comparison of values recorded in different season, the pH value obtained during the post monsoon period is found to be lower over pre-monsoon. The lowest pH values is recorded in the core region while, the highest value in the soil of disturbed land.

The values of **soil electrical conductivity (EC)** are found mostly varying with difference in the area of study site and in certain cases with the influence of season. The EC values range from 0.02dS/m to 0.05dS/m during the pre-monsoon period and from 0.02dS/m to 0.063dS/m during the post-monsoon period. The data indicate a decreasing trend in the EC value with the highest value being recorded in the soil of core area of sacred grove, immediately followed by the transition area and then the lowest value in the disturbed land. The comparison of data obtained in two study season, with respect to the core area shows relatively higher EC value in the post monsoon season while, no change is found in the EC values of soil in the transition and disturbed area (figure F3).

D) Poyyara study site

The details of physical properties of soil samples collected from the Poyyara site of smallest extent selected for the study during the pre-monsoon as well as the post-monsoon season are shown in the figure F4.

The values of **soil moisture content (MC)** show differences between soils collected from different regions of study. The highest MC is obtained in the core region of sacred grove while, the lowest in the disturbed land, during both the study season. Comparatively higher soil MC is recorded in the soil of all the study regions during the post-monsoon season over the pre-monsoon. The enhancements in the moisture content are 29.85%, 14.08% and 16.39% respectively in the core, transition and disturbed land over the pre-monsoon values. The highest difference in soil moisture content of 43.68% and 52.75% are recorded between the core region of grove and disturbed non-sacred grove land during the pre-monsoon and post-monsoon periods respectively. The lowest difference in moisture content of 15.18% and 12.84% are recorded between the transition and disturbed regions during the pre-monsoon and post-monsoon periods respectively.

The **porosity of soil** samples exhibit a decreasing trend with the highest value being recorded in the core region of grove, followed by region of transition and the lowest value in the disturbed non-sacred grove region. With respect to the soil of core and transition region, an increase of 2.7% and 1.63% respectively while, with respect to disturbed land a reduction of 0.38% are recorded during the post-monsoon over the pre-monsoon. The highest difference in porosity values is recorded between the core and disturbed region (12.98% and 15.65% respectively during the pre-monsoon and post-monsoon periods). This is immediately followed by the difference recorded between the core and transition region (10.75% and 11.72% respectively) while, the lowest difference in porosity is recorded between the transition region and the disturbed land (2.50% and 4.46% respectively).

The **bulk density** values show an increasing trend from the core region of sacred grove to transition region and the highest value in the soil of disturbed land, during both the sampling periods (figure F4). With an exception of soil in the disturbed region, the BD value of soil is found to decrease in the post-monsoon period over the pre-monsoon values whereas the disturbed region exhibited a slight increase. This accounts for a reduction of 3.05% and 1.43% respectively for core and transition regions while, an enhancement of 1.36% for disturbed region. The highest difference in bulk density value of 9.66% and 13.61% is obtained between the core and the disturbed region, immediately followed by values of 6.43% and 7.97% between the core and transition region and the lowest difference of 3.4% and 6.12% between the transition and disturbed regions, each respectively during the pre-monsoon and post-monsoon periods.

The highest **water holding capacity** (WHC) of soil is recorded in the core region, followed by region of transition and the lowest WHC is recorded in the region of disturbed land, irrespective of the season. Compared to values of soil in the core and transition regions recorded during the pre-monsoon, the values tend to improve during the post-monsoon while, with respect to the soil of disturbed land a reduction is recorded during the post-monsoon. This accounted for an increase of 8.55% and 6.4% of WHC respectively for core and transition region while a reduction of 0.17% for disturbed land over the pre-monsoon values. The difference in the WHC recorded between soil of core region and disturbed land are 10.58% and 18.36%; the difference between the transition and disturbed region are 3.6% and 9.92% and the difference between the core region and the transition region are 7.24% and 9.37%, each respectively during the pre-monsoon and post-monsoon periods.

The **pH** of soil samples collected from different regions of Poyyara study site showed differences but all the values are within the acidic range. The pH values range from 5.83 to 6.15 during the pre-monsoon and from 5.65 to 6.4 during the post-monsoon period. An increasing trend in the pH values are found during both the seasons where, the lowest values are recorded in the core region, increased towards the transition and then the highest values recorded in the disturbed land. The comparison of pH values obtained in the two season indicated that the pH value in the soil of core area is decreasing during the post-monsoon over the pre-monsoon values, whereas the pH values are increasing with respect to the soil in the transition region and disturbed land.

The **electrical conductivity** (EC) of soil is found to vary with differences in area and season of collection at poyyara site. The EC values range from 0.023dS/m to 0.04dS/m during the pre-monsoon period while this range from 0.02dS/m to 0.045dS/m during the post-monsoon period. The data indicate a decreasing trend in the EC value during the pre-monsoon period, the highest value being recorded in the core area of sacred grove and decrease in the direction of transition region and then disturbed land but during the post-monsoon period, the transition region recorded slightly lower EC value compared to disturbed non-sacred grove area. In the core area of grove, comparatively higher EC values is recorded in the post monsoon period while higher values for transition and disturbed regions are recorded during the pre-monsoon period.

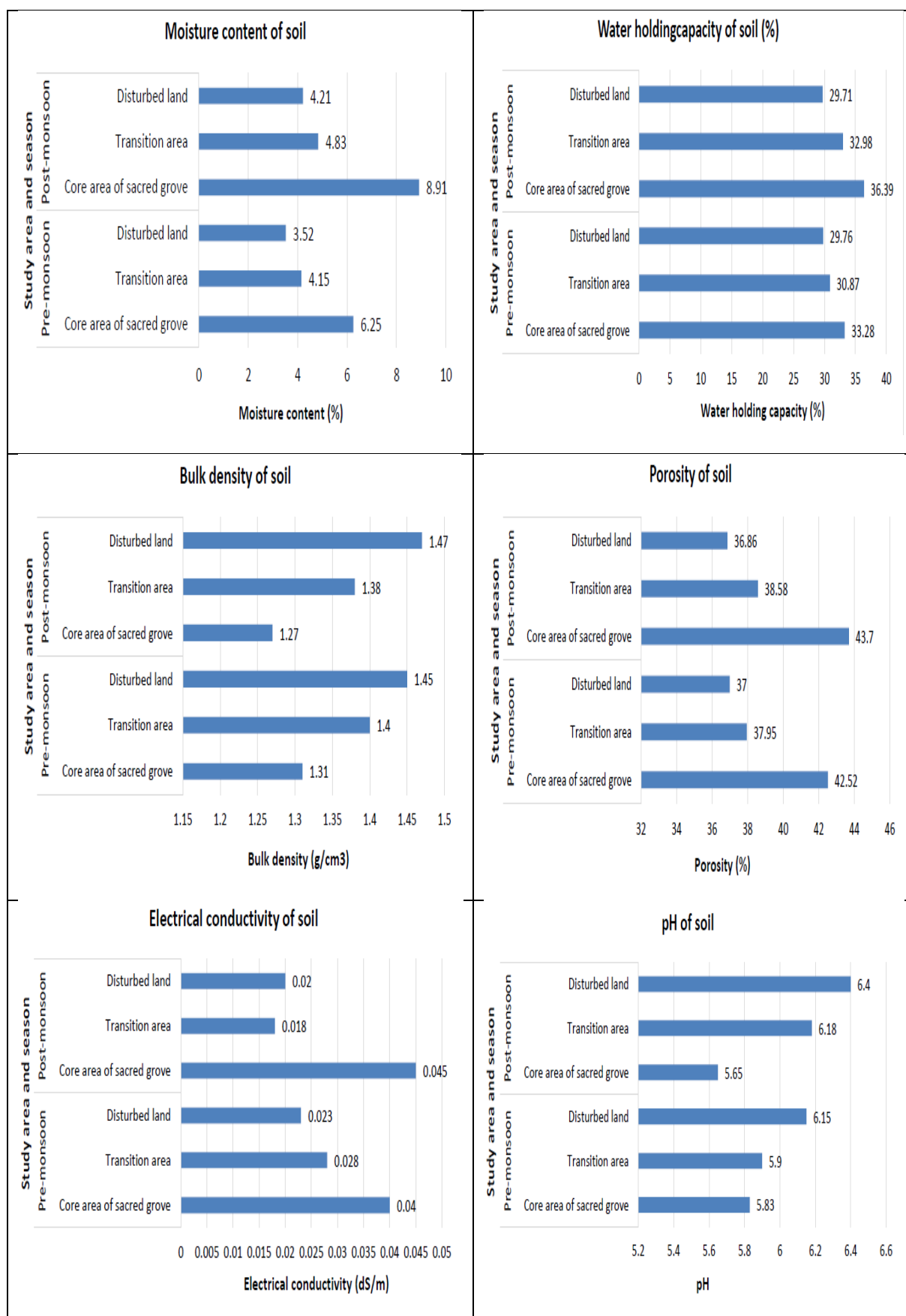
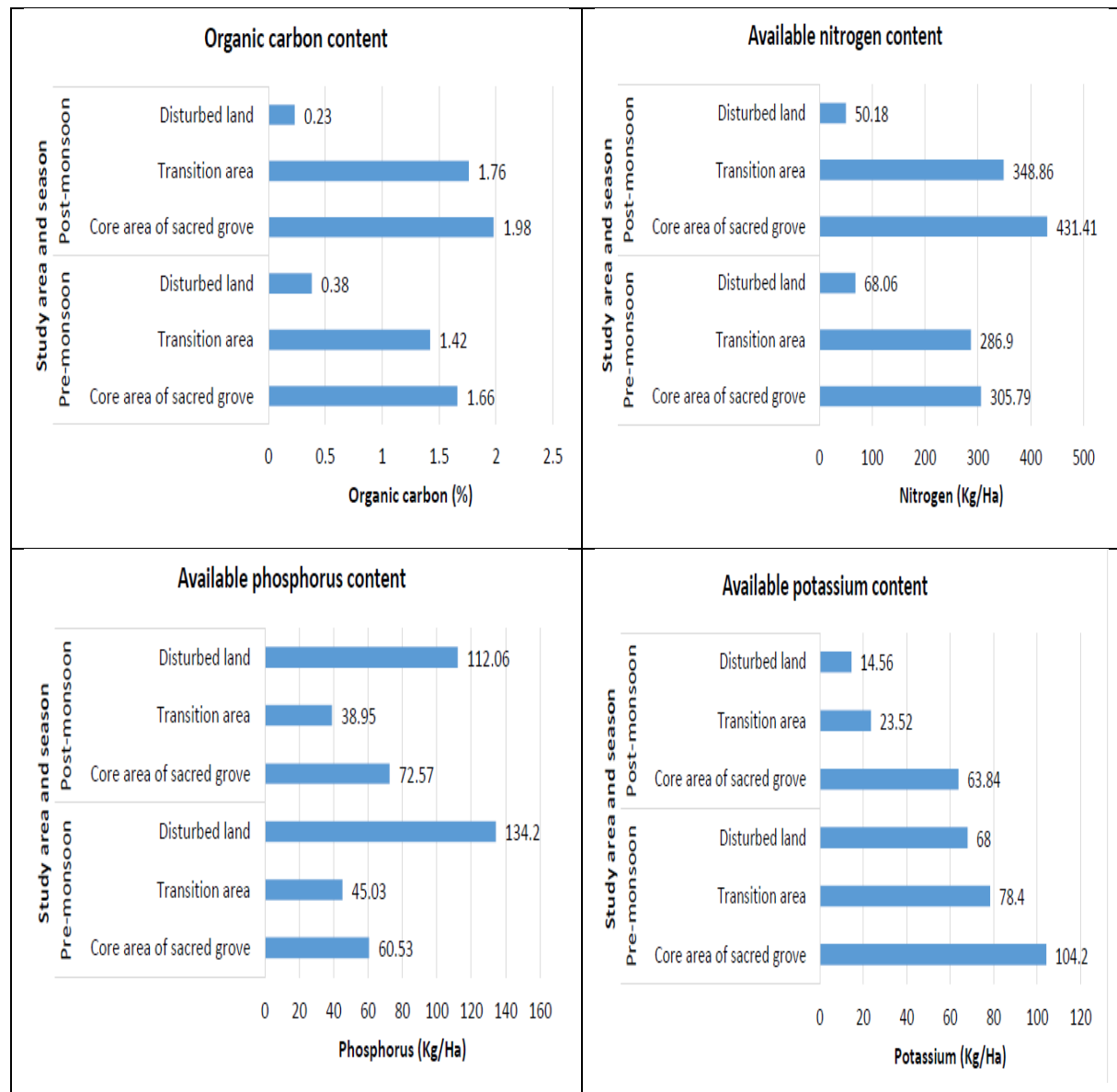


Figure F4: The status of various physical properties of soil samples collected from different regions in different season at Poyyara study site

II) Analysis of Soil Chemical Properties

1) Sankulangara study site

Various chemical properties of soil samples collected from the Sankulangara study site are shown in figure F5 and figure F6. The data presented in the figure F5 shows difference in the concentration status of various macro elements in the soil of core region of grove, the transition region and in the disturbed non-sacred grove region.



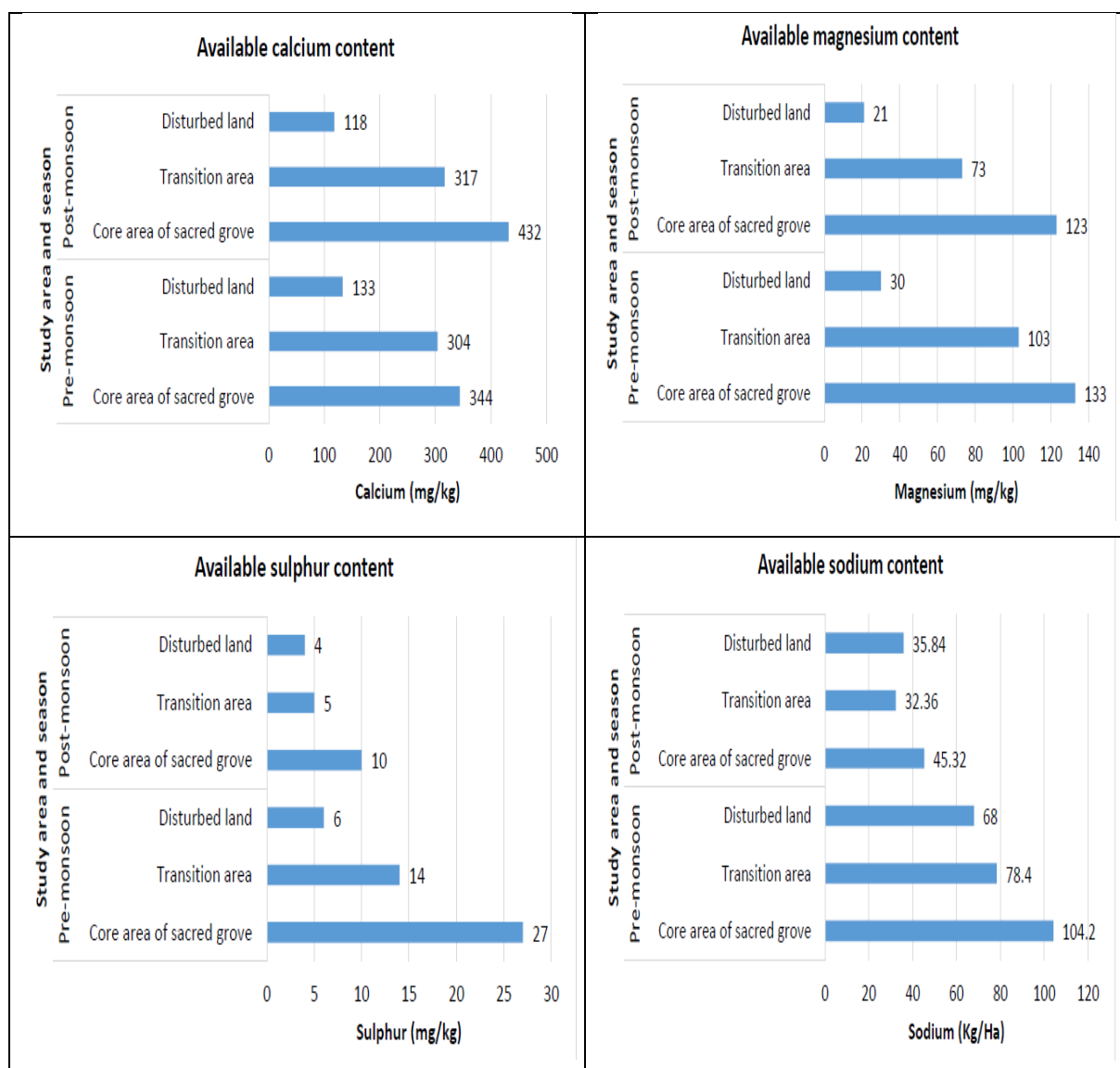


Figure F5: The macronutrient status of soil samples collected from different regions of Sankulangara study site during the pre-monsoon and post-monsoon periods

Highest **organic carbon (OC)** content is obtained in the core region of sacred grove, followed by transition region and the lowest content in the soil of disturbed non-sacred grove region. The soil samples collected from the core region and the transition region recorded comparatively higher OC values during the post-monsoon period compared to pre-monsoon and this accounted for an enhancement of 16.16% and 19.32% OC content respectively during the post-monsoon. However, the disturbed non-sacred grove land recorded higher values during the pre-monsoon and this accounted for a reduction of 39.47% during the post-monsoon compared to pre-monsoon. The highest difference in OC content of 77.11% and 88.38% is recorded between the soil in the core region of sacred grove and the disturbed non-sacred grove region during the pre-monsoon and post-monsoon period respectively.

The available **nitrogen** content obtained from different soil samples show a decreasing trend during both the sampling periods with the highest value being recorded in the core region of grove, followed by the transition region and then the lowest value in the disturbed non-sacred grove region (figure F5). The nitrogen content in the core and transition regions are found increasing during the post-monsoon period over the pre-monsoon while, the content is found to decrease for disturbed region. This accounted for an increase of 29.12% and 17.76% respectively for core and transition region and a decrease of 26.27% for disturbed land, during the post-monsoon. The highest difference in available nitrogen content is recorded between the core and disturbed region and are 77.74% during the pre-monsoon and 88.37% during the post-monsoon periods.

The result of available **phosphorus** shows the highest value in the disturbed non-sacred grove area which is followed by core area and lowest value in the transition area. The concentration of phosphorus in the core region tend to increase during the post-monsoon period compared to pre-monsoon whereas the concentration tends to decrease with respect to transition and disturbed region (figure). The increase is 16.59% in the core area while the decrease is 13.50% and 16.5% respectively in the transition and disturbed area. The concentration of available **potassium** in the analyzed soil samples show the highest concentration in the core region, followed by transition region and the lowest in the disturbed land, in both the sampling periods. The comparison of potassium concentrations obtained in both the seasons indicate higher concentrations during the pre-monsoon period in all the regions. Maximum difference in soil potassium content is obtained between the core and disturbed region during the pre-monsoon as well as post-monsoon periods and the differences are 34.74% and 20.92% respectively during the pre-monsoon and post-monsoon period.

The comparison of available **calcium** in the soil samples of core, transition and disturbed region show that the maximum concentration of calcium is recorded in the core region of grove while the minimum concentration in the disturbed non-sacred grove region during both sampling periods. The concentration of calcium is 61.34% and 72.69% lower in the disturbed land compared to core area during the pre-monsoon and post-monsoon periods respectively. The comparison of calcium concentration obtained in different seasons indicate, the core and transition regions record comparatively higher values in the post-monsoon period and an average increase of 20.37% and 4.1% respectively over the pre-monsoon values. However, the calcium concentration of disturbed region records a reduction of 11.28% during the post-monsoon over the pre-monsoon. The concentration of available **magnesium** in different soil

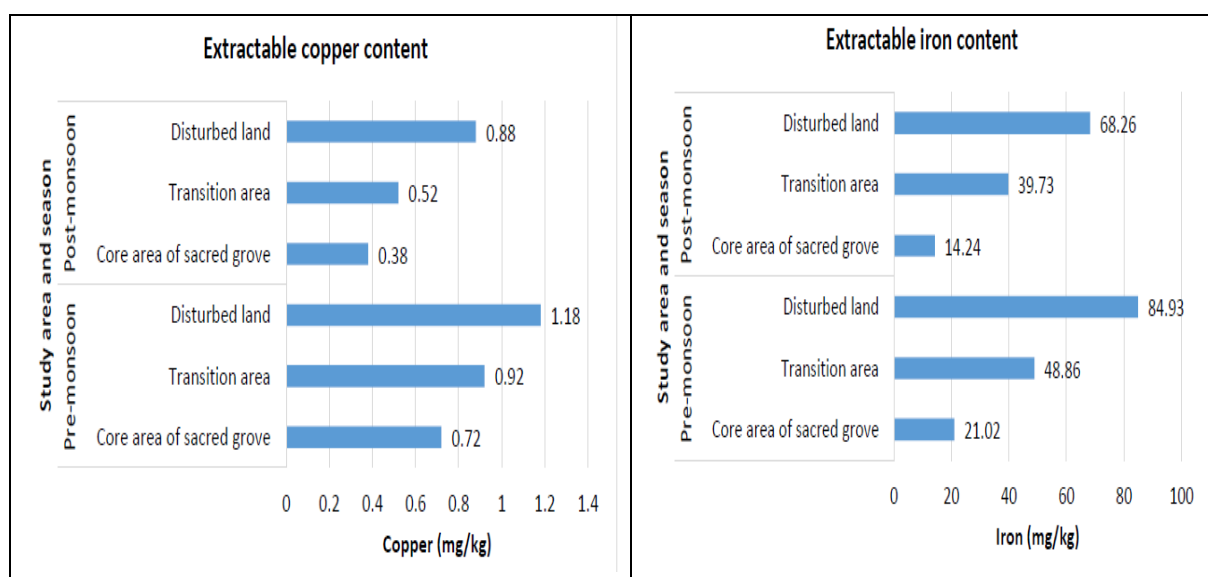
samples showed a decreasing trend from the highest concentration recorded in the core region towards the transition and finally the lowest concentration in the disturbed non-sacred grove region irrespective of the season. Comparatively higher values of magnesium concentration are recorded during pre-monsoon when compared to post-monsoon (figure F5). Reduction of 7.52% magnesium concentration is recorded in the post-monsoon period with respect to core region whereas this is 29.12% and 30% respectively in the soil of transition and disturbed land. The highest difference of 77.44% and 82.93% is obtained in the pre-monsoon and post-monsoon season respectively between the core region of sacred grove and disturbed land.

The concentration of **available sulphur** record the highest in the core region, followed by transition region and the lowest in the disturbed non-sacred grove region. Comparatively higher values are recorded during the pre-monsoon in all the regions over the post-monsoon values and this accounted for a reduction of 62.96%, 64.29% and 33.33% respectively for core, transition and disturbed land during the post-monsoon. The highest difference in soil sulphur concentration is 77.78% and 60% between the core and disturbed non-sacred grove land respectively during the pre-monsoon and post-monsoon season. Almost similar trend is recorded with respect to the concentration of available **sodium** but with an exception during the post-monsoon where the soil samples collected from the disturbed land recorded comparatively higher values of sodium than the region of transition. The comparisons of sodium concentration in different seasons indicate comparatively higher values recorded during the pre-monsoon. The highest difference in sodium concentration is obtained between soil in the core region of grove and the region of disturbed land during the pre-monsoon (34.74%) while the highest difference is between the core and the transition region during the post-monsoon (28.6%).

The status of micronutrient concentration in the analysed soil samples at Sankulangara site showed differences between soil samples (figure F6). The concentration of **extractable copper and iron** are found higher in the disturbed land and their concentration tend to decrease in the direction of transition region and then the core region of sacred grove. Reduction of 38.98% and 75.25% respectively for copper and iron is recorded in the core region over disturbed region during the pre-monsoon while the reductions are increased to 56.82% and 79.14% respectively during the post-monsoon. All the soil samples exhibit comparatively higher concentrations of copper and iron during the pre-monsoon period over post-monsoon. This account for a reduction of 47.22% and 47.61% respectively for copper and

iron in the core region during the post-monsoon whereas in the disturbed land, a reduction of 25.42% and 19.62% respectively for copper and iron is recorded.

The figure F6 shows the concentrations of **extractable Zinc, Manganese and Boron** are higher in the core region of sacred grove and tend to decrease in the direction of transition region and finally the lower concentrations are recorded in the disturbed non-sacred grove region. The comparison of zinc, manganese and boron values obtained from the soil of core region with disturbed region show an increase of 77.06%, 56.07% and 78.13% respectively in the core region during the pre-monsoon period while, during the post-monsoon period the increment is 78.53%, 79.14% and 77.59% respectively. The concentration of these nutrients obtained in different seasons in all the regions of study revealed that higher concentrations of zinc and boron are recorded during the post-monsoon period while, that of manganese is recorded higher values during the pre-monsoon. This accounted for an increase of 37.61% and 44.83% in the core region respectively for zinc and boron and a decrease of 46.96% for manganese, during the post-monsoon period over pre-monsoon. With respect to the soil of disturbed land, the increase is 33.33% and 46.15% respectively for zinc and boron but a decrease of 20.74% for manganese.



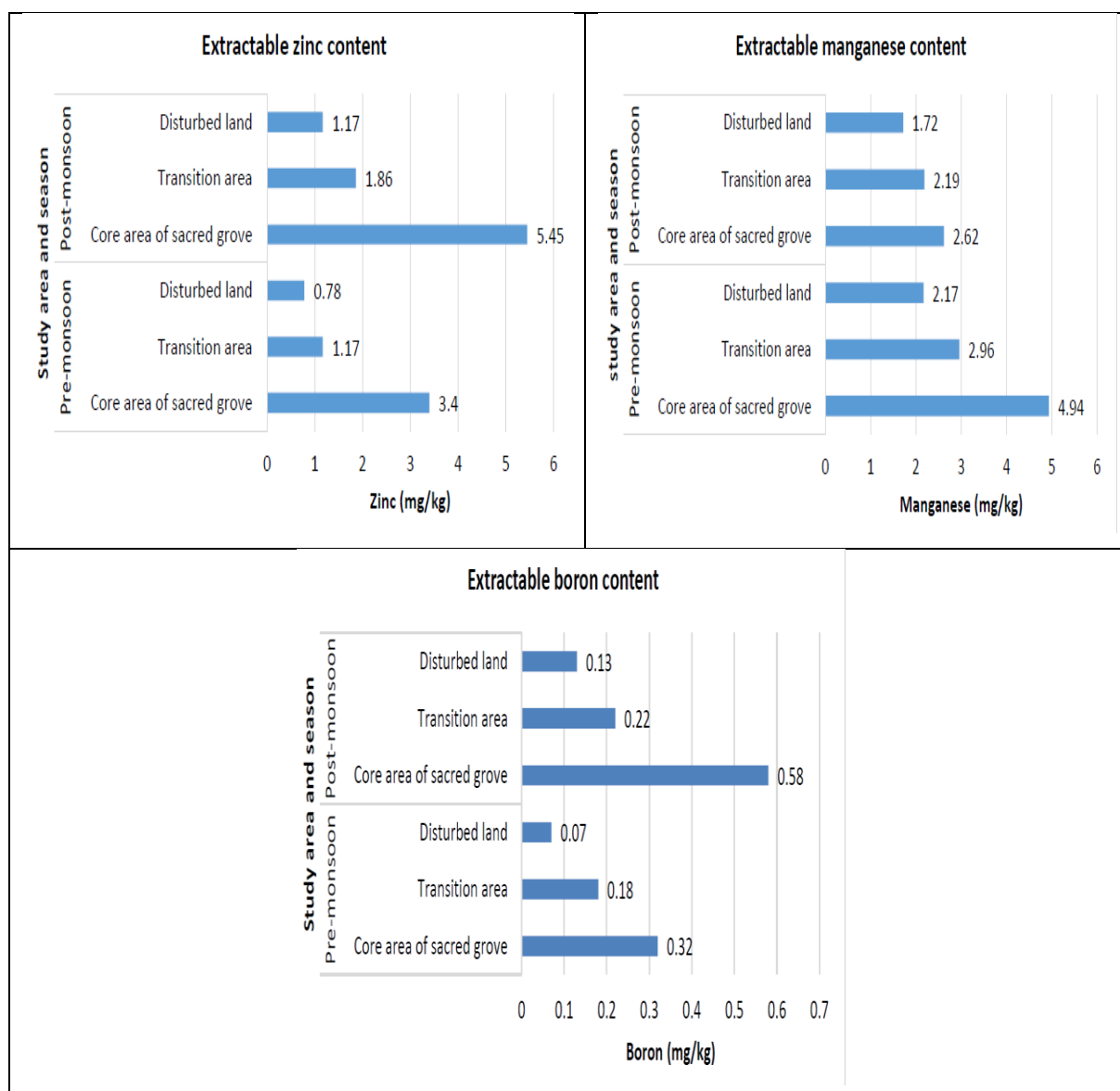
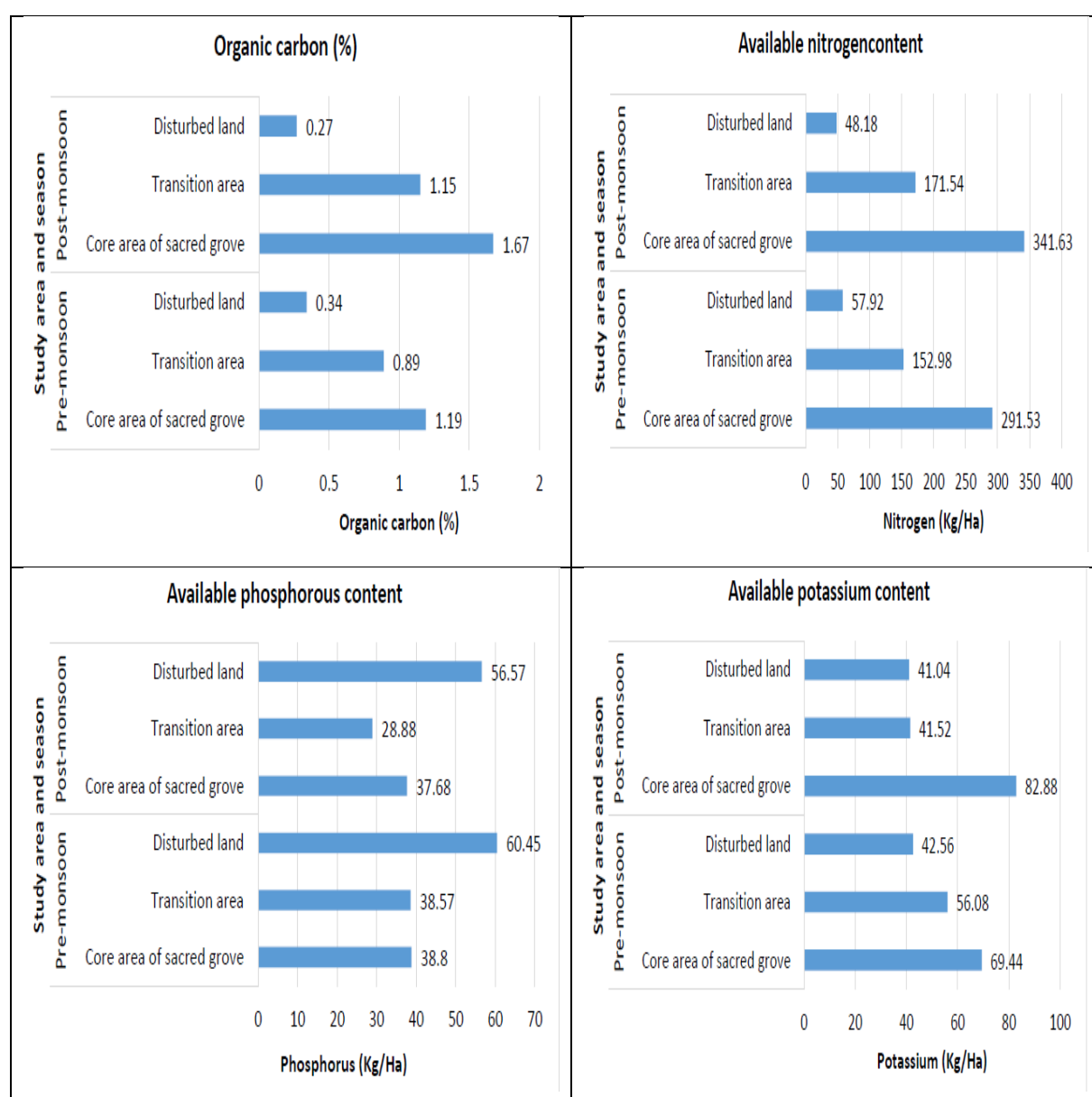


Figure F6: The micronutrient status of soil samples collected from different regions of Sankulangara study site during the pre-monsoon and post-monsoon periods

2) Palliyana study site

The chemical properties of soil samples collected from the different regions of Palliyana site during the pre-monsoon as well as post- monsoon season are depicted in figure F7. The concentrations of **organic carbon (OC)** and **available nitrogen** content show differences between soil samples. A decreasing trend in the OC and available nitrogen content is observed from the highest concentration values being recorded in the core region of sacred grove towards the transition region and then the lowest concentration in the disturbed non-sacred grove region. The concentration of both the parameters in the soil samples of core and transition region are found to increase during the post-monsoon period over the pre-monsoon concentration whereas, the concentration of these parameters decreases with respect to

disturbed region. The increase is 28.74% and 22.61% with respect to OC content and 14.66% and 10.82% of available nitrogen content each respectively for core and transition regions and the decrease is 20.59% and 16.82% with respect to disturbed land respectively for OC content and available nitrogen content. The highest difference in soil OC content as well as available nitrogen is recorded between the soil of core region and the disturbed land. This is 71.43% and 80.13% respectively for OC content and available nitrogen during the pre-monsoon period and this is 83.83% and 85.9% respectively during the post-monsoon period.



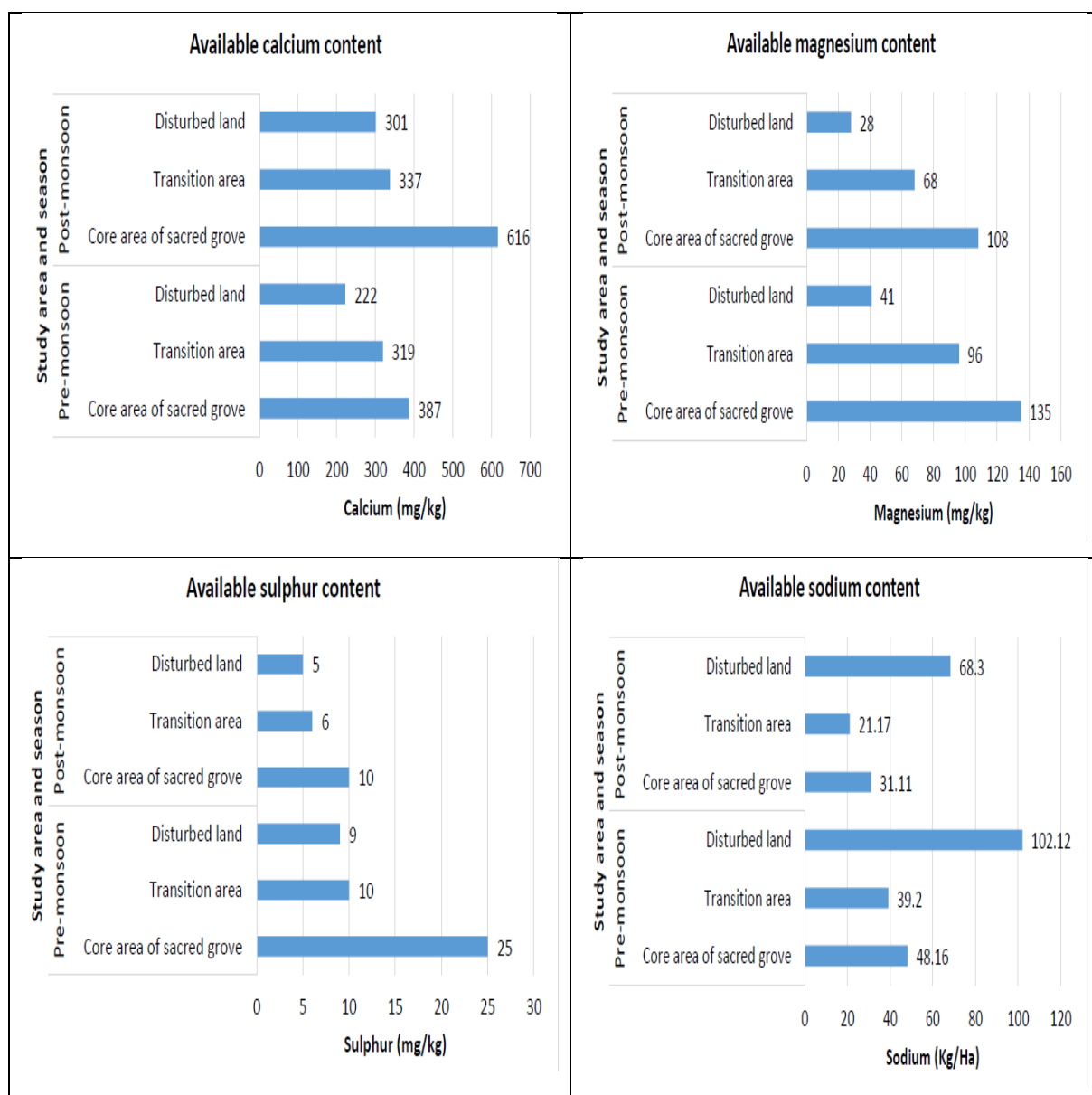


Figure F7: The macronutrient status of soil samples collected from different regions of Palliyana study site during the pre-monsoon and post-monsoon periods

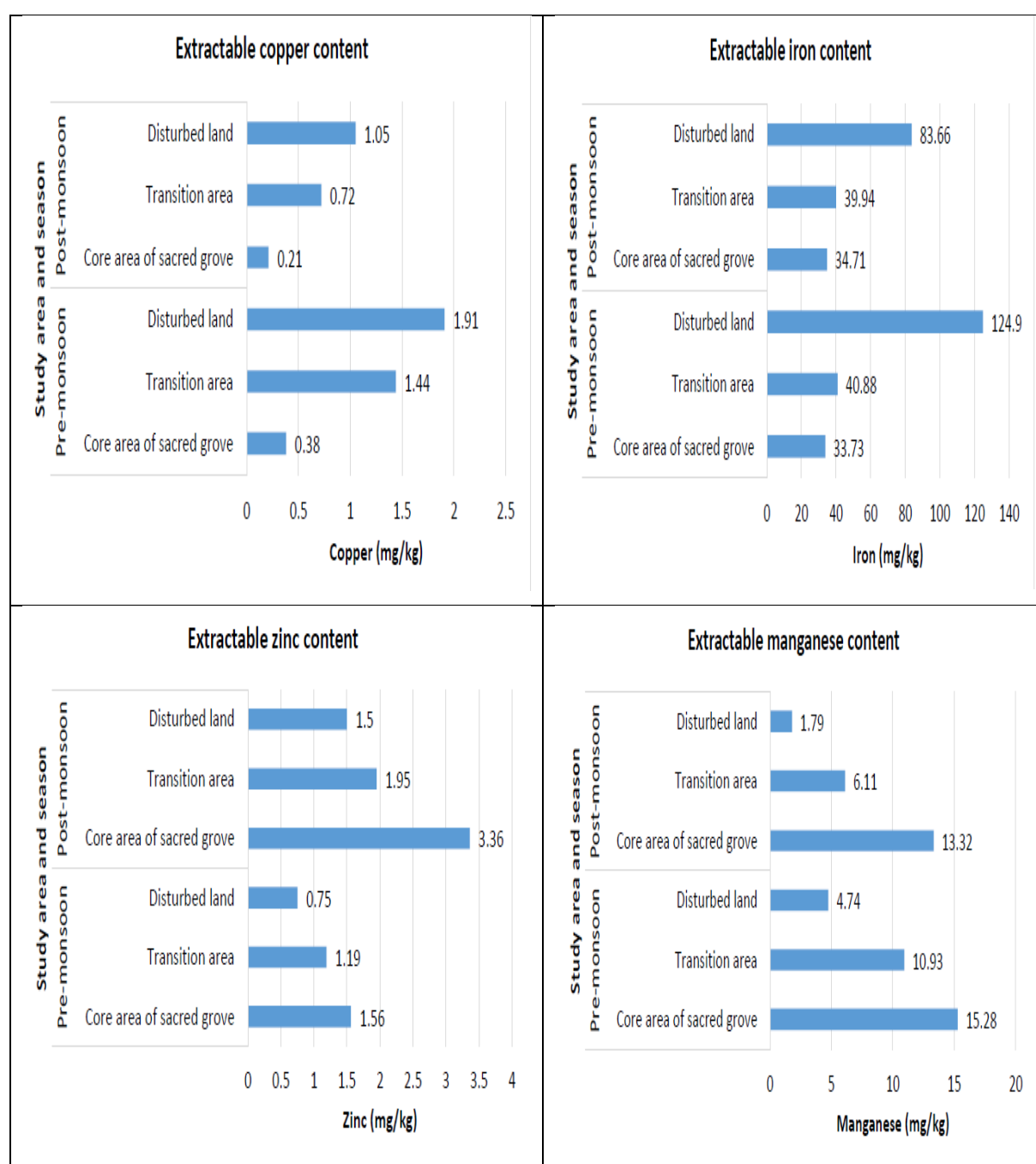
The concentration of **available phosphorus (P)** and **sodium (Na)** obtained from the different soil samples at Palliyana site record the highest value in the disturbed non-sacred grove land which is followed by core region of sacred grove and lowest value in the transition region in both the sampling periods. The highest difference in available phosphorus as well as sodium contents are found recorded between the transition and disturbed region and the differences are 36.2% and 61.61% respectively for phosphorus and sodium during the pre-monsoon and 48.95% and 69% respectively during the post-monsoon. The comparison of P as well as Na concentration obtained in different sampling periods show a decreased concentration in all the regions during the post-monsoon over pre-monsoon concentrations.

The **available potassium** and **calcium** concentrations obtained from different soil samples indicate a decreasing trend in both the study season where, the highest concentration is recorded in the core region of sacred grove immediately followed by the transition region and lowest concentration in the disturbed non-sacred grove region. Comparatively higher concentrations of calcium are found recorded during the post-monsoon period over the pre-monsoon and this accounted for an average increase of 37.18%, 5.34% and 26.25% respectively in the soil of core, transition and disturbed regions. However, with respect to the potassium concentrations during the post-monsoon, although an increase of 16.22% is recorded in the core region, the concentrations in the transition and disturbed regions record a decrease of 25.96% and 3.57% respectively over the pre-monsoon concentrations. The highest difference in potassium as well as calcium concentrations is obtained between the soil of core region of grove and the disturbed non-sacred grove land (figure F7). This recorded an average difference of 38.71% and 50.48% for potassium during the pre-monsoon and post-monsoon period respectively while an average difference of 42.64% and 51.14% for calcium respectively.

The data shows the concentrations of **available magnesium as well as sulphur** exhibit a decreasing trend with the maximum concentration in the core region and decreasing in the direction of transition and finally the minimum concentration being recorded in the disturbed region, irrespective of the season (figure F7). The highest difference in concentration is obtained between the soil of core and disturbed region and differences are 69.39% and 74.07% for magnesium and 64% and 50% for sulphur respectively during the pre-monsoon and post-monsoon periods. The comparison of concentrations due to seasonal variations indicates that the higher values of magnesium and sulphur are recorded during the pre-monsoon season compared to post-monsoon. This account for a reduction of 20%, 29.17% and 31.71% respectively in core, transition and disturbed land in the magnesium concentration while a reduction of 60%, 40% and 44.44% respectively in the sulphur concentration during the post-monsoon.

The details of micronutrient status in the Palliyana study site is depicted in the figure F8. The difference in the concentrations of **copper and iron** in different regions indicate an increasing trend from the lowest concentration recorded in the core regions of sacred groves towards the transition regions and then the highest concentrations in the disturbed non-sacred grove regions. The highest average increase of 80.1% and 80% for copper concentrations and 72.99% and 58.51% for iron concentrations are recorded in the disturbed non-sacred grove region over

the concentrations of core region of sacred grove respectively during the pre-monsoon and post-monsoon seasons. However, the concentrations of micronutrients **zinc**, **manganese** and **boron** exhibited a reverse trend where the highest concentration is recorded in the core regions of sacred groves and decrease towards the transition regions and finally the lowest concentrations in the disturbed non-sacred grove regions. In the pre-monsoon period, the decrease in the concentration of disturbed region over the concentrations of core region are 51.92%, 68.98% and 89.47% respectively for zinc, manganese and boron while, during the post-monsoon period the decrease are 55.36%, 86.56% and 43.18% respectively.



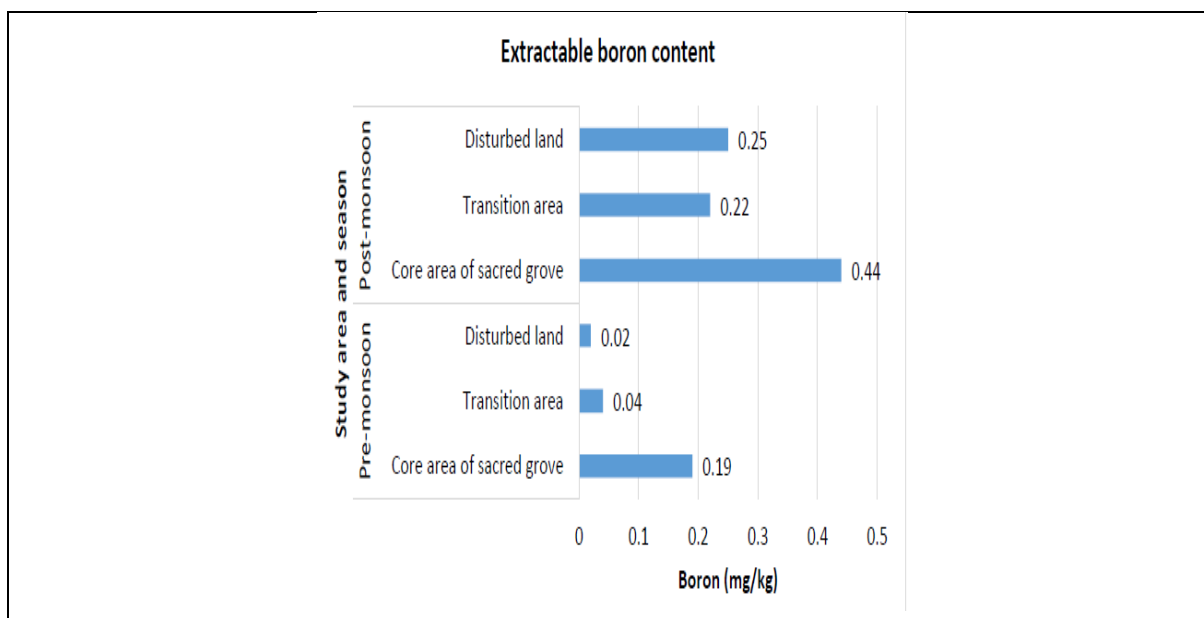


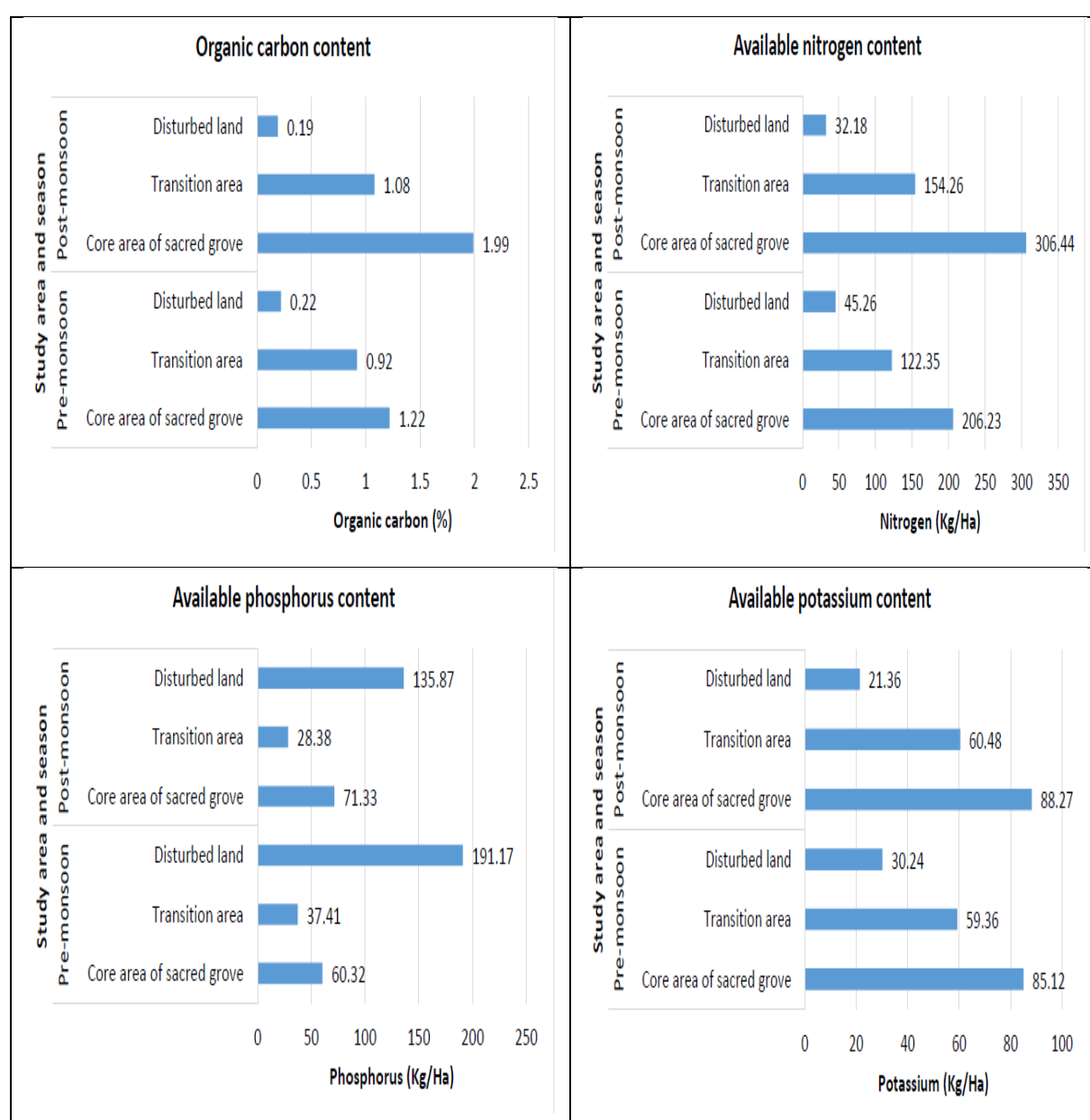
Figure F8: The micronutrient status of soil samples collected from different regions of Palliyana study site during the pre-monsoon and post-monsoon periods

The comparison of seasonal variation in the concentrations of micronutrients copper and iron indicate with an exception of iron concentration in the core region of sacred grove, the concentrations in all the soil samples collected during the pre-monsoon season are found to increase compared to post-monsoon concentrations. However, on comparing the concentrations of extractable zinc, manganese and boron obtained from different soil samples, it reveals that the concentrations of zinc and boron tend to increase during the post-monsoon season while that of manganese decrease over pre-monsoon concentrations (figure F8).

3) Nambiyath study site

The macro and micro nutrient status of soil samples collected from different regions at Nambiyath site during the pre-monsoon and post- monsoon season are depicted in figure F9 and figure F10 respectively. The data presented in the figure 9 showed differences in the concentration of various macro elements in different soil samples. Highest **organic carbon (OC)** content is obtained from the soil of core region of sacred grove followed by transition region and the lowest OC content in the soil of disturbed non-sacred grove region. The values of OC content are comparatively higher during the post-monsoon period with respect to core and transition regions whereas the OC value decreased for disturbed land during the post-monsoon. In the post-monsoon period compared to pre-monsoon, an increase of 38.69% and 14.81% of OC content are recorded respectively in the core and transition regions while the decrease recorded is 13.64% is recorded in the disturbed land. The highest difference in OC

content is recorded between soil in the core region and disturbed land and this recorded a difference of 81.97% and 90.45% respectively during the pre-monsoon and post-monsoon period. Almost similar trend is also recorded with respect to content of available **nitrogen** where the highest difference of 78.05% and 89.5% is recorded between the core and the disturbed region during the pre-monsoon and post-monsoon periods respectively. The nitrogen content in the soil of core and transition regions are found to enhance during the post-monsoon period while the content is lowered with respect to the soil of non-sacred grove region. The enhancements in the contents are 32.70% and 20.69% respectively for core and transition region while the decrease is 28.9% for the disturbed land.



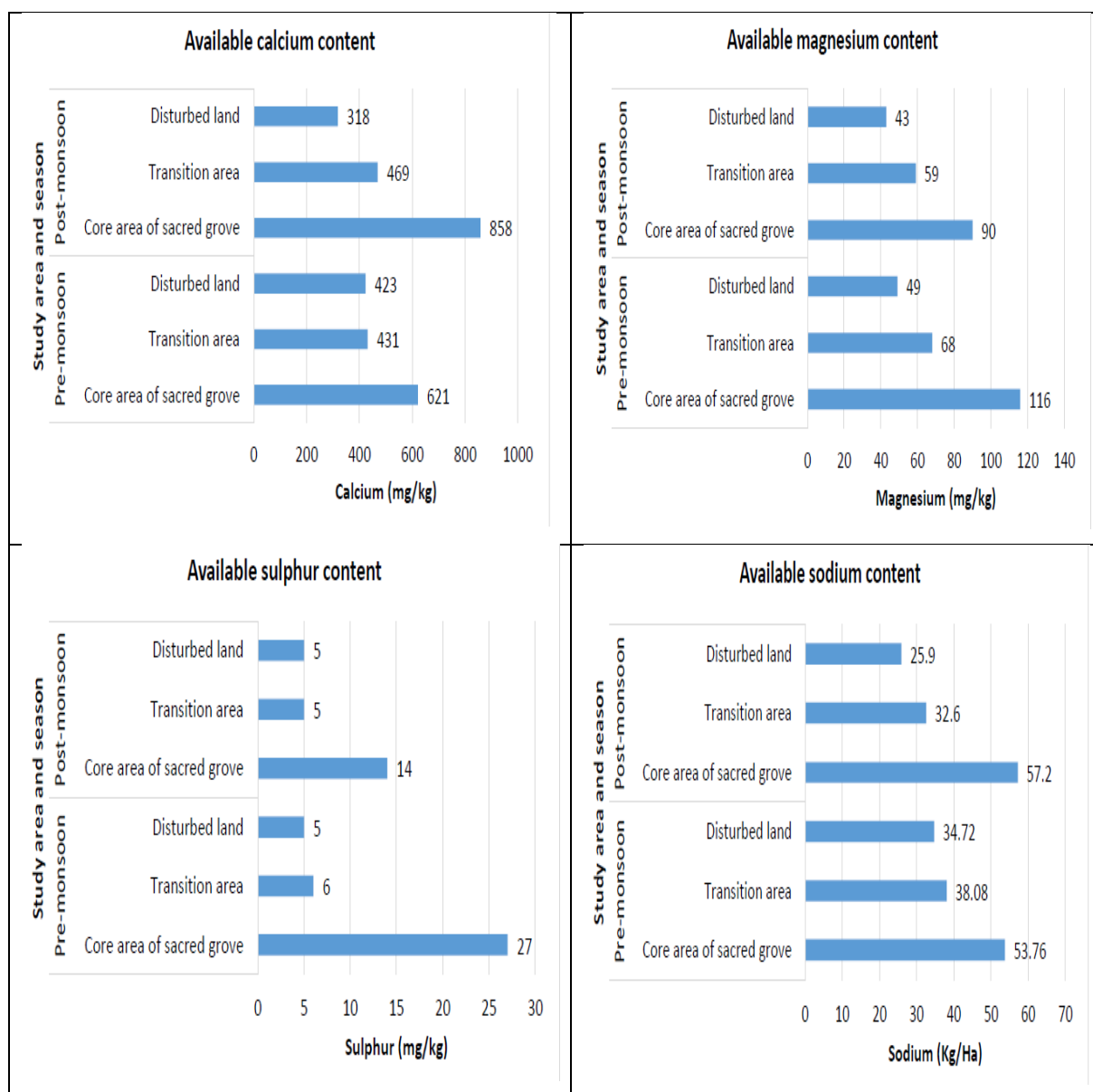


Figure F9: The macronutrient status of soil samples collected from different regions of Nambiyath study site during the pre-monsoon and post-monsoon periods

The available **phosphorus** content in the soil of Nambiyath site showed the highest value recorded in the disturbed land, followed by core region and lowest value in the transition region. The phosphorus content in the soil of core region is found to increase during the post-monsoon period compared to pre-monsoon whereas, the content tend to decrease with respect to transition and disturbed land. The increase is 15.44% in the core area while decreases are 24.14% and 28.93% respectively in the transition and disturbed regions over the pre-monsoon values. With respect to the **potassium** concentration, the highest concentration is recorded in the core area followed by transition and lowest concentration in the disturbed area, irrespective of the season. In the core and transition area, the potassium concentrations are comparatively

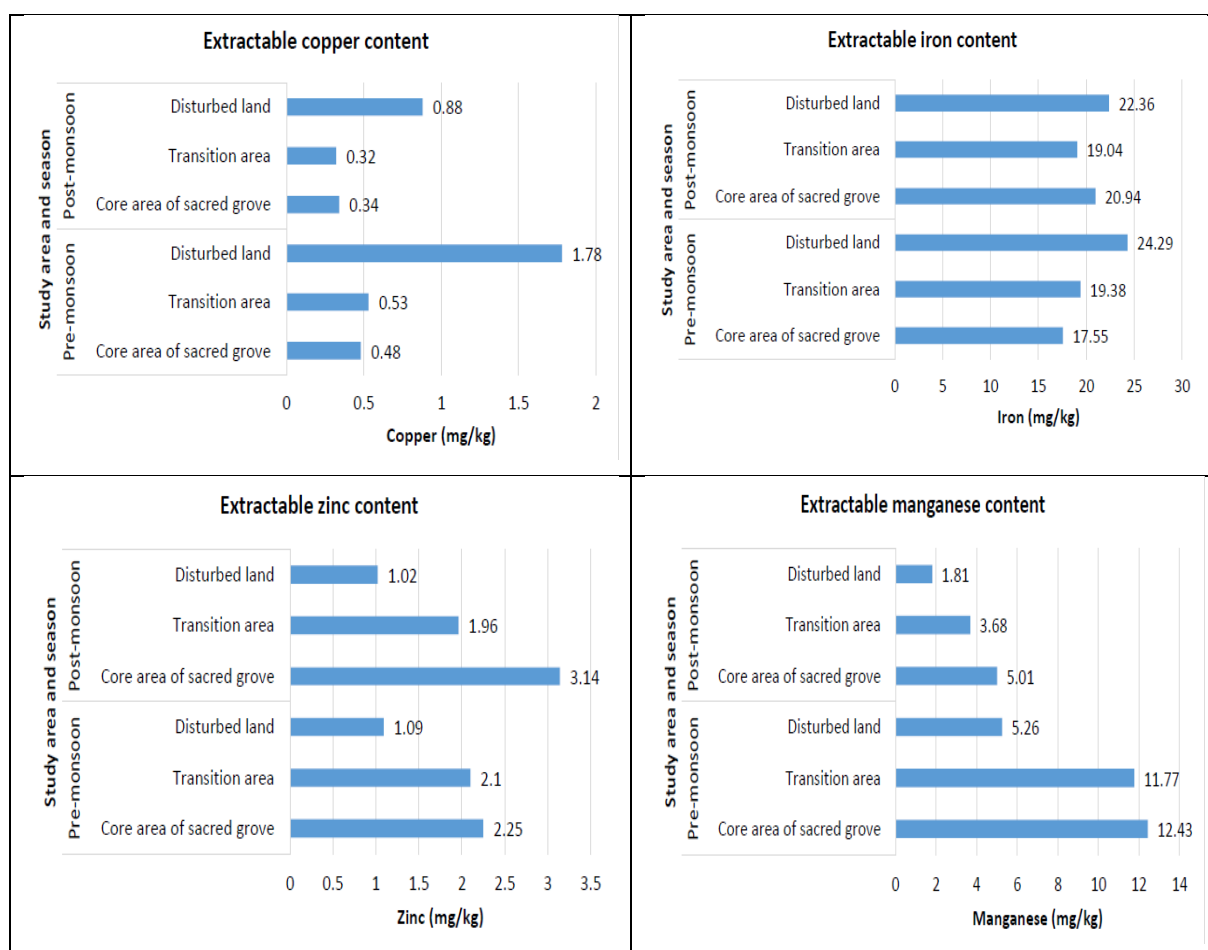
higher in the post-monsoon period and are 3.57% and 1.85% higher respectively over pre-monsoon values. However, the disturbed area recorded a reduction of 29.37% over pre-monsoon concentration. Difference in available potassium concentration between the soil samples of core area and disturbed area recorded the highest difference and are 64.47% and 75.8% during the pre-monsoon and post-monsoon seasons respectively.

The concentrations of **calcium** depicted in the figure F9 show decreasing trends in the concentration where maximum concentration of calcium is recorded in the soil of core region of sacred grove which is followed by transition region and the minimum concentration recorded in the disturbed non-sacred grove region. The results indicate that the calcium concentrations are comparatively higher during the post-monsoon period over pre-monsoon with respect to soil of core and transition region and the increases are 27.62% and 9.81% respectively. However, the soil of disturbed region recorded lower calcium concentrations during the post-monsoon period and it recorded a reduction of 24.82% over the pre-monsoon value. The highest difference in calcium concentration is obtained between the soil of core and the disturbed region and is 31.88% during the pre-monsoon and 62.94% during the post-monsoon periods. The **magnesium** content recorded highest concentration in the core area and decreases in the direction of transition and disturbed area, during both sampling periods. Higher values of magnesium concentration are recorded during the pre-monsoon compared to post-monsoon and this account for a reduction of 22.41%, 13.24% and 12.24% respectively in the soil of core, transition and disturbed area during the post-monsoon. The highest difference in magnesium concentration is between the soil of core and disturbed non-sacred grove land and is 57.76% during the pre-monsoon and 52.22% during the post-monsoon periods.

With respect to available **sulphur**, the highest difference in sulphur concentration is recorded between the core and disturbed area and the differences are 81.48% during the pre-monsoon period while it is 64.29% during the post-monsoon period. Comparatively higher concentrations are recorded during the pre-monsoon period compared to post-monsoon and this accounted for a decrease of 48.15% and 16.67% respectively for core and transition region during the post-monsoon while no change in concentration recorded for soil in the disturbed non-sacred grove region. Similarly, the highest difference in sodium concentration is obtained between the soil of core and disturbed land and these are 35.42% during the pre-monsoon and 54.72% during the post-monsoon periods. However, comparatively higher values of sodium concentration for the core region of grove is recorded during the post-monsoon period while

higher values for the transition and disturbed regions are recorded in the pre-monsoon period (figure F9).

The details of micronutrient concentrations in the soil samples of core area of sacred grove, the transition area and the disturbed non-sacred grove area at Nambiyath site revealed variations among soil samples. Higher concentration of micronutrients **copper and iron** are recorded in the disturbed non-sacred grove region, followed immediately by transition region and then the lower concentrations recorded in the core region of sacred grove with certain exceptions during the post-monsoon season with respect to core region. With the exception of iron value in the core region, all the soil samples have comparatively higher concentrations of copper and iron during the pre-monsoon period over the post-monsoon concentrations. The concentration of iron in the core region is 16.19% lower during the pre-monsoon than the post-monsoon. The highest difference in concentration of copper and iron is recorded between the soil of disturbed and core region and are 73.03% and 27.75% respectively during the pre-monsoon while highest difference during the post-monsoon is between transition region and disturbed region and are 63.64% and 14.85 respectively for copper and iron concentrations.



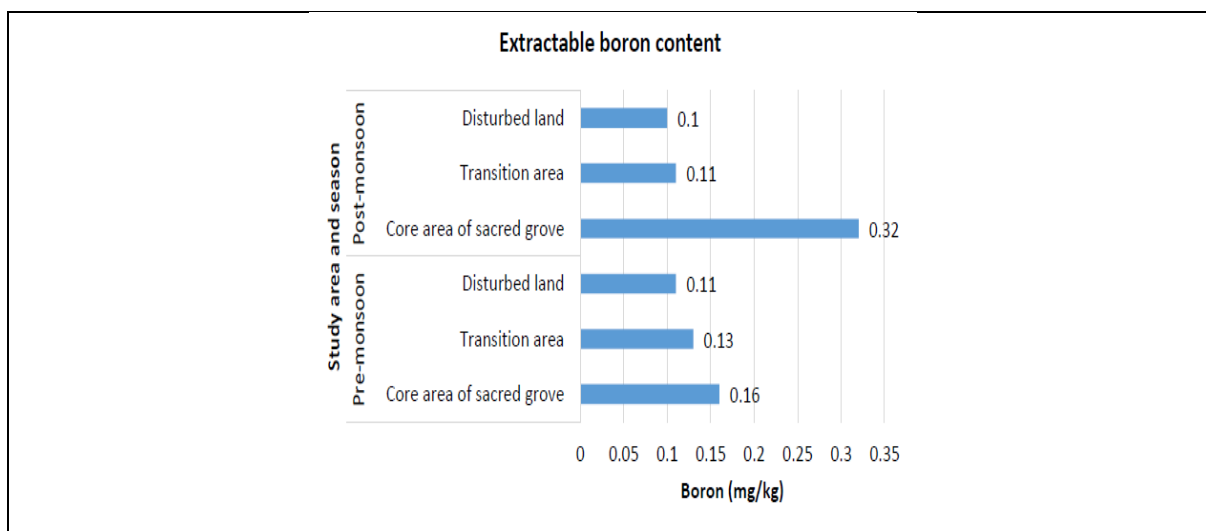


Figure F10: The micronutrient status of soil samples collected from different regions of Nambiyath study site during the pre-monsoon and post-monsoon periods

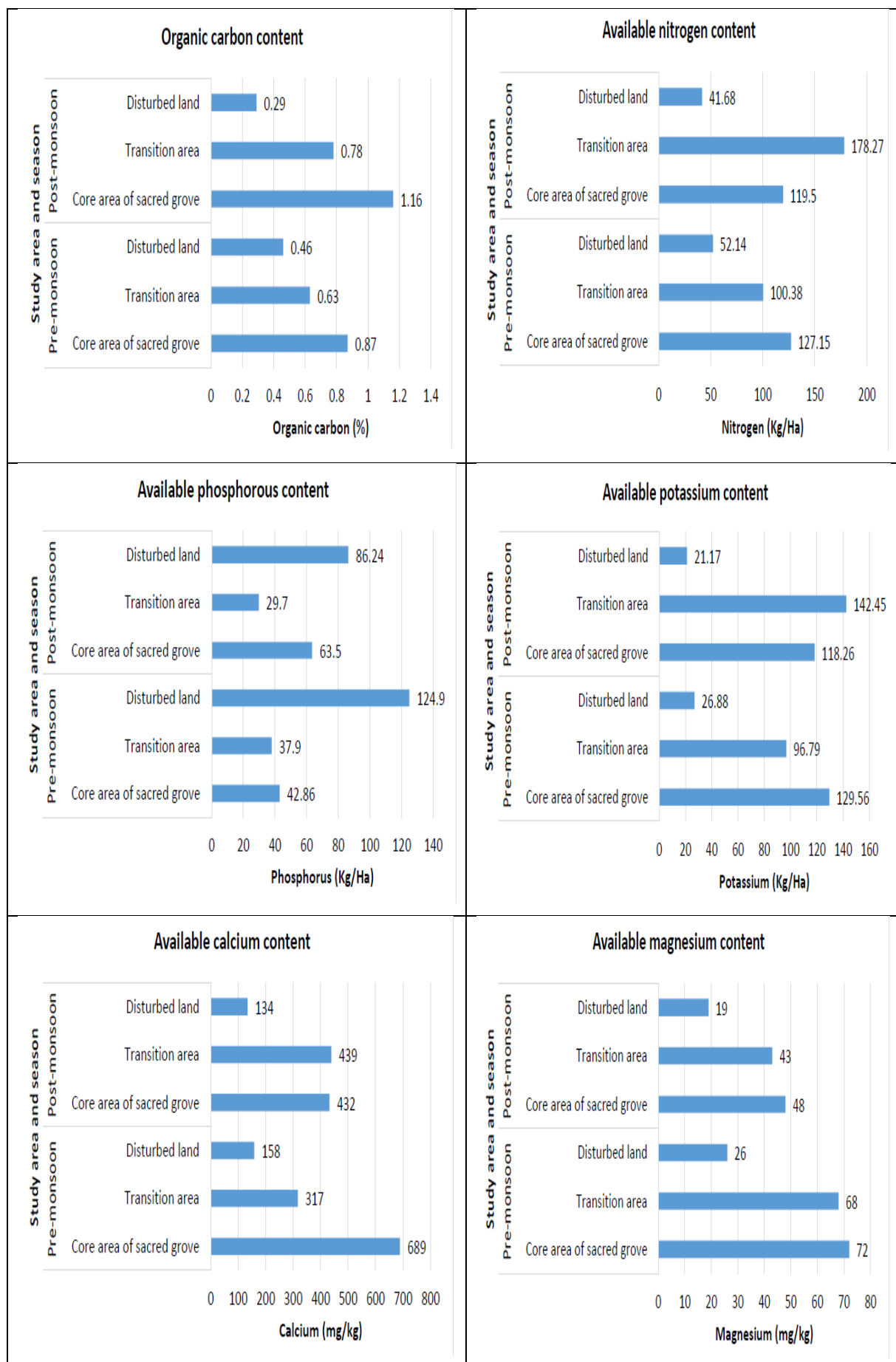
The concentrations of **zinc, manganese and boron** indicate a decreasing trend from the highest concentration recorded in the core region of sacred grove to transition region and then to disturbed non-sacred grove region. The highest difference in concentrations are recorded between the soils of core region and the disturbed region in all the cases. This account for a difference of 51.56%, 57.68% and 31.25% respectively for zinc, manganese and boron during the pre-monsoon and a difference of 67.52%, 63.87% and 68.75% respectively during the post-monsoon. The comparison of concentrations obtained in different seasons indicate in the soil of core region, the higher concentrations of zinc and boron recorded during the post-monsoon season and this account for increased concentrations of 28.34% and 50% respectively for zinc and boron over pre-monsoon concentrations. The transition and disturbed non-sacred grove regions record higher concentrations of zinc and boron during the pre-monsoon season and this account for increased concentrations of 6.67% and 15.38% respectively over post-monsoon concentrations. However, with respect to manganese, higher soil concentrations are recorded during the pre-monsoon season compared to post-monsoon in all the regions and this accounts for an increase of 59.69%, 68.73% and 65.59% concentrations respectively in the core, transition and disturbed regions over their post-monsoon concentrations (figure F10).

4) Poyyara study site

The details of macro elements in the soil samples collected from the Poyyara study site during the pre-monsoon and post- monsoon periods are depicted in figure F11. The **Organic Carbon (OC)** content in the soils show decreasing trend from the core area of sacred grove towards the transition area and then the soil of disturbed non-sacred grove area. The OC content of soil in

the core and transition area recorded an increase of 25% and 19.23% respectively during the post-monsoon period over the content of pre-monsoon period while a decrease of 36.96% OC content recorded for the soil in the disturbed area over the pre-monsoon content. The highest difference in OC content is recorded between the soil of core and the disturbed area and is 47.13% during the pre-monsoon and 75% during the post-monsoon period. With respect to available nitrogen, the highest content during the pre-monsoon is recorded in the soil of core area of grove, followed by transition and then disturbed non-sacred grove area. However, during the post-monsoon season the highest nitrogen content is recorded in the transition area and this is followed by core and then disturbed area. The highest difference in available nitrogen content is obtained between the core region and disturbed region (58.99%) during the pre-monsoon while during the post-monsoon period is between the transition and disturbed region (76.62%).

The results of available **phosphorus** concentration revealed the highest concentration is obtained in the disturbed land which is immediately followed by core area and lowest concentration in in the transition area during both the sampling periods (figure). Highest difference in phosphorus concentration is obtained between soil in the transition and disturbed area and this is 69.66% during the pre-monsoon and 65.56% during the post-monsoon season. The **concentrations of** available **potassium** content shows higher potassium content during the pre-monsoon is recorded in the core region of sacred grove followed by transition and the lowest content in the disturbed non-sacred grove region while during the post-monsoon period, higher content is recorded in the transition region immediately followed by core and then disturbed region. The highest difference in potassium content recorded between core region and disturbed region (79.25) in the pre-monsoon period while it is between transition region and disturbed region (85.14%) during the post-monsoon.



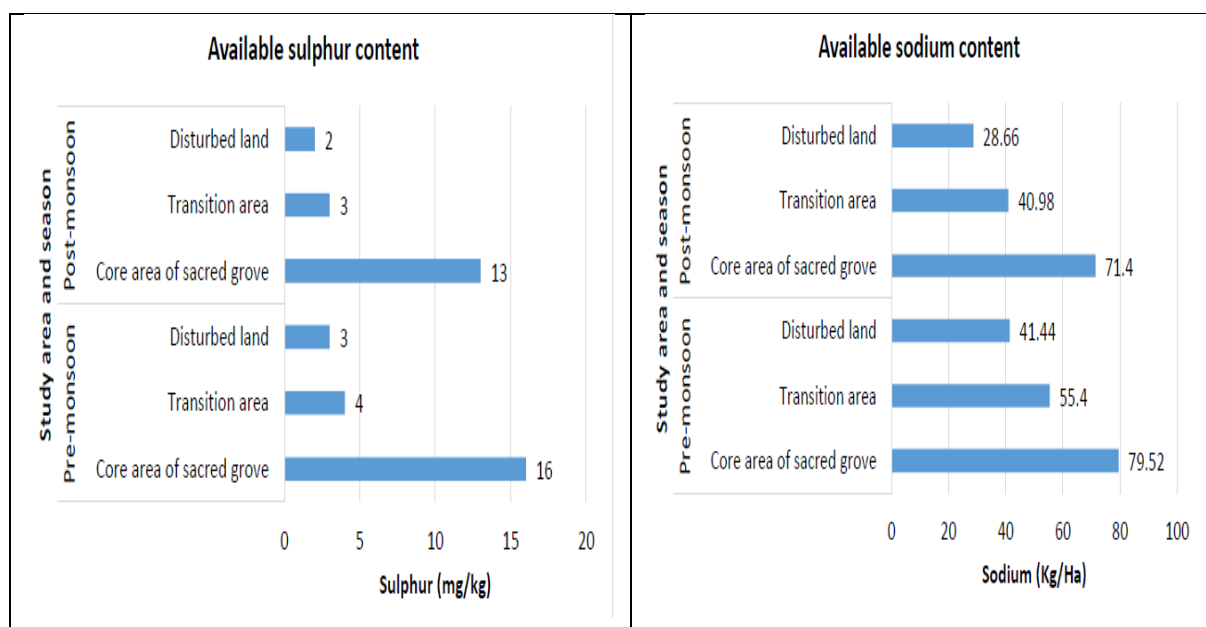


Figure F11: The macronutrient status of soil samples collected from different regions of Poyyara study site during the pre-monsoon and post-monsoon periods

The results of **Calcium** content obtained during the pre-monsoon period show that the core region of sacred grove record higher concentration and decrease towards the transition region and then the disturbed non-sacred grove region. However, during the post-monsoon period, slightly higher concentration is recorded in the transition region, immediately followed by core region and then the disturbed region. The highest difference in calcium concentrations of 77.06% obtained between core and the disturbed regions during the pre-monsoon and during the post-monsoon it is 69.48% between the transition and the disturbed region. Comparative analysis of calcium concentrations obtained in different season reveal the highest concentration in the core and the disturbed region are recorded during the pre-monsoon period (689 mg/kg and 158mg/kg respectively) and these are 37.30% and 15.19% higher respectively than the post-monsoon concentrations. However, the transition region recorded highest concentration during the post-monsoon period (439mg/kg) and this is 27.79% higher than the pre-monsoon concentration.

The **magnesium** concentration is tend to decrease from the soil of core area of sacred grove to transition and then to disturbed non-sacred grove area, irrespective of the sampling periods and all the regions recorded comparatively higher concentration during the pre-monsoon compared to post-monsoon. The reductions in the magnesium concentration during the post-monsoon are 33.33%, 36.76% and 26.92% respectively for core, transition and disturbed area during the post-monsoon. The maximum difference in magnesium concentration is obtained between the

soil of core and disturbed region and these are 63.89% during the pre-monsoon and 60.41% during the post-monsoon periods.

The concentrations of available **sulphur** and **sodium** at Poyyara site show a decreasing trend from the core region to transition region and then to disturbed non-sacred grove region, irrespective of the season. Difference in concentration between core and disturbed region during the pre-monsoon for sodium is 47.89% while for sulphur is 81.25% whereas, the same during the post-monsoon period is 59.86% for sodium and for sulphur is 84.62%. This indicates higher difference in the concentration occurred during the post-monsoon period. However, the comparison of concentrations obtained in different season indicates, comparatively higher values recorded during the pre-monsoon period in all the study regions for both the elements (figure F11).

The details of micronutrient status analysed in the soil samples in the core area of sacred grove, the transition area and the disturbed non-sacred grove area at Poyyara study site indicate differences in the concentration of micronutrients between soil samples (figure F12). The results show an increasing trend in the concentration of extractable **copper and iron** from the soil of core area of sacred grove to transition and then to disturbed non-sacred grove area, with an exception of decreased concentration of copper in the disturbed region over the transition region during the pre-monsoon. Comparatively higher concentrations are recorded during the pre-monsoon period over the post-monsoon. Reduction of 30.16% and 38.50% respectively for the concentration of copper and iron in the core area and similarly 30.89% and 6.93% reductions respectively in the transition area and 19.66% and 11.88% reductions respectively in the disturbed region are occurred in the post-monsoon concentrations over the pre-monsoon concentrations. The highest difference in concentration of copper is recorded between the soil of transition and disturbed areas during the pre-monsoon (48.78%) and during the post-monsoon it is between core and disturbed areas (53.19%) while in the case of iron concentration, the highest difference is recorded between the core and disturbed regions during both the seasons and are 89.46% during the pre-monsoon and 92.65% during the post-monsoon.

With the exception of extractable **zinc and manganese** concentration in the transition area during the post-monsoon period, the concentrations of **zinc, manganese and boron** obtained from different soil samples indicate a decreasing trend where, the highest concentration is recorded in the core region followed immediately by transition region and then the lowest

concentration in the disturbed region. However, the concentration of zinc and manganese during the post-monsoon period recorded higher than core and disturbed areas.

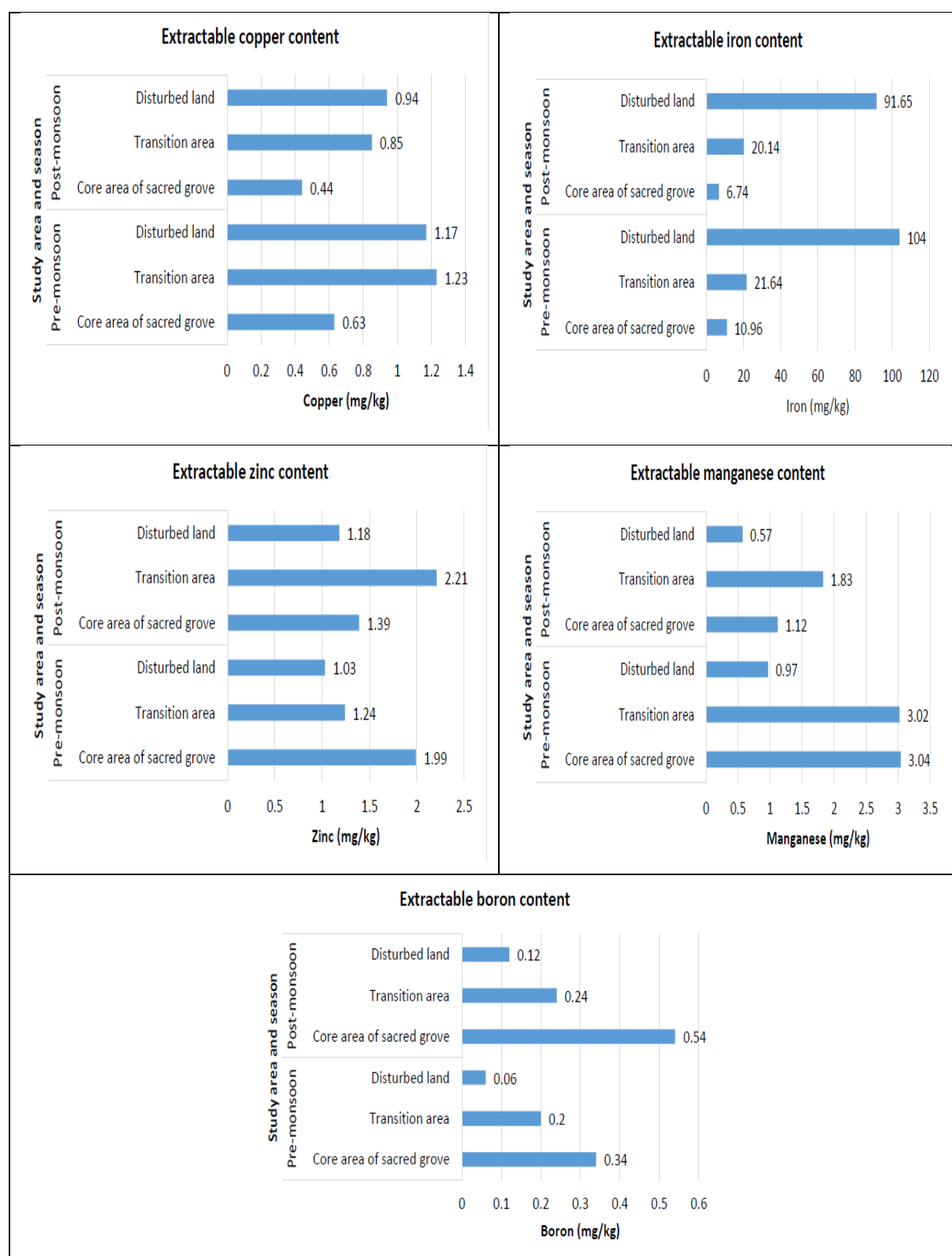


Figure F12: The micronutrient status of soil samples collected from different regions of Poyyara study site during the pre-monsoon and post-monsoon periods

The comparison of seasonal variation in the concentration of manganese reveal higher concentration values are recorded during the pre-monsoon period and are 63.16%, 39.40% and 41.24% more than the post monsoon concentrations respectively for the core, transition and disturbed areas. However, the concentrations of boron recorded higher in the post-monsoon period and are 37.04%, 16.67% and 50% more than the pre-monsoon concentrations respectively for the core, transition and disturbed areas. Whereas in the case of zinc, the transition and disturbed areas recorded higher concentrations during the post-monsoon period and are 43.89% and 12.71% respectively while, the soil of core area recorded higher concentrations during the pre-monsoon period and is 30.15% over the post-monsoon concentration (figure F12).

Discussion

I) Soil Physical Properties

The analysis of soil moisture content and water holding capacity of soil in the core area of selected sacred groves, the transition areas and the disturbed non-sacred lands reveal that the soil in the core area maintained comparatively higher moisture content (MC) and water holding capacity (WHC), irrespective of pre-monsoon and post-monsoon periods. The present study generally observe a progressive decrease in the soil moisture content and water holding capacity from core area of sacred grove to transition area and then to disturbed non-sacred grove area. The higher soil moisture content and water holding capacity in the grove area could be the result of reduced surface evaporation due to higher floristic composition and distribution. Higher floristic composition particularly of trees in the groves naturally cause high rate of litter fall and their decomposition. This process naturally may improve organic matter and humus content in the soil, which are known to improve water holding capacity and moisture content of soil due to lower bulk density (Johan, 1998). The higher decomposition rate of organic matter in the area can improve the binding and aggregation of smaller soil particles and this can cause increased pore space and improvement in specific surface area (Volk & Ullery, 1993; Vengadaramana & Jashothan, 2012), which in turn improves water retention capacity of the soil. However, the lower moisture content and water holding capacity of soil in the disturbed and transition regions compared to the grove regions in the present study could be the result of faster evaporation loss of water from the floor area. The hot and dry climatic environment existing in the disturbed non-sacred grove regions might also contribute to this phenomenon. The poor floristic composition oriented reduction in litter fall deposition and their decomposition and direct falling of sunlight in the ground area due to poor tree canopy cover are the major factors contributing towards higher loss of surface water in the disturbed lands.

The study revealed the MC and WHC of soil in most of the study regions generally tend to increase during the post-monsoon period over the pre-monsoon values. However, certain exceptions are observed with respect to soil in the disturbed non-sacred grove land at Sankulangara and Poyyara where, WHC values slightly tend to decrease over the pre-monsoon values. The enhancement in the MC and WHC of soil during the post-monsoon period may be due to the improvements in the soil quality factors such as higher organic matter and humus

content, lower bulk density and increased specific surface area compared to pre-monsoon period. The decreased WHC recorded in the disturbed soil of Sankulangara and Poyyara can be attributed to higher reduction in the soil organic matter and humus content through leaching process that occur during the rain. The comparative analysis revealed the maximum difference in moisture content and water holding capacity is existing between the soil in the grove regions and the disturbed non-sacred grove regions in all the study sites and the differences are found significant during the pre-monsoon as well as post-monsoon periods. Similarly, the differences occurred in the soil due to seasonal variation are also found significantly higher in the core region in all the study sites while it is found not significant with respect to disturbed non-sacred grove regions at Palliyana and Poyyara sites in the case of MC and Sankulangara, Palliyana and Poyyara sites in the case of WHC (table F1 & table F2).

Table F1: Comparison of soil moisture content in various regions of the selected study sites during the pre-monsoon season and post-monsoon periods

Study site	Mean value and SD of soil moisture content (%)					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Sankulangara site	9.06 ±0.25	7.40 ±0.30	3.64 ±0.26	14.01 ±0.17	11.10 ±0.77	4.42 ±0.68
	The 't' value and significant level in the average soil moisture content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Core zone of grove	Disturbed non-sacred grove land X Disturbed non-sacred grove land	
	30.595		27.591	-33.360		-2.154
	P<0.001		P<0.001	P<0.001		P<0.05
Palliyana site	7.48 ±1.12	5.54 ±0.93	3.51 ±0.59	10.72 ±1.66	7.69 ±2.04	4.08 ±0.70
	The 't' value and significant level in the average soil moisture content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Core zone of grove	Disturbed non-sacred grove land X Disturbed non-sacred grove land	
	6.270		7.386	-3.239		-1.245
	P<0.001		P<0.001	P<0.05		NS*
Nambiyath site	7.53±0.77	5.24±0.73	3.34 ±0.10	10.92±1.37	6.75 ±2.08	4.44±0.49
	The 't' value and significant level in the average soil moisture content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Core zone of grove	Disturbed non-sacred grove land X Disturbed non-sacred grove land	
	10.724		10.9225	-4.311		-4.385
	P<0.001		P<0.001	P<0.05		P<0.05
Poyyara site	6.25±0.69	4.15 ±0.55	3.52±0.60	8.91±0.31	4.83 ±0.31	4.21±0.56
	The 't' value and significant level in the average soil moisture content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Core zone of grove	Disturbed non-sacred grove land X Disturbed non-sacred grove land	
	5.956		14.552	-6.974		-1.668
	P<0.001		P<0.001	P<0.001		NS*

NS* - Not significant

Table F2: Comparison of water holding capacity of soil in various regions of the selected study sites during the pre-monsoon season and post-monsoon periods

Study site	Mean value and SD of water holding capacity of soil (%)					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Sankulangara site	38.5450 ±0.52	34.72±1.08	29.99±0.84	44.36 ±1.13	38.81±2.17	29.77±1.37
	The 't' value and significant level in the water holding capacity					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Core zone of grove	Disturbed non-sacred grove land X Disturbed non-sacred grove land	
	17.284	16.411		-9.332	0.277	
	P<0.001	P<0.001		P<0.001	NS*	
Palliyana site	36.72±1.14	32.99 ±0.82	29.36 ±0.70	40.67 ±0.56	35.54±0.52	30.23±1.10
	The 't' value and significant level in the water holding capacity					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Core zone of grove	Disturbed non-sacred grove land X Disturbed non-sacred grove land	
	10.990	16.947		-6.208	-1.343	
	P<0.001	P<0.001		P<0.001	NS*	
Nambiyath site	36.10 ±0.98	31.09 ±0.93	28.31 ±0.57	40.64 ±0.88	34.63 ±0.45	30.02 ±0.99
	The 't' value and significant level in the water holding capacity					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Core zone of grove	Disturbed non-sacred grove land X Disturbed non-sacred grove land	
	13.737	16.046		-6.890	-2.993	
	P<0.001	P<0.001		P<0.001	P<0.05	
Poyyara site	33.28 ±0.73	30.87 ±0.76	29.76 ±0.53	36.39 ±0.65	32.98 ±1.0	29.71 ±0.55
	The 't' value and significant level in the water holding capacity					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Core zone of grove	Disturbed non-sacred grove land X Disturbed non-sacred grove land	
	7.812	15.736		-6.396	0.131	
	P<0.001	P<0.001		P<0.001	NS*	

NS* - Not significant

The bulk density of the soil is playing an important role in deciding the health and productivity of the soil. The bulk density is one of the key factors which determine the soil environment for microbial activity and nutrient availability. The present study clearly reveal that there are differences in bulk density between soil of various regions in all the study sites and the values are found increasing in the direction of core region of sacred grove → the transition region → disturbed non-sacred grove region. The influence of seasonal variation in the bulk density values of soil reveal that with the exception of soil in the disturbed non-sacred grove region, the values in all the regions tend to decrease during the post-monsoon period over the pre-monsoon values. The values of bulk density in the disturbed regions are found not much influenced by the seasonal variations, mostly the values are slightly increasing and in certain cases no change is observed. The statistical analysis revealed the differences are maximum and significant between the bulk density values of soil in the core region of grove and disturbed non-sacred region in all the study sites during both the season. The difference in the values due to seasonal variation showed the bulk density values in the soil of core region is significantly different while the differences in the soil of disturbed non-sacred grove region is insignificant in all the study sites (table F3). The higher values of bulk density recorded by the soil of disturbed non-sacred grove land in the present study may be attributed to poor floristic composition particularly due to lower tree density and their frequency in the area. The lower floristic composition in the disturbed area may cause increased soil strength and decreased soil porosity and this might be due to poor root growth of trees and other plants. However, the lower bulk density values in the soil of sacred grove regions can be attributed to the vigorous growth of the tree root systems in the area combined with the influence of rich humus content in the soil as a result of frequent addition of leaf litter and their decomposition by microorganisms. The present study observations and interpretations are in similar lines with the reports of Nambiar and Sands (1992) and Enrique et al. (2015) on the bulk density and porosity of soil.

Table F3: Comparison of bulk density of soil in various regions of the selected study sites during the pre-monsoon season and post-monsoon periods

Study site	Mean value and SD of bulk density of soil (g/cm ³)					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Sankulangara site	1.11 ±0.04	1.20 ±0.05	1.38 ±0.09	1.01 ±0.05	1.14 ±0.03	1.39 ±0.09
	The 't' value and significant level in the average bulk density					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	-5.556		-7.637	3.228		
	P<0.001		P<0.001	P<0.05		
Paliyana site	1.27 ±0.09	1.35 ±0.05	1.40 ±0.08	1.09 ±0.05	1.30 ±0.03	1.40 ±0.03
	The 't' value and significant level in the average bulk density					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	-2.227		-10.333	3.486		
	P<0.05		P<0.001	P<0.05		
Nambiyath site	1.21 ±0.09	1.34 ±0.04	1.41 ±0.05	1.07 ±0.04	1.27 ±0.03	1.43 ±0.05
	The 't' value and significant level in the average bulk density					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	-3.972		-10.943	2.978		
	P<0.05		P<0.001	P<0.05		
Poyyara site	1.31 ±0.03	1.40 ±0.05	1.45 ±0.05	1.27 ±0.04	1.38 ±0.08	1.47 ±0.01
	The 't' value and significant level in the average bulk density					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	-4.800		-10.830	1.738		
	P<0.05		P<0.001	P<0.05		

NS* - Not significant

Porosity is one of the important soil physical factors to be considered with respect to quality of soil as it decides the space for storage, the movement of groundwater and infiltration property of the soil. The porosity values are found greater in the soil of core region of sacred grove which is immediately followed by transition region and the lowest porosity is recorded in the disturbed non-sacred region with respect to all the studied sites of different extent. The study further revealed the porosity values of soil generally tend to improve during the post-monsoon period over the pre-monsoon values, with certain exceptions with respect to soil in the disturbed non-sacred grove land at Sankulangara and Poyyara study sites where, porosity slightly tend to decrease over the pre-monsoon values. Statistical analysis revealed that the difference in soil porosity values between the core region of groves and non-sacred grove regions are significant. The difference in porosity values occurred due to the influence of seasonal variation are mostly not significant with the exception of soil in the core region of grove at Sankulangara and Palliyana study sites (table F4). The better porosity values in the soil of sacred groves might be the result of fine-textured soil in the area. The fine components formed by the microbial decomposition of thick deposition of leaf litter particularly of trees in the grove area are usually less dense than the mineral components which may favour the building of fine textured soil by lowering of bulk density and improving the air space between and within the soil aggregates (Kêsik et al., 2010; Portella et al., 2012; Enrique et al., 2015).

Table F4: Comparison of soil porosity in various regions of the selected study sites during the pre-monsoon season and post-monsoon periods

Study site	Mean value and SD of soil porosity (%)					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Sankulangara site	45.55 ±0.61	42.57 ±0.58	36.73 ±1.81	49.16 ±0.70	43.22 ±1.62	36.63 ±1.21
	The 't' value and significant level of average soil porosity					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	9.241		17.949	-7.821		
	P<0.001		P<0.001	P<0.001		
Palliyana site	44.07 ±0.93	39.04 ±1.57	36.18 ±0.99	46.16 ±2.0	40.79 ±2.0	36.37 ±1.06
	The 't' value and significant level of average soil porosity					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	11.629		8.683	-1.900		
	P<0.001		P<0.001	NS*		
Nambiyath site	44.11 ±1.28	40.34 ±1.53	36.42 ±0.95	47.57 ±1.98	42.36 ±0.71	36.47 ±0.99
	The 't' value and significant level of average soil porosity					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	9.659		10.038	-2.939		
	P<0.001		P<0.001	P<0.05		
Poyyara site	42.5175 ±0.91	37.95 ±1.09	37.00 ±0.71	43.70 ±0.94	38.58 ±2.07	36.86 ±0.66
	The 't' value and significant level of average soil porosity					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	9.578		11.864	-1.801		
	P<0.001		P<0.001	NS*		

NS* - Not significant

Soil electrical conductivity (EC) is the ability of soil water to carry the electrical current and this can provide a good indication of the amount of nutrients available for the plants to absorb. The present study shows the soil in the sacred grove region recorded comparatively higher EC value over other region in all the study sites during the pre-monsoon as well as post-monsoon seasons. The differences in EC value recorded between the core region of grove and disturbed non-sacred grove regions in all the study sites revealed significantly higher EC values in the soil of groves. However, the study observed only with an exception in the case of core region of grove in the Sankulangara study site, the seasonal variation has not caused significant difference in the EC values in any of the analysed regions in the study (table F5). The higher EC value in the core region of groves may be attributed to the higher release of soluble inorganic ions from the rich soil organic matter, favoured by increased soil porosity and higher moisture content (Granged, 2011). The study generally observe a negative correlation between EC value and bulk density in the analysed soil samples while there is a positive correlation between EC value, porosity, moisture content and inorganic matter content of analysed soil samples in all the study sites.

Table F5: Comparison of soil electrical conductivity in various regions of the selected study sites during the pre-monsoon season and post-monsoon periods

Study site	Mean value and SD of soil electrical conductivity (dS/m)					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Sankulangara site	0.070 ±0.008	0.040 ±0.008	0.020 ±0.008	0.090 ±0.008	0.060 ±0.008	0.020 ±0.008
	The 't' value and significant level in the average soil electrical conductivity					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	8.660		12.124	-3.464		
	P<0.001		P<0.001	P<0.05		
Palliyana site	0.045 ±0.013	0.035 ±0.021	0.020 ±0.008	0.058 ±0.017	0.035 ±0.013	0.023 ±0.013
	The 't' value and significant level in the average soil electrical conductivity					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	3.273		3.300	-1.168		
	P<0.05		P<0.05	NS*		

Nambiyath site	0.050 ±0.014	0.035 ±0.017	0.020 ±0.008	0.063 ±0.01	0.035 ±0.024	0.020 ±0.012	
	The 't' value and significant level in the average soil electrical conductivity						
	Pre-monsoon		Post-monsoon		Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	3.674		5.667		-1.464		0.00
	P<0.05		P<0.001		NS*		NS*
Poyyara site	0.040 ±0.008	0.028 ±0.01	0.023 ±0.005	0.045 ±0.013	0.018 ±0.01	0.020 ±0.008	
	The 't' value and significant level in the average soil electrical conductivity						
	Pre-monsoon		Post-monsoon		Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	3.656		3.273		-0.655		0.522
	P<0.05		P<0.05		NS*		NS*

NS* - Not significant

pH is a good measure of acidity and alkalinity of soil water suspension and provides good indication of the soil chemical properties (Trivedy & Goel, 1986). The soil pH values are found within the acidic range in all the study sites. Comparatively lower pH values are recorded in the soil of core region during both the seasons and the values are found gradually increasing in the direction of transition region and then disturbed non-sacred grove region. Comparing the pH values obtained during different seasons, soil samples collected during the post monsoon season recorded higher values than during the pre-monsoon. Comparatively higher differences in pH values are recorded between the soil of core and disturbed region in all the study sites during both the season and the differences are significant. The statistical analysis also revealed the differences in the pH value occurred due to seasonal variation in the core region in all the study sites and with an exception at Palliyana site in the case of disturbed non-sacred grove region are differed significantly (table F6). The difference in soil pH of various regions in all the study sites may be related to differences in the dynamics of the soil organic matter (Bell & Raczkowski, 2008). Lower pH values of soils in the sacred grove region compared to transition and disturbed non-sacred grove regions observed in the study might be due to higher release of hydrogen ions from rich organic matter content of the soils (Porter et al., 1980). Higher production of organic acids and CO₂ due to higher decomposition rate of rich dead organic matter in the soil of sacred groves by microbial activity and their higher accumulation due to

comparatively low rate of leaching could be the result of lower pH values (Arunachalam & Arunachalam, 1999). Further, the increased uptake of base elements from soil of grove area by rich vegetation may further contributed towards lowering the pH values (Osman, 2013).

Table F6: Comparison of soil pH in various regions of the selected study sites during the pre-monsoon and post-monsoon periods

Study site	Mean value and SD of soil pH					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Sankulangara site	4.83 ±0.13	5.18 ±0.1	6.05 ±0.06	4.63 ±0.13	5.03 ±0.13	6.35 ±0.06
	The 't' value and significant level in the average soil pH					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	17.697		-24.920	2.248		-7.348
	P<0.001		P<0.001	P<0.05		P<0.001
Palliyana site	5.63 ±0.1	6.35 ±0.06	6.43 ±0.1	5.50 ±0.14	6.08 ±0.013	6.53 ±0.01
	The 't' value and significant level in the average soil pH					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	-11.817		-12.004	1.464		-1.477
	P<0.001		P<0.001	NS*		NS*
Nambiyath site	5.05 ±0.13	5.70 ±0.22	6.23 ±0.05	4.78 ±0.05	5.53 ±0.1	6.15 ±0.06
	The 't' value and significant level in the average soil pH					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	-16.974		-36.006	3.973		1.964
	P<0.001		P<0.001	P<0.05		P<0.05

Poyyara site	5.83 ±0.1	5.90 ±0.1	6.15 ±0.6	5.65 ±0.06	6.18 ±0.05	6.40 ±0.1
	The 't' value and significant level in the average soil pH					
	Pre-monsoon		Post-monsoon		Pre-monsoon X Post-monsoon	
	Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove	Core zone of grove X Core zone of grove	Disturbed non-sacred grove land X Disturbed non-sacred grove land	
	-5.814	-15.00	3.130		-5.000	
	P<0.001	P<0.001	P<0.05		P<0.05	

NS* - Not significant

The study observed that the soil in the transition regions in most of the study sites are found holding comparatively better soil physical properties compared to disturbed non-sacred grove regions. This can be attributed to the influence of dead plant residues and the decomposed organic matter contents that are distributed and leaching from the grove regions to the region of transition.

With respect to the analysis on the influence of differences in extent of the selected sacred groves on various physical properties of soil in the study sites indicated that maximum differences are obtained between the Sankulangara grove of largest extent and Poyyara grove of smallest extent and all the differences are found significantly differed during the pre-monsoon as well as post-monsoon periods (table F7). The physical properties such as soil moisture content and water holding capacity during the pre-monsoon period and soil moisture content and pH during the post monsoon period are recorded a progressive improvement along with increase in extent of the groves. However, other physical properties in different periods with respect to Sankulangara and Nambiyath groves are found not followed such a trend and where the values of soil physical properties in the Nambiyath grove are found more improved than the Sankulangara grove of largest extent. Although this is the situation, there is clear differences between the physical properties of these two comparatively larger extents with that of Poyyara grove of smallest extent selected for the study. Therefore these inferences clearly revealed the differences in extent and the floristic composition of the selected groves have significant influence on various physical properties of the soil, although there is contradictions among groves of larger extents.

Table F7: The ‘t’ value and significant level in various physical properties of soil between the core region of selected sacred groves of different extents during the pre-monsoon and post-monsoon periods

Soil physical parameters	Core zone Sankulangara grove X Core zone Palliyana grove	Core zone Sankulangara grove X Core zone Nambiyath grove	Core zone Sankulangara grove X Core zone Poyyara grove
	Pre-monsoon period		
Soil moisture content (%)	2.756	3.760	7.633
	P<0.05	P<0.05	P<0.001
Water holding capacity of soil (%)	2.913	4.412	11.768
	P<0.05	P<0.05	P<0.001
Bulk density of soil (g/cm ³)	-3.222	-2.085	-7.262
	P<0.05	P<0.05	P<0.001
Soil porosity (%)	2.650	2.027	5.553
	P<0.05	P<0.05	P<0.001
Soil electrical conductivity (dS/m)	3.273	2.449	5.196
	P<0.05	P<0.05	P<0.05
Soil pH	-10.119	-2.496	-12.649
	P<0.001	P<0.05	P<0.001
	Post-monsoon period		
Soil moisture content (%)	3.955	4.478	28.678
	P<0.05	P<0.05	P<0.001
Water holding capacity of soil (%)	5.828	5.189	12.219
	P<0.001	P<0.05	P<0.001
Bulk density of soil (g/cm ³)	-2.396	-1.931	-8.588
	P<0.05	NS*	P<0.001
Soil porosity (%)	2.841	1.518	9.328
	P<0.05	NS*	P<0.001
Soil electrical conductivity (dS/m)	3.434	4.371	5.892
	P<0.05	P<0.05	P<0.001
Soil pH	-9.245	-2.216	-14.807
	P<0.001	P<0.05	P<0.001

NS*- Not significant

II) Soil Chemical Properties

The chemical properties of soil in the sacred groves generally differ from that of soil in the transition regions and disturbed non-sacred grove regions in all the study sites. The result indicate that the majority of the macronutrient parameters recorded comparatively higher values in the soil collected from the core region of sacred groves. This is immediately followed

by the transition region and lower values are recorded in the disturbed non-sacred grove regions. However there are few exceptions observed. The exceptions include available phosphorus content in all the study sites and sodium content in Palliyana site show higher concentration in the soil of disturbed land and this in turn is followed by grove region and then the transition region. Whereas at Poyyara study site during the post-monsoon period, the concentration of nitrogen, potassium and calcium recorded higher concentrations in the transition region and this in turn is followed by grove region and then the disturbed non-sacred grove region. Similarly, at Sankulangara site during the post-monsoon period, the concentration of sodium in the transition region recorded a lower value than the disturbed non-sacred grove region. The comparative evaluation of various macro element concentrations obtained in different season revealed the core region of sacred groves or both core and the transition regions of all the study sites with certain exceptions at Sankulangara and Palliyana recorded comparatively higher values for organic carbon (OC), nitrogen (N), calcium (Ca), phosphorus (P) and potassium (K) during the post-monsoon period compared to pre-monsoon. However, macronutrients such as sodium (Na), magnesium (Mg) and sulphur (S) recorded comparatively higher concentrations during the pre-monsoon, with certain exceptions at Nambiyath site. In the Poyyara sacred grove, with the exception of OC and P content, all other macronutrients recorded higher values during the pre-monsoon period.

The comparison of various microelement concentrations in different regions of all the selected study sites revealed maximum difference in the concentration of most of the macro elements are found to exist between the core region of groves and the disturbed non-sacred grove regions during the pre-monsoon as well as post-monsoon periods. Similarly, the study generally found that the concentration of macro elements are either increasing or decreasing due to seasonal variations and the concentration of majority of the elements particularly in the core region of groves are tending to increase considerably during the post-monsoon period over the pre-monsoon concentration. The statistical analysis revealed that the differences are higher and significant in both the above aspects in majority of the cases (table F8 to table F20).

Table F8: Comparison of soil organic carbon content in various regions of the selected study sites during the pre-monsoon and post-monsoon periods

Study site	Mean value and SD of soil organic carbon content (%)					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Sankulangara site	1.66 ±0.08	1.42 ±0.07	0.38 ±0.03	1.98 ±0.04	1.76 ±0.07	0.23 ±0.02
	The 't' value and significant level in the organic carbon content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		
	25.948		67.777	-6.197		
	P<0.001		P<0.001	P<0.05		
Paliyana site	1.19 ±0.08	0.89 ±0.05	0.34 ±0.03	1.67 ±0.11	1.15 ±0.09	0.27 ±0.03
	The 't' value and significant level in the organic carbon content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		
	17.231		21.268	-6.112		
	P<0.001		P<0.001	P<0.05		
Nambiyath site	1.22 ±0.08	0.92 ±0.07	0.22 ±0.03	1.99 ±0.11	1.08 ±0.07	0.19 ±0.04
	The 't' value and significant level in the organic carbon content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		
	20.272		26.636	-9.805		
	P<0.001		P<0.001	P<0.001		
Poyyara site	0.87 ±0.06	0.63 ±0.05	0.46 ±0.04	1.16 ±0.11	0.78 ±0.06	0.29 ±0.04
	The 't' value and significant level in the organic carbon content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		
	9.848		12.874	-4.009		
	P<0.001		P<0.001	P<0.05		

Table F9: Comparison of available nitrogen content in various regions of the selected study sites during the pre-monsoon and post-monsoon periods

Study site	Mean value and SD of available nitrogen content in the soil (kg/ha)					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Sankulangara site	305.79 ±18.91	286.90 ±22.165	68.06 ±6.38	431.41 ±27.41	348.86 ±15.69	50.18 ±3.97
	The 't' value and significant level in the available nitrogen content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	20.632		23.841	-6.534		
	P<0.001		P<0.001	P<0.05		
Paliyana site	291.53 ±11.55	152.98 ±7.83	57.92 ±4.62	341.63 ±12.65	171.54 ±8.12	48.18 ±3.84
	The 't' value and significant level in the available nitrogen content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	32.527		38.447	-5.066		
	P<0.001		P<0.001	P<0.05		
Nambiyath site	206.23 ±6.7	122.35 ±7.28	45.26 ±3.64	306.44 ±13.78	154.26 ±6.84	32.18 ±1.14
	The 't' value and significant level in the available nitrogen content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	36.586		34.355	-11.329		
	P<0.001		P<0.001	P<0.001		
Poyyara site	127.15 ±6.38	100.38 ±4.88	52.14 ±2.51	119.50 ±4.29	178.27 ±7.83	41.68 ±1.96
	The 't' value and significant level in the available nitrogen content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	18.950		28.578	1.723		
	P<0.001		P<0.001	NS*		

Table F10: Comparison of available phosphorus content (kg/ha) in the soil of various regions in the selected study sites during the pre-monsoon and post-monsoon periods

Study site	Mean value and SD of available phosphorus content (kg/ha) in the soil					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Sankulangara site	60.53 ±2.80	45.03 ±3.12	134.20 ±9.65	72.57 ±6.3	38.95 ±2.32	112.06 ±10.45
	The 't' value and significant level in the available phosphorus content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		
	-12.699		-5.606	-3.025		
	P<0.001		P<0.05	P<0.05		
Palliyana site	38.80 ±2.71	38.57 ±1.53	60.45 ±2.47	37.68 ±3.13	28.88 ±1.33	56.57 ±3.15
	The 't' value and significant level in the available phosphorus content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		
	-10.226		-7.367	0.471		
	P<0.001		P<0.05	NS*		
Nambiyath site	60.32 ±3.01	37.41 ±2.30	191.17 ±7.95	71.33 ±2.55	28.38 ±2.32	135.87 ±8.49
	The 't' value and significant level in the available phosphorus content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		
	-26.661		-12.610	-4.833		
	P<0.001		P<0.001	P<0.05		
Poyyara site	42.86 ±1.69	37.90 ±1.87	124.90 ±5.63	63.50 ±2.15	29.70 ±1.22	86.24 ±3.61
	The 't' value and significant level in the available phosphorus content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		
	-24.174		-9.374	-13.073		
	P<0.001		P<0.001	P<0.001		

Table F11: Comparison of available potassium content in the soil of various regions in the selected study sites during the pre-monsoon and post-monsoon periods

Study site	Mean value and SD of available potassium content (kg/ha) in the soil					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Sankulangara site	104.20 ±9.69	78.40 ±4.55	68.00 ±2.74	63.84 ±3.35	23.52 ±1.58	14.56 ±1.15
	The 't' value and significant level in the available potassium content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	6.226		24.099	6.818		31.149
	P<0.05		P<0.001	P<0.05		P<0.001
Paliyana site	69.44 ±2.64	56.08 ±2.55	42.56 ±1.80	82.88 ±3.25	41.52 ±1.67	41.04 ±0.75
	The 't' value and significant level in the available potassium content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	14.571		21.727	-5.560		1.350
	P<0.001		P<0.001	P<0.05		NS*
Nambiyath site	85.12 ±2.63	59.36 ±1.91	30.24 ±1.65	88.27 ±3.47	60.48 ±2.14	21.36 ±1.16
	The 't' value and significant level in the available potassium content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	30.616		31.657	-1.251		7.626
	P<0.001		P<0.001	NS*		P<0.05
Poyyara site	129.56 ±8.02	96.79 ±3.55	26.88 ±1.26	118.26 ±5.14	142.45 ±4.96	21.17 ±1.34
	The 't' value and significant level in the available potassium content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	21.897		31.659	2.054		5.377
	P<0.001		P<0.001	NS*		P<0.05

Table F12: Comparison of available calcium content in the soil of various regions in the selected study sites during the pre-monsoon and post-monsoon periods

Study site	Mean value and SD of available calcium content (mg/kg) in the soil					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Sankulangara site	344 ±18	304 ±12	133 ±8	432 ±21	317 ±14	118 ±8
	The 't' value and significant level in the available calcium content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	18.310		24.616	-5.533		2.388
	P<0.001		P<0.001	P<0.05		P<0.05
Paliyana site	387 ±12	319 ±16	222 ±10	616 ±30	337 ±17	301 ±13
	The 't' value and significant level in the available calcium content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	19.061		16.927	-12.505		-8.525
	P<0.001		P<0.001	P<0.001		P<0.001
Nambiyath site	621 ±25	431 ±17	423 ±13	858 ±41	469 ±16	318 ±13
	The 't' value and significant level in the available calcium content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	12.221		21.652	-8.489		10.024
	P<0.001		P<0.001	P<0.001		P<0.001
Poyyara site	689 ±20	317 ±15	158 ±5	432 ±11	439 ±96	134 ±6
	The 't' value and significant level in the available calcium content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	44.711		40.222	19.446		5.255
	P<0.001		P<0.001	P<0.001		P<0.05

Table F13: Comparison of available magnesium content in the soil of various regions in the selected study sites during the pre-monsoon and post-monsoon periods

Study site	Mean value and SD of available magnesium content (mg/kg) in the soil					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Sankulangara site	133 ±7	103 ±8	30 ±2	123 ±5	73 ±3	21 ±0
	The 't' value and significant level in the available magnesium content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	24.440		33.861	2.097		
	P<0.001		P<0.001	NS*		
Palliyana site	135 ±7	96 ±4	41 ±2	108 ±5	68 ±4	28 ±1
	The 't' value and significant level in the available magnesium content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	22.694		28.190	5.518		
	P<0.001		P<0.001	P<0.05		
Nambiyath site	116 ±7	68 ±3	49 ±2	90 ±4	59 ±3	43 ±2
	The 't' value and significant level in the available magnesium content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	16.070		19.038	5.830		
	P<0.001		P<0.001	P<0.05		
Poyyara site	72 ±4	68 ±2	26 ±2	48 ±3	43 ±2	19 ±1
	The 't' value and significant level in the available magnesium content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	20.138		17.936	9.111		
	P<0.001		P<0.001	P<0.001		

Table F14: Comparison of available sulphur content in the soil of various regions in the selected study sites during the pre-monsoon and post-monsoon periods

Study site	Mean value and SD of available sulphur content (mg/kg) in the soil					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Sankulangara site	27 ±2	14 ±2	6 ±1	10 ±1	5 ±1	4.0 ±0
	The 't' value and significant level in the available sulphur content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	21.378		9.569	14.832		
	P<0.001		P<0.001	P<0.001		
Paliyana site	25 ±2	10 ±1	9 ±1	10 ±1	6 ±1	5 ±1
	The 't' value and significant level in the available sulphur content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	13.586		6.785	12.376		
	P<0.001		P<0.05	P<0.001		
Nambiyath site	27 ±2	6 ±1	5 ±0	14 ±2	5 ±1	5 ±0
	The 't' value and significant level in the available sulphur content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	15.647		9.884	7.519		
	P<0.001		P<0.001	P<0.05		
Poyyara site	16 ±2	4 ±0	3 ±0	13 ±2	3 ±0	2 ±0
	The 't' value and significant level in the available sulphur content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	9.688		12.827	1.472		
	P<0.001		P<0.001	NS*		

Table F15: Comparison of available sodium content in the soil of various regions in the selected study sites during the pre-monsoon season and post-monsoon periods

Study site	Mean value and SD of available sodium content (kg/ha) in the soil					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Sankulangara site	104.20 ±9.69	78.40 ±4.55	68.0 ±2.74	45.32 ±5.62	32.36 ±1.81	35.84 ±2.64
	The 't' value and significant level in the available sodium content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		
	6.226		2.644	9.104		
	P<0.05		P<0.05	P<0.001		
Palliyana site	48.16 ±1.53	39.20 ±1.1	102.12 ±11.44	31.11 ±2.1	21.17 ±1.68	68.30 ±8.43
	The 't' value and significant level in the available sodium content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		
	-8.098		-7.415	11.366		
	P<0.001		P<0.05	P<0.001		
Nambiyath site	53.76 ±2.62	38.08 ±1.48	34.72 ±1.23	57.20 ±1.72	32.60 ±1.80	25.90 ±2.65
	The 't' value and significant level in the available sodium content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		
	11.394		17.160	-1.901		
	P<0.001		P<0.001	NS*		
Poyyara site	79.52 ±2.75	55.40 ±1.46	41.44 ±2.11	71.40 ±3.80	40.98 ±14.08	28.66 ±1.34
	The 't' value and significant level in the available sodium content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		
	19.028		18.372	2.998		
	P<0.001		P<0.001	P<0.05		

The results of the soil micronutrient parameters in the present study reveal that the concentration of Zn, Mn and B generally tend to exhibit a decreasing trend from soil of sacred grove region to transition region and then to disturbed non-sacred grove region, with certain exceptions. The exceptions include the concentration of boron in the transition region during the post-monsoon at Palliyana site where the concentration is lower than disturbed region. Similarly, the concentration of Zn and Mn during the post-monsoon period at Poyyara site are higher than the core and disturbed regions. However, the study revealed that concentrations of Cu and Fe in all the study sites are generally tend to exhibit a reverse trend where higher concentration in the disturbed non-sacred grove regions, followed by transition regions and then lowest concentration in the core regions of groves, but with certain exceptions. The exceptions include the concentration of Cu and Fe in the transition region during the post-monsoon period at Nambiyath site, which recorded lower concentration than the concentration in the core region. Similarly at Poyyara site during the pre-monsoon, the Cu concentration in the transition region recorded higher concentration than disturbed region.

The comparison in the concentrations obtained in two different season with respect to Zn and B indicates, higher values for both being recorded during the post-monsoon period with certain exceptions. The exceptions include the concentrations of transition and disturbed region at Nambiyath site where their higher values are recorded in the pre-monsoon period and similarly the concentration of Zn in the core region at Poyyara site is also higher in the pre-monsoon than post-monsoon period. The concentrations of Mn, Cu and Fe obtained in two different seasons indicate their higher concentration values in the pre-monsoon period than the post-monsoon but with the exception that the concentration of Fe in the core region at Palliyana and Nambiyath sites are exhibited higher concentration in the post-monsoon period. The statistical analysis revealed that most of the differences in micronutrient concentrations between various study regions particularly between the core region of sacred groves and disturbed non-sacred grove regions and similarly with certain exceptions, the variation in the concentrations in different regions due to seasonal differences are significant (table F16 to table F20)

Table F16: Comparison of extractable copper content in the soil of various regions in the selected study sites during the pre-monsoon season and post-monsoon periods

Study site	Mean value and SD of extractable copper content (mg/kg) in the soil					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Sankulangara site	0.72 ±0.11	0.92 ±0.08	1.18 ±0.12	0.38 ±0.06	0.52 ±0.07	0.88 ±0.09
	The 't' value and significant level in the extractable copper content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		
	-4.894		-8.006	4.700		
	P<0.05		P<0.001	P<0.05		
Palliyana site	0.38 ±0.07	1.44 ±0.12	1.91 ±0.11	0.21 ±0.05	0.72 ±0.07	1.05 ±0.09
	The 't' value and significant level in the extractable copper content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		
	-20.325		-14.131	3.423		
	P<0.05		P<0.001	P<0.05		
Nambiyath site	0.48 ±0.07	0.53 ±0.07	1.78 ±0.13	0.34 ±0.06	0.32 ±0.05	0.88 ±0.05
	The 't' value and significant level in the extractable copper content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		
	-15.250		-11.975	2.630		
	P<0.001		P<0.001	P<0.05		
Poyyara site	0.63 ±0.09	1.23 ±0.11	1.17 ±0.06	0.44 ±0.05	0.85 ±0.09	0.94 ±0.08
	The 't' value and significant level in the extractable copper content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		
	-8.647		-9.180	3.196		
	P<0.001		P<0.001	P<0.05		

Table F17: Comparison of extractable iron content in the soil of various regions in the selected study sites during the pre-monsoon season and post-monsoon periods

Study site	Mean value and SD of extractable iron content (mg/kg) in the soil					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Sankulangara site	21.02 ±1.15	48.86 ±3.05	84.93 ±3.65	14.24 ±0.88	39.73 ±1.08	68.26 ±2.36
	The 't' value and significant level in the extractable iron content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	-28.926		-37.148	8.110		
	P<0.001		P<0.001	P<0.001		
Palliyana site	33.73 ±2.14	40.88 ±2.86	124.90 ±5.69	34.71 ±1.85	39.94 ±1.88	83.66 ±3.47
	The 't' value and significant level in the extractable iron content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	-25.976		-21.561	-0.600		
	P<0.001		P<0.001	NS*		
Nambiyath site	17.55 ±1.33	19.38 ±1.48	24.29 ±2.15	20.94 ±1.69	19.04 ±0.56	22.36 ±2.52
	The 't' value and significant level in the extractable iron content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	-4.618		-0.811	-2.730		
	P<0.05		NS*	P<0.05		
Poyyara site	10.96 ±1.22	21.64 ±2.85	104.0 ±4.66	6.74 ±0.46	20.14 ±1.98	91.65 ±3.92
	The 't' value and significant level in the extractable iron content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	-33.454		-37.262	5.606		
	P<0.001		P<0.001	P<0.05		

Table F18: Comparison of extractable zinc content in the soil of various regions in the selected study sites during the pre-monsoon season and post-monsoon periods

Study site	Mean value and SD of extractable zinc content (mg/kg) in the soil					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Sankulangara site	3.40 ±0.32	1.17 ±0.11	0.78 ±0.09	5.45 ±0.42	1.86 ±0.09	1.17 ±0.08
	The 't' value and significant level in the extractable zinc content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	13.652		17.339	-6.725		
	P<0.001		P<0.001	P<0.05		
Palliyana site	1.56 ±0.11	1.19 ±0.13	0.75 ±0.08	3.36 ±0.18	1.95 ±0.12	1.50 ±0.11
	The 't' value and significant level in the extractable zinc content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	10.315		15.272	-14.779		
	P<0.001		P<0.001	P<0.001		
Nambiyath site	2.25 ±0.18	2.10 ±0.12	1.09 ±0.09	3.14 ±0.18	1.96 ±0.14	1.02 ±0.08
	The 't' value and significant level in the extractable zinc content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	9.984		18.641	-6.056		
	P<0.001		P<0.001	P<0.05		
Poyyara site	1.99 ±0.13	1.24 ±0.09	1.03 ±0.11	1.39 ±0.08	2.21 ±0.36	1.18 ±0.14
	The 't' value and significant level in the extractable zinc content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	9.764		2.256	6.808		
	P<0.001		P<0.05	P<0.05		

Table F19: Comparison of extractable manganese content in the soil of various regions in the selected study sites during the pre-monsoon season and post-monsoon periods

Study site	Mean value and SD of extractable manganese content (mg/kg) in the soil					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Sankulangara site	4.94 ±0.13	2.96 ±0.09	2.17 ±0.11	2.62 ±0.16	2.19 ±0.12	1.72 ±0.11
	The 't' value and significant level in the extractable manganese content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	28.174		8.028	19.492		5.010
	P<0.001		P<0.001	P<0.001		P<0.05
Palliyana site	15.28 ±1.08	10.93 ±0.21	4.74 ±0.12	13.32 ±1.16	6.11 ±0.35	1.79 ±0.14
	The 't' value and significant level in the extractable manganese content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	16.800		17.092	2.142		27.710
	P<0.001		P<0.001	P<0.05		P<0.001
Nambiyath site	12.43 ±1.37	11.77 ±0.86	5.26 ±0.22	5.01 ±0.68	3.68 ±0.16	1.81 ±0.16
	The 't' value and significant level in the extractable manganese content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	8.950		7.934	8.403		21.967
	P<0.001		P<0.001	P<0.001		P<0.001
Poyyara site	3.04 ±0.16	3.02 ±0.12	0.97 ±0.08	1.12 ±0.08	1.83 ±0.09	0.57 ±0.07
	The 't' value and significant level in the extractable manganese content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove		Disturbed non-sacred grove land X Disturbed non-sacred grove land
	20.043		8.962	18.590		6.518
	P<0.001		P<0.001	P<0.001		P<0.05

Table F20: Comparison of extractable boron content in the soil of various regions in the selected study sites during the pre-monsoon season and post-monsoon periods

Study site	Mean value and SD of extractable boron content (mg/kg) in the soil					
	Pre-monsoon			Post-monsoon		
	Core zone of grove	Transition zone	Disturbed non-sacred grove land	Core zone of grove	Transition zone	Disturbed non-sacred grove land
Sankulangara site	0.32 ±0.06	0.18 ±0.03	0.07 ±0.01	0.58 ±0.04	0.22 ±0.03	0.13 ±0.02
	The 't' value and significant level in the extractable boron content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	7.119		17.428	-6.245		
	P<0.05		P<0.001	P<0.05		
Palliyana site	0.19 ±0.04	0.04 ±0.01	0.02 ±0.01	0.44 ±0.06	0.22 ±0.04	0.25 ±0.04
	The 't' value and significant level in the extractable boron content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	7.141		4.564	-6.005		
	P<0.05		P<0.05	P<0.05		
Nambiyath site	0.16 ±0.03	0.13 ±0.02	0.11 ±0.01	0.32 ±0.06	0.11 ±0.02	0.10 ±0.02
	The 't' value and significant level in the extractable boron content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	2.739		6.025	-4.131		
	P<0.05		P<0.05	P<0.05		
Poyyara site	0.34 ±0.06	0.20 ±0.04	0.06 ±0.01	0.54 ±0.07	0.24 ±0.06	0.12 ±0.05
	The 't' value and significant level in the extractable boron content					
	Pre-monsoon		Post-monsoon	Pre-monsoon X Post-monsoon		
	Core zone of grove X Disturbed non-sacred grove land		Core zone of grove X Disturbed non-sacred grove land	Core zone of grove X Core zone of grove Disturbed non-sacred grove land X Disturbed non-sacred grove land		
	7.973		8.457	-3.757		
	P<0.001		P<0.001	P<0.05		

Comparatively higher concentration status of majority of the macro and micro elements observed in the soil of sacred groves particularly in the Sankulangara and Palliyana groves of larger extents over the soil of transition and disturbed non-sacred grove regions in the study sites may be due to better floristic composition and organic matter content of the groves. Rich vegetation particularly of trees existing in an area can maintain a constant supply of organic matter content through continuous addition of leaf litter and other plant components (Yang et al., 2005; Bhat & Jan, 2010). Better soil physical properties and environmental conditions contributed by rich ground vegetation and higher rate of decomposition of organic matter by microorganisms in the grove area may be the reason for better soil chemical property. However, when the Poyyara study site is compared with other sites, higher concentration values of certain elements like N, K and Ca is recorded in the soil of transition region over the core region of grove during the post-monsoon period. This may be due to the fact that, the Poyyara grove is more prone to leaching of organic matter and nutrients compared to other groves. This can be attributed to the high interference of external pressures due to smaller size of the grove. Lower concentration of many nutrients in the disturbed non-sacred grove and transitions regions observed in the study may be due to considerable reduction in the quantity and quality of vegetation and lower rate of release of mineral nutrients into the soil (Park et al., 2002). This could be the result of unfavorable microenvironment and poor microbial decomposition activity existing in these areas. Further, considerably lower quantity of litter fall deposition, particularly in the disturbed non-sacred grove regions, are not enough to replenish the depleted nutrient level by the uptake as well as the leaching process in the soil (Gosz et al., 1976; Morrison, 1991). However, higher concentration of Cu and Fe elements observed in the soil of disturbed regions over the grove and transition regions in the study may be due to the influence of industrial pollution. The analysis of soil chemical properties in the transition regions generally exhibit comparatively better nutrient status over the disturbed non-sacred grove regions in majority of the study sites. These observations in the present investigation may be due to several factors which include comparatively higher vegetation stand and the leaching of humus and nutrients from grove area to immediate adjacent areas.

The significant improvements in the concentrations of many macro and micro elements during the post-monsoon period in the grove regions and to certain extent in the transition regions compared to disturbed non-sacred grove regions can be attributed to the higher decomposition rate of organic matter and increased rate in the release of nutrients into the pool of nutrients in the soil. The organic matter content and their decomposition and release of nutrients in the soil

of a particular region are depending on several factors which include vegetation, season, climate and disturbances in the area (Schlesinger, 1977; Binkley, 1995). The litters are considered as natural fertilizers in the soil of natural ecosystem as these are the major raw material for the replenishment of nutrients in the soil. Favorable soil and microclimatic environment, particularly during the post-monsoon period could be able to trigger growth and diversity of microbial population and rate of decomposition activity. Accumulation of organic matter and nutrients from the grove regions through leaching during the monsoon towards the transition area may be the major reason for better soil chemical properties in the transition regions than the disturbed non-sacred grove regions. However, the decreasing trend and low concentration status of majority of the nutrients in the disturbed land with poor floristic composition and density during the post-monsoon period can be attributed to the erosion of organic matter and nutrients from the surface soil due to the heavy rain that occurred during the monsoon. Further, greater reduction in the canopy cover, particularly of trees and very low litter deposition can cause hot and dry climatic environment in the disturbed regions as a result of direct falling of sunlight on the ground. This may weaken microbial growth and decomposition activity, which in turn reduce the release of nutrients into the soil. In addition, the utilization of nutrients by the existing vegetation and reduction in the replenishment into the pool of nutrients in the soil of disturbed region can add to the lower level concentration status of nutrients.

The differences in extent of the grove is found to have some influence on the mineral nutrient concentration in the soil of grove and transition regions. With certain exceptions in Palliyana sacred grove, the investigation generally revealed the concentration of nutrient elements such as OC, N, Ca, P, and K generally tend to increase in the soil of groves as the extent of the grove area is increased. However the study further observed, the influence of grove extent on the nutrient concentration in the soil that works in accordance with the diversity and density of plants in the area. This can be attributed to enhanced localization of organic matter and nutrient elements in the grove region by reducing loss through leaching process. This is achieved by the abundance of ground cover by the litter fall and profuse root system which hold and protect the soil from erosion. Whereas, the concentrations of elements such as Na, Mg and S are not found increasing with the extent of the grove area and instead with certain exceptions, somewhat a decreasing trend is observed. This may be due to increased uptake of these elements by the vegetation and compared to the replenishment rate of these elements into the nutrient pool in the soil. The analysis on the effect of grove size on the concentration status of micronutrient

elements in the soil show differences from that of macro elements. Not any regular steady increasing or decreasing trend in the concentration of microelements is observed in the study in accordance with the size of the grove. However with exceptions, somewhat higher microelement concentrations are recorded in the grove with comparatively higher area.

Conclusion

The studies on the physical and chemical properties of soil in the sacred grove regions, transition regions and highly disturbed non-sacred grove regions in all the study sites clearly revealed significant role of sacred groves or undisturbed forest vegetation in the maintenance of quality and productivity of the soil. Higher floristic composition and diversity, higher microbial population and high rate of litter decomposition in the grove area compared to other areas of study could be the reason for better physical and chemical properties. The better physical parameters of the soil in the grove such as high soil porosity, moisture content and water holding capacity are clear indications of influence by rich vegetation stand and high organic matter content in the area. Similarly, higher or sufficient concentrations of majority of the nutrient elements particularly organic carbon content, nitrogen, phosphorus, calcium and potassium in the soil of grove regions revealed better microbial population and their decomposition activity. However the destruction of forest plants by human interference and activities like slash and burn practice for agricultural production, cutting of trees for timber and removal of forest for construction and developmental activities can cause degradation in the forest ecosystem, particularly the soil quality and its environment, which is a complex system bound by physical, chemical and microbiological parameters (Sahani & Behera, 2001; Olanrewaju, 2008). Significantly lower or undesirable status of majority of the physical and chemical parameters recorded in the soil of disturbed non-sacred grove regions in all the study sites is a clear indication of human interference and disturbances. Higher bulk density, lower moisture content and water holding capacity, low concentrations of many macro and microelements in the soil of disturbed regions reveal significant reduction in organic matter content and microbial decomposition activities. The comparatively better soil physical and chemical properties observed in the transition regions over the disturbed regions in the study sites may be due to the influence of leaching process and the better climatic environment prevailing in the grove region on the immediate transition areas of the grove. The present study finds that, the soil in the grove and immediate transition regions are found with improved quality during the post-monsoon period over the pre-monsoon status while that of disturbed regions exhibit a reverse trend. The investigation further observed and concluded that, as size of the grove is increasing, many of the physical and chemical parameters of the soil in the grove are found improving progressively and significantly. These improvements are also found positively influencing the quality of soil in the immediate transition regions to certain extend.

References

- Alifragis, D., & Papamichos, N. T. (1990). Conservation of forest soil productivity. Proceedings of the third National Soil Conference. 187–195.
- Amusan, A. A., Shitu, A. K., Makinde, W. O., & Orewole, O. (2006). Assessment of changes in selected soil properties under different land use in Obafemi Awolowo University Community, Nigeria. *Electronic Journal of Environmental, Agricultural and Food Chemistry*, 5(1), 1178–1184.
- Arunachalam, K., & Arunachalam, A. (1999). Recovery of a felled subtropical humid forest: microclimate and soil properties, *Ekologia*, 18 (3), 287–300.
- Bell, M. C., & Raczkowski, C. W. (2008). Soil property indices for assessing short-term changes in soil quality. *Renewable Agriculture and Food Systems*, 23, 70–79.
- Berg, B., Ekbohm, G., Johansson, M. B., McClaugherty, C., Rutigliano, F., & De Santo, A. V. (1996). Maximum decomposition limits of forest litter types: a synthesis. *Canadian Journal of Botany*, 74(5), 659– 672.
- Bhat, D. M., Murali, K. S., & Ravindranath, N. H. (2001). Formation and recovery of secondary forests in India: a Particular reference to Western Ghats in South India. *Journal of Tropical Forest Science*, 13(4), 601– 620.
- Bhat, N. H., & Jan, S. (2010). Decomposition pattern and nitrogen release from *Ulmus Villosa* leaf litter in Dachigam National Park, Jammu & Kashmir. *Research Journal of Agricultural Sciences*, 1(4), 363– 365.
- Bhardwaj, S. D., & Panwar pankaj. (2005). *Handbook of Practical Forestry*, Agrobios, Jodhpur, p150.
- Binkley, D. (1995). *The Influence of Tree Species on Forest Soils: Processes and Patterns*. Agronomy Society of New Zealand Special Publication 10, Wellington, New Zealand.
- Burton, S., Shah, P. B., & Schreier, H. (1989). Soil degradation from converting forest land into agriculture in the Chitawan district of Nepal. *Mountain Research and Development*, 9(4), 393–404.
- Carney, K. M., Matson, P. A. (2006) The influence of tropical plant diversity and composition on soil microbial communities. *Microbial Ecology*, 52(2), 226–238.

- Cavelier, J., Mitchell, T., Aide, M., Dupuy, J. M., Eusse, A.M., & Santos, C. (1999). Long-term effects of deforestation on soil properties and vegetation in a tropical lowland forest in Colombia. *Ecotropicos*, 12(2), 57–68.
- Corns, I. G. W. (1988). Compaction by forestry equipment and effects on coniferous seedling growth on four soils in the Alberta foothills. *Canadian Journal of Forest Research*, 18(1), 75–84.
- Enrique Arévalo-Gardini., Manuel Canto., Julio Alegre., Oscar Loli., Alberto Julca., & Virupax Baligar. (2015). Changes in soil physical and chemical properties in long term improved natural and traditional agroforestry management systems of Cacao genotypes in Peruvian Amazon. *Plos One*, 10(7), 1–29.
- FAO. (2006). *Global Forest Resources Assessment 2005*. Progress towards sustainable forest management. FAO Forestry Paper 147. Food and Agriculture Organization of the United Nations, Rome.
- Froehlich, H. A., & McNabb, D. H. (1984). *Minimizing soil compaction in Pacific Northwest forests*. In Stone EL (ed) Forest soils and treatment impacts. Department of Forestry, University of Tennessee: Knoxville, 159–192.
- Froelich, H. A., Miles, D. W. R., & Robbins, R. W. (1986). Growth of young *Pinus ponderosa* and *Pinus contorta* on compacted soil in Central Washington. *Forest Ecology and Management*, 15(4), 285–294.
- Gale, M. R., Grigal, D. F. (1987). Vertical root distribution of northern tree species in relation to successional status. *Canadian Journal of Forest Research*, 17(8), 829–834.
- Gosz, J. R., Likens, G. E., & Bormann, F. H. (1976). Organic matter and nutrient dynamics of the forest and forest floor in the Hubbard Brook Forest. *Oecologia*, 22(4), 305–320.
- Granged, A. J. P., Zavala, L. M., Jordán, A., & Moreno, G. (2011). Post-fire evolution of soil properties and vegetation cover in a Mediterranean heath land after experimental burning: A 3-year study. *Geoderma*, 164(1-2), 85–94.
- Grogan, P., Lalnunmawia, F., & Tripathi, S. K. (2012). Shifting cultivation in steeply sloped regions: a review of management options and research priorities for Mizoram state, Northeast India. *Agroforestry Systems*, 84(2), 163–177.
- Gupta, U. C. (1967). A simplified method for determining hot water-soluble boron in podzol soils. *Soil Science*, 103, 424–428.
- Hanway, J. J., & Heidel, H. (1952). *Soil analysis methods as used in Iowa State College*, Soil Testing Laboratory. Iowa State College Bulletin, 57, 1–131.

- Henderson, S. L., Dandie, C. E., Patten, C. L., Zebarth, B. J., Burton, D. L., Tevor J. T., & Goyer, C. (2010). Changes in denitrifier abundance, denitrification gene mRNA levels, nitrous oxide emissions and denitrification in anoxic soil microcosms amended with glucose and plant residues. *Applied And Environmental Microbiology*, 76(7), 2155–2164.
- Jackson, M. L. (1973). *Soil Chemical Analysis* (II Edition). Prentice Hall of India Private Limited, New Delhi, India. 315–344.
- Jagdish Singh., Amit Salaria., & Amit Kaul. (2015). Impact of soil compaction on soil physical properties and root growth: a review. *International Journal of Food, Agriculture and Veterinary Sciences*, 5 (1), 23–32.
- Johan Arvidsson. (1998). Influence of soil texture and organic matter content on bulk density, air content, compression index and crop yield in field and laboratory compression experiments. *Soil and Tillage Research*, 47(1-2), 159–170.
- Kaiser, K., Guggenberger, G., & Zech, W. (2001). Isotopic fractionation of dissolved organic carbon in shallow forest soils as affected by sorption. *European Journal of Soil Sciences*, 52(2), 585–597.
- Keenan, R. J., Hambleton, A., Robson, K., & Webb, M. (1998). *Growth Response of Three Rainforest Cabinet Timber to Fertilizer Application in Plantations in North Queensland*. In: Schulte A, Ruhayat D (Eds) *Soils of Tropical Forest Ecosystems: Characteristics, Ecology and Management*. Springer, Berlin.
- Kêsik, T., Baewicz-WoŹniak, M., & Wach, D. (2010). Influence of conservation tillage in onion production on the soil organic matter content and soil aggregate formation. *International Agrophysics*, 24, 267–273.
- Kramer, P. J. (1949). *Plant and Soil Water Relationship*. McGraw-Hill, New York, USA.
- Lees, J. C. (1972). Soil aeration response to drainage intensity in basin peat. *Forestry*, 45(2), 135–143.
- Lindsay, W. L., & Norvell, W. A. (1978). Development of a DTPA soil test for zinc, iron, manganese and copper. *Journal of Soil Science Society of America*, 42(3), 421–428.
- Liu, S. J., Yang, W. B., & Shi, A. H. (2000). Screening of the high lipid production strains and studies on its flask culture conditions. *Microbiology*, 27(2), 93–97.
- Lu, D., Moran, E., & Mausel, P. (2002). Linking Amazonian secondary succession forest growth to soil properties. *Land Degradation and Development*, 13(4), 331–343.
- Massoumi, J., & Cornfield, A. H. (1963). A rapid method for determination sulphate in water extracts of soils. *Analyst*, 88(1045), 321–322.

- McMahon, S., Simcock, R., Dando, J., & Ross, C. (1999). A fresh look at operational soil compaction. *New Zealand Journal of Forest*, 44(3), 33–37.
- Minore, D., & Weatherley, H. G. (1990). Effects of site preparation on Douglas- fir seedling growth and survival. *Western Journal of Applied Forestry*, 5(2), 49–51.
- Morrison, I. K. (1991). Addition of organic matter and elements to the forest floor of an old-growth *Accer saccharum* forest annual litterfall. *Canadian Journal of Forest Research*, 21(4), 461–468.
- Nambiar, E. K. S., & Sands, R. (1992). Effects of compaction and simulated root channels in the subsoil on root development, water uptake and growth of radiata pine. *Tree Physiology*, 10(3), 297–306.
- Nelofer Jamil., Naheed Sajjad., Humaira Ashraf., Zubia Masood., Zahoor Ahmed Bazai., Rukhsana Khan., Nida Anjum., Farah Akmal., Nazia Arbab., Palwasha Tareen., & Rabail Khan. (2016). Physical and chemical properties of soil quality indicating forests productivity: A Review. *American-Eurasian Journal of Toxicological Sciences*, 8 (2), 60–68.
- Olanrewaju, O. D. (2008). Changes in soil properties following conversion of humid tropical rainforest of Nigeria into cocoa agroforests. *Journal of Applied Biological Sciences*, 2(3), 9–13.
- Osman, K. (2013). *Physical Properties of Forest Soils*. In: *Forest Soils*. Springer, Cham.
- Park, J. H., Kalbitz, K., & Matzner, E. (2002). Resource control on the production of dissolved organic carbon and nitrogen in a deciduous forest floor. *Soil Biology and Biochemistry*, 34(6), 1391.
- Patt, J., Carmeli, D., & Zafir, T. (1966). Influence of soil physical condition on root development and on production of citrus trees. *Soil Science*, 102(2), 82–84.
- Paul, K. I., Polglase, P. J., Smethurst, P. J., O'Connell, A. M., Carlyle, C. J., & Khanna, P. K. (2004). Soil temperature under forests: a simple model for predicting soil temperature under a range of forest types. *Journal of Agricultural and Forest Meteorology*, 121(1-3), 167–182.
- Plymale, A. E., Boerner, R. E. J., & Logan, T. J. (1987). Relative nitrogen mineralization and nitrification in soils of two contrasting hardwood forests: Effects of site microclimate and initial chemistry. *Forest Ecology and Management*, 21(1-2), 21–36.
- Portella, C. M. R., Guimarães, M. F., Feller, C., Fonseca, I. C. B., & Filho, J. T. (2012). Soil

- aggregation under different management systems. *Revista Brasileira de Ciência do Solo*, 36, 1868–1877.
- Porter, W. M., Cox, W. 1., & Wilson, I. (1980). Soil acidity- it is a problem in Western Australia? *Australian Journal of Agricultural Research*, 21(4), 126–33.
- Rasiah, V., & Kay, B. D. (1995). Runoff and soil loss as influenced by selected stability parameters and cropping and tillage practices. *Geoderma*, 68(4), 321–329.
- Richards, D., & Cockroft, B. (1974). Soil physical properties and root concentrations in an irrigated apple orchard. *Australian Journal of Experimental Agriculture and Animal Husbandry*, 14(66), 103–107.
- Rockich, D. P., Meney, K. A., Dixon, K. W., & Sivasithamparam, K. (2001). Impact of soil disturbance on root development in woodland communities in Western Australia. *Australian Journal of Botany*, 49(2), 169–183.
- Sahani, U., & Behera, N. (2001). Impact of deforestation on soil physicochemical characteristics, microbial biomass and microbial activity of tropical soil. *Land Degradation and Development*, 12(2), 93–105.
- Sakai, H., Nordfjell, T., Saudicani, K., Talbot, B., & Bollehuus, E. (2008). Soil compaction on forest soils from different kinds of tyres and trucks and possibility of accurate estimate. *Croatian Journal of Forest Engineering*, 29(1), 15–27.
- Schaetzl, R. J., & Thompson, M. L. (2015). *Soils: Genesis and Geography*, 2 Edition, Cambridge University Press, New York, USA, pp: 795.
- Schlesinger, W. H. (1977). Carbon balance in terrestrial detritus. *The Annual Review of Ecology*, 8(1), 51–81.
- Sims, J. T., & Johnson, G. V. (1991). Micronutrient soil tests. pp. 427-476. J.J. Mortvedt, F.R. Cox, L.M. Shuman and R.M (Eds.). In: *Micronutrients in Agriculture*, 2nd Ed. Soil Science Society of America.
- Skoog, D. A., Leary, J. J., Nathan, W. Bower. (1992). Principles of instrumental analysis. 4th edition. *Journal of Chemical Education*, 69(8), 224.
- Sokolovskaya, N. A., Revut, I. B., Markov, I. A., & Shevlyakov, I. R. (1977). The role of soil density in forest regeneration. *Lesovedenie*, 2, 44–51.
- Sollins, P., Grier, C. C., McCorison, F. M., Cromack, K., Fogel, Jr R., & Fredriksen, R. L. (1980). The internal element cycles of an old-growth Douglas-fir ecosystem in Western Oregon. *Ecological Monographs*, 50(3), 261–285.
- Spittlehouse, D. L., & Stathers, R. J. (1990). *Seedling Microclimate*. British Columbia Ministry of Forests, Victoria, Land Management Rep no. 65.

- Strickland, T. C., & Fitzgerald, J. W. (1984). Formation and mineralization of organic sulfur in forest soils. *Biogeochemistry*, 1, 79–95.
- Subbia, B. V., & Asija, G. L. (1956). A rapid procedure for estimation of available nitrogen in soils. *Current Science*, 25(8), 259–260.
- Swift, M. J., Heal, O. W., & Anderson, J. M. (1979). *Decomposition in Terrestrial Ecosystems*. London: Blackwell scientific.
- Tabatabai, M. A. (1982). *Methods of Soil Analysis*. Part 2. 2nd Ed. Agron. Monogr. In A.L. Page et al. (Ed.) 9. ASA and SSSA, Madison, Wis. Sulfur. 501–538.
- Taylor, H. M. (1971). *Effects of soil strength on seedling emergence, root growth and crop yield*. In: Barnes, K.K., Carleton, W.M., Taylor, H.M., Throckmorton, R.I., & Vandenberg, G.E. (eds) *Compaction of agricultural soils*. St Joseph. (ASAE. Monogr.).
- Tilman, D., & Lehman, C. (2001). Human-caused environmental change: impacts on plant diversity and evolution. *Proceedings of the national academy of sciences of the United States of America*, 98(10), 5433–5440.
- Tisdall, J. M., & Oades, J. M. (1980). The management of ryegrass to stabilize aggregates in a red-brown earth. *Australian Journal of Soil Research*, 18(4), 415–422.
- Trivedy, R. K., & Goel, P. K. (1986). *Chemical and Biological Methods for Water Pollution Studies*, Environment Publication, Karad. 220pp.
- Vengadaramana, A., & Jashothan, P. T. J. (2012). Effect of organic fertilizers on the water holding capacity of soil in different terrains of Jaffna peninsula in Sri Lanka. *Journal of Natural product and Plant Resources*, 2(4), 500–503.
- Vitousek, P. M., & Reiners, W. A. (1975). Ecosystem succession and nutrient retention: a hypothesis. *Bio Science*, 25, 376–380.
- Vitousek, P. M., & Sanford, R. L. Jr. (1986). Nutrient cycling in moist tropical forest. *Annual Review of Ecology, Evolution and Systematics*, 17, 137–167.
- Volk, V. V., & Ullery, C. H. (1993). Dep. of Soil Sci., Oregon state Univ, Corvallis, 1–50.
- Walkley, A., & Black, I. A. (1934). An examination of the Degtjareff method for determining organic matter, and a proposed modification of the chromic acid titration method. *Soil Science*, 37(1), 29–38.
- Watanabe, F. S., & Olsen, S. R. (1965). Test of an ascorbic acid method for determining phosphorus in water and NaHCO₃ extracts from soils. *Journal of Soil Science Society of America*, 29, 677–678.

- Wronski, E. B., & Murphy, G. (1994). *Responses of Forest Crops to Soil Compaction*. In: Soane, B.D., van Ouwerkerk, C. (ed) *Soil Compaction in Crop Production*. Elsevier Science.
- Yang, W. Q., Wang, K. Y., Kellomaki, S., & Gong, H. (2005). Litter dynamics of three subalpine forests in Western Sichuan. *Pedosphere*, 15(5), 653–659.
- Youngberg, C. T. (1970). *Soils and Tree Growth Requirements*. In: Berg AB (ed) *Management of young-growth Douglas-fir and Western Hemlock*. Oregon State University Sen Forestry, 34–37.
- Zheng, F. L. (2005). Effects of accelerated soil erosion on soil nutrient loss after deforestation on the loess plateau. *Pedosphere*, 15(6), 707–715.

CHAPTER-8

Microclimatic studies in the selected sacred groves and disturbed non-sacred grove lands

Introduction

There are many general reports on the importance of sacred groves in maintaining the ecosystem balance however, the scientific data based research results on their role particularly to maintain the microclimatic aspects of an ecosystem is very less. Therefore one of the challenging tasks before the ecologist is to make aware the public as well as the concerned organizations and government bodies regarding the important relationship that exists between the vegetation and the climatic conditions in ecosystems through scientific approach (Davis & Richardson, 1995). The present investigation is carried out in this contest. The investigation believes, passing the scientific information obtained from the comparative analysis of vegetation stand and their impact on climatic conditions existing in the selected sacred groves and the disturbed non-sacred grove lands, may influence the concerned towards strengthening the conservation activities of the existing sacred groves, as part of future ecosystem maintenance.

Review of Literature

The sacred groves in a region are found to influence the interaction between the biotic and abiotic factors such as flora, fauna and microclimate of soil and atmosphere in the region (Rajendraprasad, 1995). The study conducted by Chandrashekhara and Sankar (1998) observed that many processes which are essential for the better maintenance of an ecosystem via retention of water in the area, protection from heavy winds by acting as shelter belt, maintenance of better microclimatic conditions such as temperature and humidity, up keeping nature's beauty with abundance of fresh air are performed by sacred groves. When considering the water cycle in a region, the process of evaporation plays a vital role. In the total moisture content of the atmosphere, about 90% of the moisture is generally derived from evaporation loss from land surface and various water resources whereas, the rest of the 10% is found coming from the process of plant transpiration (United States Geological Survey, 2011).

In canopy harvested regions of forests, where plant groups like herbs and shrubs including woody plants are found to re-emerge densely giving a low insulating cover over the ground which favour a reduction in temperature and thereby maintain or enhance the humidity of the floor area (Weng et al., 2007). Robert et al. (2008) in their study observed that as a result of timber harvesting from forest areas, gaps in the canopy develops which permit direct falling of sun light on the forest floor causing high floor temperature and decreased moisture content of soil. The evaporation rate of moisture from the soil surface is depended on various factors such as temperature variations, velocity of wind, air humidity and texture of soil (Wild, 2003).

Wainwright et al. (1999) has recorded an observation that the rate of soil moisture evaporation retards when vegetation shade and their cover is present in an area. In areas with warmer temperature and wind blowing, the evaporation rate is noticed to be higher (Strangeways, 2003). On analyzing the difference in air and soil temperature under canopy area and open area, it is identified that factors like radiation from sun, speed of wind and availability or non-availability of canopy hold a significant correlation (Morecroft et al., 1998). Robert et al. in 2008 conducted a study with respect temperatures of floor area and air area of forest ecosystem and observed that the temperature was greater in summer compared to spring in both the cases while at the same

time it was marginally higher in the floor area over the air area. Similarly in their study, they also observed that the relative humidity was higher during the summer season compared to spring season in the disturbed forest area on comparison with undisturbed forest.

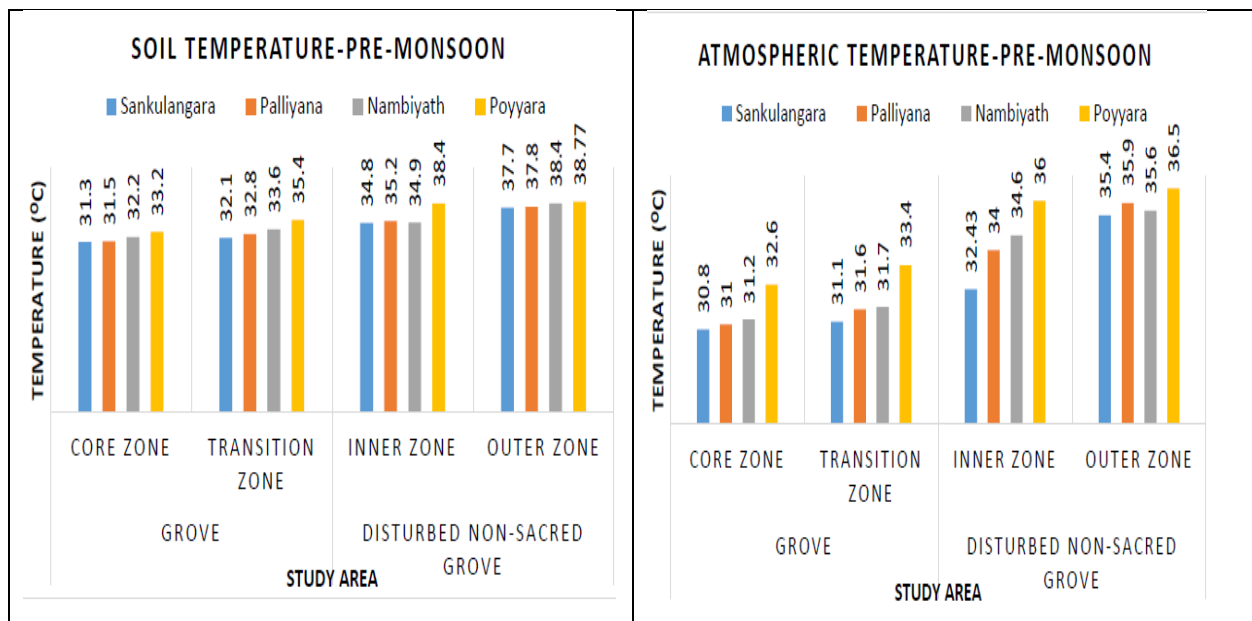
Materials and Methods

Microclimatic parameters such as temperature and humidity in the soil and atmosphere of all the selected sacred groves and disturbed non-sacred grove lands of similar extent are analyzed and compared. The data collections are carried by demarking the study into four zones. Each sacred grove are demarked into Core zone and Transition zone while each disturbed non-sacred grove lands into Inner zone (the region nearest to the grove region) and Outer zone (the region maximum away from the grove). The climatic parameters are measured by using Thermo-Hygrometer (TA318) during the mid-day period. The study is conducted during the pre-monsoon (April-May) and post-monsoon (August-September) period of 2015-2017.

The mean value and standard deviation of different parameters in selected sacred groves and disturbed non-sacred grove lands are determined and compared statistically using 't' test of SPSS statistics 20.

Results

Soil and atmospheric air temperature within the selected sacred groves and adjacent disturbed non-sacred grove lands of similar extent during pre-monsoon and post-monsoon periods are analyzed and the results obtained are shown in figure 1. The data indicates the soil as well as atmospheric temperature recorded in the disturbed non-sacred grove regions are comparatively higher when compared to the data recorded in the sacred grove regions in all the study sites, irrespective of the season. The highest temperature is found generally recorded in the outer zone of disturbed lands and then tended to decrease towards the grove regions in the direction of inner zone of disturbed land → transition zone and finally the lowest value is recorded in the core zone of grove. The overall comparison of temperature values obtained in various regions of different groves as well as non-sacred grove lands selected in the study indicate that comparatively the lowest temperature values in both the soil and atmosphere are recorded in the core zone of Sankulangara grove while the highest values recorded in the outer zone of disturbed non-sacred land at Poyyara during the pre-monsoon as well as post-monsoon periods.



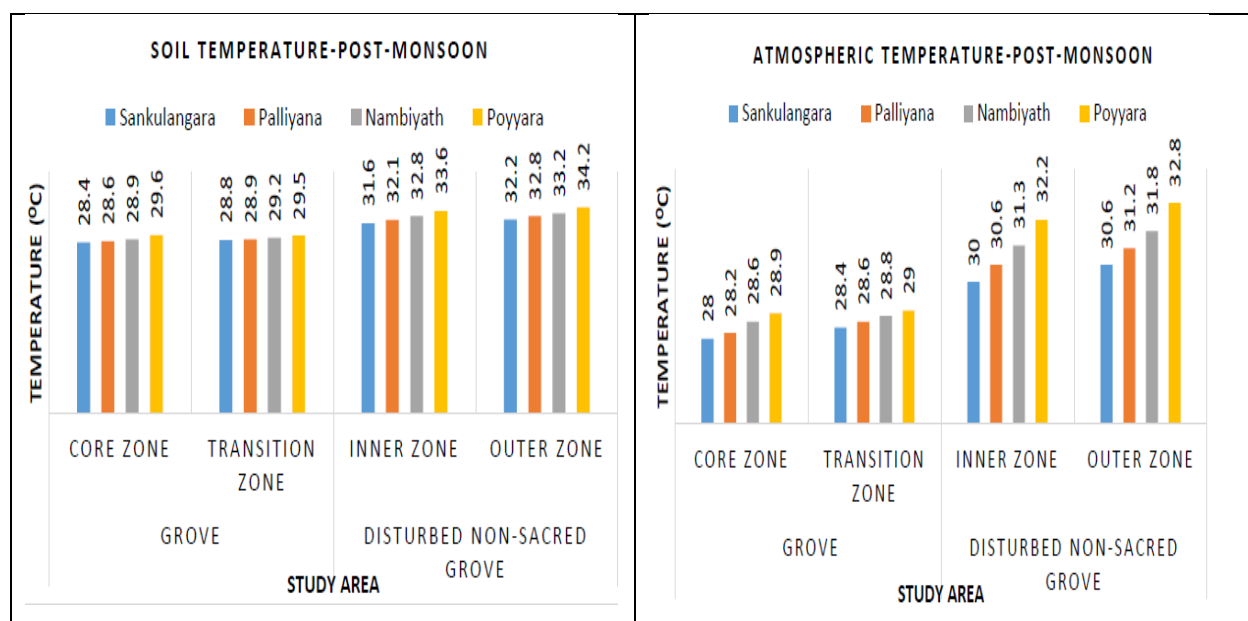


Figure G1: Soil and atmospheric temperature status in selected sacred groves and disturbed non-sacred grove lands during the pre-monsoon and post-monsoon season

The data on humidity in the soil and atmosphere collected are depicted in the table 4 to table 8. The data indicates lower values of humidity are recorded in the sacred grove regions at Sankulangara and Palliyana sites compared to the disturbed non-sacred grove regions of similar extent, during the pre-monsoon as well as post-monsoon periods. The highest humidity value with respect to both soil and atmosphere are recorded in the inner zone of disturbed lands and this is followed by the outer zone, transition zone and the lowest value recorded in the core zone of sacred groves. However, the humidity data collected from the study regions of comparatively smaller extent at Nambiyath and Poyyara sites showed a different trend. Only with an exception during the post-monsoon period at Nambiyath site, the higher values of humidity are recorded either in the transition or in the core regions of groves during the pre-monsoon as well as post-monsoon periods. During the pre-monsoon, the highest humidity value recorded in the transition zone at Nambiyath site whereas in the core zone of grove at Poyyara site while during the post monsoon, the highest soil and atmospheric humidity values recorded in the inner zone of disturbed non-sacred grove land at Nambiyath site whereas highest value in the transition zone of grove at Poyyara site. With respect to the lowest value of humidity recorded in Poyyara and Nambiyath sites, the outer zone of disturbed land recorded the lowest value, with the exception

during the post-monsoon period at Nambiyath site, where the core zone of grove recorded the lowest value.

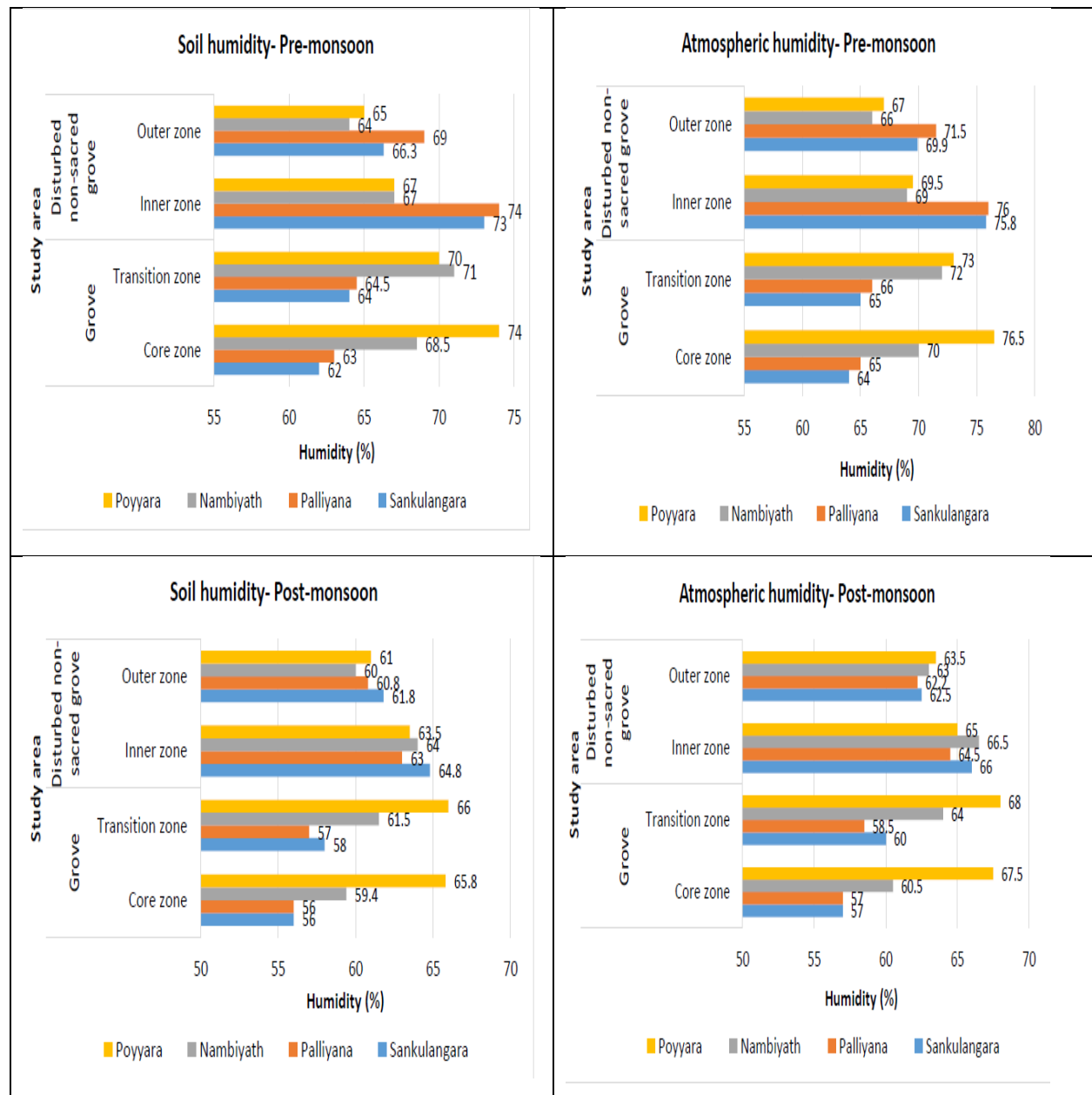


Figure G2: Soil and atmospheric humidity status in selected sacred groves and disturbed non-sacred grove lands during the pre-monsoon and post-monsoon season

Discussion

The data reveals the soil as well as atmospheric temperature recorded in the disturbed non-sacred grove regions are higher compared to the sacred grove regions during the pre-monsoon and post-monsoon periods. The differences are mostly significant (table 1 to table 4). The difference is more prominent when the temperature recorded in the outer zone of disturbed lands is compared with the core zone of sacred groves and this difference is found maximum during the pre-monsoon periods. The highest difference of 16.98% in the soil temperature is recorded between the outer zones of disturbed land and the core zone of sacred grove at Sankulangara study site while the lowest difference of 14.43% in the soil recorded at Poyyara study site. With respect to the atmospheric temperature, the highest difference is 13.65% which is recorded at Palliyana study site while the lowest difference is 10.68% recorded at Poyyara study site. However, the analysis of the same in the post-monsoon data revealed the highest difference in the soil temperature recorded between the outer zones of disturbed lands and the core zone of sacred groves is 13.45% at Poyyara study site while lowest difference is 11.80% and it is recorded in the Sankulangara site. The analysis of atmospheric temperature showed the highest difference is 11.89% in the Poyyara study site while lowest difference is 8.5% in the Sankulangara site. This observation in the study revealed that, as the extent of the grove area is increasing from Poyyara sacred grove of smallest extent to the Sankulangara sacred grove of largest extent, the difference in soil as well as atmospheric temperature between the groves and the disturbed lands generally tended to increase during the pre-monsoon while tended to decrease during the post-monsoon periods. The analysis of temperature recorded in the inner and outer zones of disturbed lands showed comparatively lower values of temperature in the inner zone of all the study sites, irrespective of the season. This may be due to the influence of better microclimatic conditions existing in the groves on the immediately adjacent disturbed areas.

Table G1: Soil temperature status in selected sacred groves and disturbed non-sacred grove lands during the pre-monsoon season

Study site	Mean value and SD of soil temperature			
	Sacred grove		Disturbed non-sacred grove land	
	Core zone	Transition zone	Inner Zone	Outer Zone
Sankulangara site	31.30 °C ±0.80	32.10 °C ±0.90	34.80 °C ±1.50	37.70 °C ±1.70
	The ‘t’ value and significant level of average soil temperature between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-1.151	-3.57	-5.90	-5.04
	NS*	P<0.05	P<0.05	P<0.05
Paliyana site	31.50 °C ±0.80	32.80 °C ±1.00	35.20 °C ±0.80	37.80 °C ±1.80
	The ‘t’ value and significant level of average soil temperature between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-1.758	-3.411	-5.540	-4.206
	NS*	P<0.05	P<0.05	P<0.05
Nambiyath site	32.20 °C ±0.90	33.60 °C ±0.70	34.90 °C ±1.40	38.40 °C ±1.50
	The ‘t’ value and significant level of average soil temperature between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-2.127	-2.810	-6.139	-5.023
	NS*	P<0.05	P<0.05	P<0.05
Poyyara site	33.2 °C ±0.90	35.4 °C ±1.1	38.4 °C ±2.4	38.77 °C ±2.75
	The ‘t’ value and significant level of average soil temperature between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-2.681	-3.514	-3.340	-1.974
	P<0.05	P<0.05	P<0.05	NS*

NS*- Not significant

Table G2: Atmospheric temperature status in selected sacred groves and disturbed non-sacred grove lands during the pre-monsoon season

Study site	Mean value and SD of soil temperature			
	Sacred grove		Disturbed non-sacred grove land	
	Core zone	Transition zone	Inner Zone	Outer Zone
Sankulangara site	30.8 °C ±0.7	31.1 °C ±0.9	32.43 °C ±1.59	35.4 °C ±1.8
	The ‘t’ value and significant level of average atmospheric temperature between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-0.456	-1.624	-4.125	-3.701
	NS*	NS*	P<0.05	P<0.05
Paliyana site	31 °C ±0.9	31.6 °C ±1.0	34 °C±1.6	35.9 °C ±1.69
	The ‘t’ value and significant level of average atmospheric temperature between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-0.772	-2.831	-4.037	-3.469
	NS*	P<0.05	P<0.05	P<0.05
Nambiyath site	31.2 °C ±0.8	31.7 °C ±0.8	34.6 °C ±1.6	35.6 °C ±1.7
	The ‘t’ value and significant level of average atmospheric temperature between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-0.765	-3.292	-4.056	-3.595
	NS*	P<0.05	P<0.05	P<0.05
Poyyara site	32.6 °C ±1.0	33.4 °C ±1.2	36 °C ±2.2	36.5 °C ±2.4
	The ‘t’ value and significant level of average atmospheric temperature between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-0.887	-2.437	-2.598	-2.001
	NS*	P<0.05	P<0.05	NS*

Table G3: Soil temperature status in selected sacred groves and disturbed non-sacred grove lands during the post-monsoon season

Study site	Mean value and SD of soil temperature			
	Sacred grove		Disturbed non-sacred grove land	
	Core zone	Transition zone	Inner Zone	Outer Zone
Sankulangara site	28.4°C ±0.3	28.8°C ±0.4	31.6°C ±0.8	32.2°C ±0.9
	The ‘t’ value and significant level of average soil temperature between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-1.386	-6.487	-6.938	-5.979
	NS*	P<0.05	P<0.001	P<0.05
Palliyana site	28.6°C ±0.4	28.9°C ±0.4	32.1°C±0.8	32.8°C ±1.0
	The ‘t’ value and significant level of average soil temperature between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-0.919	-6.778	-6.754	-6.272
	NS*	P<0.05	P<0.05	P<0.05
Nambiyath site	28.9°C ±0.5	29.2°C ±0.3	32.8°C ±0.7	33.2°C ±1.0
	The ‘t’ value and significant level of average soil temperature between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-0.891	-7.853	-6.662	-6.636
	NS*	P<0.001	P<0.05	P<0.05
Poyyara site	29.6°C ±0.5	29.5°C ±0.8	33.6°C ±1.1	34.2°C ±1.5
	The ‘t’ value and significant level of average soil temperature between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	0.184	-5.734	0.275	-4.789
	NS*	P<0.05	P<0.05	P<0.05

Table G4: Atmospheric temperature status in selected sacred groves and disturbed non-sacred grove lands during the post-monsoon season

Study site	Mean value and SD of soil temperature			
	Sacred grove		Disturbed non-sacred grove land	
	Core zone	Transition zone	Inner Zone	Outer Zone
Sankulangara site	28 °C ±0.4	28.4 °C ±0.5	30 °C ±0.7	30.6 °C ±0.9
	The ‘t’ value and significant level of average atmospheric temperature between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-1.082	-4.297	-4.572	-3.701
	NS*	P<0.05	P<0.05	P<0.05
Paliyana site	28.2 °C ±0.5	28.6 °C ±0.6	30.6 °C ±0.9	31.2 °C ±1.1
	The ‘t’ value and significant level of average atmospheric temperature between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-0.887	-4.038	-4.300	-3.594
	NS*	P<0.05	P<0.05	P<0.05
Nambiyath site	28.6 °C ±0.4	28.8 °C ±0.3	31.3 °C ±0.8	31.8 °C ±0.9
	The ‘t’ value and significant level of average atmospheric temperature between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-0.693	-5.229	-5.628	-5.477
	NS*	P<0.05	P<0.05	P<0.05
Poyyara site	28.9 °C ±0.4	29 °C ±0.6	32.2 °C ±1.2	32.8 °C ±1.4
	The ‘t’ value and significant level of average atmospheric temperature between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-0.240	-4.519	-4.639	-4.321
	NS*	P<0.05	P<0.05	P<0.05

Morecroft et al. (1998) compared the air and soil microclimates of deciduous forest land with an open site at Witham Woods, Oxford, UK and reported that the effect of forest cover on soil and air temperatures are much considerable and could be lowered under the canopy of forest land than at the open site during the summer. Similarly, Johnson et al. (1985) observed that whole-tree harvesting in an oak forest in Virginia resulted in an increase in the temperature of 6-8 °C in the month of July and August, compared to the adjacent uncut area. The present study results are in same lines with the above observations. The study indicates that the sacred groves are playing an important role in regulating the temperature within the grove and nearest immediate area. This could be due to the dense canopy of sacred groves particularly the tree canopy, which act as a protective cover and provide cool climate to the area. The release of large quantity of water vapour through transpiration and its retention might be the factor that contribute to this situation. Further the ground vegetation cover together with thick layer of litter fall act as insulation to the ground area which considerably reduce the loss of water through evaporation and regulate soil temperature.

The analysis of soil and atmospheric humidity in the present study revealed the Sankulangara and Palliyana groves of comparatively larger extents have recorded lower values of humidity during the pre-monsoon as well as post-monsoon periods, over the values of humidity recorded in their corresponding disturbed non-sacred grove lands. However, this trend turned to be in opposite condition with respect to Poyyara and Nambiyath groves of comparatively smaller extent. The values of humidity in these groves are found recorded higher than the values of their corresponding disturbed lands, with an exception during the post-monsoon period at Nambiyath grove. The lower values of humidity recorded in the Sankulangara and Palliyana groves can be attributed to the lower rate of surface evaporation loss of water from the ground area due to thick layer of litter fall and the lower wind flow within these groves due to rich vegetation and canopy cover. Therefore, the major source of water vapour that contribute towards the humidity factor in the grove is generally from the transpiration. The comparative analysis of humidity values recorded in the grove regions with that of disturbed non-sacred grove regions, the differences are found significant in majority of the cases particularly when the humidity values in the core region of groves are compared to inner and outer regions of their corresponding disturbed lands (table 5 to table 8).

Table G5: Soil humidity status in selected sacred groves and disturbed non-sacred grove lands during the pre-monsoon season

Study site	Mean value and SD of soil humidity (%)			
	Sacred grove		Disturbed non-sacred grove land	
	Core zone	Transition zone	Inner Zone	Outer Zone
Sankulangara site	62.0 ±2.0	64.0 ±2.0	73.0 ±3.0	66.3 ±2.5
	The ‘t’ value and significant level of average soil humidity between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-1.225	-5.284	-2.326	-1.244
	NS*	P<0.05	P<0.05	NS*
Paliyana site	63.0 ±3.0	64.5 ±2.0	74.0 ±3.5	69.0 ±3.0
	The ‘t’ value and significant level of average soil humidity between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-0.721	-4.133	-2.449	-2.162
	NS*	P<0.05	P<0.05	NS*
Nambiyath site	68.5 ±2.0	71.0 ±3.0	67.0 ±3.0	64.0 ±2.5
	The ‘t’ value and significant level of average soil humidity between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-1.201	0.721	2.435	3.105
	NS*	NS*	P<0.05	P<0.05
Poyyara site	74.0 ±4.0	70.0 ±3.0	67.0 ±3.0	65.0 ±3.0
	The ‘t’ value and significant level of average soil humidity between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	1.386	2.425	3.118	2.041
	NS*	P<0.05	P<0.05	NS*

Table G6: Atmospheric humidity status in selected sacred groves and disturbed non-sacred grove lands during the pre-monsoon season

Study site	Mean value and SD of atmospheric humidity (%)			
	Sacred grove		Disturbed non-sacred grove land	
	Core zone	Transition zone	Inner Zone	Outer Zone
Sankulanagar site	64 ±3	65±2	75.8 ±3	69.9±3
	The ‘t’ value and significant level of average atmospheric humidity between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-.480	-4.817	-2.409	-2.354
	NS*	P<0.05	P<0.05	P<0.05
Palliyana site	65±2.5	66±3	76±3	71.5±3
	The ‘t’ value and significant level of average atmospheric humidity between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-.444	-4.879	-2.883	-2.245
	NS*	P<0.05	P<0.05	P<0.05
Nambiyath site	70 ±3	72 ±3.5	69±2	66±2
	The ‘t’ value and significant level of average atmospheric humidity between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-.751	.480	1.922	2.578
	NS*	NS*	NS*	P<0.05
Poyyara site	76.5±3.5	73±3	69.5 ±3	67 ±3
	The ‘t’ value and significant level of average atmospheric humidity between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	1.315	2.630	3.569	2.449
	NS*	P<0.05	P<0.05	P<0.05

Table G7: Soil humidity status in selected sacred groves and disturbed non-sacred grove lands during the post-monsoon season

Study site	Mean value and SD of soil humidity (%)			
	Sacred grove		Disturbed non-sacred grove land	
	Core zone	Transition zone	Inner Zone	Outer Zone
Sankulangara site	56 ±1.0	58 ±1.0	64.8 ±2.0	61.8 ±1.5
	The ‘t’ value and significant level of average soil humidity between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-2.449	-6.816	-5.572	-3.651
	P<0.05	P<0.05	P<0.05	P<0.05
Palliyana site	56 ±1.0	57 ±1.0	63 ±1.5	60.8±2.0
	The ‘t’ value and significant level of average soil humidity between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-1.225	-6.725	-3.718	-2.943
	NS*	P<0.05	P<0.05	P<0.05
Nambiyath site	59.4 ±1.0	61.5 ±1.5	64 ±1.5	60 ±1.0
	The ‘t’ value and significant level of average soil humidity between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-2.018	-4.420	-0.735	1.441
	NS*	P<0.05	NS*	NS*
Poyyara site	65.8 ±2	66 ±1.0	63.5 ±1.0	61 ±1.0
	The ‘t’ value and significant level of average soil humidity between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-0.155	1.782	3.718	6.124
	NS*	NS*	P<0.05	P<0.05

Table G8: Atmospheric humidity status in selected sacred groves and disturbed non-sacred grove lands during the post-monsoon season

Study site	Mean value and SD of atmospheric humidity (%)			
	Sacred grove		Disturbed non-sacred grove land	
	Core zone	Transition zone	Inner Zone	Outer Zone
Sankulanagar site	57 ±1.0	60±1.0	66±1.0	62.5 ±2.0
	The ‘t’ value and significant level of average atmospheric humidity between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-3.674	-11.023	-4.260	-1.936
	P<0.05	P<0.001	P<0.05	NS*
Palliyana site	57±1.0	58.5±1.5	64.5±2.0	62.2±2.0
	The ‘t’ value and significant level of average atmospheric humidity between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-1.441	-5.809	-4.028	-2.563
	NS*	P<0.05	P<0.05	P<0.05
Nambiyath site	60.5±1.0	64±2.0	66.5±1.0	63±1.0
	The ‘t’ value and significant level of average atmospheric humidity between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-2.711	-7.348	-3.062	.775
	P<0.05	P<0.05	P<0.05	NS*
Poyyara site	67.5 ±1.5	68 ±1.0	65 ±2.0	63.5 ±1.0
	The ‘t’ value and significant level of average atmospheric humidity between different regions			
	Core zone X Transition zone	Core zone X Inner Zone	Core zone X Outer Zone	Transition zone X Outer Zone
	-0.480	1.732	3.843	5.511
	NS*	NS*	P<0.05	P<0.05

It is generally estimated that in the atmospheric humidity, only about 10% of the moisture is contributed by process of plant transpiration while the rest of the 90% moisture is contributed by surface evaporation from the ground and water sources (USGS, 2011). The evaporation loss of water from the ground surface usually occurs at higher rate when the influence of external factors such as sunlight radiations and the presence of wind are higher in the area. Therefore, the loss of moisture through evaporation from the surface soil of a highly disturbed forest or open field may be higher compared to the loss of moisture from the grove soil under protection of rich vegetation cover (Abdulsahim, 2003). The higher values of humidity recorded in the Poyyara and Nambiyath groves of smaller extent in the study compared to their corresponding disturbed lands may be due to higher vapour content in the area. This can be attributed to the cumulative effect of higher transpiration rate as well as the evaporation loss of water from the ground area due to the increased influence of external environmental factors, which in turn can be attributed to the smaller size of the groves which allows the interference of warmer temperature and wind to the more interior part of the grove area.

The analysis on the effect of differences in extent of selected sacred groves on various climatic parameters in the study revealed gradual but steady improvements in favourable temperature and humidity factors in the direction of Poyyara→Nambiyath→Palliyana→Sankulangara (figure 1 and figure 2). This can be attributed to the influence of gradual improvements in floristic diversity and richness in the groves along with increasing extent of the grove area. The maximum difference in temperature as well as humidity values in the soil and atmosphere are obtained between the core zone in Poyyara grove of smallest extent and the core zone in the Sankulangara grove of largest extent and the differences are found significant (table 9 & table 12). Similarly, the differences in humidity values between the core zone of Nambiyath and Sankulangara are also found significant.

Table G9: The ‘t’ value and significant level of soil temperature and humidity between the core zones of selected sacred groves of different extents during the pre-monsoon and post-monsoon

Soil parameter	Core zone Sankulangara grove X Core zone Palliyana grove	Core zone Sankulangara grove X Core zone Nambiyath grove	Core zone Sankulangara grove X Core zone Poyyara grove
Pre-monsoon			
Temperature	-0.306	-1.295	-2.733
	NS*	NS*	P<0.05
Humidity	-0.480	-3.980	-4.648
	NS*	P<0.05	P<0.05
Post-monsoon			
Temperature	-0.693	-1.485	-3.565
	NS*	NS*	P<0.05
Humidity	0.000	-4.164	-7.591
	NS*	P<0.05	P<0.05

Table G10: The ‘t’ value and significant level of atmospheric temperature and humidity between the core zones of selected sacred groves of different extents during the pre-monsoon

Atmospheric parameter	Core zone Sankulangara grove X Core zone Palliyana grove	Core zone Sankulangara grove X Core zone Nambiyath grove	Core zone Sankulangara grove X Core zone Poyyara grove
Pre-monsoon			
Temperature	-0.304	-0.652	-2.554
	NS*	NS*	P<0.05
Humidity	-0.444	-2.449	-4.697
	NS*	P<0.05	P<0.05
Post-monsoon			
Temperature	-0.541	-1.837	-2.756
	NS*	NS*	P<0.05
Humidity	0.000	-4.287	-10.088
	NS*	P<0.05	P<0.001

Conclusion

Analysis of temperature in the soil and atmosphere in the study sites revealed comparatively low temperature is maintained within all the selected sacred grove regions compared to disturbed non-sacred grove regions. However, with respect to the humidity factor, even though the sacred groves of larger extent followed the similar trend of temperature, the groves of smaller extent exhibited a reverse trend. Therefore the present study concludes that the sacred groves are playing an important role in rejuvenating and maintaining a better microclimatic conditions in the area. However, the study further conclude that the extent of the grove area is also playing a key role in regulating the microclimatic conditions, as there exists a positive correlation between the size of the grove and the level of temperature and humidity.

References

- Abdulsahim Ansari. (2003). *Influence of Forests on Environment*. Proceedings of the XII World Forestry Congress, Quebec City, Canada. Cambridge: Cambridge University Press.
- Chandrashekara, U. M., & Sankar, S. (1998). *Ecological and social importance of conservation of sacred groves in Kerala*. KFRI Research Report 152, Kerala Forest Research Institute Peechi, Thrissur.
- Davis, G., & Richardson, D. (1995). *Mediterranean Type Ecosystems: The Function of Biodiversity*. Springer, Berlin.
- Johnson, J. E., Smith, D. W., & Burger, J. A. (1985). Effects on the forest floor of whole tree harvesting in an Appalachian oak forest. *American Midland Naturalist*, 114(1), 51–61.
- Morecroft, M. D., Taylor, M. E., & Oliver, H. R. (1998). Air and soil microclimates of deciduous forest land compared to an open site. *Agricultural and Forest Meteorology*, 90(1-2), 141–156.
- Rajendraprasad, M. (1995). *The Floristic, Structural and Functional Analysis of Sacred Groves of Kerala*. Ph.D. Thesis, University of Kerala, Thiruvananthapuram, Kerala.
- Robert Brooks, T., Thomas, D., & Kyker-Snowman. (2008). Forest floor temperature and relative humidity following timber harvesting in southern New England. USA. *Forest Ecology and Management*, 254, 65–73.
- Strangeways, I. (2003). *Measuring the Natural Environment*. (2nd Ed.) Cambridge: Cambridge University Press.
- United States Geological Survey. (USGS). (2011). *Water science for schools*. Retrieved from <http://ga.water.usgs.gov/edu/watercyclesummary.html>.
- Wainwright, J., Mulligan, M., & Thornes, J. (1999). *Plants and Water in Drylands*. In: Baird, A. J., & Wilby, R. L. (Eds.) *Eco-hydrology: Plants and water in terrestrial and aquatic environments*. London: Routledge Publishers, 78 – 126.
- Weng, S. H., Kuo, S. R., Guan, B. T., Chang, T. Y., Hsu, H. W., & Shen, C. W. (2007). Microclimatic responses to different thinning intensities in a Japanese cedar plantation of northern Taiwan. *Forest Ecology and Management*, 241(1-3), 91–100.
- Wild, A. (2003). *Soils, Land and Food: Managing the Land During the Twenty-first Century*. Cambridge University Press, U.K.

CHAPTER- 9

Diversity, distribution and traditional use of ethnomedicinal plants in the selected sacred groves and disturbed non-sacred grove lands

Introduction

The survey conducted by the All India Coordinated Research Project on Ethnobiology (AICRPE) during the last decade recorded over 8000 species of wild plants used by tribal and other traditional communities in India for treating various health problems (Laloo et al., 2006). As per WHO estimate, about 80% of the population in the world relies on traditional systems of medicine for the prevention as well as for the treatments of various diseases, where plants are the major natural component for treatments compared to natural resources (Duraipandiyar et al., 2006). The plant based medicines generally exert their medicinal action through the synergistic or combined action of multiple bioactive compounds by acting at particular infectious target in connection with a physiological process. This kind of combined action by phytocompounds not only help to avoid the side effects in connection with continuous use of a single xenobiotic and highly active compound in the body but also ensures effectiveness against multiple pathogens and further reduce the chances of these organisms to develop into resistant pathogens. (Kaufman et al., 1999). However, now a day the most serious problem we face in our rural as well as urban area is the large scale destruction of our forest vegetation which lead to the scarcity or disappearance of many valuable medicinal plants of traditional use. This situation can be due to the lack of awareness or as part of various developmental activities or industrial processes. Whatever is often neglected is the pharmacological importance of this safer, cheaper and reliable source of drugs for the future. Today most of our areas have only certain patches or remnants of forest, the so called sacred groves, which are protected under the ground of religious faith. These sacred groves are considered as treasure house of rare and endangered plant species and abode of many medicinal plants but now they are also facing threats due to various man made activities. Therefore it is very important to protect these patches of surviving climax vegetation in some way. Here comes the relevance of ethnobotanical study and documentation of data on medicinal plants and dissemination of this information to the public

to make them aware regarding the need of maintaining such natural resources for the future. The present study is carried out to collect information on the ethnomedicinal wealth of selected sacred groves in terms of diversity, density and traditional uses of ethnomedicinal plants and to compare this with the present status of nearby disturbed non-sacred grove lands.

Review of literature

Till the discovery of antibiotics or analgesics in the early twentieth century, herbal medicine was the basic system of healthcare. Due to the fast therapeutic actions of synthetic drugs, the allopathic system soon gained popularity and the herbal medicine was set aside (Singh, 2007). But now a reverse trend is experienced from synthetic to herbal system which is coined as “Return to Nature”. For millions of years, plants have been known for their medicinal value and valued as therapeutic agents used in the treatment of various diseases as well as ailments (Sharma et al., 2008). The traditional system of health care using medicinal plants is gaining world wide recognition. Several documented studies have been carried out regarding the protection of medicinal plants available in the sacred groves in various regions of India (Vartak et al., 1987; Bhakat & Pandit, 2004; Pandit & Bhakat, 2007). An awareness on the importance of medicinal plants has not only created an interest in learning more about sacred groves and its ecological relevance but also has emphasized the need for scientific methods of conservation of nature which was earlier based on social and cultural belief systems.

Right from the pre-Vedic era, nature conservation has been in practice in India as a tradition. Accordingly, the sacred groves, which are patches of natural ecosystem have been preserved, they being the habitat for many threatened, endangered and endemic taxa and examples of genetic resource conservation. The sacred groves are known to be treasure houses of numerous Ayurvedic and folk medicinal plants and serves as reservoirs of diverse varieties of plants like wild yams, mango, pepper etc. Sacred groves are highly significant as 60% of the species regenerating there have medicinal properties and almost 40% of these medicinal plants are only specific to that grove (Boraiah et al., 2003). Plant species ranging from 7000 to 10000 have been identified to be of medicinal value and are used in the traditional medical system of Ayurveda and Siddha as well as in folklore medicine. Several endemic rare plant species are found to inhabit the sacred groves and can be considered to be fragments of natural forest which remain conserved due to the age old belief that the residing deities in these groves should not be disturbed. These groves hence account for richness in biodiversity as well as play an important role in nature conservation (Francis et al., 2013). Due to this, the sacred groves still contain a plethora of gene pool of species of ethno medicinal importance. Since ancient days, the ethno botanical application of plants, derived from biodiversity, has

been practiced to treat diseases as well as for good health. It can be said that the foundation of human survival and economic stability is Biodiversity (Singh et al., 1994) which comprise of various resources on which not only families and communities depend upon but also nations and coming generations too rely on (Dowdeswell, 1995). Sustainability of biological resources is dependent on its proper management (McNeely et al., 1990) which ensures its conservation for the future. About 8000 species of medicinal plants are identified in India (Ved et al., 2001).

The biodiversity of medicinal plants associated with the sacred groves are being preserved because many of these groves are owned by community who still practice traditional system of management which is sustainable. The logic behind the preservation of biodiversity by the tribal community is that their livelihood is completely dependent on the natural resources. The intelligence with which the tribal community utilizes the biological resources with sustainability thereby conserving them is to be essentially identified (Rajendran & Agarwal, 2007). However, the present concern is regarding the preservation threat and disintegration faced by the sacred groves. This kind of degradation has a negative effect on the tribal folk as well as on their traditional mastery on the plant community (Basu, 2009). In India, there exist an inter link between nature and community and this can be correlated to our unique diversity on medical plant resources, however, anthropogenic pressures are posing a severe threat to our traditionally and culturally connected biodiversity (Yadav et al., 2010). The taint in culture of tribes along with the disintegration of sacred groves as a result of anthropogenic activities and edaphic factors could cause an imbalance not only in the conservation and sustainable usage of medicinal plants, but also derail the practices followed through traditional knowledge (Behera et al., 2015). The conservation and protection of biodiversity by the ethnic group anywhere in the world from ancient times is attributed to the emotional attachment and symbiotic relation they hold with nature. The same can be seen in the case of sacred groves which are rich biodiversity fragments of original forests protected by the locals in the name of native cultural and devoted beliefs along with certain taboos. Urbanization and developmental activities along with population explosion and deficiency of human care have contributed to the disappearance of vast areas of medicinal plants. However, in many parts of India the sacred groves are found to possess abundantly diverse medicinal plant species and the groves also provide a favorable habitat for their natural and sustainable regeneration. The comparison on the medicinal quality of plants specific to each grove to those inhabiting other areas have also been studied (Boraiah et al., 2003). It is hence necessary to document such

observations which are relevant for the conservation of sacred groves for the future and to understand the potential of the medicinal plants and its usage in natural health and hygiene improvement. Biswas et al. (2003) and Srinivasamurthy et al. (2003) carried out many studies related to the use and conservation of medicinal plants in several regions of India.

The traditional beliefs and cultural practices of the ethnic tribes throughout the world hold a close association with the protection and preservation of sacred groves. Though the heritage have survived through many generations, it is unfortunate that the changing social setup, enhanced consumerism for better living standards and shift in belief systems attained through modern education have caused the erosion of taboos and beliefs which were the epic of sacred grove conservation (Rao, 1996). Many wild species are overexploited all over the world to meet the demand caused by traditional medicine. It is in this context that the research works should concentrate on the usage of plants and animals in traditional medicine with emphasis on the ethnic and ecological features linked with these practices (Alves & Rosa, 2005). Studies have revealed that in the last three decades, degradation of natural forests have decreased the availability of common species of medicinal plants which signifies a reduction in many prospective pharmaceutical drugs used in the developed world as well as the fading away of the only health care choice for the lower strata of population in both urban and rural areas (Shanley & Luz, 2003). It is noticed that industrialization together with urbanization has caused the displacement of native medical system by western medicine as a result of which the traditional knowledge in this field is fast disappearing due to changes in cultural practices and reduced access to natural sources of medicinal products both in rural and urban areas (Romulo & Ierece, 2007). In many regions of the Third world, due to the degradation and conversion of forests into savanna, savanna changing to scrublands and bushes and scrublands then into deserts, several species of plants are observed to vanish altogether and such a problem may threaten the practice of traditional medicine; with a few exceptions, all medicines are made from concoctions prepared with plants, plant organs or their secreted products (Kerharo, 1975).

Materials and methods

Study area

Four selected sacred groves and their corresponding disturbed non-sacred grove land of similar extent are subjected to analysis for a comparative evaluation of ethnomedicinal plant wealth. The study is conducted during the period December 2015 - December 2017.

Distribution, diversity and traditional use of ethnomedicinal plants

The details of ethnomedicinal plants and their traditional uses are collected through survey, discussions and interviews with local people and traditional healers in the area. The identification and other required information of ethnomedicinal plants are done with the help of referred books and reports (Khare, 2007; Krishnan Nambiar et al., 1985; Akhtar et al., 1992; The Ayurvedic Pharmacopoeia of India, 2004). Ethnomedicinal plants belonging to different group such as trees, shrubs, herbs, lianas and climbers are selected and analysed for the following parameters.

1. Identification and distribution of ethnomedicinal plants

2. Relative density of species (RD) =
$$\frac{\text{Number of individuals of the species} \times 100}{\text{Number of individuals of all species}}$$

3. Relative frequency of species (RF) =
$$\frac{\text{Number of quadrats of occurrence of the species} \times 100}{\text{Number of quadrats of occurrence of all species}}$$

4. Dominance of ethnomedicinal family, genera and species- based on the total population count and diversity

5. Diversity Index of ethnomedicinal plants (Shannon Wiener, 1949)

$$\text{Shannon Wiener Index (H')} = -\sum_{i=1}^s (p_i \ln p_i)$$

Where, p_i = fraction of the entire population made up of species

s = numbers of species encountered, Σ = sum from species 1 to s

6. Parts used and ethnomedicinal uses

Results

A) Sankulangara study site

The ethnobotanical study conducted in Sankulangara sacred grove identified 28 plant species as commonly used ethnomedicinal plants by the local people and traditional healers in the area for the treatment of various ailments. These plants are distributed in 26 genera belonging to 22 families (table H1). This constituted around 27.72% of the total plant species represented in the grove. The ethnomedicinal plant population constituted around 29.92% of the entire plant population in the grove. The data revealed that the highest percentage of ethnomedicinal plant species is belonging to the plant group trees (28.57%) followed by climbers (21.43%), shrubs (21.43%), herbs (17.86%) and lianas (10.71%). In the disturbed land, 14 plant species are identified as ethnomedicinal and they are distributed in 12 genera belonging to 10 families (table H2). This constituted around 23.33% of the total plant species represented and the total number of ethnomedicinal plants constituted around 28.66% of the entire plant population in the disturbed land. The highest percentage of ethnomedicinal plant species in the disturbed land is belonging to the plant group herbs (57.14%) followed by shrubs (21.43%), trees (14.29%) and climbers (7.14%). With the exception of herbs, all the plant groups in disturbed land recorded lower representations of ethnomedicinal plant species compared to sacred grove and the decrease recorded are 75%, 50% and 83.33% respectively for trees, shrubs and climbers while an increase of 37.5% is recorded for herbs. No lianas were recorded as ethnomedicinal in disturbed land.

Table H1: Distribution details of ethnomedicinal plants in the Sankulangara sacred grove

SI No	Botanical Name	Family	Habit	No. of plants	Relative density	Relative frequency	Diversity Index (H)
1	<i>Abrus precatorius</i>	Leguminosae	Climber	19	2.99	4.17	0.1
2	<i>Asparagus racemosus</i>	Liliaceae	Climber	16	2.52	4.17	0.09
3	<i>Connarus monacarpus</i>	Connaraceae	Liana	2	0.31	1.39	0.02
4	<i>Desmodium gangeticum</i>	Leguminosae	Herb	11	1.73	4.17	0.07
5	<i>Elephantopus scaber</i>	Asteraceae	Herb	12	1.89	4.17	0.07
6	<i>Gnetum ula</i>	Gnetaceae	Liana	55	8.66	5.56	0.21
7	<i>Hibiscus rosa-sinensis</i>	Malvaceae	Shrub	13	2.05	4.17	0.08
8	<i>Holigarna arnottiana</i>	Anacardiaceae	Tree	14	2.2	4.86	0.08
9	<i>Hopea ponga</i>	Dipterocarpaceae	Tree	101	15.9	5.56	0.29
10	<i>Hydnocarpus pentandrus</i>	Flacourtiaceae	Tree	24	3.78	5.56	0.12
11	<i>Ichnocarpus frutescens</i>	Apocynaceae	Climber	48	7.56	4.17	0.2
12	<i>Kamettia caryophyllata</i>	Apocynaceae	Climber	12	1.89	2.08	0.07
13	<i>Laportea interrupta</i>	Urticaceae	Herb	10	1.57	2.08	0.07
14	<i>Memecylon grande</i>	Melastomataceae	Shrub	25	3.94	4.86	0.13
15	<i>Mussaenda frondosa</i>	Rubiaceae	Shrub	6	0.94	2.08	0.04
16	<i>Ocimum basilicum</i>	Lamiaceae	Herb	2	0.31	1.39	0.02
17	<i>Ocimum tenuiflorum</i>	Lamiaceae	Shrub	5	0.79	2.08	0.04
18	<i>Polyalthia korinti</i>	Annonaceae	Shrub	17	2.68	4.17	0.1

19	<i>Quassia indica</i>	Simaroubaceae	Tree	27	4.25	5.56	0.13
20	<i>Sterculia guttata</i>	Sterculiaceae	Tree	4	0.63	2.08	0.03
21	<i>Strychnos minor</i>	Loganiaceae	Climber	53	8.35	4.86	0.21
22	<i>Syzygium lanceolatum</i>	Myrtaceae	Tree	4	0.63	2.08	0.03
23	<i>Syzygium zeylanicum</i>	Myrtaceae	Shrub.	11	1.73	2.78	0.07
24	<i>Tabernaemontana alternifolia</i>	Apocynaceae	Tree	12	1.89	4.17	0.07
25	<i>Terminalia bellirica</i>	Combretaceae	Tree	1	0.16	0.69	0.01
26	<i>Tiliacora racemosa</i>	Menispermaceae	Climber	78	12.3	4.86	0.26
27	<i>Torenia bicolor</i>	Scrophulariaceae	Herb	18	2.83	2.78	0.1
28	<i>Uvaria narum</i>	Annonaceae	Liana	35	5.51	3.47	0.16
TOTAL				635	29.9	28.8	2.89

Table H2: Distribution details of ethnomedicinal plants in the disturbed non-sacred grove land at Sankulangara site

SI No	Botanical name	Family	Habit	No. of plants	Relative density	Relative frequency	Diversity Index (H)
1	<i>Aerva lanata</i>	Amaranthaceae	Climber	9133	14.4	10.26	0.279
2	<i>Biophytum reinwarattii</i>	Oxalidaceae	Herb	2780	4.37	7.692	0.137
3	<i>Cyathula prostrata</i>	Amaranthaceae	Herb	3574	5.62	7.692	0.162
4	<i>Cynodon dactylon</i>	Poaceae	Herb	30180	47.5	10.26	0.354
5	<i>Cyperus rotundus</i>	Cyperaceae	Herb	4765	7.49	8.974	0.194
6	<i>Hydnocarpus pentandrus</i>	Flacourtiaceae	Herb	3	0.005	2.564	0.0005
7	<i>Ichnocarpus frutescens</i>	Apocynaceae	shrub	9	0.01	3.846	0.001
8	<i>Laportea interrupta</i>	Urticaceae	Shrub	2383	3.75	6.41	0.123
9	<i>Leucas aspera</i>	Lamiaceae	Shrub	3177	5	6.41	0.15
10	<i>Phyllanthus amarus</i>	Euphorbiaceae	Shrub	7545	11.9	10.26	0.253
11	<i>Sida acuta</i>	Malvaceae	Shrub	13	0.02	7.692	0.002
12	<i>Sida cordifolia</i>	Malvaceae	Tree	12	0.02	6.41	0.002
13	<i>Sida rhombifolia</i>	Malvaceae	Shrub	14	0.02	7.692	0.002
14	<i>Tabernaemontana alternifolia</i>	Apocynaceae	Tree	5	0.01	3.846	0.0007
TOTAL				63593	28.7	26.26	1.66

In sacred grove, the family with highest number of ethnomedicinal plant population is recorded in Dipterocarpaceae, which have a total of 101 individuals. This is immediately followed by Menispermaceae and Apocynaceae with a total population of 78 and 72 respectively. The data shows the family with maximum number of ethnomedicinal plant genera and species are recorded under Apocynaceae, which include 3 genera and 3 species. Immediately followed by the family Apocynaceae is Annonaceae and Leguminosae, consisting of 2 genera and 2 species each (table H1). The ethnomedicinal plant genera as well as the plant species with highest number of representation is recorded by the tree *Hopea ponga*, which is having a total representation of 101 each for genera and species. *Hopea ponga* is immediately followed by the climber *Tiliacora racemosa* (78 each for genera and species) and then the liana *Gnetum ula* (55 each for genera and species).

In the disturbed land, the family which occupied highest number of ethnomedicinal plant population is Poaceae and have total of 30180 plants. The family Poaceae is immediately followed by Amaranthaceae and then Euphorbiaceae, with a total population of 12706 and 7545 respectively. The family with maximum number of ethnomedicinal genera and species are recorded under Amaranthaceae and Apocyanaceae, which include 2 genera and 2 species each. This is immediately followed by the family Malvaceae and this consists of 1 genus and 3 species (table H2). The plant genus as well as the plant species with highest number of

representation in the disturbed land is recorded by the herb *Cynodon dactylon* (30180 each for genus and species). This is immediately followed by the herb *Aerva lanata* (9133 each for genera and species) and then the herb *Phyllanthus amarus* (7545 each for genera and species).

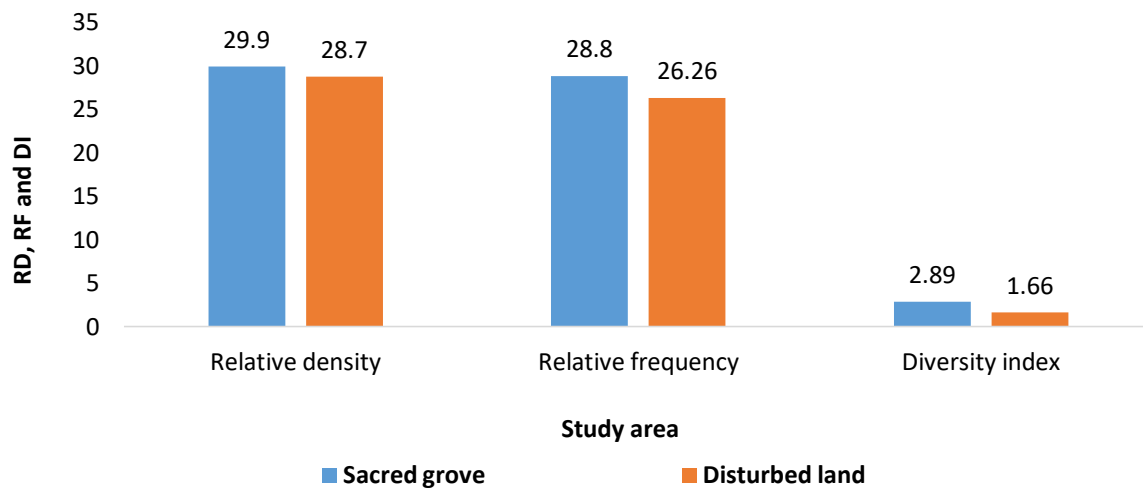


Figure H1: Comparison of relative density, relative frequency and diversity index of ethnomedicinal plants in Sankulangara sacred grove and disturbed non-sacred grove land

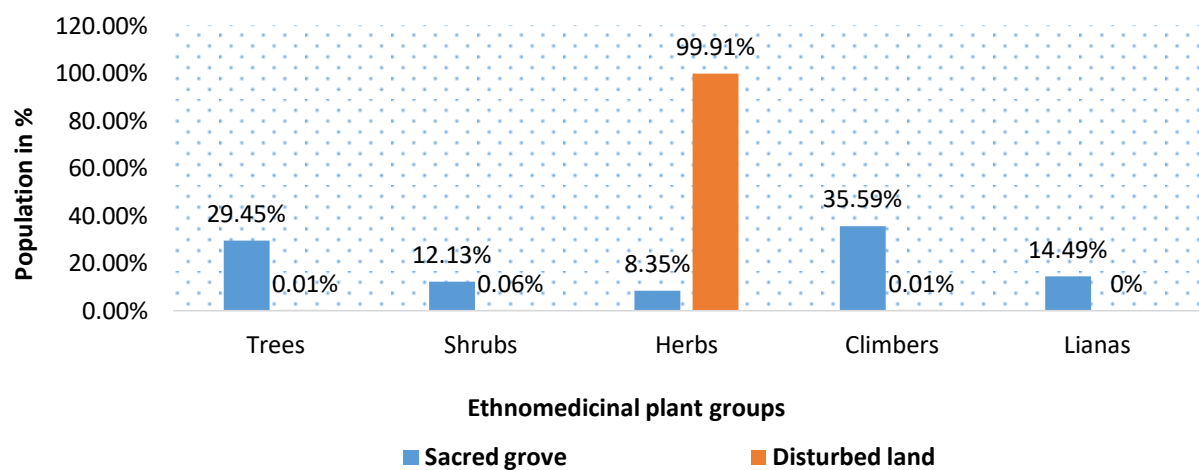


Figure H2: Population wise distribution of various ethnomedicinal plant groups in Sankulangara sacred grove and disturbed non-sacred grove land

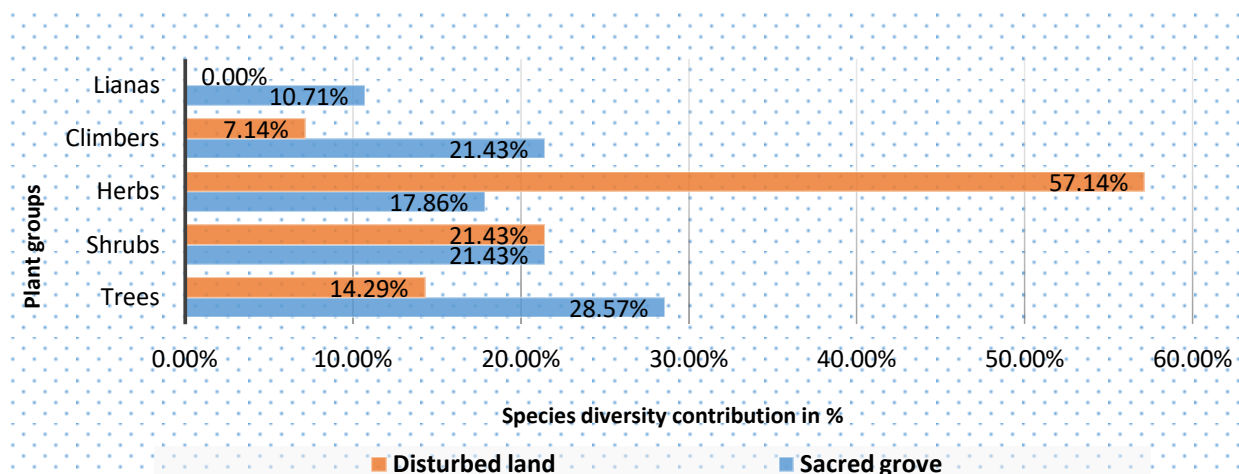


Figure H3: Species diversity contribution of various ethnomedicinal plant groups in the Sankulangara sacred grove and disturbed non-sacred grove land

The details of identified ethnomedicinal plants such as scientific name, local name, parts used and traditional use in the treatment of ailments in Sankulangara sacred grove and in the disturbed non-sacred grove land are shown in table H9 and table H10 respectively.

B) Palliyana study site

22 plant species are identified as commonly used ethnomedicinal plants by the local people and traditional healers in the Palliyana grove area. These plants are distributed in 22 genera belonging to 17 families and constitute around 21.78% of the total plant species represented in the grove and the total population of ethno medicinal plants is around 23.66% of the entire plant population in the grove (table H3). The data revealed that the highest percentage of ethnomedicinal plant species is belonging to the plant group trees (50%). This is followed by climbers (27.27%), shrubs (13.64%) and then herbs and lianas (4.55% each). The family with highest number of ethnomedicinal plant population in the Palliyana sacred grove is recorded in Apocynaceae, which have a total of 64 individuals. This is immediately followed by Rubiaceae and Euphorbiaceae, having a total population of 44 and 43 individuals respectively. The data showed that the maximum number of ethnomedicinal genera and species are recorded in the family Apocynaceae. This included 3 genus and 3 species. Immediately followed by the family Apocynaceae is Rubiaceae and Leguminosae, each consisting of 2 genus and 2 species. The plant genus as well as species with maximum number of representation is recorded by the climber *Ichnocarpus frutescens*, which is having a total representation of 59 each for plant genus and species. This is immediately followed by the climber *Tinospora sinensis* (40 each for plant genus and species) and then the shrub *Ixora coccinea* (38 each for plant genus and species).

In the disturbed land, 12 plant species are identified as ethnomedicinal and are distributed in 10 genera belonging to 9 families (table H4). This constitute around 15.79% of the total plant species represented in the disturbed land. The total ethnomedicinal population is around 19.02% of the entire plant population in the selected disturbed land. The highest percentage of ethnomedicinal plant species in the disturbed land is belonging to herbs and shrubs (41.67% each) and this is followed by trees and climbers (8.33% each). With the exception of herbs and shrubs, all other plant groups in disturbed land recorded lower representations of ethnomedicinal plant species compared to sacred grove. They recorded a decrease of 90.9%, 83.33% and 100% respectively for trees, climbers and lianas while an increase of 80% and 40% are recorded for herbs and shrubs respectively. The plant group liana is totally absent in disturbed land. The family which occupied the highest number of ethnomedicinal plant population is Amaranthaceae which have a total of 14245 plants. The family Amaranthaceae is immediately followed by Poaceae and then Euphorbiaceae with a total population of 8013 and 5342 respectively. The family with maximum number of ethnomedicinal genera is recorded under Amaranthaceae, which included 2 genera. All other families have only 1 genus each. The highest number of ethnomedicinal plant species is recorded under the family Malvaceae which include 3 species. The plant genus and species with maximum number of representation is recorded by the herbaceous plants *Cynodon dactylon* and *Cyathula prostrata* (8013 each for genus and species for both). These plants are immediately followed by the herb *Aerva lanata* (6232 each for genus and species).

Table H3: Distribution details of ethnomedicinal plants in the Palliyana sacred grove

SI No	Botanical Name	Family	Habit	No. of plants	Relative density	Relative frequency	Diversity Index (H)
1	<i>Abrus precatorius</i>	Leguminosae	Climber	36	8.867	5.83	0.215
2	<i>Alstonia scholaris</i>	Apocynaceae	Tree	1	0.246	0.97	0.015
3	<i>Aporosa cardiosperma</i>	Euphorbiaceae	Tree	10	2.463	4.85	0.091
4	<i>Aristolochia indica</i>	Aristolochiaceae	Climber	21	5.172	3.88	0.153
5	<i>Asparagus racemosus</i>	Liliaceae	Climber	21	5.172	3.88	0.153
6	<i>Bridelia stipularis</i>	Euphorbiaceae	Tree	33	8.128	3.88	0.204
7	<i>Cyperus rotundus</i>	Cyperaceae	Herb	26	6.404	3.88	0.176
8	<i>Diospyros malabarica</i>	Ebenaceae	Tree	2	0.493	1.94	0.026
9	<i>Garcinia gummi-gutta</i>	Clusiaceae	Tree	12	2.956	5.83	0.104
10	<i>Gnetum ula</i>	Gnetaceae	Liana	16	3.941	7.77	0.127
11	<i>Gymnema sylvestre</i>	Asclepiadaceae	Climber	14	3.448	3.88	0.116
12	<i>Holigarna arnotiana</i>	Anacardiaceae	Tree	20	4.926	7.77	0.148
13	<i>Hydnocarpus pentandrus</i>	Flacourtiaceae	Tree	20	4.926	7.77	0.148
14	<i>Ichnocarpus frutescens</i>	Apocynaceae	Climber	59	14.53	7.77	0.28
15	<i>Ixora coccinea</i>	Rubiaceae	Shrub	38	9.36	7.77	0.222
16	<i>Memecylon depressum</i>	Melastomataceae	shrub	11	2.709	2.91	0.098
17	<i>Mimusops elengi</i>	Sapotaceae	Tree	13	3.202	6.8	0.11
18	<i>Mussaenda frondosa</i>	Rubiaceae	Shrub	6	1.478	1.94	0.062

19	<i>Saraca asoca</i>	Leguminosae	Tree	1	0.246	0.97	0.015
20	<i>Tabernaemontana alternifolia</i>	Apocynaceae	Tree	4	0.985	1.94	0.046
21	<i>Terminalia bellirica</i>	Combretaceae	Tree	2	0.493	0.97	0.026
22	<i>Tinospora sinensis</i>	Menispermaceae	Climber	40	9.852	6.8	0.228
TOTAL				406	23.66	21.02	2.76

Table H4: Distribution details of ethnomedicinal plants in the disturbed non-sacred grove land at Palliyana site

SI No	Botanical name	Family	Habit	No. of plants	Relative density	Relative frequency	Diversity Index (H)
1	<i>Aerva lanata</i>	Amaranthaceae	Herb	6232	19.97	11.5	0.322
2	<i>Cyathula prostrata</i>	Amaranthaceae	Herb	8013	25.67	13.1	0.349
3	<i>Cynodon dactylon</i>	Poaceae	Herb	8013	25.67	13.1	0.349
4	<i>Datura stramonium</i>	Solanaceae	shrub	3	0.01	1.64	0.001
5	<i>Garcinia gummi-gutta</i>	Clusiaceae	Tree	2	0.006	3.28	0.001
6	<i>Ichnocarpus frutescens</i>	Apocynaceae	Climber	9	0.029	4.92	0.002
7	<i>Lawsonia inermis</i>	Lythraceae	Shrub	2	0.006	1.64	0.001
8	<i>Leucas aspera</i>	Lamiaceae	Herb	3561	11.41	9.84	0.248
9	<i>Phyllanthus amarus</i>	Euphorbiaceae	Herb	5342	17.11	11.5	0.302
10	<i>Sida acuta</i>	Malvaceae	Shrub	13	0.042	9.84	0.003
11	<i>Sida cordifolia</i>	Malvaceae	Shrub	9	0.029	8.2	0.002
12	<i>Sida rhombifolia</i>	Malvaceae	Shrub	14	0.045	11.5	0.003
Total				31214	19.02	18.21	1.58

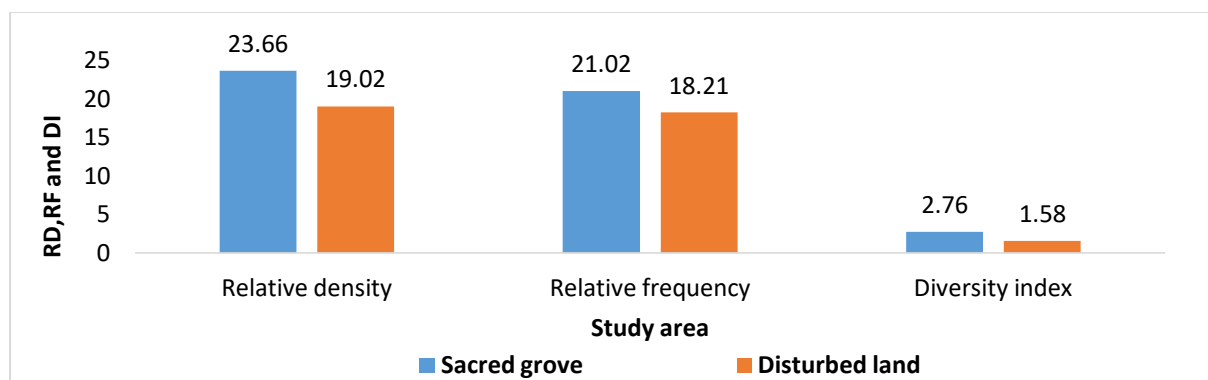


Figure H4: Comparison of relative density, relative frequency and diversity index of ethnomedicinal plants in Palliyana sacred grove and disturbed non-sacred grove land

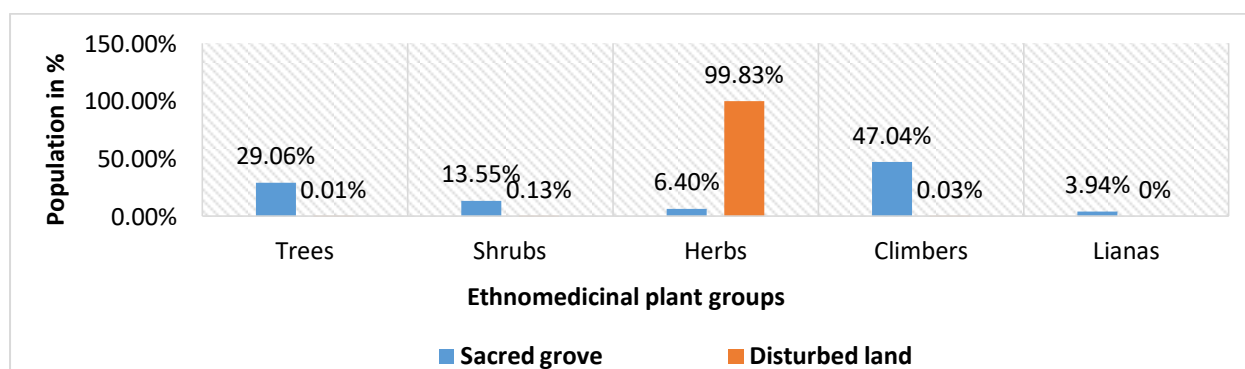


Figure H5: Population wise distribution of various ethnomedicinal plant groups in Palliyana sacred grove and disturbed non-sacred grove land

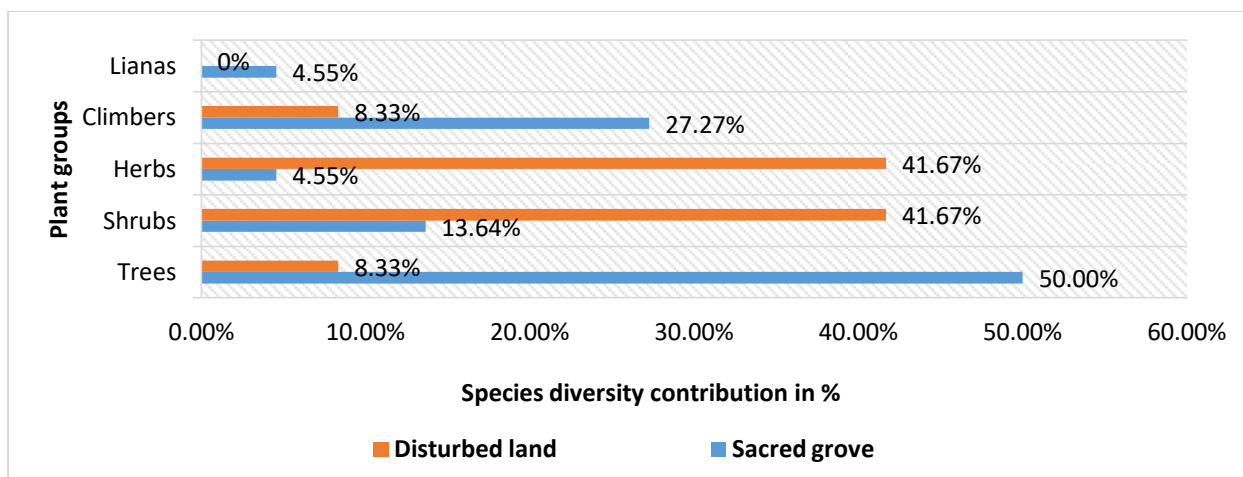


Figure H6: Species diversity contribution of various ethnomedicinal plant groups in Palliayana sacred grove and disturbed non-sacred grove land

The details of ethnomedicinal plants such as local name, useful part and the traditional uses in treating ailments in the Palliayana sacred grove and in the corresponding disturbed non-sacred grove land of similar extent are shown in table H9 and table H10 respectively.

C) Nambiyath sacred grove and disturbed non-sacred grove land

Ethnomedicinal plants identified in the Nambiyath sacred grove along with their distribution details are shown in table H5. Twenty two plant species are identified as commonly used ethnomedicinal plants by the local people and traditional healers in the area. These plants are distributed in 22 genera belonging to 18 families and constituted around 27.16% of the total plant species represented while, total population of ethnomedicinal plants constituted about 32.9% of the entire plant population in the grove. Comparatively higher number of ethnomedicinal plant species in the grove is represented by the plant group trees (36.36%). This is followed by herbs (22.73%), climbers (18.18%), shrubs (13.64%) and the lowest representation by lianas (9.09%). In the disturbed land, 18 plant species are identified as ethnomedicinal and are distributed in 15 genera belonging to 14 families (table 6). This constituted 33.33% of the total plant species represented and their total population is covered by about 41.62% of the entire plant population in the disturbed land. The highest proportion of ethnomedicinal plant species in the disturbed land is represented by the plant group herbs (61.11%) and this is followed by shrubs and climbers (16.67% each) and then trees (5.56%). No lianas are recorded as ethnomedicinal in the disturbed land. With the exception of herbs and shrubs, all other plant groups in disturbed land recorded lower representations of ethnomedicinal plant species compared to sacred grove. The decrease identified are of 87.5%,

25% and 100% respectively for trees, climbers and lianas while an increase of 54.55% is recorded for herbs whereas no difference was recorded with respect to shrubs.

Table H5: Distribution details of ethnomedicinal plants in the Nambiyath sacred grove

SI No	Botanical Name	Family	Habit	No. of plants	Relative density	Relative frequency	Diversity Index (H)
1	<i>Abrus precatorius</i>	Leguminosae	Climber	18	5.96	2.63	0.168
2	<i>Aerva lanata</i>	Amaranthaceae	Herb	10	3.311	7.02	0.113
3	<i>Alstonia scholaris</i>	Apocynaceae	Tree	1	0.331	0.88	0.019
4	<i>Asparagus racemosus</i>	Liliaceae	Climber	10	3.311	1.75	0.113
5	<i>Boerhaavia diffusa</i>	Nyctaginaceae	Herb	12	3.974	6.14	0.128
6	<i>Curculigo orchoides</i>	Hypoxidaceae	Herb	16	5.298	4.39	0.156
7	<i>Cyathula prostrata</i>	Amaranthaceae	Herb	13	4.305	6.14	0.135
8	<i>Diospyros malabarica</i>	Ebenaceae	Tree	5	1.656	3.51	0.068
9	<i>Dracaena terniflora</i>	Dracaenaceae	Shrub	13	4.305	4.39	0.135
10	<i>Emilia sonchifolia</i>	Asteraceae	Herb	17	5.629	5.26	0.162
11	<i>Garcinia gummi-gutta</i>	Clusiaceae	Tree	3	0.993	2.63	0.046
12	<i>Gnetum ula</i>	Gnetaceae	Liana	55	18.21	7.02	0.31
13	<i>Holigarna arnottiana</i>	Anacardiaceae	Tree	7	2.318	4.39	0.087
14	<i>Hydnocarpus pentandrus</i>	Flacourtiaceae	Tree	14	4.636	6.14	0.142
15	<i>Ichnocarpus frutescens</i>	Apocynaceae	Climber	18	5.96	7.02	0.168
16	<i>Ixora coccinea</i>	Rubiaceae	Shrub	27	8.94	7.02	0.216
17	<i>Mimusops elengi</i>	Sapotaceae	Tree	5	1.656	3.51	0.068
18	<i>Mussaenda frondosa</i>	Rubiaceae	Shrub	5	1.656	2.63	0.068
19	<i>Tabernaemontana alternifolia</i>	Apocynaceae	Tree	9	2.98	5.26	0.105
20	<i>Terminalia bellirica</i>	Combretaceae	Tree	2	0.662	0.88	0.033
21	<i>Tinospora sinensis</i>	Menispermaceae	Climber	7	2.318	4.39	0.087
22	<i>Uvaria narum</i>	Annonaceae	Liana	35	11.59	7.02	0.25
Total				302	33.15	28.15	2.78

Table H6: Distribution details of ethnomedicinal plants in the disturbed non-sacred grove land at Nambiyath site

SI No	Botanical Name	Family	Habit	No. of plants	Relative density	Relative frequency	Diversity Index (H)
1	<i>Abrus precatorius</i>	Leguminosae	Climber	10	0.048	6.38	0.004
2	<i>Achyranthes aspera</i>	Amaranthaceae	Herb	2732	13.19	8.51	0.267
3	<i>Aerva lanata</i>	Amaranthaceae	Herb	3339	16.12	8.51	0.294
4	<i>Andrographis echinoides</i>	Acanthaceae	Herb	2125	10.26	5.32	0.234
5	<i>Andrographis paniculata</i>	Acanthaceae	Herb	2125	10.26	7.45	0.234
6	<i>Anisomeles indica</i>	Lamiaceae	Herb	1518	7.331	4.26	0.192
7	<i>Boerhavia diffusa</i>	Nyctaginaceae	Herb	1518	7.331	5.32	0.192
8	<i>Cyperus rotundus</i>	Cyperaceae	Herb	2125	10.26	5.32	0.234
9	<i>Ichnocarpus frutescens</i>	Apocynaceae	Climber	11	0.053	5.32	0.004
10	<i>Leucas aspera</i>	Lamiaceae	Herb	1821	8.794	4.26	0.214
11	<i>Oldenlandia corymbosa</i>	Rubiaceae	Herb	1214	5.863	4.26	0.166
12	<i>Phyllanthus amarus</i>	Euphorbiaceae	Herb	1214	5.863	4.26	0.166
13	<i>Quassia indica</i>	Simaroubaceae	Tree	1	0.005	1.06	5E-04
14	<i>Scoparia dulcis</i>	Scrophulariaceae	Herb	911	4.399	3.19	0.137
15	<i>Sida cordifolia</i>	Malvaceae	Shrub	9	0.043	6.38	0.003
16	<i>Sida rhombifolia</i>	Malvaceae	Shrub	10	0.048	7.45	0.004
17	<i>Sida mysorensis</i>	Malvaceae	Shrub	7	0.034	5.32	0.003
18	<i>Tiliacora racemosa</i>	Menispermaceae	Climber	17	0.082	7.45	0.006
Total				20707	41.97	37.9	2.35

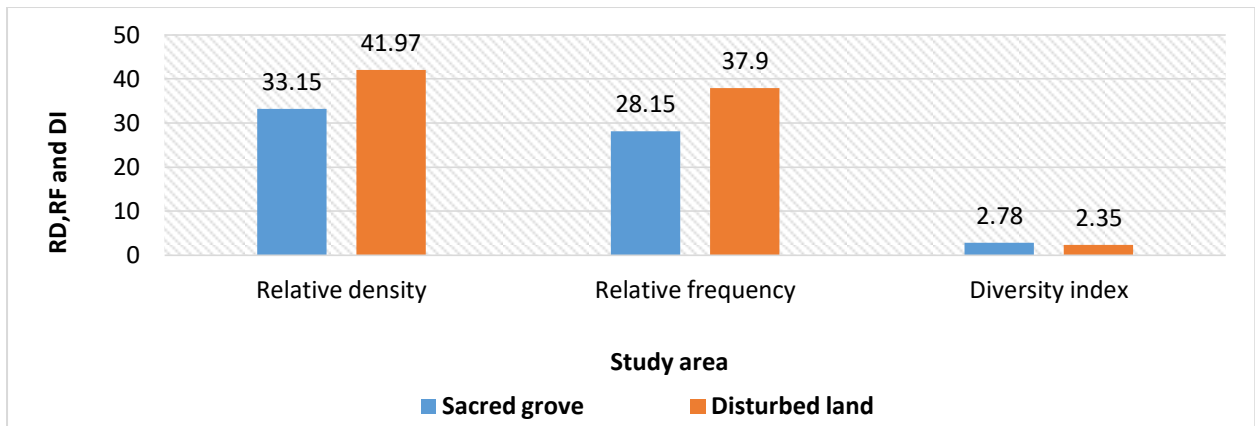


Figure H7: Comparison of relative density, relative frequency and diversity index of ethnomedicinal plants in Nambiyath sacred grove and disturbed non-sacred grove land

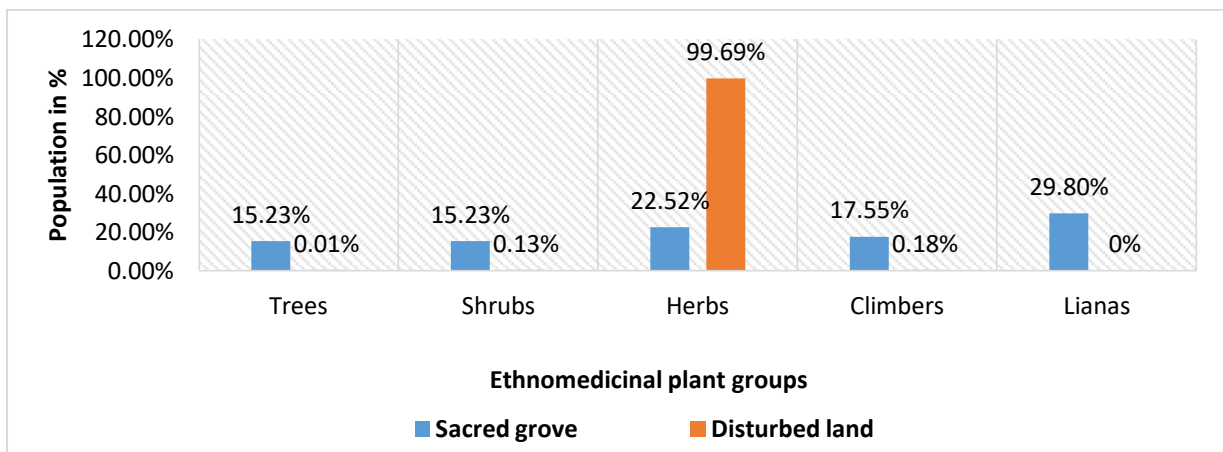


Figure H8: Population wise distribution of various ethnomedicinal plant groups in Nambiyath sacred grove and disturbed non-sacred grove land

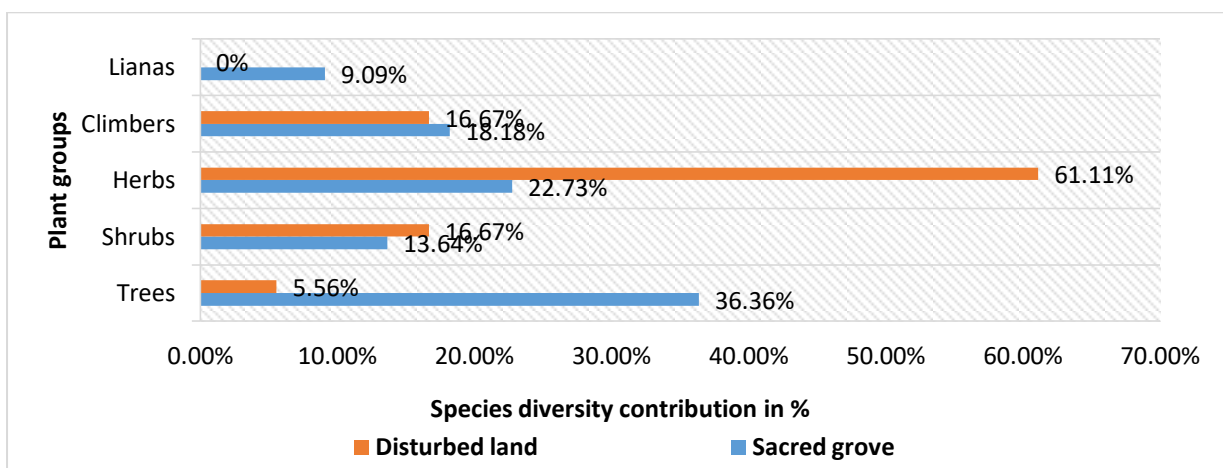


Figure H9: Species diversity contribution of various ethnomedicinal plant groups in Nambiyath sacred grove and disturbed non-sacred grove land

The family with highest number of ethnomedicinal plant population in Nambiyath sacred grove is Gnetaceae, which have a total of 55 plants. This is immediately followed by Annonaceae and Rubiaceae with a total population of 35 and 32 plants respectively. The highest number of ethnomedicinal genera and species are recorded under the family Apocynaceae, which include 3 genera and 3 species. Followed by the family Apocynaceae is Amaranthaceae and Rubiaceae which consist of 2 genera and 2 species each. The plant genera as well as species which recorded the highest number of representation is by the liana *Gnetum ula* (55 each for genera and species), immediately followed by the liana *Uvaria narum* (35 each for genera and species) and then the shrub *Ixora coccinea* (27 each for genera and species). The data obtained from the disturbed land showed the highest ethnomedicinal plant population in the family Amaranthaceae, which have a total of 6071 plants. Amaranthaceae is immediately followed by the family Acanthaceae and then Cyperaceae with a total population of 4250 and 2125 respectively. The family with maximum number of ethnomedicinal genera is recorded under the Amaranthaceae (2 genera) while highest number plant species is recorded by Malvaceae (3 species). Immediately followed by Malvaceae, the families Amaranthaceae and Acanthaceae recorded 2 species each. The plant genus as well as the species which recorded highest number of individual representation is by the herb *Aerva lanata* (3339 each). This is immediately followed by the herb *Achyranthes aspera* (2732 each for genus and species) and then *Andrographis echiodides*, *Andrographis paniculata* and *Cyperus rotundus* (2125 each for genus and species in each case). The details of identified ethnomedicinal plants such as local name, useful part and the traditional uses in treating ailments in the Nambiyath sacred grove and in the corresponding disturbed non-sacred grove land are shown in table H9 and table H10 respectively.

D) Poyyara study site

The details of ethnomedicinal plants identified in the Poyyara sacred grove is shown in table H7. Twenty plant species are identified as commonly used ethnomedicinal plants in the area. These plants are distributed in 20 genera belonging to 16 families and constituted 33.9% of the total plant species in the grove. Total population of ethnomedicinal plants occupied 30.23% of the entire plant population in the grove. The highest number of ethnomedicinal plant species is represented by the plant group herbs (35%) and this is followed by trees (30%), climbers (20%), shrubs (10%) and the lowest representation by the lianas (5%). The family which recorded highest ethnomedicinal plant population is Loganiaceae with a total of

41 individuals. The Loganiaceae is immediately followed by Rubiaceae and then Leguminosae with a total population of 33 and 26 respectively. The maximum number of ethnomedicinal genera and species are recorded under the families Rubiaceae, Leguminosae, Apocyanaceae and Amaranthaceae, each consisting of 2 genus and 2 species. The most dominant genus as well as the species is the climber *Strychnos minor* (41 each for plant genera and species). This is immediately followed by the climbers *Cyphostemma trilobata* and *Abrus precatorius* (20 each for both plants).

In the disturbed land, 11 plant species are identified as ethnomedicinal and are distributed in 11 genera belonging to 9 families (table 8). These plant species are about 42.31% of the total plant species represented and their total population constituted 69.32% of the entire plant population in the disturbed land. The details such as local name, useful part and their traditional uses in treating various ailments are shown in table 9. The highest proportion of ethnomedicinal plant species in the disturbed land is belonging to the plant group herbs (81.82%) and this is followed by shrubs and climbers (9.09% each). No species of trees and lianas are recorded as ethnomedicinal in the disturbed land. With the exception of 22.22% increase in the diversity of plant species in the plant group herbs, all other plant groups in disturbed land recorded lower representations or even total absence of ethnomedicinal plant species compared to sacred grove. Reduction of 50% and 75% is recorded respectively for shrubs and climbers while total absence for lianas & trees. The family which occupied the highest number of ethnomedicinal plant population in the disturbed land is Amaranthaceae (1012 plants) and this is immediately followed by Euphorbiaceae (911 plants). The maximum number of ethnomedicinal genera and species are recorded under the families Amaranthaceae and Euphorbiaceae; each consists of 2 genera and 2 species. The dominant genera and the species in the disturbed land are represented by a number of herbaceous plants of equal distribution. This includes *Achyranthes aspera*, *Aerva lanata*, *Cynodon dactylon*, *Cyperus rotundus*, *Leucas aspera* and *Phyllanthus amarus*, each having a total representation of 506 genera and species each.

Table H7: Distribution details of ethnomedicinal plants in the Poyyara sacred grove

SI No	Botanical Name	Family	Habit	No. of plants	Relative density	Relative frequency	Diversity Index (H')
1	<i>Abrus precatorius</i>	Leguminosae	Climber	20	9.615	8.25	0.225
2	<i>Aegle marmelos</i>	Rutaceae	Tree	1	0.481	1.03	0.026
3	<i>Aerva lanata</i>	Amaranthaceae	Herb	6	2.885	4.12	0.102
4	<i>Biophytum reinwardtii</i>	Oxalidaceae	Herb	6	2.885	4.12	0.102
5	<i>Boerhaavia diffusa</i>	Nyctaginaceae	Herb	4	1.923	3.09	0.076
6	<i>Cissus trilobata</i>	Vitaceae	Climber	20	9.615	7.22	0.225

7	<i>Cyathula prostrata</i>	Amaranthaceae	Herb	10	4.808	5.15	0.146
8	<i>Desmodium gangeticum</i>	Leguminosae	Herb	6	2.885	4.12	0.102
9	<i>Emilia sonchifolia</i>	Asteraceae	Herb	5	2.404	3.09	0.09
10	<i>Garcinia gummi-gutta</i>	Clusiaceae	Tree	3	1.442	3.09	0.061
11	<i>Gnetum ula</i>	Gnetaceae	Liana	13	6.25	7.22	0.173
12	<i>Holigarna arnottiana</i>	Anacardiaceae	Tree	3	1.442	3.09	0.061
13	<i>Hopea ponga</i>	Dipterocarpaceae	Tree	1	0.481	1.03	0.026
14	<i>Hydnocarpus pentandrus</i>	Flacourtiaceae	Tree	4	1.923	4.12	0.076
15	<i>Ichnocarpus frutescens</i>	Apocynaceae	Climber	15	7.212	6.19	0.19
16	<i>Ixora coccinea</i>	Rubiaceae	Shrub	18	8.654	8.25	0.212
17	<i>Polyalthia korintii</i>	Annonaceae	Shrub	13	6.25	7.22	0.173
18	<i>Spermacoce articularis</i>	Rubiaceae	Herb	15	7.212	7.22	0.19
19	<i>Strychnos minor</i>	Loganiaceae	Climber	41	19.71	8.25	0.32
20	<i>Tabernaemontana alternifolia</i>	Apocynaceae	Tree	4	1.923	4.12	0.076
Total				208	33.44	34.4	2.65

Table H8: Distribution details of ethnomedicinal plants in the disturbed non-sacred grove land at Poyyara site

SI No	Botanical Name	Family	Habit	No. of plants	Relative density	Relative frequency	Diversity Index (H')
1	<i>Abrus precatorius</i>	Leguminosae	Climber	8	0.188	10.7	0.012
2	<i>Achyranthes aspera</i>	Amaranthaceae	Herb	506	11.86	8.93	0.253
3	<i>Aerva lanata</i>	Amaranthaceae	Herb	506	11.86	7.14	0.253
4	<i>Andrographis paniculata</i>	Acanthaceae	Herb	404	9.47	5.36	0.223
5	<i>Boerhavia diffusa</i>	Nyctaginaceae	Herb	405	9.494	7.14	0.224
6	<i>Cynodon dactylon</i>	Poaceae	Herb	506	11.86	10.7	0.253
7	<i>Cyperus rotundus</i>	Cyperaceae	Herb	506	11.86	7.14	0.253
8	<i>Euphorbia hirta</i>	Euphorbiaceae	Herb	405	9.494	10.7	0.224
9	<i>Leucas aspera</i>	Lamiaceae	Herb	506	11.86	10.7	0.253
10	<i>Phyllanthus amarus</i>	Euphorbiaceae	Herb	506	11.86	10.7	0.253
11	<i>Sida cordifolia</i>	Malvaceae	Shrub	8	0.188	10.7	0.012
Total				4266	69.33	47.86	2.21

The details of ethnomedicinal plants identified in the Poyyara sacred grove and in the corresponding disturbed non-sacred grove land such as local name, useful part and the traditional uses in treatment of ailments are shown in table H9 and table H10 respectively.

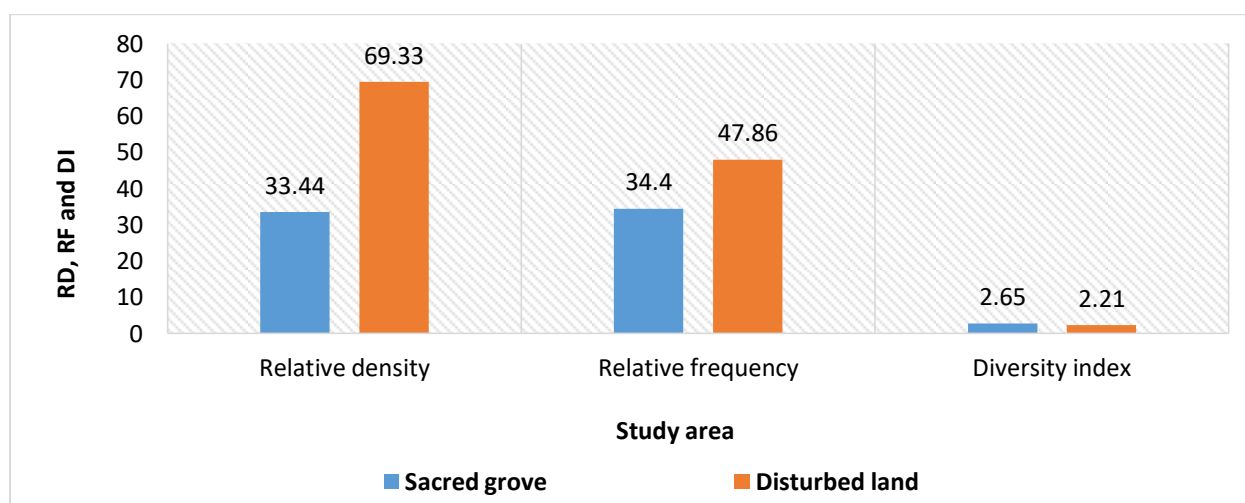


Figure H10: Comparison of relative density, relative frequency and diversity index of ethnomedicinal plants in Poyyara sacred grove and disturbed non-sacred grove land

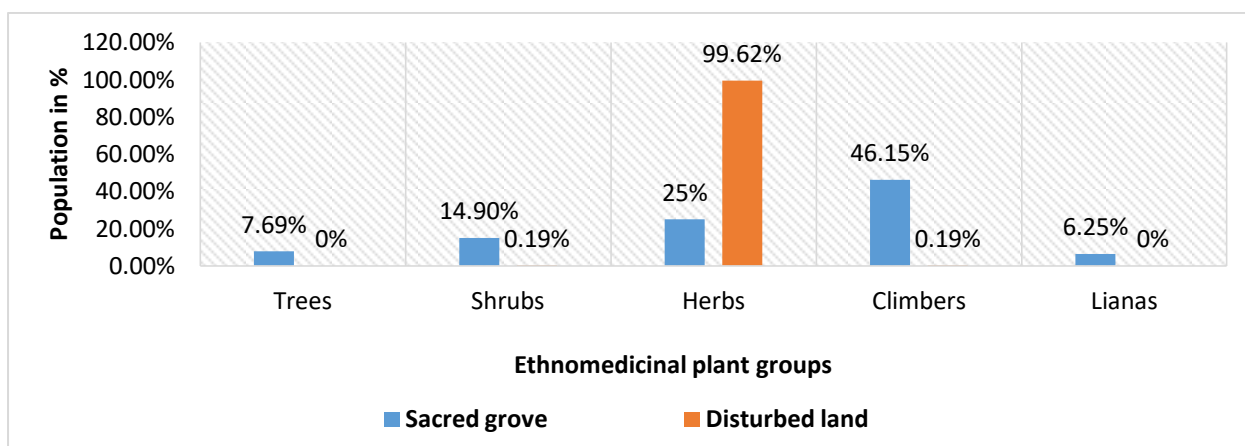


Figure H11: Population wise distribution of various ethnomedicinal plant groups in Poyyara sacred grove and disturbed non-sacred grove land

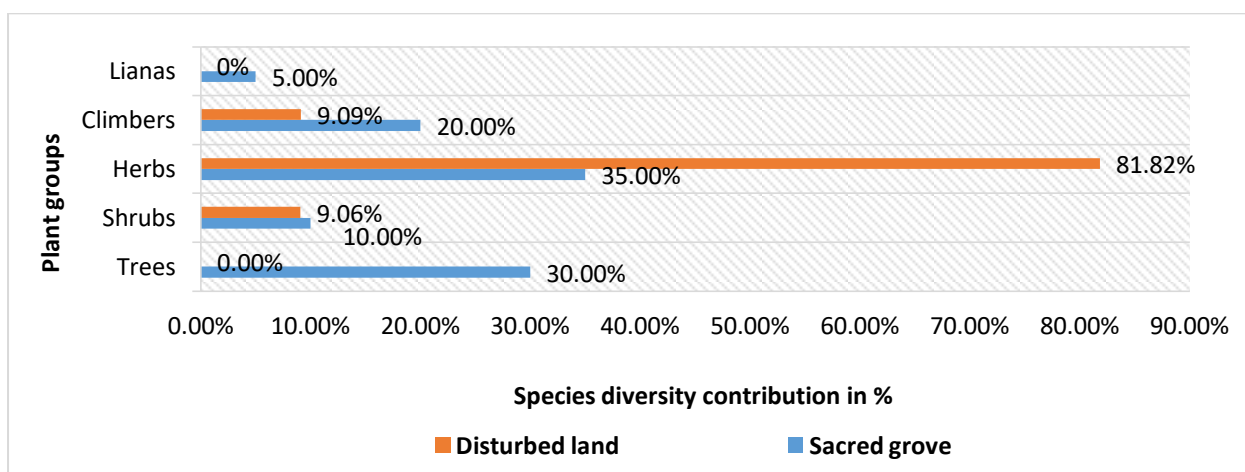


Figure H12: Species diversity contribution of various ethnomedicinal plant groups in Poyyara sacred grove and disturbed non-sacred grove land

Table H9: Details of ethnomedicinal plants, parts used, ethnomedicinal uses in the selected four sacred groves

Sl. No	Name of the species	Local name	Parts used	Medicinal uses
1	<i>Abrus precatorius</i> *(SaSG, PaSG, NaSG, PoySG)	Kunni	Whole plant	Leaf juice is a blood purifier. Root paste is applied on swellings and skin diseases. Plant extract is boiled with coconut oil is used as hair tonic.
2	<i>Aegle marmelos</i> * (PoySG)	Koovalam	Leaves	Aqueous extract of leaves are used to treat asthma, anti-diabetic, jaundice. Seeds shows anti-allergic activity. Roots shows anti-inflammatory effect.
3	<i>Aerva lanata</i> * (NaSG, PoySG)	Cherula	Whole plant	Whole plant is boiled with water and this decoction is used for the treatment of cough and urinary problems.
4	<i>Alstonia scholaris</i> * (PaSG, NaSG)	Ezhilampala	Bark	Decoction of bark is used in the treatment of diarrhoea, dysentery, liver complaints, skin diseases and rheumatic pains. Milky juice is applied to ulcers.
5	<i>Aporosa cardiosperma</i> (PaSG)	Vetti	Roots	Oral administration of root extract is used for jaundice.
6	<i>Aristolochia indica</i> * (PaSG)	Karalakam	Whole plant	Seeds are used to treat dry cough and pain in the joints. Decoction of roots are recommended in cases of cholera, diarrhoea and leucoderma. Plant is anti-poisonous.

7	<i>Asparagus racemosus</i> * (SaSG, PaSG, NaSG)	Sathavari	Tubers	Root is used in the treatment of throat problems, tuberculosis, leprosy, epilepsy, diseases of blood, kidney and liver and gonorrhoea. A decoction of tubers in milk is very effective in bladder problems. The root extract with a honey is given against colic.
8	<i>Biophytum reinwardtii</i> * (PoySG)	Mukkutti	Whole plant	Whole plant is crushed and juice is used for cough, asthma and oral administration of cooked whole plant with duck egg is used for piles.
9	<i>Boerhaavia diffusa</i> (NSG, PoSG)	Thazhuthama	Whole plant	Oral administration of decoction of whole plant is useful for asthma, dysentery and diarrhea.
10	<i>Bridelia stipularis</i> * (PSG)	Cherupanachi	Roots, leaves and bark	Aqueous extraction of bark is used to prepare a mouth wash, paste of leaves and stem cure eczema. Oral administration of decoction of root and stem for asthma, cough and internal sores.
11	<i>Cyphostemma trilobata</i> * (PaSG)	Neelachunnabuvalli	Leaves and root	Powdered leaves and roots are mixed with heated castor oil is externally applied on area affected by rheumatism.
12	<i>Connarus monocarpus</i> * (SaSG)	Kurilathali	Leaves	Pounded leaves are applied to painful swellings, seeds are used to treat nervous disorders, contraceptive also. Root extract is used against sore throat, asthma, fever and skin diseases.
13	<i>Curculigo orchioideis</i> * (NaSG)	Nilappana	Rhizome	Rhizome is boiled in water and make paste with milk is used for asthma, bronchitis and jaundice.
14	<i>Cyathula prostrata</i> * (NaSG, PoySG)	Cherukadaladi	Whole plant	Whole plant is crushed and ground into a paste is applied for skin diseases. Decoction of roots is given for dysentery.
15	<i>Cyperus rotundus</i> * (PaSG)	Muthanga	Rhizome	Powdered rhizome is mixed with milk is used for digestive disorders and renal problems.
16	<i>Desmodium gangeticum</i> * (SaSG, PoySG)	Orila	Roots	Root paste is applied for chronic fever, cough, vomiting, asthma and rheumatism.
17	<i>Diospyros malabarica</i> * (PaSG, NaSG)	Panachi	Bark and seeds	Infusion of fruits is used to sore throat. Fruit juice is used as an application for wounds and ulcers. Oral administration of seed oil is given in diarrhoea and dysentery.
18	<i>Dracaena terniflora</i> * (NaSG)	Manjakantha	Root	Root extract is applied for skin diseases, consumption of aqueous extract is useful for jaundice.
19	<i>Elephantopus scaber</i> * (SaSG)	Anachuvadi	Whole plant	A decoction of leaves and roots is used to treat diarrhoea, dysentery and swelling or pain in the stomach. Bruised leaves are applied to ulcers and eczema.
20	<i>Emilia sonchifolia</i> * (NaSG, PoySG)	Muyalcheviyan	Whole plant	A decoction of whole plant used to treat tonsillitis, bleeding piles and fever. Whole plant is crushed and made paste is applied on throat is beneficial for sore throat.
21	<i>Garcinia gummi-gutta</i> * (PaSG, NaSG, PoySG)	Kudampulli	Roots, leaves and fruits.	A decoction of the fruit rind is used for the treatment of rheumatism, bowel complaints, piles and disorders in the womb.
22	<i>Gnetum ula</i> * (SaSG, PaSG, NaSG, PoySG)	Odavalli	Seeds	Seed oil is externally applied on area affected by rheumatism.
23	<i>Gymnema sylvestre</i> * (PaSG)	Chakkarakolli	Roots, leaves	Roots and leaves are boiled with water and this extract used for balancing the blood sugar levels, cough and sore eye.
24	<i>Hibiscus rosa-sinensis</i> * (SaSG)	Chembarathi	Root, leaves, flower	Crushed leaves with water is used as hair tonic. Decoction of boiled flowers used for menstrual problems.
25	<i>Holigarna arnottiana</i> * (SaSG, PaSG, NaSG, PoySG)	Cheru	Bark	Highly diluted bark decoction mixed with milk and turmeric used in mild skin problems.
26	<i>Hopea ponga</i> * (SaSG, PoySG)	Thambakam	Root, Bark	Root decoction taken orally for piles. Bark paste mixed with milk taken to minimize spreading of poison during snake bite.
27	<i>Hydnocarpus pentandrus</i> * (SaSG, PaSG, NaSG, PoySG)	Marotti	Seeds	Seed oil applied to area affected by rheumatism.
28	<i>Ichnocarpus frutescens</i> * (SaSG, PaSG, NaSG, PoySG)	Parvalli	Root, leaves	Root and leaf extract is applied externally to treat back pain and skin diseases.
29	<i>Ixora coccinea</i> * (PaSG, NaSG, PoySG)	Marunnuchethi	Flowers	Water boiled with the leaves is an effective wash in skin diseases, Oil prepared with the flowers is used for external application in itch and skin eruptions. Flower buds are used in the treatment of conjunctivitis and redness of the eyes. The decoction of root is effective in dysentery, gonorrhoea, leucorrhoea and nausea.
30	<i>Kametia caryophyllata</i> * (SaSG)	Narumarathivu	Leaves, roots	Decoction of the whole plant is used for leprosy and arthritis. Leaf paste is applied on affected area for itches and scabies.

31	<i>Laborite interrupta</i> * (SaSG)	Choriyanam	Leaves, root, fruits.	Root is crushed and juice taken for fever and leaves crushed and made paste is directly applied to headache.
32	<i>Memecylon depressum</i> * (PaSG)	Kaikkathetti	Bark and fruits	Leaf paste used in snake bite. A lotion prepared from the leaves is used in ophthalmia. Fruits are used to treat skin diseases.
33	<i>Memecylon grande</i> * (SaSG)	Palluvirisa	Bark, fruits	Leaf paste used in snake bite. Root decoction is used for abnormal menstrual periods.
34	<i>Mimusops elengi</i> * (PaSG, NaSG)	Elanji	Bark and fruit	A decoction of the bark forms a good gargle in odontalgia, oral administration of ripe fruit pulp is used against dysentery.
35	<i>Mussaenda frondosa</i> * (SaSG, PaSG, NaSG)	Vellilam	Leaves	Decoction of stem is used as a remedy for cough and decoction of root is given against white leprosy. Aqueous extract of leaves in hot water used as shampoo.
36	<i>Ocimum basilicum</i> * (SaSG)	Ramathulasi	Leaves	Decoction made from boiled leaves is used for headaches, coughs, and diarrhea. Leaf crushed and made paste with turmeric is orally administered for worms.
37	<i>Ocimum tenuiflorum</i> * (SaSG)	Krishna thulasi	Leaves	Decoction made from leaves boiled with water is used for cough, fever and leaves crushed and made paste is directly applied as antidote for insect bites.
38	<i>Polyalthia korinti</i> * (SaSG, PoySG)	Karuvalli, Korandippanal	Leaves, bark	Decoction of bark is used for cold and cough, Leaf paste is applied as antidote for snake bite.
39	<i>Quassia indica</i> * (SaSG)	Karingotta	Bark, seeds	An infusion of leaves is used to kill lice, fleas, and white ants. Seeds are used against bilious fever and are used as a purgative and emetic. Oil from seeds is used as an external application in rheumatism.
40	<i>Saraca asoca</i> * (PaSG)	Asokam	Bark and Flowers	The bark is a uterine tonic and it is used extensively leucorrhoea and various forms of menstrual disorders. It cures inflammation of the cervical glands, thirst and burning sensation.
41	<i>Spermocoe articularis</i> * (PoySG)	Kudalchurukki/ Natthachuri / Tharthavel	Whole plant	Leaves extract is used for haemorrhoids and gall stones. Seeds for diarrhoea and dysentery. Root is used as mouthwash to cure toothache. Decoction of whole plant is used to headache.
42	<i>Sterculia guttata</i> * (SaSG)	Peenaari/Kavalam	Bark, seeds	Leaves and bark grinded using water and this paste is applied for swellings.
43	<i>Strychnos minor</i> * (SaSG, PoySG)	Cherukanjiravalli	Bark	Leaves and roots are boiled in oil and applied to rheumatic swellings. Bark is used as antipyretic.
44	<i>Syzygium lanceolatum</i> * (SaSG)	Karinjaval	Fruits	Oral administration of decoction of fruits are used for piles.
45	<i>Syzygium zeylanicum</i> * (SaSG)	Poochapazham	Leaves, fruits	Decoction of fruits are orally taken for diarrhea and leaf paste is applied on anti-rheumatic.
46	<i>Tabernaemontana alternifolia</i> * (SaSG, PaSG, NaSG, PoySG)	Kuruttupala	Leaves	Latex from leaves directly applying on warts, wounds and other skin diseases.
47	<i>Terminalia bellirica</i> * (SaSG, PaSG, NaSG)	Thanikka	Fruits, seeds	Powdered seeds and fruits with honey are used for cough and fever.
48	<i>Tiliacora racemosa</i> * (SaSG)	Vallikanjiram	Bark, root, leaves	Paste of bark, root and leaves used as antidote for snake bite.
49	<i>Tinospora sinensis</i> * (PaSG, NaSG)	Chittamruthu	Whole plant	Plant juice is recommended for gonorrhoea. Decoction of stem is used in the treatment of giddiness, piles, anaemia, diabetes, vaginal and urethral discharges and enlarged spleen.
50	<i>Torenia bicolor</i> * (SaSG)	Malatilata, Malatipuspam	Whole plant	Juice taken from the crushed whole plant is applied for eye infections.
51	<i>Uvaria narum</i> * (SaSG, NaSG)	Paanal	Roots	A decoction of roots are used to stomach pain after childbirth. External application of root extract is used for skin problems.

***mark and letters in parathesis indicate occurrence of ethnomedicinal plant species in study areas**

SaSG, PaSG, NaSG & PoySG represent Sankulangara sacred grove, Palliyana sacred grove, Nambiyath sacred grove & Poyyara sacred grove respectively.

Table H10: Details of ethnomedicinal plants, parts used, ethnomedicinal uses in the selected four disturbed non-sacred grove lands

Sl. No	Name of the species	Local name	Parts used	Medicinal uses
1	<i>Abrus precatorius</i> * (NaDL, PoDL)	Kunni	Whole Plant	Leaf juice is a blood purifier. Root paste is used for swellings and skin diseases. Plant extract is boiled with coconut oil.
2	<i>Achyranthes aspera</i> * (NaDL, PoyDL)	Kadaladi	Whole plant	Leaf juice is useful for wounds. A paste of seeds with water in which rice has been washed, is reckoned to be beneficial in cases of bleeding piles. Root is boiled with water is useful for urinary problems.
3	<i>Aerva lanata</i> * (SaDL, PaDL, NaDL, PoyDL)	Cherula	Whole plant	Whole plant is boiled with water and this decoction is used for the treatment of cough and urinary problems.
4	<i>Andrographis echinoides</i> * (NaDL)	Gopuramthangi	Whole plant	Plant extract is used to poisonous stings of some insects, influenza and malaria.
5	<i>Andrographis paniculata</i> * (NaDL, PoyDL)	Kiriyathu	Whole plant	Decoction of whole plant cures dysentery, worm infection, liver disorders, it also help to reduce weight of the body.
6	<i>Anisomeles indica</i> * (NaDL)	Karithumba	Leaves and roots	Decoction of roots for urinary affections. Oil from the plant is used against uterine disorders.
7	<i>Biophytum reinwarattii</i> * (SaDL)	Mukkutti	Whole plant	Whole plant is crushed and juice is used for cough, asthma and oral administration of cooked whole plant with duck egg is used for piles.
8	<i>Boerhavia diffusa</i> (NaDL, PoyDL)	Thazhuthama	Whole plant	A decoction of the roots in milk is useful for oedema, decoction of roots are useful in the treatment of asthma, anaemia and internal inflammation.
9	<i>Cyathula prostrata</i> * (SaDL, PaDL)	Cherukadaladi	Whole plant	Whole plant is crushed and ground into a paste is applied for skin diseases. Decoction of roots is given for dysentery.
10	<i>Cynodon dactylon</i> * (SaDL, PaDL, PoyDL)	Karuka, Karukapullu	Whole plant	Plant juice is applied to fresh cuts and wounds. A decoction of the root is given in cases of dropsy and secondary syphilis.
11	<i>Cyperus rotundus</i> * (SaDL, NaDL, PoyDL)	Muthanga	Rhizome	Peeled rhizome is crushed and boiled in milk is used as anti-venom, liver problems and fever.
12	<i>Datura stramonium</i> * (NaDL)	Ummam	Leaves, seeds and flowers	Juice of plant parts are used to treat asthma, rheumatism, gout, hair fall, dandruff and fistulas.
13	<i>Euphorbia hirta</i> * (PoyDL)	Nilappala	Whole plant	Plant extract is used to treat respiratory ailments and worm infestation in children.
14	<i>Garcinia gummi-gutta</i> * (PaDL)	Kudampulli	Roots, leaves and fruits.	A decoction of the fruit rind is used for the treatment of rheumatism, bowel complaints, piles and disorders in the womb.
15	<i>Hydnocarpus pentandrus</i> * (SaDL)	Marotti	Seeds	Oil from the seed is directly applied for rheumatism.
16	<i>Ichnocarpus frutescens</i> * (SaDL, PaDL, NaDL)	Parvalli	Root and leaves	Root and leaf extract are applied externally to treat back pain and skin diseases.
17	<i>Laportea interrupta</i> * (SaDL)	Choriyanam	Leaves, root and fruits.	Root is crushed and juice taken for fever, leaf paste is applied for headache.
18	<i>Lawsonia inermis</i> * (PaDL)	Mylanchi	Leaves, seeds and bark	External application of paste of leaves, seeds and bark is used to treat skin diseases.
19	<i>Leucas aspera</i> * (SaDL, PaDL, NaDL, PoyDL)	Thumpa	Leaves and Flowers	The plant juice is directly applied for skin diseases and headache.
20	<i>Oldenlandia corymbosa</i> * (NaDL)	Parpadakapullu	Whole plant	Plant extract is used to snake bite and whole plant is boiled with water is useful for liver problems.
21	<i>Phyllanthus amarus</i> * (SaDL, PaDL, NaDL, PoyDL)	Keezharnelli, Kiruthaanelli	Whole plant	Whole plant is crushed and ground into a paste with milk and consumed on empty stomach for liver problems.
22	<i>Quassia indica</i> * (NaDL)	Karingotta	Seeds, leaves and oil	An infusion of leaves is used to kill lice, fleas, and white ants. Seeds are used against bilious fever and are used as a purgative and emetic. Oil from seeds is used as an external application in rheumatism.
23	<i>Scoparia dulcis</i> * (NaDL)	Kallurukki	Whole plant	Decoction of the root is given in blennorrhagia and in excessive menstruation. Infusion of the plant is useful for the treatment of urolithiasis.
24	<i>Sida acuta</i> * (SaDL, PaDL)	Anakurunthotti, Cheruparava	Roots	A decoction of leaves and roots is given in haemorrhoids and impotence, decoction of root is used for nervous and urinary diseases.
25	<i>Sida cordifolia</i>	Kurunthotti	Roots	Decoction of whole plant is used for rheumatism, Root juice

	* (SaDL, PaDL, NaDL, PoyDL)			is used for healing wounds and fever.
26	<i>Sida mysorensis</i> * (NaDL)	Katukurunthotti	Leaves	Paste of leaves are applied externally to heal the wounds.
27	<i>Sida rhombifolia</i> * (SaDL)	Kurunthotti, Vankurunthotti	Roots	A decoction of the roots mixed with milk is used in rheumatism, arthritis and allied complaints and decoction of roots facilitate child birth.
28	<i>Sida rhombifolia</i> * (PaDL, NaDL)	Kurunthotti, Vankurunthotti	Roots	A decoction of the roots mixed with milk is used in rheumatism, arthritis and allied complaints and decoction of roots facilitate child birth.
29	<i>Tabernaemontana alternifolia</i> * (SaDL)	Kuruttupala	Leaves	Latex from leaves directly applying on warts, wounds and other skin diseases.
30	<i>Tiliacora racemosa</i> * (NaDL)	Vallikanjiram	Leaves and seeds	Paste of bark, root and leaves used as antidote for snake bite.

***mark and letters in parenthesis indicate occurrence of ethnomedicinal plant species in study areas**

SaDL, PaDL, NaDL & PoyDL represent Sankulangara disturbed land, Palliyana disturbed land, Nambiyath disturbed land & Poyyara disturbed land respectively.

Discussion

The analysis of occurrence, distribution and diversity of ethnomedicinal plants in the selected sacred groves and their corresponding disturbed non-sacred grove lands revealed considerable differences in the overall ethnomedicinal plant wealth. The species diversity of ethnomedicinal plants in all the studied groves are found remarkably higher compared to the disturbed land of similar extents. 20 - 28 plant species are identified as commonly used ethnomedicinal plants in the groves while it is 11-18 plant species in the disturbed lands. The results showed 50.0%, 45.45%, 18.18% and 45.0% higher species diversity in sacred groves respectively at Sankulangara, Palliyana, Nambiyath and Poyyara compared to their corresponding selected disturbed non-sacred grove lands. Similarly, the diversity of plant genus as well as the family is also found very higher in sacred groves compared to disturbed lands. The study recorded 53.85%, 54.55%, 31.82% and 45.0% increase in the diversity of plant genus and 54.55%, 47.06%, 22.22% and 43.75% increase in the diversity of families in the selected sacred groves over disturbed lands respectively at Sankulangara, Palliyana, Nambiyath and Poyyara study sites (table H14). The species diversity index analysed using the Shannon Wiener Diversity Index (H') revealed higher diversity index values in all the sacred groves over the values of their corresponding disturbed non-sacred grove lands. The comparison of diversity index among different ethnomedicinal plant groups showed, with the exception of herbs, all other groups in sacred groves such as trees, shrubs, climbers and lianas are having higher values compared to the values of disturbed lands whereas, the ethnomedicinal herbs recorded significantly higher diversity index values in all the disturbed lands than their corresponding sacred groves (table H13).

The analysis of dominance done in the selected sacred groves revealed the family Dipterocarpaceae with highest population count of 101 ethnomedicinal plants (constituted 15.91% of the total population of ethnomedicinal plants and 4.76% of the entire plant population) is the most dominant family in the Sankulangara sacred grove. Similarly, the family Apocynaceae with highest population of 64 individuals (constituted 15.91% of the total population of ethnomedicinal plants and 3.73% of the entire plant population) in Palliyana grove; the Gnetaceae with highest population of 55 plants (constituted 18.21% of the total population of ethnomedicinal plants and 6.04% of the entire population) in Nambiyath grove and the family Loganiaceae with highest population of 41 individuals (constituted 21.81% of the total population of ethnomedicinal plants and 6.59% of the entire

plant population) in Poyyara sacred grove are recorded as most dominant families. However, the dominance of families when considered on the basis of maximum diversity in the genera and species occupied by families, Apocynaceae is the most dominant family in Sankulangara, Palliyana and Nambiyath sacred groves while in the case of Poyyara sacred grove, the maximum diversity for both genera and species are recorded equally by four different families which include Apocyanaceae, Rubiaceae, Leguminosae and Amaranthaceae (table H1, H3, H5 & H7). However, the analysis done in the selected disturbed non-sacred grove lands revealed a different picture. When the dominance is considered based on the total population of ethnomedicinal plants occupied by the families; the Poaceae is the most dominant in the disturbed land at Sankulangara with a total plant population of 30180 individuals. This constituted 47.46% of the total ethnomedicinal population and 13.60% of the entire plant population in the study area. The data obtained from other disturbed lands in the study revealed the family Amaranthaceae as most dominant with highest population of 14245, 6071 and 1012 ethnomedicinal plants respectively at Palliyana, Nambiyath and Poyyara. This constituted 45.64%, 29.32% and 23.72% of the total ethnomedicinal population and 8.68%, 12.20%, and 16.44% of the entire plant population in the disturbed lands respectively at Palliyana, Nambiyath and Poyyara. However, when the dominance is considered based on the highest diversity for genera and species, the disturbed land at Sankulangara site showed Amaranthaceae and Apocyanaceae as the most dominant families based on the diversity of genera while this is Malvaceae based on the diversity of species. At Palliyana and Nambiyath sites, the highest diversity for genera is recorded by the family Amaranthaceae alone and species diversity by Malvaceae while at Poyyara site, the highest diversity for both genera and species is recorded by both Amaranthaceae and Euphorbiaceae (table H2, H4, H6 & H8).

The analysis in the dominance of ethnomedicinal genera and the species done in the selected sacred groves revealed the representation of most dominant genera and the species from diverse plant groups. The tree *Hopea ponga* is the most dominant genus as well as the species in the Sankulangara sacred grove and the plant has total population of 101 individuals and RD value of 15.91. Similarly, the climber *Ichnocarpus frutescens* (59 individuals and RD value 14.53) in Palliyana grove; the liana *Gnetum ula* (55 individuals and RD value 18.21) in Nambiyath grove and the climber *Strychnos minor* (41 individuals and RD value 21.81) in Poyyara grove are identified as most dominant genera as well as species. However, the analysis carried out in the disturbed lands revealed most of the dominant genera as well as the

species identified are belonging to the plant group herbs. The herb *Cynodon dactylon* is identified as the most dominant genus as well as the species at Sankulangara site (30180 individuals and RD value 13.60 each for genus and species). Similarly, the herbs *Cynodon dactylon* and *Cyathula prostrata* at Palliyana site (8013 individuals and RD value 25.67 each for both the plant); the herb *Aerva lanata* at Nambiyath site (3339 and RD value 16.12 each for genera and species) and the herbaceous members *Achyranthes aspera*, *Aerva lanata*, *Cynodon dactylon*, *Cyperus rotundus*, *Leucas aspera* and *Phyllanthus amarus* at Poyyara site (506 individuals and RD value 11.86 each for all the plants) are the most dominant genera and species identified in the disturbed lands. The study further noticed similar observation as in the case of general floristic analysis in the chapter 3, the overall population count of ethnomedicinal plants in the disturbed lands are found significantly higher even when the diversity as well as the population count of majority of the ethnomedicinal plant groups trees, climbers, lianas and shrubs are very low in disturbed lands compared to sacred groves. The over dominance of ethnomedicinal herbaceous plants in the disturbed lands may be due to favourable environment such as availability of sunlight and absence of resistance by thick layer of litter which are favouring the seeds of herbaceous plants to germinate, emerge and establish in the area (Alejandro et al., 2014; Xiong & Nilsson, 1999).

Table H11: Comparison of relative density (RD) of different ethnomedicinal plant groups in the selected sacred groves and disturbed non-sacred grove lands

Study area	Relative density of plant groups (RD)				
	Trees	Shrubs	Herbs	Climber	Lianas
Sankulangara sacred grove	29.45	12.13	8.35	35.59	14.49
Palliyana sacred grove	29.06	13.55	6.40	47.04	3.94
Nambiyath sacred grove	15.23	15.23	22.52	17.55	29.80
Poyyara sacred grove	7.69	14.9	25.0	46.15	6.25
Disturbed lands of different extent					
Disturbed land- Sankulangara	0.01	0.06	99.91	0.01	0.0
Disturbed land- Palliyana	0.01	0.13	99.83	0.03	0.0
Disturbed land- Nambiyath	0.01	0.13	99.69	0.18	0.0
Disturbed land- Poyyara	0.0	0.19	99.62	0.19	0.0

Table H12: Comparison of relative frequency distribution of different ethnomedicinal plant groups in the selected sacred groves and disturbed non-sacred grove lands

Study area	Relative frequency distribution of plant groups (RFD)				
	Trees	Shrubs	Herbs	Climber	Lianas
Sacred groves of different extent					
Sankulangara Sacred Grove	30.56	20.14	14.58	24.31	10.42
Palliyana Sacred Grove	43.69	12.62	3.88	32.04	7.77
Nambiyath Sacred Grove	26.32	14.04	28.95	15.79	14.04
Poyyara Sacred Grove	16.49	15.46	30.93	29.90	7.22
Disturbed lands of different extent					
Disturbed land- Sankulangara	6.41	21.79	67.95	3.850	0.0
Disturbed land- Palliyana	3.28	32.79	59.02	4.920	0.0
Disturbed land- Nambiyath	1.06	19.15	60.64	19.15	0.0
Disturbed land- Poyyara	0.0	10.71	78.57	10.71	0.0

Table H13: Comparison of diversity index (DI) of different ethnomedicinal plant groups in the selected sacred groves and disturbed non-sacred grove lands

Study area	Diversity Index of plant groups (DI)				
	Trees	Shrubs	Herbs	Climber	Lianas
Sacred groves of different extent					
Sankulangara sacred grove	0.78	0.46	0.33	0.93	0.39
Palliyana sacred grove	0.93	0.38	0.18	1.15	0.13
Nambiyath sacred grove	0.57	0.44	0.69	0.54	0.56
Poyyara sacred grove	0.33	0.39	0.81	0.96	0.17
Disturbed lands of different extent					
Disturbed land- Sankulangara	0.001	0.005	1.651	0.0013	0.0
Disturbed land- Palliyana	0.001	0.011	1.570	0.0024	0.0
Disturbed land- Nambiyath	0.001	0.010	2.329	0.0135	0.0
Disturbed land- Poyyara	0.0	0.012	2.188	0.0118	0.0

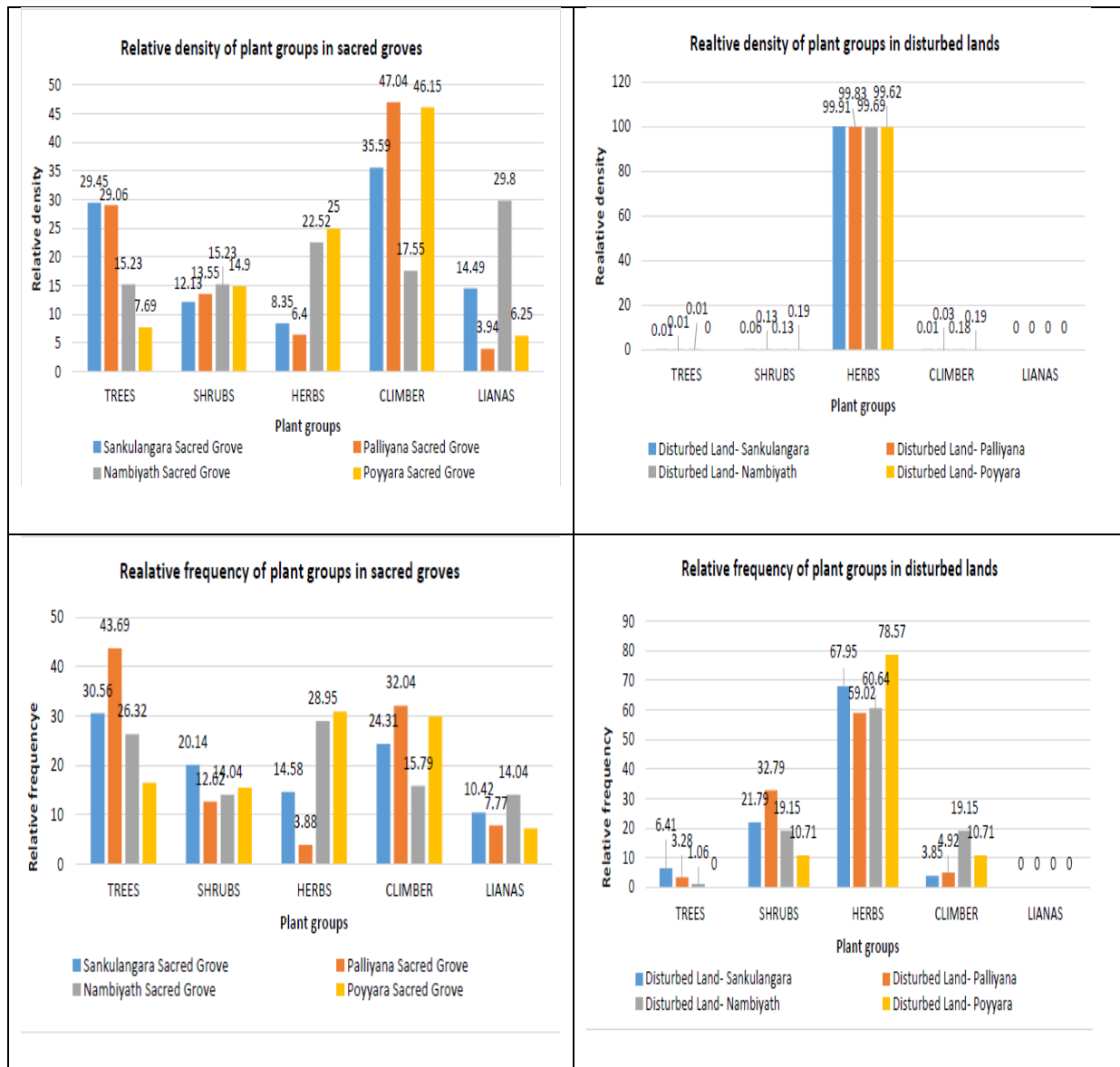
Table H14: Comparative account of ethnomedicinal plant status in selected sacred groves and disturbed non-sacred grove lands

Details		Sacred Groves				Disturbed Lands			
		SaSG	PaSG	NaSG	PoySG	SaDL	PaDL	NaDL	PoyDL
Genera		26	22	22	20	12	10	15	11
Species		28	22	22	20	14	12	18	11
Family		22	17	18	16	10	9	14	9
Trees	Species	8	11	8	6	2	1	1	0
	Population	187	118	46	16	8	2	1	0
Shrubs	Species	6	3	3	2	3	5	3	1
	Population	77	55	45	31	39	41	26	8
Herbs	Species	5	1	5	7	8	5	11	9
	Population	53	26	68	52	63537	31162	20642	4250
Climbers	Species	6	6	4	4	1	1	3	1
	Population	226	191	53	96	9	9	38	8
Lianas	Species	3	1	2	1	0	0	0	0
	Population	92	16	90	13	0	0	0	0
Total ethnomedicinal plant population		635	406	302	208	63593	31214	20707	4266
Total no. of plant species in the study area		101	101	81	59	60	76	54	26
Total plant population in the study area		2122	1716	918	622	221848	164104	49750	6153

SaSG- Sankulangara sacred grove; PaSG- Palliyana sacred grove; NaSG- Nambiyath sacred grove; PoySG- Poyyara sacred grove; SaDL- Sankulangara disturbed land; PaDL- Palliyana disturbed land; NaDL- Nambiyath disturbed land; PoyDL- Poyyara disturbed land

The analysis done in the influence of difference in extent of the study area on ethnomedicinal plant status revealed a progressive reduction in the diversity of genera as well as species of ethnomedicinal plants in the study area from sacred grove of larger extent towards smaller extent. This recorded a reduction of 23.08% and 28.57% diversity respectively for genera and species in the smallest Poyyara sacred grove compared to largest Sankulangara sacred grove. Almost similar trend is also observed with respect to the diversity of families. The number of families decreased from 22 to 16 and this recorded a reduction of 27.27% diversity in the smallest sacred grove than the largest grove. However in the disturbed non-sacred grove lands, the difference in extent of the study area is found not much influencing the diversity of

genera, species and families of ethnomedicinal plants either in a progressive increased or decreased order but instead highly irregular order is observed (figure H13).



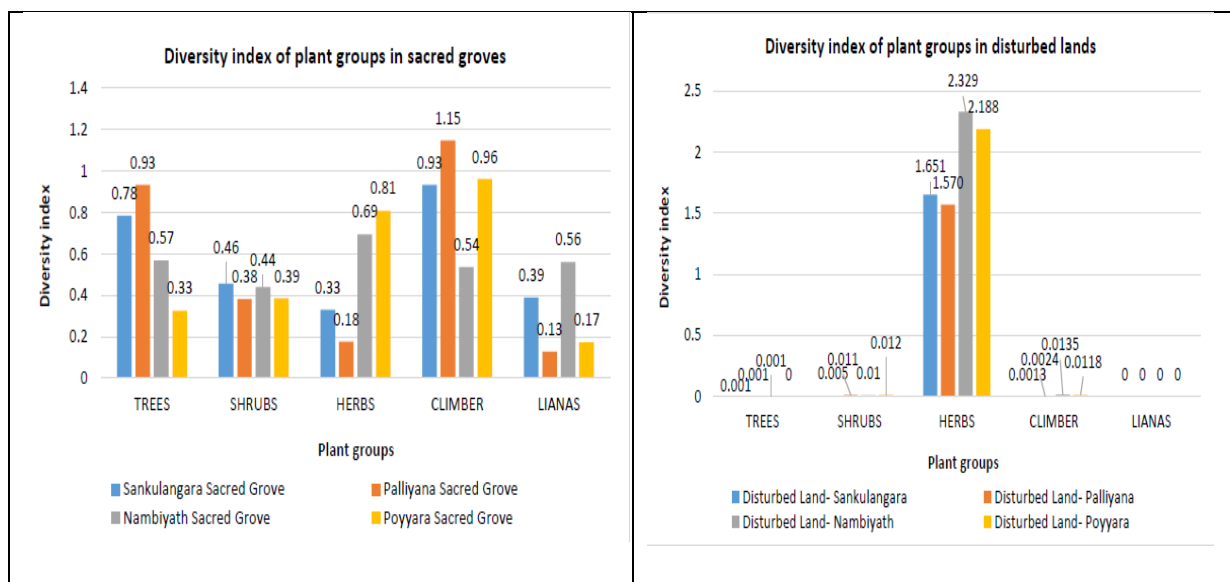


Figure H13: Comparative evaluation of selected phytosociological aspects of ethnomedicinal plant groups in the sacred groves and disturbed non-sacred grove lands

Ethnomedicinal plants listed in IUCN red list category

The ethno-medicinal tree species *Hopea ponga* of Dipterocarpaceae which is identified in Sankulangara and Poyyara sacred groves is endemic to Western Ghats-South and Central Sahyadris (Sasidharan, 2011; Nayar et al., 1990). As indicated by IUCN red list of plants, this tree species is accounted for as endangered plant species. The tree species *Saraca asoca* belonging to the family Leguminosae which is identified in the Palliyana sacred grove in the study is endemic to Andaman and Nicobar Island, Assam, Madhya Pradesh and Peninsular India. This small tree is facing serious threats due to overexploitation for medicinal use and loss of its habitat and this plant is accounted as vulnerable tree species as per IUCN red list of threatened category. The tree species *Tabernaemontana alternifolia* has a place with the family Apocynaceae and is endemic to Southern Western Ghats. This tree species is found of common occurrence in all the selected four sacred groves in the study and reported as near threatened plant species.

Conclusion

The comparative analysis in the occurrence, distribution and selected phytosociological aspects of ethnomedicinal plants in studied sacred groves revealed that the ancient beliefs and sociocultural practices played a vital role in safe guarding and conserving valuable plant resources. Be it in the fear of wrath from nature, God or Goddess, or otherwise, these patches are spared from all kinds of anthropogenic pressures. As a result the valuable medicinal plants in the grove areas are found to remain almost intact. However in the disturbed non-sacred grove areas, considerable degradation of ethnomedicinal plant wealth is observed due lack of such belief systems and subsequent human interventions. But the scenario is gradually found changing for the worse even in the protected and preserved patches especially in Kerala due to various reasons. This includes disappearance of Tharavadu system, partition of family property, shift in belief systems, developmental activities, market forces and over exploitation. Therefore it becomes difficult to protect these groves only based on the religious beliefs. There is a need to revitalize the age old ethos of conservation tactics by supplementing with indigenous and scientific knowledge regarding the importance of sacred groves in medicine and other aspects. This kind of comparative evaluation of plant diversity and medicinal plant wealth between the vegetation in sacred groves and disturbed lands in the rural and urban areas and the passing of these kind of information to the present generation is of utmost importance in understanding what the past vegetation was and how it is today. This in turn helps people to be aware of the past and the present interrelationships between human culture and plants. The present study further expects that documentation about the indigenous knowledge and practices of traditional medicine are very essential to make aware the people not only about the utilization of natural biological resources but also the value of conserving these patches of natural forest vegetation for future.

References

- Akhtar Husain., Virmani, O. P., Popli, S. P., Mishra, L. N., Gupta, M. M., Srivastava, G. N., Abraham, Z., & Singh, A. K. (1992). *Dictionary of Indian Medicinal Plants*. Central Institute of Medicinal and Aromatic Plants, Lucknow, India.
- Alejandro Loydi., Kerstin Lohse., Annette Otte., Tobias, W. Donath., & Lutz Eckstein, R. (2014). Distribution and effects of tree leaf litter on vegetation composition and biomass in a forest–grassland ecotone. *Journal of Plant Ecology*, 7 (3), 264–275.
- Alves, R. R. N., & Rosa, I. L. (2005). Why study the use of animal products in traditional medicines? *Journal of Ethnobiology and Ethnomedicine*, 1, 1–5.
- Basu, R. (2009). Biodiversity and Ethnobotany of sacred groves in Bankura district, West Bengal. *Indian Forester*, 135(6), 765–777.
- Behera, M. K., Pradhan, T. R., & Sahoo, J. (2015). Role of sacred groves in the conservation and management of medicinal plants. *Journal of Medicinal Plant Research*, 9(29), 792–798.
- Bhakat, R. K., & Pandit, P. K. (2004). An inventory of medicinal plants of some sacred groves of Purulia district, West Bengal. *Indian Forester*, 130(1), 37–43.
- Biswas, S., Jain, S. S., & Pal, M. (2003). Research needs and priorities for conservation of Indian medicinal flora. *Indian Forester*, 129 (1), 85.
- Boraiah, K. T., Vasudeva, R., Shonil, A., Bhagwat Kushalappa, C. G. (2003). Do informally managed sacred groves have higher richness and regeneration of medicinal plants than state managed reserve forests. *Current Science*, 84(6), 804–808.
- Dowdeswell Elizabeth. (1995). *Global Biodiversity Assessment*. UNEP, CUP, UK.
- Duraipandiyan, V., Ayyanar, M., & Ignacimuthu, S. (2006). Antimicrobial activity of some ethnomedicinal plants used by Paliyar tribe from Tamil Nadu, India. BMC Complement. *Alternative Medicine*, 6(1), 35–41.
- Francis Xavier, T., Auxilia, A., Suresh, M., & Kannan Arun Bastin, A. (2013). Floristic composition and practices on the selected sacred groves of Rajapalayam, Virudhunagar District, Tamil Nadu. *International Journal of Pharma and Biosciences*, 2(4), 968–973.
- Kaufman, P. B., Cseke, L. J., Warber, S., Duke, J. A., & Brielmann, H. L. (1999). *Natural Products from Plants*. CRC Press, Boca Raton, FL.
- Kerharo, J. (1975). Traditional pharmacopoeias and environment. *African environment*, 1(4), 1–30.

- Krishnan Nambiar, V. P., Sasidharan, N., Renuka, C., & Balagopalan, M. (1985). *Studies on the medicinal plants of Kerala forests*, KFRI Research Report 42, KFRI, Peechi, Thrissur, 200.
- Khare, C. P. (2007). *Indian Medicinal Plants. An Illustrated Dictionary*. Springer-Verlag Berlin/Heidelberg edition, USA.
- Laloo, R.C., Kharlukhi, L., Jeeva, S., & Mishra, B. P. (2006). Status of medicinal plants in the disturbed and the undisturbed sacred forests of Meghalaya, northeast India: population structure and regeneration efficacy of s one important species. *Current Science*, 90(2), 225–232.
- McNeely, J. A., Miller, K. R., Reid, W. V., Mittermeier, R. A., & Werner, T. B. (1990). *Conserving the World's Biological Diversity*. Global Biodiversity, IUCN, Gland, Switzerland; WRI, CI, WWF-US, and the World Bank, Washington, D.C.
- Nayar, M. P., & Addale Rama Krishna Sastry. (1990). *Red Data Book of Indian Plants*. Botanical Survey of India, 3.
- Pandit, P. K., & Bhakat, R. K. (2007). Conservation of biodiversity and ethnic culture through sacred groves in Midnapore district, West Bengal, India. *Indian Forester*, 133(3), 32.
- Rajendran, S. M., & Agarwal, S. C. (2007). Medicinal plants conservation through sacred forests by ethnic tribal of Virudhunagar district, Tamil Nadu. *Indian Journal of Traditional Knowledge*, 6(2), 328–333.
- Rao, P., Barik, S. K., Pandey, H. N., & Tripathi, R. S. (1997). Tree seedling germination, establishment in tree fall gaps and understory in subtropical forests of northeast India. *Australian Journal of Ecology* 22(2), 136–145.
- Rômulo, R. N., Alves Ierecê, M. L., & Rosa. (2007). Biodiversity, traditional medicine and public health: where do they meet? *Journal of Ethnobiology and Ethnomedicine*, 3(14), 3–14.
- Sasidharan, N. (2011). Flowering Plants of Kerala.ver.2.0, KFRI, Peechi.
- Shanley, P., & Luz, L. (2003). The impacts of forest degradation on medicinal plant use and implications for health care in eastern Amazonia. *BioScience*, 53 (6), 573–584.
- Shannon, C. E., & Wiener, W. (1949). *The Mathematical Theory of Communication*. Urbana, University of Illinois Press, 177.

- Sharma, A., Shanker, C., Tyagi, L., Singh, M., & Rao, C.V. (2008). Herbal medicine for market potential in India: An Overview. *Academic Journal of Plant Sciences*, 1(2), 26–36.
- Singh, J. S., Raghubanshi, A. S., & Varshney, C. K. (1994). Integrated biodiversity research in India. *Current Science*, 66(70), 109.
- Singh, A. (2007). Herbal medicine-dream unresolved. *Pharmacognosy Reviews*, 1(2), 75–376.
- Srinivasamurthy, T. S., Mohan, K., Prabhakaran, V., Jadhav, S. N., Satish, E., Ravikumar, K., & Utkarsh, G. (2003). Medicinal plant conservation and sustainable use through forest gene banks. *Indian Forester*, 129 (2), 179.
- The Ayurvedic Pharmacopoeia of India. (2004). Part I, Vol I to IV, (API), Ministry of Health, Govt. of India, New Delhi.
- Vartak, V. D., Kumbhojkar, M. S., & Nipuge, D. S. (1987). Sacred groves in tribal areas of Western Ghats: treasure grove of medicinal plants. *Bulletin of Medico-Ethno-Botanical Research*, 8, 77–78.
- Ved, D. K., Parthima, C. L., Morton Nancy., & Darshan, S. (2001). Conservation of Indian's medicinal plant diversity through a novel approach of establishing a network of *in situ* gene banks, In: Uma Shaanker, R., Ganeshaiah, K. N., & Bawa, K. S. (eds) *Forest Genetic Resources: Status, Threats and Conservation Strategies*, (Oxford & IBH, New Delhi), 183.
- Xiong, S., & Nilsson, C. (1999). The effects of plant litter on vegetation: a meta- analysis. *Journal of Ecology*, 87(6), 984–94.
- Yadav, J. P., Sanjay Yadav., Vedpriya Arya., & Manju Panghal. (2010). Sacred groves in conservation of Plant biodiversity in Mahendergarh district of Haryana. *Indian Journal of Traditional Knowledge*, 9(4), 693–700.

Summary and Conclusion

In the present scenario, the demand for forest resources and forest area for various developmental and cultivation activities have enhanced considerably due to high population pressure and urbanization. This has resulted in decreased size of natural forest vegetation at an alarming rate, globally. Many vast areas of forests are hugely degraded in terms of diversity and abundance, while many are drastically reduced to smaller areas. Sacred groves are the relics of original vast gregarious forest vegetation that once existed before in the region, which are safeguarded by the society or local people in the name of worship of deities. In many parts of India, sacred groves are representative of surviving examples of climax vegetation. However, these groves are also gradually degrading and disappearing under the pressure of over exploitation, population increase and modernization. The lack of proper awareness among the public and local people on the relevance of sacred groves as basic natural resource for present and future generations is one of the pivotal factors responsible for the various anthropogenic damages to sacred groves. Detailed scientific approach and analysis is necessary to obtain data for convincing explanations on various aspects to reveal and insist the public on the importance of conservation and management of sacred groves. In this context the present study is carried out in the Coastal Belt of Thrissur district, Kerala. The study involved a detailed survey of sacred groves in the Coastal Belt of Thrissur district for the basic data collection such as existence, location, ownership, the presiding deity and the extent of grove area. From the survey, four sacred groves of different extents are selected for the detailed study in comparison with adjacent disturbed non-sacred grove lands of similar extents. The selected groves are Sankulangara grove of comparatively the largest extent, followed by Palliyana grove, Nambiyath grove and the Poyyara grove of the smallest extent.

One of the major objectives of the present study is comparative analysis of floristic and phytosociology of selected study areas. The prominent plant groups selected for the detailed analysis in each study area are trees, shrubs, herbs, climbers and lianas. The various aspects analysed include plant density, frequency, dominance, basal area of trees, importance value index, species richness index, species diversity index and similarity index. A brief study on the occurrence, identification and comparison of other plant groups such as epiphytes, parasites,

pteridophytes, bryophytes, algae, lichens and macro fungi are also carried out. The tree regeneration status in the selected groves and adjacent disturbed lands are analysed. The other major aspects considered for the study include comparative analysis on the population of major groups of soil microbes, physical and chemical properties of soil and microclimatic parameters in the soil and atmosphere during the period of pre-monsoon and post-monsoon between the selected sacred groves and disturbed non-sacred grove lands. Comparative analysis on the status of ethnomedicinal plant diversity in the selected groves and disturbed lands are carried out for understanding their existence, distribution and use in traditional medicine. The study further analysed the impact of difference in extent of the selected grove areas on various aspects considered for the study.

The results of comparative analysis showed/ regarding the diversity of plant genus and plant species, the average density and frequency of plant species, species diversity index and the species richness index are generally found higher and significant in all the studied sacred groves compared to their corresponding disturbed non-sacred grove lands of similar extents. The similarity index analysis between sacred groves and disturbed lands revealed significantly lower similarity while comparatively higher similarity index is recorded between groves. The comparative analysis indicated that significant reductions have occurred in the plant species in all the non-sacred grove lands compared to the sacred groves. The most predominant plant species and family and other dominant plants and families and their level of dominance identified in the groves are characteristics of natural forest vegetation while the dominant ones that are identified in the disturbed lands are found characteristics of degraded and highly disturbed forest vegetation.

The tree regenerate analysis revealed satisfactory regeneration behaviour of tree species with high seedling and sapling density in sacred groves while incomplete regeneration or even total absence of regenerate representation for majority of the tree species in the disturbed non-sacred grove lands. The population analysis of various microbial groups carried out in the investigation revealed direct correlation between the vegetation stand quantity and quality in the area. The majority of the microbial groups are found to generally exhibit their highest population count in the core region of sacred grove, which is followed by the region of transition and finally, the lowest count being recorded in the disturbed non-sacred grove region during the pre-monsoon as

well as post-monsoon period. The majority of the favourable physical and chemical properties attributed to good soil are found significantly higher in the soil of grove regions compared to transition and disturbed non-sacred grove regions. The study observed that the soil in the grove and immediate transition regions are found with improved quality during the post-monsoon period over the pre-monsoon status while that of disturbed regions exhibit a reverse trend with certain physical and chemical parameters. The microclimatic analysis in the study regions indicate that comparatively better favourable temperature and humidity are recorded in the core regions of groves over the disturbed non-sacred grove regions as well as transition regions during the pre-monsoon and post-monsoon periods, with certain exceptions with respect to humidity in the case of Poyyara and Nambiyath grove of smaller extents. The study reveals that considerable ruination has happened to majority of the ethnomedicinal plants which were endemic in the non-sacred grove regions while many valuable plants of ethnomedicinal importance in the grove regions are found to remain almost intact. The analysis on the influence of differences in extent of the selected groves on various aspects in the study revealed majority are found improving along with increases in the extent.

The overall inference obtained from the present investigation reveals undoubtedly that significant degradation due to severe anthropogenic interferences has occurred in the floristic composition and structure of all the selected non-sacred grove regions and this has created an unfavorable habitat and environmental condition for the accommodation, establishment and regeneration of many diverse plant species characteristic to unstressed natural forest habitat. The absolute absence of plant group lianas and gymnosperms and significant decrement in the density as well as diversity of different plant like trees, climbers, pteridophytes and lichens are the clear indications of the above inference. On the other hand, the better ecological balance and adaptability of many diverse plant species which enable them to establish and regenerate sustainably in the groves are due to favorable physical, chemical and microbiological properties of soil and microclimatic conditions that are sustained in the grove environment supported by the quality, quantity and diversity of vegetation stand. Severe disturbances in non-sacred grove lands due to easy access and lack of restriction to human interferences have led to the reduction in diversity and vegetation stand characteristics. However, sustainability in the diversity and richness of original forest vegetation stand characteristics in the studied groves is a clear

indication of effectiveness in the protection and conservation of sacred groves from anthropogenic disturbances on the grounds of spiritual and religious faith. However, the present scenario is gradually found changing for the worse even in the protected and preserved patches of forest, especially in Kerala as part of fast urbanization and modernization along with population pressure. Therefore, there is an urge to reiterate the age old ethos of conservation tactics based on the belief system supplemented by indigenous and scientific knowledge in various aspects which support the preservation and management of sacred groves for the future. The need of the hour is to create awareness on conservation strategies, not merely based on the belief system but with a concrete, genuine and empirical foundation, through observation and scientific analysis. This alone can convince and educate the local public to support preservation and management of sacred groves for the future. The present investigation believes that scientific comparative evaluation of plant density, diversity, quality of soil and environments and ethnomedicinal plant status between sacred groves and disturbed non-sacred grove lands in the rural and urban areas and transfer of the collected information to the present generation is of utmost importance in understanding what the past vegetation was and how it is today and how degraded our environment is. The study believes that documentation on the indigenous knowledge and practices of traditional medicine are very essential to make aware the people not only about the utilization of these natural biological resources but also the need of conserving the natural forest vegetation for future.

The study concludes with few suggestions

- Grass root level awareness program among local people on preservation by deploying a separate team by Government/NGO and encourage social media campaigns.
- Create, develop and maintain patches of forest in feasible areas by planting suitable plant species of ecological and social values from diverse groups.
- Conservation of existing sacred groves by providing financial support and technical expertise to the owners by the Government/NGO.
- Assign “greening” target to Government departments/Educational institutions/ Residence associations/Private and Public industries and acknowledge them.
- Effective and stringent law may be enforced for safe guarding the existing sacred groves.

JINCY. T. S “A COMPARATIVE ASSESSMENT OF SOIL PROPERTY, FLORISTIC COMPOSITION, PHYTOSOCIOLOGY AND DIVERSITY OF ETHNOMEDICINAL PLANTS BASED ON THE EXTENT OF SELECTED SACRED GROVES AND ADJACENT DISTURBED LAND IN THE COASTAL REGION OF THRISSUR DISTRICT, KERALA, INDIA.” THESIS. PG DEPARTMENT OF BOTANY & RESEARCH, SREE NARAYANA COLLEGE, NATTIKA, UNIVERSITY OF CALICUT, 2019.

APPENDIX - I

LIST OF PUBLICATIONS AND ABSTRACTS

A. Research papers in peer reviewed international/national journals

1. Jincy, T. S., & Subin, M. P. (2018). Impact of human interference on ethnomedicinal plant wealth and diversity- a comparative study of Sankulangara sacred grove and a disturbed non-sacred grove land located at S.N.puram, Thrissur district, Kerala. *Review of Research*, 7 (7), 1-15. (UIF-5.2331)
2. Jincy, T. S., & Subin, M. P. (2016). Role of Sacred Groves in Ameliorating Soil Physical Properties and Microclimate: A Case Study of Sree Sankulangara Sacred Grove and Adjacent Disturbed Land at S.N Puram, Thrissur, Kerala. *Paripex-Indian Journal of Research*, 5(9), 345-351. (SJIF – 5.215)
3. Jincy, T.S., & Subin, M. P. (2015). A Detailed Survey on Sacred Groves of Different extents in the Coastal Belt of Thrissur District, Kerala, India. *Gobal Journal for Research Analysis*, 4 (11), 162-171. (SJIF- 3.1218)

B. Research papers in seminar/conference proceedings/book paper presentation

1. Jincy, T. S., & Subin. M. P. (2018). Sacred groves under threat- a case study of Nambiyath sacred grove located in the coastal belt of Thrissur District, Kerala. *Proceedings of National Conference on “Biodiversity and its Conservation: Priorities and Challenges”* (NCBCPC-2018) 12th - 13th March-2018, Organised by Department of Botany, Bharathiar Univeristy, Coimbatore, p.21-27. (ISBN : 978-93-84234-71-3)
2. Jincy, T. S., & Subin. M. P. (2018). Impact of human interference on ethnomedicinal plant wealth and diversity- A comparative study of Sankulangara sacred grove and a disturbed non-sacred grove land located at S.N. Puram, Thrissur District, Kerala. *Proceedings of International Conference on “Science and Humanities for Grooming the Future: An Interdisciplinary Approach”* ICSHI-2018, Organized by CDC, Bharatiar University, Coimbatore.



A Detailed Survey on Sacred Groves of Different extends in the Coastal Belt of Thrissur District,Kerala,India

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ABSTRACT

Sacred groves represent a major effort to recognize and conserve ethnic biodiversity traditionally. As an ecosystem, they even help in soil and water conservation besides preserving the rich biological diversity and microclimatic conditions of the region. Now a day the environmental significance of the sacred groves is a matter well forgotten and are gradually disappearing under the influence of changing socioeconomic scenario, disappearance of the tharavadu system, shift in belief systems, development projects and other anthropogenic activities, and many of them are now just relics of a once-gregarious vegetation. Under these circumstances, preservation, conservation and management of these groves warrant top priority. However no concrete steps are being initiated to protect and conserve these groves and this may be mainly due to lack of awareness regarding the environmental significance of sacred groves by the local people together with lack of proper information regarding their existence in the region by the public and concerned agencies who are entrusted to safe guard the existing groves in the region. If concrete steps are not taken to stop their deterioration, these micro cosmos will disappear from the face of earth, resulting in loss of biodiversity which may include valuable species of flora and fauna and finally cause imbalance in the ecosystem. A detailed survey of sacred groves is the first and foremost step to be carried out to inform and make aware the organizations and bodies who are supposed to protect these natural resource pockets. Thrissur is one of the districts having large number of sacred groves in Kerala which are distinct and unique in biological diversity. It is understood from people inhabiting the vicinity of groves in the coastal belt of Thrissur district that most of the groves have started gradual deterioration in terms of biological diversity, composition and extend due to various anthropogenic interventions. In the present study a detailed survey of existence of sacred groves in the coastal belt of Thrissur district has been conducted. Various information regarding sacred groves such as name, location, extend, deity, ownership and management etc were collected and documented.

Key words : Sacred groves, survey, coastal belt of Thrissur district

INTRODUCTION

Kerala has a rich tradition of nature conservation and Sacred Groves are small patches of native vegetation traditionally been protected on the grounds of spiritual and religious faith. There are many myths, legends and faith associated with the sacred groves of Kerala. In Kerala locally they are known as "Kavu" or "Sarpakkaavu" or "Nagavanam" and are usually not destroyed under fear of wrath from presiding deity. The sacred groves of North Kerala are mostly associated with Goddess whereas in South Kerala they are associated mostly with snake worship. The deities in the sacred groves are at times represented by some trees and a stone slab installed at the base of the tree is the altar on which the offerings are made. So these trees are planted and protected and preserved intact from human interference. Thus, the sacred groves serve as unique example of in situ genetic resource conservation through the involvement of local people in the most economic and efficient manner.

Sacred groves are the treasure house of rare and endangered species of animals and abode of many medicinal, endemic, endangered and wild relatives of cultivated species which may have definite role to play in the future species improvement programs. They are also having rich diversity of many plant species which are very relevant to the maintenance of ecosystem balance. As an ecosystem, sacred groves help in soil and water conservation, besides preserving the biological wealth. According to Rajendraprasad (1995), sacred groves with their complex array of interaction, influence the flora and fauna of the region as well as the microclimate of that locality. The soils of sacred groves show high porosity and low bulk density compared to the soils of the vicinity. The thick litter cover and channels created by soil macro fauna together enhances water retention, root system development, gaseous exchange, and heat conductance. Sacred groves enrich the soil through its rich litter and the nutrients generated by litter decomposition are not only recycled within the sacred grove ecosystem but also find their way into the adjoining agro ecosystems (Ramachandran et al., 1991). The ponds and streams adjoining the groves serve as perennial water sources, serving as the last resort to many animals and birds for their water requirements, especially during summer.

In the words of Dr. M. S. Swaminathan, "Unlike a botanical garden, where a wide range of trees and plants are collected and cultivated for the purpose of our education and enjoyment, the sacred groves are one method of expressing the gratitude of human families to the trees which sustain and support life under a given agro-ecological condition". Gadgil and Vartak (1975) observed that in many parts of India, sacred groves represent surviving examples of climax vegetation but these groves are also gradually disappearing under the influence of modernization. Though ancient people of India established sound socio-cultural practices epitomizing in situ conservation of biological and genetic diversity of sacred groves, in recent times this has been ignored. Sacred groves in Kerala are facing serious threats due to various reasons. One of the main reasons which is causing serious threats to the existence of sacred grove in coastal belt as well as in Thrissur district or in Kerala as a whole is the disappearance of Tharavadu system and partition of family properties. In cases where sacred grove and its premises are handed over to a family who has no faith in keeping the integrity of the Kavu, it may lead to the total deterioration of natural vegetation. Other anthropogenic interventions contributing towards this include shift in belief systems, market forces and over exploitation, developmental projects, grazing and poaching and other antisocial activities. However no concrete steps are being initiated to protect and conserve these groves and this may be mainly due to lack of awareness regarding the importance of sacred groves in maintenance of ecosystem balance, biodiversity conservation and for maintaining the microclimatic conditions of the region. Under these circumstances, preservation, conservation and management of the sacred groves warrants top priority. Kerala has roughly about 1500 sacred groves and Thrissur is one of the districts having large number of sacred groves which are distinct and unique in biological diversity. It is understood from people inhabiting the vicinity of groves that most of the groves have started gradual deterioration in terms of cultural values, floristic richness, composition and diversity. The present work is being proposed in the above context. A detailed survey of existence of sacred groves in the coastal belt of Thrissur district has not yet been conducted. The present authors believe that a detailed survey of these natural resource pockets is the first and very important step to be carried out to inform and make aware the public, concerned

organizations and government bodies regarding the existence, location, associated deities, ownership and extend of each sacred grove in the area to take necessary precautions for conservation and environmental protection as a sacred duty. Both Union and State Governments should accord high priority to identifying and managing this source of genetic wealth and need to act fast.

MATERIALS AND METHODS

Area of study

The area of study is the coastal belt of Thrissur district, Kerala which is spread over 16 panchayaths and one municipality. The area lies at 10.52°N 76.21°E and has an average altitude of 2.83m. The average maximum temperature is 33°C and average minimum temperature is 20°C. Average annual rainfall is 2500mm. The soil is sandy loam to laterite and acidic with pH value ranging from 4.6 to 5.8

Survey of sacred groves

A detailed survey of sacred groves in the coastal belt of Thrissur district was carried out during the year 2014. Information on the existence of sacred groves was collected through personal contacts with villagers, temple authorities and various social organizations in the area. The information collected include location, name of sacred grove, ownership/managed by, extend or area and presiding deity of each sacred grove. Whenever any sacred grove is visited, the local people and related temple worshippers were interviewed to confirm the above facts and also to elicit information about the presence of other groves in the locality.



Figure: 1 Map of study area showing sixteen panchayaths and one municipality in the coastal belt of Thrissur district with corresponding number of sacred groves

RESULT AND DISCUSSION

The data obtained from the detailed survey of sacred groves existing in different panchayath and municipality in the coastal belt of Thrissur district is depicted in table 1-20. Sacred groves may range in their size from a group of few trees to a forest of trees (Ramakrishnan et al., 1998). The survey revealed the existence of a good number of sacred groves of different extend in the coastal belt of Thrissur district ranging from 0.00004 Sq. Km (1cent) to 0.00635 Sq. Km (157 cents). Data shows the highest number of protected area as sacred groves is recorded in the Punayur panchayath area with a total number of 27 groves while the lowest number of groves is recorded in the Chavakkad Municipality area with a total number of 5 groves. However, considering the total area covered by sacred groves, Vatana-pally panchayath occupied the highest position with a total area of 0.01052 Sq. Km (260 cents) and is about 0.080% of the entire 13.18 Sq. Km area of the panchayath while the least area is occupied by the Edathirithy panchayath with a total grove area of 0.00077 Sq. Km (19 cents) which constituted only about 0.005% of the entire 16.63 Sq. Km area of the panchayath. With respect to individual sacred groves, the highest extend is occupied by Sree Sankulangara Kavay (1) (0.00635 Sq. Km) in Sree Narayanapuram panchayath while lowest area noticed is 0.00004 Sq.Km which is found to exist in many panchayaths.

The survey further reveals a grand total of 261 groves existing in the coastal belt of Thrissur district which all together cover an area of 0.07019 Sq. Km (1734.5 cents) and constitute about 0.032% of the entire 222.38 Sq. Km area of coastal belt. The survey result shows the size of the sacred grove varies as small as 1cent to as big as 157 cents and the data further reveals (table 2) about 83.14% of the total sacred groves are smaller in size and belong to the size range of 1-9 cents, 15.71% belongs to the size range of 10-49 cents and 0.77% and 0.38% respectively belongs to the size range of 50-90 cents and 91 cents and above.

The survey results reveal that majority of the sacred groves in the coastal belt of Thrissur district are owned either by individual families or group of families and this constituted around 51.34% of ownership by individual families and 46.74% of ownership with group of families while the remaining 1.92% is owned and managed by temple devaswom/trust (table 3). The study also reveals that sacred groves in the coastal belt are mostly dedicated to Snake God or Goddess or both. The deities in the sacred groves are variously known as 'Nagam, Nagaraja, Sarpam, Karinagam, Anjana maninagam and Nagayakshi'. Many sacred groves have more than one deity, of which the patron deity is usually a Snake God and has one or more supporting deities like Bhagavathi, Durga, Devi, Ayyappan, Annapoorneshwari, Muthappan, Hanuman etc. However few cases of sacred groves were noted where the Snake God is not the patron deity but the supporting deity and this constituted around 11.49% of total 261 sacred groves surveyed. Other patron deity noted during the survey includes Bhagavathi, Devi, Ayyappan, Durga, Siva, Brahmarakshassu, Sasthavu, Bhadrakali, Vanabhuvaneshwari, Ganapathi, Vanadurga etc.

The data related to sacred groves derived from the present survey clearly indicates, still there is considerable number of small pockets or patches of natural vegetation in the coastal belt of Thrissur district which represent the ancient Indian way of in situ conservation of genetic diversity and they act as nursery and store house of many of the local ayurvedic, tribal and folk medicines. The protection and maintenance of these natural resources is very essential as we all know that the protection of the environment and life supporting systems are interwoven with conservation of these biological diversities. But the encroachment has resulted in the shrinkage of many of sacred groves in the coastal belt of Thrissur district during last few decades. Some of the typical examples include Sree Sankulangara Kavay belonging to Sree Narayanapuram panchayath and Adiparambil kavay belonging to Valappad panchayath which were previously reported as having an area of around 499 cents and 84 cents by Chandrashekara and Sankar (1998) and Sujana and Sivaperuman (2008) respectively. The present survey revealed both the sacred groves have undergone splitting and area considerably reduced to 187 cents and 30 cents respectively.

CONCLUSION

The authors would like to conclude that the preservation and maintenance of the existing sacred groves in this coastal area is an important necessity to prevent the relics from total depletion. The information collected in the survey may be useful for the public, NGOs and Govt organizations to locate and to take initiatives towards protection of these groves. Further the authors suggest that Government may encourage and support the conservation of these sacred groves by way of financial support and technical expertise to its owners. Further, the local bodies, NGOs and forest department may be empowered with law enforcement to safe guard the existing sacred groves in the region.

TABLE 1
Details of different panchayaths and municipality, total number of sacred groves existing and total area of sacred groves covered in the coastal belt of Thrissur district in Kerala

Sl.No	Panchayath/Municipality	Total area of Panchayath/ Municipality (Sq.Kms)	Total no. of sacred groves	Total area of sacred groves (Cent)	Total area of sacred groves (Sq.Kms)	Total area of sacred groves (%)
1	Punnayurkulam	18.71	18	66	0.00267	0.014
2	Punnayur	16.60	27	109	0.00441	0.027
3	Chavakkad Municipality	12.41	5	37	0.00150	0.012
4	Kadappuram	9.63	7	38	0.00154	0.016
5	Orumanayur	5.19	12	79.5	0.00322	0.062
6	Engandiyur	15.68	20	100	0.00405	0.026
7	Vatanappally	13.18	13	260	0.01052	0.080
8	Thalikulam	10.89	8	63	0.00255	0.023
9	Nattika	9.60	25	120	0.00486	0.051
10	Edathirithy	16.63	6	19	0.00077	0.005
11	Valappad	14.33	17	146	0.00591	0.041
12	Kaipamangalam	13.70	26	145	0.00587	0.043
13	Perinjanam	9.30	14	59	0.00239	0.026
14	Mathilakam	12.92	6	41	0.00166	0.013
15	Sree Narayanapuram	19.26	14	246	0.00996	0.052
16	Edavilangu	7.60	26	159	0.00643	0.085
17	Eriyad	16.75	17	70	0.00283	0.017
Grand total of coastal belt of Thrissur		222.38	261	1734.5	0.07019	0.032

TABLE 2
Details of various size ranges of sacred groves existing in the coastal belt of Thrissur district in Kerala

Panchayath/ Municipality	Size range of sacred				Total no of sacred groves
	1-9 cents	10-49 cents	50-90 cents	91 cents and above	
Punnayurkulam	17	1	-	-	18
Punnayur	26	1	-	-	27
Chavakkad Municipality	4	1	-	-	5
Kadappuram	5	2	-	-	7
Orumanayur	11	1	-	-	12
Engandiyur	18	2	-	-	20
Vatanappally	6	5	2	-	13
Thalikulam	6	2	-	-	8
Nattika	21	4	-	-	25
Edathirithy	6	-	-	-	6
Valappad	13	4	-	-	17
Kaipamangalam	21	5	-	-	26
Perinjanam	12	2	-	-	14
Mathilakam	5	1	-	-	6
Sree Narayanapuram	10	3	-	1	14
Edavilangu	21	5	-	-	26
Eriyad	15	2	-	-	17
Total	217	41	2	1	261

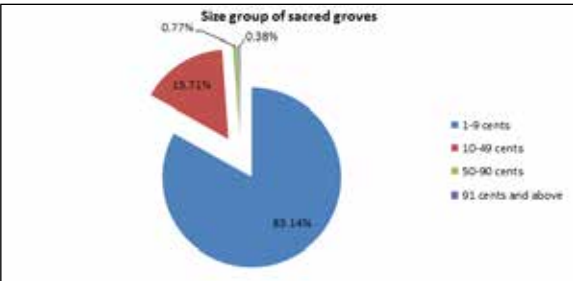


Figure: 2 Details of percentage distribution of different size range group of sacred groves in the coastal belt of Thrissur district in Kerala

TABLE 3
Details showing the ownership category of sacred groves in the coastal belt of Thrissur district in Kerala

Sl.No	Panchayath/ Municipality	Sacred groves owned and maintained by		
		Individual family	Group of family	temple devaswom trust
1	Punnayurkulam	9	9	-
2	Punnayur	13	14	-
3	Chavakkad Municipality	0	5	-
4	Kadappuram	0	7	-
5	Orumanayur	10	2	-
6	Engandiyur	7	13	-
7	Vatanappally	5	8	-
8	Thalikulam	4	4	-
9	Nattika	18	7	-
10	Edathirithy	2	3	1
11	Valappad	11	6	
12	Kaipamangalam	15	10	1
13	Perinjanam	8	6	
14	Mathilakam	2	4	-
15	Sree Narayanapuram	7	5	2
16	Edavilangu	13	12	1
17	Eriyad	10	7	-
Total		134	122	5

TABLE 4**Details of sacred groves in Punnayurkulam Panchayath in the coastal belt of Thrissur district**

Panchayath/ Municipality/	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Punnayurkulam Panchayath	1	Edakkara Ashari kavu	Nagaraja and Bhaghavathi	15	Individual family
	2	Padinjakkara kavu	Nagam	4	Individual family
	3	Karimbanakkal Kavuvu	Nagam	5	Individual family
	4	Payyarlikavu	Nagam	3	Individual family
	5	Kizhakkekara Kavuvu	Nagam	4	Individual family
	6	Karipayikavu	Nagam	3	Individual family
	7	Nakkola Kavuvu	Nagam	3	Individual family
	8	Manayil Kavuvu	Nagam	3	Individual family
	9	Punnor kshethrakavu	Nagaraja	3	Group of family
	10	Nalappattu Nagakavu	Nagam	2	Group of family
	11	Ambazhathel Kavuvu	Nagam	4	Group of family
	12	Pavittakulangara Kshetrakavu	Nagaraja	3	Group of family
	13	Kalarikkal Kshetrakavu	Nagam	2	Group of family
	14	Karimpanakkal Kavuvu	Nagam	3	Individual family
	15	Manikandeswara Kshetrakavu	Nagaraja	3	Group of family
	16	Periyambala Kshetrakavu	Nagaraja	2	Group of family
	17	Ayyappankavu	Ayyappan, Nagaraja	2	Group of family
	18	Sivalaya Kshetrakavu	Nagaraja and Nagayakshi	2	Group of family

TABLE 5**Details of sacred groves in Punnayur Panchayath in the coastal belt of Thrissur district**

Panchayath/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Punnayur Panchayath	1	Erancheri Durga Bhagavathi Kshetra kavu	Bhagavathi, Nagaraja	4	Group of family
	2	Karuthedath Kshetrakavu	Nagam	3	Group of family
	3	Edakkara Kunnathu Kavuvu	Nagam	3	Group of family
	4	Patharikavu	Nagam	2	Individual family
	5	Kalathiparambil Kavuvu	Nagam	3	Individual family
	6	Panthayi Kshetrakavu	Nagaraja	4	Group of family
	7	Akkiparambathu Kavuvu	Nagam	2	Individual family
	8	Pavittakulangara Kshetrakavu	Nagaraja	6	Group of family
	9	Mambully Kshetrakavu	Nagaraja	3	Group of family
	10	Edakkattu Bhagavathi Kshetrakavu	Bhagavathi, Nagaraja and Nagayakshi	4	Group of family
	11	Periyamballa kavuvu	Nagam	3	Individual family
	12	Ottaini Kshetra kavuvu	Nagam	3	Group of family
	13	Anjarekavu	Brahmarakshassu and Nagam	4	Individual family
	14	Mathramkottu Kshetra kavuvu	Nagam	5	Group of family
	15	Ayyappan kavuvu	Ayyappan and Nagam	5	Group of family
	16	Kalathil kavuvu	Nagam	3	Individual family
	17	Chandirathil kavuvu	Nagam	4	Individual family
	18	Aviyoor kalari kavuvu	Nagam	5	Group of family
	19	Kadampully Bhagavathi kshetra kavuvu	Bhagavathi, Nagaraja	6	Group of family
	20	Kunnathu kavuvu	Nagam	20	Individual family
	21	Kalarikkal kavuvu	Nagam	3	Individual family
	22	Kothamuthithara kavuvu	Nagam	2	Individual family
	23	Amarayil kavuvu	Nagam	2	Individual family
	24	Kuranjiyoor kavuvu	Nagam	2	Individual family
	25	Kizhapattu Kavuvu	Nagam	3	Individual family
	26	Ambalam kavuvu	Nagam	3	Group of family
	27	Panikker kavuvu	Nagam	2	Group of family

TABLE 6**Details of sacred groves in Chavakkad Municipality in the coastal belt of Thrissur district**

Panchayath/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Chavakkad Municipality	1	Manathala Nagayakhi kavuvu	Nagaraja and Nagayakshi	20	Group of family
	2	Nariyambully Kshetra kavuvu	Nagam	4	Group of family
	3	Chamundeshwari Bhagavathy kshetra kavuvu	Bhagavathy, Nagam	3	Group of family
	4	Nediyedath Kshetra kavuvu	Nagaraja	5	Group of family
	5	Kalathil Kshetra kavuvu	Nagaraja and Nagayakshi	5	Group of family

TABLE 7**Details of sacred groves in Kadappuram Panchayath in the coastal belt of Thrissur district**

Panchayath/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Kadappuram Panchayath	1	Mattummal chanassery Bhagavathi Kshetra kavu	Nagaraja	10	Group of family
	2	Melepurakkal kavu	Nagaraja and Nagayakshi	6	Group of family
	3	Melepurakkal Kshetra kavu	Nagaraja and Nagayakshi	5	Group of family
	4	Kanda karuna Kshetra kavu	Nagam	3	Group of family
	5	Thondekkaran Kshetra kavu	Nagaraja	10	Group of family
	6	Kerachan Bhagavathi kavu	Bhagavathy,Nagam	2	Group of family
	7	Chevidan kulavan Kshetra kavu	Nagam	2	Group of family

Table 8**Details of sacred groves in Orumanayur Panchayath in the coastal belt of Thrissur district**

Panchayath/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Orumanayur Panchayat	1	Chendangotu tharavadu kavu	Nagam	28	Group of family
	2	Mangottu kavu	Nagam	5	Individual family
	3	Vadakkepurakkal kavu	Nagam	3	Individual family
	4	Vattekkattu kavu	Nagam	9	Individual family
	5	Paily kavu	Devi, Nagam	2	Individual family
	6	Koonampurath kavu	Sarpam	3.5	Individual family
	7	Chenda kavu	Nagam	5	Individual family
	8	Kallatt kavu	Nagam	2	Individual family
	9	Kuttikkatt kavu	Nagam	4	Individual family
	10	Valappil kavu	Nagam	2	Individual family
	11	Vadakkepurakkal kavu	Nagam	8	Individual family
	12	Chennangattu Kshetra kavu	Nagam	8	Group of family

TABLE 9**Details of sacred groves in Engandiyur Panchayath in the coastal belt of Thrissur district**

Panchayath Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Engandiyur Panchayath	1	Ellathum kavu	Nagam	25	Individual family
	2	Ayiramkanni Kshetra kavu	Bhagavathy, Nagaraja	10	Group of family
	3	Kalari kadu kavu	Kari nagam	8	Individual family
	4	Kadavil kottukkal kavu	Nagam	2	Individual family
	5	Vadakkekavu Kshetram	Nagam	5	Group of family
	6	Kalathil kavu	Nagam	2	Individual family
	7	Kanda karna kshetra kavu	Nagaraja	5	Group of family
	8	Panayamkulangara Kshetra kavu	Nagaraja	4	Group of family
	9	Karapurath kavu	Nagam	2	Individual family
	10	Kondrappassery kavu	Nagam	3	Individual family
	11	Chanassery Kshetra kavu	Nagaraja	5	Group of family
	12	Vadakkumchery Kshetra kavu	Nagaraja	4	Group of family
	13	Thachapully Kshetra kavu	Nagaraja	5	Group of family
	14	Kanjirathara Kshetra kavu	Nagaraja	4	Group of family
	15	Panikkassery Kshetra kavu	Nagam	3	Group of family
	16	Puthiyedathu kavu	Nagam	4	Individual family
	17	Karuppadath Kshetra kavu	Nagam	2	Group of family
	18	Therambil Kshetra kavu	Nagaraja	3	Group of family
	19	Meledath Kshetra kavu	Nagaraja	2	Group of family
	20	Pallithazhath Kshetra kavu	Nagam	2	Group of family

TABLE 10**Details of sacred groves in Vatanapally Panchayath in the coastal belt of Thrissur district**

Panchayath/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Vatanapally Panchayath	1	Kalappurakkal kavu	Nagam	25	Individual family
	2	Kottai Chalippattu kavu	Nagaraja	25	Group of family
	3	Kozhiparambil kavu	Bhagavathy and Vishnumaya,Nagam	18	Individual family
	4	Vaalath Bhagavathy kshetra kavu	Bhagavathy,Nagaraja	6	Group of family
	5	Palliyanakkadu Temple kavu	Ashtanagangal	90	Group of family
	6	Puthillathu Kav	Nagam	50	Group of family
	7	Poyyara kavu	Nagaraja and Nagayakhi	10	Group of family
	8	Sangaramangalam Devi temple	Devi, Nagangal	20	Group of family
	9	Meprengattu Kshetra kavu	Nagangal	8	Group of family
	10	Chettikadu Kav	Nagam	2	Individual family
	11	Vatanapally Thattan kavu	Nagam	2	Individual family
	12	Kongattil Kav	Nagam	2	Group of family
	13	Elethu Kav	Nagam	2	Individual family

TABLE 11**Details of sacred groves in Thalikulam Panchayath in the coastal belt of Thrissur district**

Panchayath/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Thalikulam Panchayath	1	Vallath sarpakavu	Anjana maninagam	3	Individual family
	2	Sree Dharmasastha kshetrakavu	Sasthavu, Nagaraja and Anjana maninagam	10	Group of family
	3	Nambiyathu kavu	Karinagam and Anjana maninagam	30	Individual family
	4	Chettikkadu Sarpakavu	Karinagam and Anjana maninagam	3	Group of family
	5	Aparambathu Sarpakavu	Nagarajavu and Nagayakshi	8	Individual family
	6	Kaliparambil kavu	Nagam	3	Individual family
	7	Sree Paradevatha nagathan kavu	Devi, Nagam	4	Group of family
	8	Sree Eranezhathu Bhagavathi Kshetra kavu	Bhagavathi,Nagarajavu and Nagayakshi	2	Group of family

TABLE 12**Details of sacred groves in Nattika Panchayath in the coastal belt of Thrissur district**

Panchayath/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Nattika Panchayath	1	Kaliyarakkal kavu	Bhagavathi, Kali and Chithrakoodam	22	Individual family
	2	Eranezhathu kavu	Nagayakshi	2	Individual family
	3	Nhayakkatt kavu	Nagam	2	Individual family
	4	Vellanchery kavu	Nagarajavu and Nagayakhi	2	Group of family
	5	Panapparambil kavu	Nagam	2	Individual family
	6	Panakkal pulakkaparambil kavu	Karinagam and Anjana maninagam	6	Individual family
	7	Panakkal kurumbepadath sree Bhadrakali temple	Bhadrakali, Kainagam and Anjana maninagam	6	Group of family
	8	Pozhekkadavil kavu	Nagam	2	Individual family
	9	Iyyani kavu	Nagam	2	Individual family
	10	Pandamparambil kavu	Nagam	2	Individual family
	11	Njayapilly illam	Nagam	2	Individual family
	12	Chembipparambil kavu	Nagam	2	Individual family
	13	Cherthedath kavu	Nagam	3	Individual family
	14	Arayamparambil kavu	Nagam	2	Individual family
	15	Puthanparambil Kav	Nagam	2	Individual family
	16	Vallath kavu	Nagam	2	Individual family
	17	Unniyaranpurakkal Kav	Nagangal	10	Individual family
	18	Pannipulath Kav	Vanabhuvaneshwari,karinagam and Maninagam	10	Group of family
	19	Kallingal kavu	Nagaraja, Karinagam, Anjana maninagam and Durga	8	Individual family
	20	Kanjirapparambil kavu	Nagam	2	Individual family
	21	Thekkepanakkal kavu	Nagam	2	Individual family

Nattika Panchayath	22	Kongattil kavu	Nagam	5	Group of family
	23	Vattezhathu kavu	Maninagam	6	Group of family
	24	Pandankulangara Kshetra Kavuvu	Nagaraja,Nagayakshi,Karinagam,Maninagam	15	Group of family
	25	Kalarikkal Sree Mahadurgadevi Kshetra Kavuvu	Durga,Nagam	1	Group of family

TABLE 13**Details of sacred groves in Edathiruthy Panchayath in the coastal belt of Thrissur district**

Panchayath/Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Edathiruthy Panchayath	1	Kollara Ponnempambil Yakshi kavu	Nagam	4	Group of family
	2	Choorapetti kavu	Nagam	5	Individual family
	3	Thechi kavu Ayyappan kavu	Ayyappan, Nagam	3	Group of family
	4	Kannanamkulangara Siva temple	Siva, Nagam	1	Devaswom
	5	Kollara Bhagavathi kshetra kavu	Bhagavathi, Nagam	2	Group of family
	6	Kallungal kavu	Nagam	4	Individual family

TABLE 14**Details of sacred groves in Valappad Panchayath in the coastal belt of Thrissur district**

Panchayath/Municipality	Sl. No.	Name of the Grove	Deity	Area(cent)	Ownership/ Managed by
Valappad panchayath	1	Adiparambil kavu	Nagayakshi and Sarpam	30	Individual family
	2	Valavath Durga devi temple	Mani nagam Kari nagam and Anjana mani nagam	2	Group of family
	3	Thamburan kavu	Vairanagam, Nagayakshi and Anjana maninagam	40	Group of family
	4	Adiparambil Kshetra kavu	Nagarajavu and Nagayakshi	30	Group of family
	5	Adikarathu sarpakkavu	Nagayakshi and Bhagavathi	2	Individual family
	6	Adikarathu kavu	Nagarajavu Nagayakshi and Annapoorneshwari	15	Individual family
	7	Vazhappully kavu	Nagam	1	Individual family
	8	Kakkaparambil kavu	Nagam	2	Individual family
	9	Valiparambil kavu	Nagam	2	Individual family
	10	Poyyara kavu	Nagam	2	Individual family
	11	Pazhasshi Nagadevatha kavu	Nagam	3	Group of family
	12	Nediyirippil kavu	Nagam	2	Individual family
	13	Pallathu Kavuvu	Nagam	3	Individual family
	14	Moonamkutty Kavuvu	Nagam	2	Individual family
	15	Pathattu Kavuvu	Nagam	2	Individual family
	16	Kozhissery KshetraKavuvu	Devi, Nagaraja and Nagayakshi	4	Group of family
	17	Njattuvetty Sree Kallada Bhagavathy Kshetra Kavuvu	Bhagavathy,Nagayakshi,Karinagam	4	Group of family

TABLE 15**Details of sacred groves in Kaipamangalam Panchayath in the coastal belt of Thrissur district**

Panchayath/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Kaipamangalam Panchayath	1	Daivathin kavu	Nagam	10	Group of family
	2	Kalapparambath kavu	Nagam	6	Individual family
	3	Vengaly kavu	Karinagam and Maninagam	3	Individual family
	4	Karayavattathu kavu	Nagam	2	Individual family
	5	Pattathu kavu	Nagam	2	Individual family
	6	Kuttikkattu kshetra kavu	Nagaraja	4	Group of family
	7	Malayattil Kshetra kavu	Nagaraja	30	Group of family
	8	Kottarathu Sree Dharma daiva kavu	Nagaraja	20	Group of family
	9	Kaduvetti Kshetra kavu	Nagam	18	Group of family
	10	Chonipparambil kavu	Nagam	5	Group of family
	11	Njattuvetti Kshetra kavu	Nagam	5	Group of family
	12	Agastheswara Siva Kshetra kavu	Nagam	10	Devaswom
	13	Paraparambil kavu	Nagam	2	Individual family
	14	Kalarikkal kavu	Nagam	2	Individual family
	15	Kilikkottu kavu	Nagam	2	Individual family
	16	Punnakkal kavu	Nagayakshi	5	Individual family
	17	Mundassery parambil kavu	Nagam	2	Individual family
	18	Chennamkulam kavu	Nagam	2	Individual family
	19	Kanjiraparambil kavu	Nagam	1	Individual family
	20	Palliyil kavu	Nagam	2	Individual family
	21	Koottalaparambil kavu	Nagam	3	Individual family
	22	Kozhiparambil kavu	Karinagam and Maninagam	2	Individual family
	23	Anjarassery kavu	Nagam	1	Individual family
	24	Kozhissery kshetra kavu	Nagam	3	Group of family
	25	Chachamaram Kavuvu	Nagaraja, Nagayakshi, Karinagam, Anjanamani nagami	1	Group of family
	26	Karadivalavu Kavuvu	Nagam	2	Group of family

TABLE 16**Details of sacred groves in Perinjanam Panchayath in the coastal belt of Thrissur district**

Panchayath/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Perinjanam Panchayath	1	Kollara kavu	Nagam	2	Individual family
	2	Ayilyam kavu Kshetram	Nagaraja and Nagayakshi	2	Group of family
	3	Chemmathi kavu	Nagam	3	Group of family
	4	Choorakottu Kshetra kavu	Nagam	2	Group of family
	5	Palliyil Bhagavathi kshetra kavu	Bhagavathi, Nagam	2	Group of family
	6	Mangattu kavu	Nagam	3	Individual family
	7	Peedikaparambil kavu	Nagam	5	Individual family
	8	Puthiyedath kavu	Nagam	2	Individual family
	9	Karayil Kshetra kavu	Nagam	2	Individual family
	10	Puthezhath kavu	Nagam	15	Individual family
	11	Tharayil kavu	Nagam	2	Individual family
	12	Tharayapurath Kshetra kavu	Nagaraja	5	Group of family
	13	Keezhilath kavu	Nagam	10	Individual family
	14	Ganesha Kshetra kavu	Ganapathi, Nagam	4	Group of family

TABLE 17**Details of sacred groves in Mathilakam Panchayath in the coastal belt of Thrissur district**

Panchayath Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Mathilakam Panchayath	1	Killikulangara Kshetra nagakavu	Nagaraja, nagayakshi	20	Group of family
	2	Trippekulam Kshetra kavu	Nagam	8	Group of family
	3	Mannamparambil Kshetra kavu	Nagam	2	Group of family
	4	Nagayakshi Kavuvu	Nagaraja and Nagayakshi	5	Group of family
	5	Kalatheri Kavuvu	Nagam	5	Individual family
	6	Maniyakavu	Nagam	1	Individual family

TABLE 18**Details of sacred groves in Sree Narayanapuram Panchayath in the coastal belt of Thrissur district**

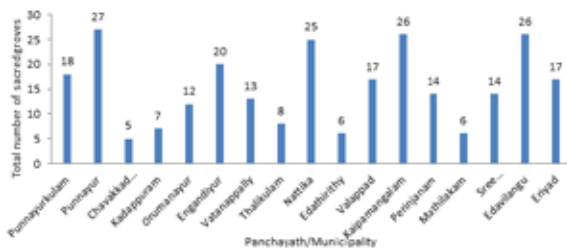
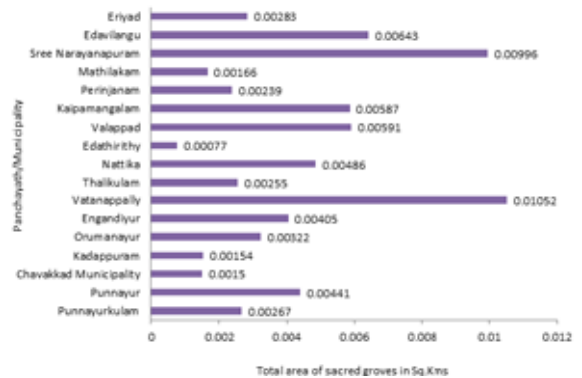
Panchayath/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Sreenarayanapuram panchayath	1	Ayyalathu Yakshi Kavu	Nagam	10	Individual family
	2	Kumaramangalathu kavu	Nagam	28	Individual family
	3	Sree Sankulangara Kavu(1)	Vanadurga and Nagam	157	Devaswom
	4	Sree Sankulangara Kavu(2)	Nagam	30	Devaswom
	5	Kanikkedathu Kavu	Nagam	5	Individual family
	6	Palapetti Kavu	Nagaraja and Nagayakshi	2	Group of family
	7	Ayyappan Kavu	Ayyappan, Devi and Nagaraja	2	Group of family
	8	Eramangalathu Kavu	Nagaraja, Nagayakshi	2	Individual family
	9	Chanaan Veetil Kavu	Nagaraja, Nagayakshi and aninagam	2	Individual family
	10	Thaivalliyil Kavu	Sarpam	1	Individual family
	11	Kalakkatil Nagakavu	Nagaraja	2	Individual family
	12	Thottapilly Kshetra Kavu	Nagam	1	Group of family
	13	Nagayakshi Kavu	Nagayakshi, Nagaraja	2	Group of family
	14	Kazhuvilangu Kshetra Kavu	Nagam	2	Group of family

TABLE 19**Details of sacred groves in Edavilangu Panchayath in the coastal belt of Thrissur district**

Panchayath/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Edavilangu Panchayath	1	Cheeriyaparambil Kshetra kavu	Nagam	10	Group of family
	2	Karayil Maruthi kshetra kavu	Nagam and Hanuman	5	Group of family
	3	Kottekkattu kshetra kavu	Nagam	4	Group of family
	4	Edachalil ponnanchery Kshetra kavu	Nagaraja	4	Group of family
	5	Naalumakkal Kshetra kavu	Nagaraja and Nagayakshi	18	Group of family
	6	Karayil kshetra kavu	Nagaraja	5	Group of family
	7	Ponathu Tharavadu Kavu	Nagaraja	2	Individual family
	8	Sree Vishnu Kshetra kavu	Nagaraja	8	Group of family
	9	Alungal Kavu	Nagam	5	Individual family
	10	Pindiyathupadi Kshetra kavu	Nagam	8	Group of family
	11	Kunnugaparambil Kavu	Nagam	5	Individual family
	12	Arrampurakkal	Nagam	3	Individual family
	13	Thayyilkavu	Nagam	2	Individual family
	14	Karayil Kavu (1)	Nagam	3	Individual family
	15	Kundiyara Kavu	Nagam	5	Individual family
	16	Mundenchery Kavu	Nagam	5	Individual family
	17	Illathumparambil Kshetra kavu	Nagaraja and Nagayakshi	15	Group of family
	18	Mullassery Nagasthana Kavu	Nagam	10	Group of family
	19	Kampilikkal Kavu	Nagam	3	Individual family
	20	Pidiyathu Kavu	Nagam	2	Individual family
	21	Karayil Kavu (2)	Nagam	4	Individual family
	22	Kunnugaparambil Kavu	Nagam	3	Individual family
	23	Edachalil Bhagavathi Kshetra Kavu	Nagam	4	Group of family
	24	Poothamveetil Sree Bhuvaneswary Kshetra kavu	Devi, Nagam	7	Group of family
	25	Vylezhathu Kshetra Kavu	Nagam	15	Devaswom
	26	Kaimaparambil Kavu	Nagam	4	Individual family

TABLE 20**Details of sacred groves in Eriyad Panchayath in the coastal belt of Thrissur district**

Panchayath/ Municipality	Sl. No.	Name of the Grove	Deity	Area (cent)	Ownership/ Managed by
Eriyad Panchayath	1	Thevali Kavu	Nagaraja	10	Individual family
	2	Ayyani Kavu	Nagam	2	Individual family
	3	Kariyethathu Kavu	Nagam	3	Individual family
	4	Parutthi Kavu	Nagam	10	Individual family
	5	Madathiparambil Kshetra kavu	Nagaraja	3	Group of family
	6	Thottarathu Kavu	Nagam	5	Individual family
	7	Kottikkal Kshetra Kavu	Nagaraja	4	Group of family
	8	Andirithi kavu	Nagam	3	Individual family
	9	Panaparambil Kavu	Nagam	2	Individual family
	10	Kuttathumveetil Kavu	Nagam	3	Individual family
	11	Akkanveetil Kshetrakavu	Nagam	5	Group of family
	12	Kaimathuruthi Kavu	Nagam	3	Individual family
	13	Tharaparambil Kshetra Kavu	Nagaraja	5	Group of family
	14	Thadikkaparambil Nagathan Kavu	Nagaraja, Nagayakshi, Maninagam and Karinagam	3	Group of family
	15	Aluparambil Kavu	Nagam	2	Individual family
	16	Kottikkal Kshetra kavu	Nagaraja	3	Group of family
	17	Sivanaga Kshetra kavu	Nagaraja and Nagayakshi	4	Group of family

**Figure: 3 Details of total number of sacred groves of different extends existing in different panchayaths and municipality along the coastal belt of Thrissur district in Kerala****Figure: 4 Details of total area covered by sacred groves of different extends in different panchayaths and municipality along the coastal belt of Thrissur district in Kerala****REFERENCES**

- [1] Gadgil, M., and Vartak, V.D. (1975), "Sacred groves of India: a plea for continued conservation." Journal of Bombay Natural History Society, 72, 314-320. [2] Rajendraprasad, M. (1995), "The Floristic, Structural and Functional Analysis of Sacred Groves of Kerala." Ph.D Thesis, University of Kerala, Thiruvananthapuram, Kerala. [3] Ramachandran, K.K., and Mohanan, C.N. (1991), "Studies on Sacred Groves of Kerala." Final Report submitted to Ministry of Environment and Forests, Government of India. [4] Chandrashekara, U.M., and Sankar, S. (1998), "Ecological and social importance of conservation of sacred groves in Kerala." KFRI Research Report, 152, 1-43. [5] Sujana, K.A., and Sivaperuman, C. (2008), "Status and conservation of threatened in selected sacred groves of coastal Kerala." Eco News, 14(2), 6-10. [6] Ramakrishnan, P.S., Saxena, K.G., and Chandrasekhara, U.M. (1998), "Conserving the sacred groves for biodiversity management." ISB and Oxford, New Delhi.



Role of Sacred Groves in Ameliorating Soil Physical Properties and Microclimate: A Case Study of Sree Sankulangara Sacred Grove and Adjacent Disturbed Land at S.N Puram, Thrissur, Kerala

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ABSTRACT

The major factor affecting the soil quality and microclimate of an area is based on the vegetation cover in that area. The present investigation deals with a comparative study on vegetation and phytosociology, physical properties of soil and microclimatic parameters between the selected Sankulangara sacred grove and the adjacent disturbed non sacred grove land at S.N Puram in the Coastal Belt of Thrissur District, Kerala. Vegetation and phytosociological analysis of both the selected lands was studied using quadrat method for trees, shrubs, herbs, lianas and climbers and has been compared. The study reveals that with respect to all the plant groups, with the exception of herbs, most of the parameters like floral density (FD), relative density (RD) and relative frequency (RF) and total basal area (TBA) of tree species were considerably higher at Sree Sankulangara sacred grove compared to adjacent disturbed non-sacred grove land. Analysis of various physical properties of soil samples collected during the pre monsoon and post monsoon season reveals a better physical property for the soils of sacred grove region. Values of moisture content, water holding capacity, porosity and electrical conductivity were recorded high in sacred grove region while values of bulk density and pH were recorded low when compared to adjacent disturbed non-sacred grove region. Analysis of temperature and humidity related to soil and atmosphere in the study sites reveals that low temperature and humidity is maintained within the grove region compared to non-sacred grove region. The investigation clearly revealed the role of sacred grove in rejuvenating and maintaining a better soil physical properties and microclimate of the region compared to a disturbed region.

KEYWORDS

Sree Sankulangara sacred grove, adjacent disturbed non-sacred grove region, vegetation, soil physical properties, microclimate

Introduction

Sacred groves are forest fragments of varying sizes traditionally been protected on the grounds of spiritual and religious faith and they are a treasure house of rare and endangered species of plants. Sacred groves are also having rich diversity of many plant species which are relevant to the maintenance of ecosystem balance. As an ecosystem, sacred groves help in soil and water conservation, besides preserving the biological wealth. Sacred groves enrich the soil through its rich litter and the nutrients generated by litter decomposition are not only recycled within the sacred grove ecosystem but also find their way into the adjoining agro ecosystems (Ramachandran et al., 1991). The thick litter cover and channels created by soil macro fauna together enhances water retention, root system development, gaseous exchange, and heat conductance. Therefore, being a unique unit in the rural landscape, the sacred grove performs several ecological functions, which can directly or indirectly help in the maintenance of ecosystem health of all interacting landscape units. According to Rajendraprasad (1995), sacred groves with their complex array of interaction, influence the flora and fauna of the region as well as the microclimate of that locality. Gadgil and Vartak (1975) observed that in many parts of India, sacred groves represent surviving examples of climax vegetation but these groves are gradually disappearing under the influence of modernization and this may be mainly due to lack of awareness regarding the importance of sacred groves in maintenance of ecosystem balance, biodiversity conservation and maintenance of microclimatic conditions. There are many general reports on the importance of sacred groves on ecosystem balance and biodiversity conservation however the scientific data based research results on their role in maintaining the physico-chemical and microclimatic aspects of an ecosystem is very less and therefore one of the challenging tasks before the ecologist is to make understand and to make aware the public, concerned organizations and government bodies regarding the important

relationship between plant wealth & diversity and the functioning & conservation of ecosystems (Davis and Richardson, 1995). The present work is being proposed in the above context. The authors believe that a detailed study of relationship between the vegetation, soil properties and microclimate at Sree Sankulangara sacred grove and comparing situation with the adjacent disturbed non-sacred grove region and passing the scientific information gathered from the study will influence the concerned regarding the importance to conserving the existing sacred groves for future ecosystem balance.

Materials and Methods

Study area and season

The study area is Sree Sankulangara sacred grove and adjacent disturbed non-sacred grove land at S.N Puram which belongs to the Coastal Belt of Thrissur District, Kerala. The study area lies at 10.52°N 76.21°E and has an average altitude of 2.83m. The sacred grove covering an area of about 157 cents (0.636 ha) and the same extent of adjacent disturbed non-sacred grove land was selected for comparison. The study was conducted during the pre monsoon (April-May) and post monsoon (August-September) period.

Vegetation and Phytosociological Analysis

Different plant groups such as trees, shrubs, herbs, lianas and climbers of both Sree Sankulangara sacred grove and adjacent disturbed non-sacred grove land were selected and analyzed for various phytosociological studies like floral distribution, floral density (FD), total floral density (TFD) and relative density(RD), after dividing the study area into approximately 4 equal quadrats of 39.25 cents (0.159ha) each while frequency (F) and relative frequency (RF) of different plant groups was analyzed after dividing each study area into eight equal quadrats of approximately 19.63 cents (0.08ha) each. Total basal area (TBA) and relative basal area (RBA) of tree species and importance value index (IVI) of Tree species and family were

analyzed and calculated following the methods of Curtls and McIntosh (1950), Misra and Purl (1954), Misra (1969), Muller and Ellenberg (1974) and Werger (1974).

Analysis of Soil Physical Properties

Separate soil samples in triplicates from core and transition region of Sree Sankulangara sacred grove and soil samples from disturbed but grove influenced and highly disturbed region of adjacent non-sacred land were collected at a depth of 30cm from the surface, using the core type soil auger to get comparatively less disturbed pedon of soil. The soil samples were then carefully transferred into air tight polythene covers and analyzed for various physical properties like soil moisture, water holding capacity, bulk density, porosity, pH and electrical conductivity. Soil moisture was estimated using the gravimetric method. Three important physical constants of the soil namely water holding capacity, bulk density and porosity were determined by Keen Rackowski box method. pH and electrical conductivity of soil samples were determined by electrometric method using Digital pH Meter and Conductivity Meter respectively.

Analysis of Microclimate

Microclimatic parameters like temperature, humidity etc in the soil and atmosphere of both Sree Sankulangara sacred grove and adjacent disturbed non-sacred grove land were analyzed and compared. Both the parameters were measured by using Thermo-Hygrometer (TA318) during the mid day period.

Results and Discussion

Trees, shrubs, herbs, lianas and climbers of Sree Sankulangara sacred grove and adjacent disturbed non-sacred grove land were the different plant groups considered for the present investigation. The data on floral distribution, density, relative density and total floral density obtained from the vegetation analysis is depicted in table 1 and 2. The highest distribution of plant group in terms of number was recorded with climbers followed by trees, shrubs, herbs and lianas in sacred grove while the highest distribution was recorded with herbs followed by shrubs, trees, climbers and no lianas were recorded in adjacent disturbed land. The data reveals the average total floral density per quadrat at Sree Sankulangara sacred grove is 530 in which the climbers recorded the highest relative density of 45.57% which was followed by trees (20.28%), Shrubs (18.40%), herbs (8.58%) and lianas (7.17%). On comparing this situation with adjacent disturbed land, the average total floral density was 55462 per quadrat which is very high compared to Sree Sankulangara sacred grove; however it can be seen that the highest relative density of plant group is recorded with herbs which constitute around 99.88% of the total floral density and the remaining plant groups together constitute only 0.12%. This clearly reveals significant reduction in the floral density of shrubs, trees, climbers and lianas in the disturbed land compared to Sree Sankulangara sacred grove which were 59.23%, 86.51%, 94.93% and 100% reduction respectively.

Relative frequency (RF) of different plant groups such as trees, shrubs, herbs, lianas and climbers in Sree Sankulangara sacred grove and adjacent disturbed non-sacred grove land was analyzed and the results are depicted in table 3. The results reveal that highest relative frequency was recorded by trees with respect to Sree Sankulangara sacred grove (30.99%) while it was by herbs with respect to disturbed non-sacred grove land (60.94%). The lowest RF value was recorded for lianas (5.63%) in Sree Sankulangara sacred grove and for climbers (5.39%) in disturbed land. Lianas were totally absent in the disturbed land. Even though the values of floral density and relative density of shrubs in disturbed land recorded significantly lower values than that in sacred grove, the relative frequency of shrub was recorded 7.11% higher and it indicates more uniform distribution of shrubs in the disturbed land compared to sacred grove.

Total basal area (TBA) and relative basal area (RBA) of tree species in Sree Sankulangara sacred grove and adjacent disturbed

non-sacred grove land was analyzed and compared. The data obtained from the analysis is depicted in table 4 and 5. Highest TBA of 645 m² was recorded in Sree Sankulangara sacred grove which is about 97.73% higher than the TBA of 14.61m² recorded in disturbed non-sacred grove land. The table 4 shows that there are about 35 different tree species identified and their basal area was recorded in sacred grove. The highest RBA was recorded with *Hopea ponga* (578 m²) which belongs to the family Dipterocarpaceae and constitute around 89.61% of total basal area of trees. However in disturbed land only 18 tree species were identified and the highest RBA was recorded with *Cocos nucifera* (9.05m²) which belongs to the family Areaceae and constitute around 62% of total basal area of trees.

Importance value index (IVI) of different tree species and family of tree species at both the study sites was analyzed and the data is shown in table 6 and 7. In Sree Sankulangara sacred grove, the tree species representing the highest IVI score was recorded by *Hopea ponga* (118.3) and the highest IVI score for the family was recorded in Dipterocarpaceae with an overall total IVI score of 132.24 and this family comprises of two tree species namely *Hopea ponga* and *Veteria indica*. In the case of adjacent disturbed land, the highest IVI score for the tree species was recorded by *Cocos nucifera* (106.8) and the highest IVI score for the family were recorded in Areaceae with an overall total IVI score of 164 which comprises of two tree species namely *Cocos nucifera* and *Areca catechu*.

The results of the vegetation analysis in the present study showed that with the exception of herbs, the floral density and relative density of different plant groups and tree species diversity and total basal area of tree species are very high in sacred grove compared to adjacent disturbed land. The dominance of herbaceous plants is also an indication of degraded forests. Besides these the analysis of importance value index (IVI) of family of different tree species in Sree Sankulangara sacred grove showed *Hopea ponga* and *Veteria indica* of Dipterocarpaceae together constitute highest IVI value while in adjacent non-sacred grove land *Cocos nucifera* and *Areca catechu* of Areaceae constitute highest IVI value. This clearly reveals that the Sree Sankulangara sacred grove is a repository of the original forest vegetation preserved on religious ground whereas adjacent land is an area of high human interference representing highly disturbed and degraded forest vegetation.

Analysis of Soil Physical Properties

Soil samples collected from different regions of Sree Sankulangara sacred grove and adjacent disturbed non-sacred grove land were analyzed for various physical properties and the results obtained are depicted in table 8 and table 9. Soil porosity is the amount of air space or void space present between soil particles of particular soil type which are important for infiltration, groundwater movement and storage space. The data shows the soil porosity is higher in sacred grove regions when compared with the disturbed non-sacred grove regions. The highest porosity value was obtained in soil sample collected from the core region of sacred grove followed by transition region of sacred grove, disturbed inner region of non-sacred grove, and the lowest value was obtained in soil sample collected from disturbed outer region of non-sacred grove. The increase in soil porosity at core region of sacred grove compared to disturbed outer region was about 6.85% and 4.06% respectively during the post monsoon season and pre monsoon season. The study reveals that when comparing the porosity values of different soil samples obtained during different seasons, the porosity values were found to improve in the post monsoon season compared to pre monsoon season and this was 4.45%, 4.55%, 1.25% and 1.66% respectively for core region, transition region, disturbed grove influenced inner region, and disturbed outer region. Higher soil porosity in the sacred grove region may be due to the existence of fine-textured soil which might be the result of higher organic matter content together with reduced soil disturbances and minimum soil compaction and erosion compared to disturbed land (Kësik et al., 2010).

Bulk density is an indicator of soil compaction and soil health. It affects infiltration, available water capacity, soil porosity, plant nutrient availability, and soil microorganism activity which influence key soil processes and productivity. The values of bulk density of soil samples collected from sacred grove regions are lower when compared to non-sacred grove regions. The data reveals more or less similar trend in the bulk density levels in different soil samples collected during both the pre monsoon and post monsoon season (table 8 and table 9). The highest bulk density value was obtained in soil samples collected from disturbed outer region followed by disturbed inner region, transition region and core region. On comparing the bulk density values obtained in different seasons, comparatively lower values were recorded in the post monsoon season and this may be due to the improvement in organic matter content of the soil which results from increased decomposition rate of dead organic matter especially litter fall due to increased microbial activity.

The average bulk density of soil at core region of sacred grove was 1.38g/cm^3 during the pre monsoon and 1.31g/cm^3 during the post monsoon season while it was 1.48g/cm^3 and 1.43g/cm^3 respectively during above seasons with respect to disturbed outer region of non-sacred grove and this was about 6.76% and 8.39% increase respectively over the core region of sacred grove. Strong relationship between organic matter content and bulk density of soil is reported by many researchers and Curtis and Post (1964) stated a reverse correlation between organic matter and bulk density. The lower bulk density and higher porosity of soil in Sree Sankulangara sacred grove compared to the adjacent disturbed land observed in the present investigation may be attributed to the higher relative density and frequency of trees. This is because as the tree density and frequency in a land increases, it may led to the vigorous growth of the root system in the soil and this has a positive effect on reducing the soil strength and there by improvement in soil aeration. However in disturbed non-sacred grove land, low tree density and frequency leads to adverse effect on root growth resulting in increased soil strength and decreased soil aeration causing increase in bulk density and decrease in soil porosity. This observation in the present study is in par with the observations of Nambiar and Sands (1992) on the effect of tree root development on the compaction of soil. Another important factor that may contribute to the lower bulk density and higher porosity of soil in Sree Sankulangara sacred grove is the frequent addition of leaf litter as organic matter. The decomposition of leaf litter by microbial organisms acts as an agent for improving the stability and quality of the soil by forming soil aggregates and promotes better pore distribution. This is because decomposed organic matter components are less dense than the mineral components and cause improvement in soil porosity and lowering of bulk density (Portella et al., 2012; Enrique et al., 2015). Pravin et al. in 2013 reported that the bulk density of a soil is found to decrease as the total micronutrient and macronutrient content in the soil increases. The lower bulk density value observed with the soils of sacred grove regions compared to non-sacred grove region in the present study may also be attributed to the difference in macro and micro nutrient content of the soil types.

The analysis of soil moisture content shows that the samples collected from Sree Sankulangara sacred grove generally maintained higher soil moisture level compared to that collected from adjacent non-sacred grove land. The highest soil moisture content was recorded in the sample collected from the core region of sacred grove while the lowest moist level was recorded in the sample collected from the disturbed outer region of non-sacred grove during both the pre monsoon as well as the post monsoon season. During the pre monsoon season, the average soil moisture content at core region of sacred grove was 8.80% while it was 3.78% at disturbed outer region of non-sacred grove and this was about 57.05% less moisture content than the core region whereas during the post monsoon season, the average soil moisture content increased to 13.84% at core region while it increased to 6.52% at disturbed outer region and is about 52.89% lower moisture

content than the core region. The data presented in the table 8 and table 9 shows a progressive decrease in soil moisture content level in the direction of core region – transition region – disturbed inner region – disturbed outer region and therefore the present investigation clearly reveals that the soil of Sree Sankulangara sacred grove has higher moisture retention capacity compared to disturbed non-sacred grove land. The higher moisture retention capacity of soil in sacred grove may be due to increased organic matter and humus content of the soil which improves water holding capacity as a result of lower bulk density (Johan, 1998). The reduced surface evaporation due to very high litter fall and their deposition over the surface soil together with specific microclimatic conditions of sacred grove due to higher density of different plant groups especially trees may also have contributed towards improved moisture retention capacity.

Water holding capacity (WHC) of the soil is the amount of water held by the capillary spaces of the soil after the percolation of gravitational water into the deeper layers. The data presented in the table 8 and table 9 reveals higher water holding capacity for soil samples collected from sacred grove regions when compared to disturbed non-sacred grove regions, during the pre monsoon as well as the post monsoon season. The highest WHC value was recorded in soil sample collected from core region and then the value gradually decreased in the direction of transition region, disturbed inner region of non-sacred grove and disturbed outer region. The WHC value recorded in the core region of sacred grove during the pre monsoon and post monsoon season was about 17.6% and 18.9% higher respectively over the values recorded in the disturbed outer region of non-sacred grove. The study generally observed that the WHC of all the soil samples collected during the post monsoon season recorded values higher than the values recorded by corresponding soil samples during the pre monsoon season. Higher water holding capacity of soils in the sacred grove regions compared to disturbed non-sacred grove regions may be because of greater floristic composition and distribution. The high rate of litter fall and their decomposition oriented increased organic matter content in the soil can improve the binding of soil particles and aggregation which results in increased pore space and improvement in specific surface area (Vengadaramana and Jashothan, 2012; Volk and Ullery, 1993). The increased pore space and large surface area of soil in sacred grove contributed by the smaller particles like clay and silt together with affinity of organic matter for water allow the soil of sacred grove to hold a larger volume of water and thereby increase water holding capacity. An important observation in this respect made was while analyzing the WHC within the non-sacred grove region, the disturbed but grove influenced inner region of non-sacred grove recorded an improved WHC compared to disturbed outer region and which was 0.95% and 3.28% increase respectively during the pre monsoon and post monsoon season. This may be attributed to the leaching of decomposed organic matter content from the grove region to the immediate adjacent disturbed land.

pH is a good measure of acidity or alkalinity of a soil water suspension and provides good indication of the soil chemical properties (Trivedy and Goel, 1986). The soil pH in sacred grove and adjacent disturbed non-sacred grove land was within the range of medium to strongly acidic however; comparatively lower pH values were recorded in the soil of sacred grove compared to adjacent disturbed land. Comparing the pH values obtained during different seasons, soil samples collected during the post monsoon season recorded pH values comparatively higher than the values recorded during the pre monsoon season. The lowest pH value was recorded in the soil at core region during both the season and the pH value of other soil samples exhibited a gradual increasing trend in the direction of transition region, disturbed but grove influenced inner region and disturbed outer region. The difference in soil pH between Sree Sankulangara sacred grove and adjacent disturbed land may be related to difference in the dynamics of the soil organic matter (Bell and Raczkowski, 2008). Lower

pH values of soils in the sacred grove region compared to disturbed region may be due to increased organic matter content of the soils contributed by high leaf litter fall from rich vegetation especially tree group. Organic matter is usually considered to lower soil pH by releasing hydrogen ions that are associated with organic anions or by nitrification in an open system (Porter et al., 1980).

Soil electrical conductivity (EC) is the ability of soil water to carry an electrical current and the EC value of a soil can give a good indication of the amount of nutrients available for the plants to absorb. The results of the electrical conductivity obtained from the analysis shows the soil samples collected from sacred grove recorded higher EC value compared to non-sacred grove regions during both the seasons. The higher EC value of soils in the Sree Sankulangara sacred grove compared to non-sacred grove region may be attributed to the higher release of soluble inorganic ions from the rich soil organic matter, favoured by increased soil porosity and higher moisture content (Granged, 2011). The present study observed a negative correlation between EC value and bulk density in the analysed soil samples while there is a positive correlation between EC value, inorganic matter, porosity and moisture content of analysed soil samples.

Analysis of Microclimate

Soil and atmospheric temperature within the Sree Sankulangara sacred grove and adjacent disturbed non-sacred grove land were analyzed during the pre monsoon as well as post monsoon season and the results are shown in table 10 and table 11. The data reveals that both soils as well as atmospheric temperature recorded in the non-sacred grove regions are higher when compared to the sacred grove regions during both seasons. The increase was more prominent when comparing the temperature recorded in the outer zone of disturbed non-sacred grove region with the core region of sacred grove and this was maximum during the pre monsoon season with an increase of 18.06% with respect to soil and 15.80% with respect to atmospheric temperatures while it was only 15.5% and 13.5% respectively during post monsoon season. The comparison between the temperatures recorded during the pre monsoon and post monsoon season within the grove as well as outside the grove reveals, the increase of temperature from post monsoon season to pre monsoon season was more prominent with respect to disturbed outer region of non-sacred grove which was 10.47% and 11.17% increase respectively for soil temperature and atmospheric temperature while with respect to core region of sacred grove, the increase was only 7.67% and 8.74% respectively for soil temperature and atmospheric temperature. Morecroft et al. (1998) compared the air and soil microclimates of deciduous forest land with an open site at Wytham Woods, Oxford, UK and reported that the effect of forest cover on soil and air temperatures were much considerable and could be lowered under the canopy of forest land than at the open site during the summer. Similarly Johnson et al. (1985) observed that whole-tree harvesting in an oak forest in Virginia resulted in an increase in the temperature of 6-8°C in the July and August, compared to the adjacent uncut land. The present study results are also in same lines with the above observations. The study reveals that the sacred groves are playing important role in regulating the temperature in the area and this may be attributed to the dense canopy of sacred grove especially the tree canopy which act as a protective cover and provide cool climate to the area resulting from the release of large quantity of water vapor through transpiration. Further the ground vegetation cover together with thick layer of litter fall act as insulation to the ground playing the role of regulating the soil temperature.

The results of the analysis of soil and atmospheric humidity are shown in table 10 and table 11. The data indicates the higher values of humidity was recorded in the non-sacred grove regions compared to sacred grove regions during both the season and the maximum difference was obtained between the outer disturbed zone of non-sacred grove and core zone of sacred grove. The increase was about 17.81%

and 16.67% respectively for soil and atmospheric humidity during the pre monsoon season while it was 10.94% and 12.12% respectively during the post monsoon season. Similar to the case with temperature parameter, while comparing the humidity values recorded during the pre monsoon and the post monsoon season, within the grove as well as outside the grove reveals, the increase of humidity from post monsoon season to pre monsoon season was more prominent with respect to outer zone of disturbed non-sacred grove region and was 15.79% and 15.38% increase respectively for soil humidity and atmospheric humidity while with respect to core region of sacred grove, the increase was only 9.52% and 10.77% respectively. Loss of moisture through evaporation from the surface soil of an open field may be higher as loss of moisture from forest soil of similar character under protection of forest cover (Abdul Sahim, 2003). The blocking of light radiation by canopy cover, lower soil temperature together with the thick cover of leaf litter on the ground and the resultant reduction in evaporation of moisture from the soil surface of sacred grove may be the reason for reduced soil and atmospheric humidity in the grove region compared to adjacent disturbed land.

Conclusion

The present study clearly reveals that the sacred groves are playing a very important role in ameliorating soil physical properties and microclimatic conditions which are very necessary for the biodiversity conservation and ecosystem balance. The overall better soil physical properties and climatic factors in Sree Sankulangara sacred grove compared to the adjacent disturbed land may be due to the rich vegetation, diversity and vigorous root system of trees and other plants in the grove area. Besides these, continuous addition of organic matter content through litter fall and comparatively less external disturbances to plant and soil in the grove land are contributing to the productive capacity of the soil favoring the maintenance of natural regeneration of vegetation, healthy climate factors and ecological patterns. Though ancient people of India established sound socio-cultural practices epitomizing in-situ conservation of biological and genetic diversity of sacred groves considering their importance in ecosystem maintenance, in recent times this has been ignored. People are gradually destroying these natural patches of forests knowingly or unknowingly for various purposes such as agriculture, construction, developmental activities etc. Therefore the situation demands an urgent need for recognizing such traditionally valued natural systems and to gear up strong actions for a combined and holistic approach for conserve such grove tradition.

Table 1: Floral distribution, floral density, relative density (RD) and total floral density of different plant groups in Sree Sankulangara sacred grove

Sl. No	Name of the Plant group	Distribution of plant	Relative density (%)	Floral density per Quadrat	Total floral density per quadrat	
					Including Herbs	Excluding Herbs
1	Trees	430	20.28	107.5	530	485
2	Shrubs	390	18.40	97.5		
3	Herbs	182	8.58	45.5		
4	Lianas	152	7.17	38.0		
5	Climber	966	45.57	241.5		

Table 2: Floral distribution, floral density, relative density (RD) and total floral density of plant groups in disturbed non-sacred grove land adjacent to Sree Sankulangara sacred grove

Sl. No	Name of the Plant group	Floral distribution of plant	Relative density (%)	Floral density per Quadrat	Total floral density per quadrat	
					Including herbs	Excluding herbs

1	Trees	57	0.026	14.5	55462	66
2	Shrubs	159	0.072	39.75		
3	Herbs	221583	99.88	55395.75		
4	Lianas	0	0.0	0.0		
5	Climber	49	0.022	12.25		

Table 3: Relative frequency (RF) of plant groups at Sree Sankulangara sacred grove and disturbed non-sacred grove land adjacent to Sree Sankulangara sacred grove

Sl. No	Name of the Plant group	Total no of quadrats of occurrence of plant groups		Relative frequency plant groups (%)	
		Sacred grove	Non-sacred grove	Sacred grove	Non-sacred grove
1	Trees	154	36	30.99	12.12
2	Shrubs	100	64	20.12	21.55
3	Herbs	70	181	14.08	60.94
4	Lianas	28	0	5.63	0
5	Climber	145	16	29.18	5.39

Table 4: Total basal area (BA) and relative basal area (RBA) of tree species at Sree Sankulangara sacred grove

Sl. No	Name of the Tree species	Family	Total basal area of the species-m ² /157 cent (0.636 ha)	Relative basal area of the species (%)
1	<i>Adenanthera pavonina</i> L.	Fabaceae	0.4	0.06
2	<i>Aphanamixis polystachya</i> (Wall.) R.N.Parker.	Meliaceae	0.69	0.11
3	<i>Aporosa cardiosperma</i> (Gaertn.) Merr.	Euphorbiaceae	0.66	0.1
4	<i>Areca catechu</i> L.	Arecaceae	0.15	0.02
5	<i>Artocarpus hirsutus</i> Lam.	Moraceae	17.2	2.67
6	<i>Carallia branchiata</i> (Lour.)Merr.	Rhizophoraceae	0.79	0.12
7	<i>Caryota urens</i> L.	Arecaceae	3.87	0.6
8	<i>Chrysophyllum cainito</i> L.	Sapotaceae	0.35	0.05
9	<i>Cinnamomum malabathrum</i> (Burm. f.) Blume.	Lauraceae	0.61	0.09
10	<i>Ficus amplissima</i> Smith.	Moraceae	6.8	1.05
11	<i>Ficus bengalensis</i> L.	Moraceae	0.83	0.13
12	<i>Ficus drupaceae</i> Thunb.	Moraceae	0.01	0.002
13	<i>Ficus religiosa</i> L.	Moraceae	0.13	0.02
14	<i>Garcinia gummi-gutta</i> L.Roxb.	Clusiaceae	0.58	0.09
15	<i>Holigarna arnottiana</i> Hook.f	Anacardiaceae	4.5	0.7
16	<i>Hopea ponga</i> (Dennst.)Mabberley.	Dipterocarpaceae	578	89.6
17	<i>Hydnocarpus pentandra</i> (Buch.Ham.)Oken.	Flacourtiaceae	1.88	0.29
18	<i>Litsea zeylanica</i> Nees&T.Nees.	Lauraceae	0.01	0.002
19	<i>Mimusops elengi</i> L.	Sapotaceae	0.99	0.15
20	<i>Olea dioica</i> Roxb.	Oleaceae	1.05	0.16
21	<i>Persea macrantha</i> (Nees) Kosterm.	Lauraceae	0.02	0.004
22	<i>Pinanga dicksonii</i> (Roxb.)Blume.	Arecaceae	0.38	0.06
23	<i>Pouteria campechiana</i> (Kunth.) Baehni.	Sapotaceae	0.04	0.01

24	<i>Quassia indica</i> (Gaertn.)Noot.	Simarou-baceae	1.64	0.25
25	<i>Saraca asoca</i> (Roxb.) de Wilde.	Fabaceae	0.01	0.001
26	<i>Sterculia guttata</i> Roxb.	Sterculiaceae	0.96	0.15
27	<i>Strychnos nux vomica</i> L.	Loganiaceae	0.67	0.1
28	<i>Syzygium lanceolatum</i> (Lam.)Wight&Arn.	Myrtaceae	0.64	0.1
29	<i>Syzygium hemisphericum</i> (Wt.) Alston.	Myrtaceae	4.01	0.62
30	<i>Tabernaemontana alternifolia</i> L.	Apocynaceae	0.19	0.03
31	<i>Terminalia bellirica</i> (Gaertn.)Roxb.	Combretaceae	0.69	0.11
32	<i>Terminalia catappa</i> L.	Combretaceae	0.01	0.002
33	<i>Veteria indica</i> L.	Dipterocarpaceae	14.0	2.18
34	<i>Vitex altissima</i> L.	Verbenaceae	1.99	0.31
35	<i>Vitex pinnata</i> L.	Verbenaceae	0.04	0.01
Grand total			645	100

Table 5: Total basal area (BA) and relative basal area (RBA) of tree species at disturbed non-sacred grove land adjacent to Sree Sankulangara sacred grove

Sl. No	Name of the Tree species	Family	Total basal area of the species-m ² /157 cent (0.636 ha)	Relative basal area of the species (%)
1	<i>Ailanthus triphysa</i> (Dennst.)Alston.	Simaroubaceae	0.526	3.6
2	<i>Anacardium occidentale</i> L.	Anacardiaceae	0.56	3.84
3	<i>Annona reticulata</i> L.	Annonaceae	0.01	0.07
4	<i>Areca catechu</i> L.	Arecaceae	2.591	17.7
5	<i>Artocarpus heterophyllus</i> Lam.	Moraceae	0.647	4.43
6	<i>Artocarpus hirsutus</i> Lam.	Moraceae	0.806	5.52
7	<i>Briedelia retusa</i> (L.) A. Juss.	Euphorbiaceae	0.006	0.04
8	<i>Carallia branchiata</i> (Lour.) Merr.	Rhizophoraceae	0.02	0.14
9	<i>Cinnamomum zeylanicum</i> Blume.	Lauraceae	0.004	0.03
10	<i>Cocos nucifera</i> L.	Arecaceae	9.05	62
11	<i>Garcinia gummi-gutta</i> L.Roxb.	Guttiferae	0.104	0.71
12	<i>Hydnocarpus pentandra</i> (Buch.-Ham.)Oken.	Flacourtiaceae	0.024	0.16
13	<i>Mangifera indica</i> L.	Anacardiaceae	0.18	1.23
14	<i>Swietenia macrophylla</i> King in Hook.	Meliaceae	0.022	0.15
15	<i>Tabernaemontana alternifolia</i> L.	Apocynaceae	0.02	0.14
16	<i>Tectona grandis</i> L.f.	Verbenaceae	0.013	0.09
17	<i>Terminalia catappa</i> L.	Combretaceae	0.013	0.09
18	<i>Vitex altissima</i> L.	Verbenaceae	0.01	0.07
GRAND TOTAL			14.61	100

Table 6: Importance Value Index (IVI) of tree species and family at Sree Sankulangara sacred grove

Sl.No	Family	Name of Tree species	RF	RD	RBA	IVI of species	IVI of Family
1	Dipterocarpaceae	Hopea ponga	5.19	23.5	89.6	118.3	132.24
		Veteria indica	4.55	7.21	2.18	13.94	
2	Moraceae	Artocarpus hirsutus	5.19	6.98	2.67	14.84	27.14
		Ficus amplissima	3.9	2.56	1.05	7.51	
		Ficus drupaceae	1.95	0.93	0.002	2.88	
		Ficus bengalensis	0.65	0.23	0.13	1.01	
		Ficus religiosa	0.65	0.23	0.02	0.9	
		Caryota urens	5.19	7.44	0.6	13.23	
3	Arecaceae	Pinanga dicksonii	3.9	2.09	0.06	6.05	22.83
		Areca catechu	2.6	0.93	0.02	3.55	
		Cinnamomum malabathrum	3.9	3.26	0.09	7.25	
4	Lauraceae	Litsea zeylanica	2.6	1.16	0.002	3.76	15.66
		Persea macrantha	3.25	1.4	0.004	4.65	
		Quassia indica	5.19	6.28	0.25	11.72	
5	Simarou-baceae						11.72
6	Flacour-tiaceae	Hydnocarpus pentandra	5.19	5.58	0.29	11.06	11.06
7	Oleaceae	Olea dioica	4.55	4.42	0.16	9.13	9.13
8	Sapotaceae	Mimusops elengi	3.9	2.79	0.15	6.84	9.12
		Chrysophyllum cainito	1.3	0.93	0.05	2.28	
9	Anacar-diaceae	Holigarna arnottiana	4.55	3.26	0.7	8.51	8.51
10	Euphor-biaceae	Aporosa cardi-osperma	4.55	3.72	0.1	8.37	8.37
11	Meliaceae	Aphanamixis polystachya	4.55	2.79	0.11	7.45	7.45
12	Apocynaceae	Tabernaemontana alternifolia	3.9	2.79	0.03	6.72	6.72
13	Verben-aceae	Vitex altissima	1.95	1.86	0.31	4.12	5.9
		Vitex pinnata	1.3	0.47	0.01	1.78	
14	Clusiaceae	Garcinia gummi-gutta	3.25	2.09	0.09	5.43	5.43
15	Myrtaceae	Syzygium hemisphericum	1.95	0.93	0.62	3.5	5.37
		Syzygium lanceolatum	1.3	0.47	0.1	1.87	
		Adenanthera pavonina	1.3	0.7	0.06	2.06	
16	Fabaceae	Saraca asoca	1.3	0.47	0.001	1.77	3.83
		Sterculia guttata	1.95	0.93	0.15	3.03	
17	Stercu-liaceae						3.03
18	Rhizo-phoraceae	Carallia branchiate	1.95	0.7	0.12	2.77	2.77
19	Combreta-ceae	Terminalia bellirica	0.65	0.23	0.11	0.99	1.87
		Terminalia catappa	0.65	0.23	0.002	0.88	
20	Logan-iaceae	Strychnos nux vomica	0.65	0.23	0.1	0.98	0.98
21	Sapotaceae	Pouteria campechiana	0.65	0.23	0.01	0.89	0.89

Table 7: Importance Value Index (IVI) of tree species and family at disturbed non-sacred grove region adjacent to Sree Sankulangara sacred grove

Sl No	Family	Name of Tree species	RF	RD	RBA	IVI	IVI of Family
1	Arecaceae	Cocos nucifera	16.7	28.1	62	106.8	164
		Areca catechu	16.7	22.8	17.7	57.2	
2	Moraceae	Artocarpus heterophyllus	5.56	3.51	4.43	13.5	25.31
		Artocarpus hirsutus	2.78	3.51	5.52	11.81	

3	Anacar-diaceae	Anacardium occidentale	5.56	3.51	3.84	12.91	18.67
		Mangifera indica	2.78	1.75	1.23	5.76	
4	Apo-cynaceae	Tabernaemontana alternifolia	8.33	8.77	0.14	17.24	17.24
5	Simarou-baceae	Ailanthus triphysa	5.56	3.51	3.6	12.67	12.67
6	Flacour-tiaceae	Hydnocarpus pentandra	5.56	5.26	0.16	10.98	10.98
7	Clusiaceae	Garcinia gummi-gutta	5.56	3.51	0.71	9.78	9.78
8	Verben-aceae	Tectona grandis	2.78	1.75	0.09	4.62	9.22
		Vitex altissima	2.78	1.75	0.07	4.6	
9	Laura-ceae	Cinnamo-mum zeylan-icum	5.56	3.51	0.03	9.1	9.1
10	Meliaceae	Swietenia macrophylla	2.78	1.75	0.15	4.68	4.68
11	Rhizo-phoraceae	Carallia branchiate	2.78	1.75	0.14	4.67	4.67
12	Com-bretaceae	Terminalia catappa	2.78	1.75	0.09	4.62	4.62
13	Annon-aceae	Annona reticulate	2.78	1.75	0.07	4.6	4.6
14	Euphor-biaceae	Briedelia retusa	2.78	1.75	0.04	4.57	4.57

Table 9: Physical properties of soil samples collected from Sree Sankulangara sacred grove and adjacent disturbed non-sacred grove during the Pre monsoon season

Param-eter	Sree Sankulangara sacred grove		Adjacent non-sacred grove	
	Core area	Transition area	Disturbed inner grove influenced	Disturbed
Moisture content (%)	8.8±0.17	7.29±0.11	6.1±0.15	3.78±0.10
Water Holding Capacity (%)	32.9±1.32	31.57±1.14	27.37±0.61	27.11±0.73
Bulk density (g/cm³)	1.38±0.02	1.4±0.02	1.47±0.02	1.48±0.02
Porosity (%)	45.29±0.69	43.28±0.64	41.59±0.86	41.23±0.65
Electrical Con-ductivity (dS/m)	0.04±0	0.04±0	0.03±0.01	0.02±0.01
pH	4.6±0.08	4.8±0	5.2±0.08	5.7±0.16

Table 8: Physical properties of soil samples collected from Sree Sankulangara sacred grove and adjacent disturbed non-sacred grove during the Post Monsoon Season

Param-eter	Sree Sankulangara sacred grove		Adjacent non-sacred grove	
	Core area	Transition area	Disturbed but grove influenced	Disturbed
Moisture content (%)	13.84±0.1	11.86±0.08	8.47±0.16	6.52±0.15
Water Holding Capacity (%)	38.89±0.94	37.97±0.83	32.61±1.27	31.54±0.78
Bulk density (g/cm³)	1.31±0.03	1.35±0.03	1.42±0.02	1.43±0.02
Porosity (%)	49.74±0.90	47.83±0.82	42.84±0.53	42.89±0.57
Electrical Con-ductivity (dS/m)	0.03±0	0.03±0	0.02±0.01	0.02±0
pH	4.7±0	4.9±0.08	5.5±0.08	5.8±0

Table 10: Climatic factors of soil and atmosphere in Sree Sankulangara sacred grove and adjacent disturbed non-sacred grove during the Post monsoon season

Parameter	Sree Sankulangara sacred grove		Adjacent non-sacred grove	
	Core area	Transition area	Disturbed but grove influenced	Disturbed
Soil temperature (°C)	28.9±0.16	29.5±0.24	32.8±0.33	34.2±0.33
Atmospheric temperature(°C)	28.2±0.08	29.1±0.08	31.2±0.16	32.6±0.24
Soil humidity (%)	57±0.08	58±0.16	58.8±0.65	64±0.98
Atmospheric humidity(%)	58±0.16	60±0.24	60.8±0.82	66±1.22

Table 11: Climatic factors of soil and atmosphere in Sree Sankulangara sacred grove and adjacent disturbed non-sacred grove during the Pre monsoon season

Parameter	Sree Sankulangara sacred grove		Adjacent non-sacred grove	
	Core area	Transition area	Disturbed but grove influenced	Disturbed
Soil temperature (°C)	31.3±0.41	32.1±0.57	34.8±0.90	38.2±1.14
Atmospheric temperature(°C)	30.9±0.33	31.7±0.16	33.2±0.33	36.7±0.73
Soil humidity (%)	63±0.16	66±0.49	68±0.82	76±1.31
Atmospheric humidity (%)	65±0.16	66±0.24	69.8±0.90	78±1.55

References

- [1] Abdul Sahim Ansari. (2003), "Influence of Forests on Environment." Proceedings of the XII World Forestry Congress, Quebec City, Canada.
- [2] Bell, M.C., and Raczkowski, C.W. (2008), "Soil property indices for assessing short-term changes in soil quality." *Renewable Agriculture and Food Systems*, 23, 70–79.
- [3] Curtis, R.O., and Pos, B. W. (1964), "Estimating Bulk Density from Organic Matter Content in Some Vermont Forest soils." *Soil Sci. Soc. Am. Proc.*, 28, 285-286.
- [4] Davis, G., and Richardson, D. (1995), "Mediterranean Type Ecosystems: The Function of Biodiversity, Springer, Berlin.
- [5] Enrique Arévalo-Gardini, Manuel Canto, Julio Alegre, Oscar Loli, Alberto Julca, and Virupax Baligar. (2015), "Changes in Soil Physical and Chemical Properties in Long Term Improved Natural and Traditional Agroforestry Management Systems of Cacao Genotypes in Peruvian Amazon." *PLoS One*, 10(7), e0132147.
- [6] Gadgil, M., Vartak, V.D. (1975), "Sacred groves of India: a plea for continued conservation." *Journal of Bombay Natural History Society*, 72, 314-320.
- [7] Granged, A.J.P., Zavala, L.M., Jordán, A., and Moreno, G. (2011), "Post-fire evolution of soil properties and vegetation cover in a Mediterranean heath land after experimental burning: A 3-year study." *Geoderma*, 164, 85–94.
- [8] Johan Arvidsson. (1998), "Influence of Soil Texture and Organic Matter Content on Bulk Density, Air Content, Compression Index and Crop Yield in Field and Laboratory Compression Experiments." *Soil and Tillage Research*, 47, 159-170.
- [9] Johnson, J.E., Smith, D.W., and Burger, J.A. (1985), "Effects on the forest floor of whole-tree harvesting in an Appalachian oak forest." *Am. Midl. Nat.*, 114, 51–61.
- [10] Késik, T., Baewicz-WoŹniak, M., and Wach, D. (2010), "Influence of conservation tillage in onion production on the soil organic matter content and soil aggregate formation." *Int. Agrophys.*, 24, 267-273.
- [11] Morecroft, M.D., Taylor, M.E., and Oliver, H.R. (1998), "Air and soil microclimates of deciduous forest land compared to an open site." *Agricultural and Forest Meteorology*, 90, 41–156.
- [12] Nambiar, E.K.S., and Sands, R. (1992), "Effects of compaction and simulated root channels in the subsoil on root development, water uptake and growth of radiata pine." *Tree Physiology*, 10, 297–306.
- [13] Portella, C.M.R., Guimarães, M.F., Feller, C., Fonseca, I.C.B., and Filho, J.T. (2012), "Soil 'aggregation under different management systems." *Rev. Bras. Ciência Solo.*, 36, 1868–1877.
- [14] Porter, W. M., Cox, W.1., and Wilson, I. (1980), "Soil acidity- it is a problem in Western Australia." *West Aust. J. Agric.*, 21, 126-33.

- [15] Pravin R. Chaudhari, Dodha V. Ahire, Vidya D. Ahire, Manab Chkravarty, and Saroj Maity. (2013), "Soil Bulk Density as related to Soil Texture, Organic Matter Content and available total Nutrients of Coimbatore Soil." *International Journal of Scientific and Research publications*, 3(2), 1-8.
- [16] Saira Chandy, M.D., Subash Chandran, I., Ramachandra, T.V. (2014), "Soil quality- comparative study between sacred and non sacred grove forests." LAKE 2014: Conference on Conservation and Sustainable Management of Wetland Ecosystems in Western Ghats, 13th-15th November 2014.
- [17] Vengadaramana, A., and Jashothan, P.T.J. (2012), "Effect of organic fertilizers on the water holding capacity of soil in different terrains of Jaffna peninsula in Sri Lanka." *J. Nat. Prod. Plant Resour.*, 2(4), 500-503.
- [18] Volk, V.V., and Ullery, C.H. (1993), *Dep. of Soil Sci., Oregon state Univ., Corvallis*, 1-50.



IMPACT OF HUMAN INTERFERENCE ON ETHNOMEDICINAL PLANT WEALTH AND DIVERSITY: A COMPARATIVE STUDY OF SANKULANGARA SACRED GROVE AND A DISTURBED NON-SACRED GROVE LAND LOCATED AT S.N.PURAM, THRISSUR DISTRICT, KERALA

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ABSTRACT

Since ancient times, a wide variety of plants have been used to treat various kinds of diseases based on the traditional knowledge. But now-a-days the major threat to this kind of treatment is the disappearance or scarcity of many valuable medicinal plants due to large scale destruction of vegetation for various reasons. Whatever be the reason, the fact that is often neglected is the pharmacological importance of this safer, cheaper and reliable source of drugs and its preservation for the future.

Objectives: Comparative analysis on the ethnomedicinal plant wealth and diversity between the Sankulangara sacred grove and the near by disturbed non-sacred grove land

Methodology: Study includes identification and distribution of ethnomedicinal plants and their uses (through survey & interviews), analysis on the phytosociological aspects such as relative density and relative frequency of plant species, dominance of ethnomedicinal family and species, Species Richness Index (Menhinick 1964) and Diversity Index (Shannon, 1963).

Results: The ethnomedicinal plant wealth and diversity is significantly higher in the grove area compared to disturbed non-sacred grove area. It is very necessary to protect and maintain these remnants of natural forest for the future.



KEYWORDS : traditional knowledge , pharmacological , ethnomedicinal plant.

INTRODUCTION

The survey conducted by the All India Coordinated Research Project on Ethnobiology (AICRPE) during the last decade recorded over 8000 species of wild plants used by the tribals and other traditional communities in India for treating various health problems (Laloo et al., 2006). The phytomedicines usually exert their medicinal effects through the additive or synergistic action of several bioactive compounds acting at single or multiple target sites associated with a physiological process. This kind of action not only eliminate the problematic side effects associated with the predominance of a single xenobiotic compound in the body but also ensure effectiveness against a wide range of pathogens and decrease the chances of these organisms developing resistance or adaptive responses (Kaufman et al., 1999). However, now a day the most serious problem we face in the rural as well as urban area is the large scale destruction of vegetation particularly forest vegetation and the disappearance or scarcity of many valuable medicinal plants of traditional use. Today most of the areas have only certain patches or remnants of forest the so called sacred

groves, which are protected under the ground of religious faith. These sacred groves are considered as treasure house of rare and endangered plant species and abode of many medicinal plants. But now they are also facing threats due to various man made activities. Therefore it is very important to protect these surviving examples of climax vegetation by any means. Here comes the importance of ethnobotanical study and documentation of data on medicinal plants and dissemination of this information to the public to make them aware of the relevance of maintaining and preserving these natural resources for future. The present study was carried out to collect information on the ethnomedicinal wealth of the selected Sankulangara sacred grove and to compare this information with present status of nearby disturbed non-sacred grove land to reveal the difference in ethnomedicinal plant diversity, wealth, pharmacological importance and to create awareness among the people about the relevance of preserving these treasure houses for future.

OBJECTIVES

Comparative analysis on the ethnomedicinal plant wealth and diversity between the Sankulangara sacred grove and the near by disturbed non-sacred grove land.

MATERIALS AND METHODS

Study area

The study area is Sankulangara sacred grove of about 0.635 hectare size and a nearby disturbed non-sacred grove land of the same extend located at Sree Narayana Puram which belongs to the Coastal Belt of Thrissur District, Kerala. The study was conducted during the period January 2016 - March 2017.

Ethnobotanical studies

The study includes comparative evaluation of information on the ethnomedicinal plants of selected sacred grove and disturbed non-sacred grove land. The details of ethnomedicinal plants and related informations were collected through survey, discussions and interviews with local people and traditional healers in the area. The identification and other required informations on ethnomedicinal plants were done with the help of referred books and reports (Krishnan et al., 1985; Akhtar, 1992; The Ayurvedic Pharmacopoeia of India, 2004; Khare, 2007). Ethnomedicinal plants belonging to different group such as trees, shrubs, herbs, lianas and climbers were selected and analysed for the following parameters.

1. Identification and distribution of ethnomedicinal plants

$$2. \text{ Relative Density of species (RD) } = \frac{\text{Number of individuals of the species} \times 100}{\text{Number of individuals of all species}}$$

$$3. \text{ Relative frequency of species (RF) } = \frac{\text{Number of quadrats of occurrence of the species} \times 100}{\text{Number of quadrats of occurrence of all species}}$$

4. Dominance of ethnomedicinal family and species- based on the total population count and diversity of ethnomedicinal plant species
5. Species richness index (Menhinick 1964)
Species richness index = $S/\sqrt{N}$ Where S - total number of the species and N - Total number of individuals in a sample
6. Diversity Index of ethnomedicinal plants- based on Shannon Wiener Index (H')
Shannon Wiener Index (H') = $-\sum \{(n/N) \ln (n/N)\}$

RESULTS AND DISCUSSION

The ethnobotanical study conducted in Sankulangara sacred grove identified 28 plant species as commonly used ethnomedicinal plants by the local people and traditional healers in the area for the treatment of various ailments. These plants are distributed in 26 genera belonging to 22 families. This constituted 27.72% of the total plant species representation and constituted around 29.92% of the entire plant population in the grove. In the disturbed non-sacred grove land, 14 plant species were identified as ethnomedicinal which comprised of 12 genera belonging to 10 families and this constituted around 23.33% of the total plant species represented and around 28.66% of the entire plant population. The highest percentage of ethnomedicinal plant species distributed in the sacred grove is represented by the plant group trees (28.57%) which are followed by climbers (21.43%), shrubs (21.43%), herbs (17.86%) and lianas (10.71%). Whereas in the disturbed land, the highest percentage of ethnomedicinal plant species belongs to herbaceous group (57.14%) and is followed by shrubs (21.43%), trees (14.29%) and the lowest representation of 7.14% of climbers (**Table-1**). The ethnomedicinal plants identified in the Sankulangara sacred grove and in the nearby disturbed land along with details such as scientific name, local name, family, habit, parts used and traditional use in treating ailments are depicted in **Table-2** and **Table-3**.

The present study analysed the density, relative density and relative frequency of each ethnomedicinal plant species as well as the sum total of ethnomedicinal plants in both the selected study area. The results obtained are shown in the **Table-4** and **Table-5**. The data revealed the tree member *Hopea ponga* belonging to the family Dipterocarpaceae recorded the highest density (101 nos.) and relative density (15.9) in the Sankulangara sacred grove. *Hopea ponga* is immediately followed by climber *Tiliacora racemosa* of Menispermaceae and then the member of lianas *Gnetum ula* of Gnetaceae. The highest relative frequency of 5.56 in the grove was shared by 3 tree members *Hopea ponga*, *Hydnocarpus pentandra* and *Quassia indica* and also a liana member *Gnetum ula*. Whereas in the disturbed non-sacred grove land, the highest density (30181 nos.) and relative density (47.5) was recorded by the herbaceous member *Cynodon dactylon* which belong to the family Poaceae. *Cynodon dactylon* was immediately followed by the herbaceous members *Aerva lanata* of Amaranthaceae and *Phyllanthus amarus* of Euphorbiaceae. The highest relative frequency of 10.26 in the disturbed land was shared by these herbaceous members. The density, relative density and relative frequency of sum total of ethnomedicinal population in the grove were 635, 29.9 and 28.8 respectively while in the disturbed land; it was 63593, 28.7 and 26.26 respectively for density, relative density and relative frequency.

The analysis on the richness of species and diversity index of ethnomedicinal plant species in the Sankulangara sacred grove showed the highest individual values of 4.01 and 0.29 respectively by the tree member *Hopea ponga* of Dipterocarpaceae. *Hopea ponga* is immediately followed by *Tiliacora racemosa* of Menispermaceae and then by *Gnetum ula* and *Strychnos minor* of Gnetaceae and Menispermaceae respectively (**Table-6**). In the disturbed land, the herbaceous member *Cynodon dactylon* of Poaceae recorded highest individual values for richness of species and diversity index which was 119.68 and 0.35 respectively. This was immediately followed by the herbaceous members *Aerva lanata* (36.22 and 0.28) of Amaranthaceae and then *Phyllanthus amarus* (29.92 and 0.25) of Euphorbiaceae. Richness of species index and diversity index of sum total of the ethnomedicinal population in the grove was 1.11 and 2.89 respectively while in the disturbed land, it was 0.06 and 1.66.

The dominance of ethnomedicinal families in the sacred grove and disturbed land in the present study was analyzed in two ways. In the analysis based on the total plant population count of ethnomedicinal plants under each family, Dipterocarpaceae was identified as the most dominant family in the grove with a total plant population of 101 trees and this constituted 15.91% of the total number ethnomedicinal plants and 4.76% of the entire population in the study area. Dipterocarpaceae was immediately followed by Menispermaceae which have a total population of 78 climbers. Menispermaceae is followed by Apocynaceae with a total population of 72, consisting of trees and climbers. This constituted 12.28% of the total number of ethnomedicinal plants and 3.68% of the entire population with respect to Menispermaceae

while 11.34% of the total number ethnomedicinal plants and 3.39% of the entire population with respect to Apocynaceae (**Table-4**). Whereas in the disturbed land, the family Poaceae was identified as the most dominant with a total plant population of 30180 herbs and this constituted 47.46% of the total number ethnomedicinal plants and 13.60% of the entire population in the study area. Poaceae was immediately followed by Amaranthaceae and then Euphorbiaceae with total plant population of 12707 and 7545 herbs respectively and these constitute 19.98% and 11.86% of the total number ethnomedicinal plants and 5.73% and 3.40% of the entire population respectively in the area (**Table-5**). However, when the dominance of family was analyzed based on the diversity of ethnomedicinal plant genus and species under the families, Apocynaceae is identified as the most dominant families in the grove, which consists of three genus and three species namely *Ichnocarpus frutescens*, *Kamettia caryophyllata* & *Tabernaemontana alternifolia*. Apocynaceae is immediately followed by Annonaceae and Fabaceae, both consisting of two genus and two species each namely *Uvaria narum* & *Polyalthia korinti* and *Abrus precatorius* & *Desmodium gangeticum* respectively. Whereas in the disturbed land, Amaranthaceae and Apocynaceae are identified as the most dominant families. Amaranthaceae consists of two genus and two species namely *Aerva lanata* and *Cyathula prostrata* with comparatively higher number of representations while Apocynaceae consists of two genus and two species namely *Ichnocarpus frutescens* & *Tabernaemontana alternifolia* with lesser number of representations compared to Amaranthaceae immediately followed by Amaranthaceae and Apocynaceae is Malvaceae which consists of one genus and three species namely *Sida acuta*, *Sida cordifolia* & *Sida rhombifolia* (**Table 4 & 5**).

Comparative evaluation of ethnomedicinal plants in the study sites reveal that only 12 genus of ethnomedicinal plants were recorded in the disturbed land in comparison to 26 plant genus in the sacred grove and this constitute about 63.64% reduction over grove region while the total number of plant species was restricted to 14 in the disturbed land compared to 28 species in the grove and this is about 50.0% reduction over the grove region. With respect to the distribution of ethnomedicinal plant species, 22 families are distributed in the sacred grove while in the disturbed land it was restricted to 10 families and this account for a reduction of 54.55% in the diversity of families over grove region. The study found the ethnomedicinal plant species of all the plant groups in disturbed land, with the exception of herbs and recorded lower representations compared to sacred grove and the decrease was 75%, 50% and 83.33% respectively for trees, shrubs and climbers while an increase of 37.5% in the species diversity was recorded for herbs. No lianas were recorded as ethnomedicinal plant species in the disturbed land.

In Sankulangara sacred grove, the highest individual values recorded for relative density, relative frequency and richness of species index is by the tree member *Hopea ponga*, which is immediately followed by the climber *Tiliacora racemosa*, then the liana *Gnetum ula*, whereas in the disturbed land, the highest individual values was recorded by the herbaceous member *Cynodon dactylon*, immediately followed by the herbaceous members *Aerva lanata* and then *Phyllanthus amarus* (**Table 4 & 5**). This clearly revealed that, *Hopea ponga* is the most dominant plant species in the grove which is immediately followed by *Tiliacora racemosa* and then *Gnetum ula* while in the disturbed land *Cynodon dactylon* is the most dominant plant species which is immediately followed by *Aerva lanata* and then the *Phyllanthus amarus*. Therefore the study further revealed that majority of the dominant ethnomedicinal plant species in the sacred grove are represented from diverse groups of plants such as trees, climbers, lianas etc. a typical characteristics of undisturbed natural forest vegetation. However, all the dominant ethnomedicinal plant species in the disturbed land are belonging to the plant group herbs- typical characteristics of degraded forest vegetation. Further the overall diversity index value recorded for ethnomedicinal plant species in the sacred grove is found 42.56% higher than the diversity index value recorded for the disturbed land. The study found the tree member *Hopea ponga* which is identified as most dominant plant species in the Sankulangara sacred grove is a listed plant in the IUCN Red list as threatened and endangered species and similarly the shrub species *Memecylon grande* is listed as vulnerable species.

However the present study noted that, the overall population count of ethnomedicinal plants in the disturbed lands recorded significantly higher value compared to sacred groves. This is due to the fact that most of the ethnomedicinal plant species in the disturbed land are belonging to the plant group herbs and due to their remarkably higher individual representation compared to herbaceous plant species of sacred groves. At the same time present investigation also revealed that the total population count as well as the diversity in the representation of ethnomedicinal plants from other diverse groups of plants such as trees and climbers are very scarce and even total absence was recorded with respect to lianas in the disturbed land. Considerable reduction in the herbaceous ethnomedicinal plant species and their population count in the Sankulangara sacred grove may be attributed to the accumulation of litter particularly by trees which usually form a thick layer over the floor area and may cause an unfavorable environment for the seeds of herbaceous plants to get germinate, emerge and establish. This interpretation is with the observations recorded by Alejandro et al (2014) who found that tree litter act as a mechanical barrier to the establishment of herbaceous seedlings, in their study conducted in the forest–grassland ecotones at Lahn-Dill highlands, Germany. Similar observation was also reported by Xiong and Nilsson (1999) who found the tree litter has strong negative effect on grassland vegetation. Further the reduction of herbs may also be due to the lack of availability of sunlight to the herbaceous plants, as the sunlight fails to penetrate and reach ground area of the grove due to thick canopy layer formed particularly by trees and lianas. Remarkably higher population of herbaceous plants and their increased diversity in the disturbed land may be due to the absence of above said barriers together with comparatively less competition from other groups of plants. However, more or less uniform distribution and better diversity of ethnomedicinal plants from diverse groups of plants in the studied sacred grove may be attributed to comparative low human interference and better environmental conditions such as the physical and chemical properties of soil, microclimate etc in the grove area.

CONCLUSION

Present investigation clearly revealed that the ethnomedicinal plant wealth in the Sankulangara sacred grove is significantly higher when compared to the nearby disturbed land. With the exception of herbs, most of the plant group such as trees, climbers, lianas and shrubs in the grove recorded higher population, species diversity and better ethnomedicinal properties. The informations on plant parts used and ethnomedicinal uses of identified plants in both sacred grove and disturbed land collected from the local people and traditional healers in the area may be useful for making certain herbal or modern medicine in the future. This type of comparative evaluation and passing of such information to the present generation is of almost importance in understanding what the past ethnomedicinal plant wealth was and how it is today. This in turn helps people to be aware of the past and the present interrelationship between human culture and plants. The present study further expects that this sort of documentation about the indigenous and scientific knowledge on ethnomedicinal plants and practices of traditional medicine are very essential in understanding the utilization of natural biological resources and is valuable for the conservation of at least these patches of original forest vegetation for the future.

Table 1: Brief Summary on Distribution of Ethnomedicinal Plants in the Study Area

Details of Study area		Study area	
		Sankulangara Sacred Grove	Disturbed Non-sacred Land
Number of Genera		26	12
Number of Species		28	14
Number of Family		22	10
Trees	Species	8	2
	Population	187	8

Shrubs	Species	6	3
	Population	77	39
Herbs	Species	5	8
	Population	53	63537
Climbers	Species	6	1
	Population	226	9
Lianas	Species	3	0
	Population	92	0
Total ethnomedicinal plant population		635	63593
Entire plant species		101	60
Entire plant population		2122	221848

Table 2: Details of Ethnobotanical Plants in the Sankulangara Sacred Grove

S.No .	Name of the Plant	Local Name	Family	Habit	Parts used	Medicinal Uses
1	Abrus precatorius L.	Kunni	Fabaceae	Climber	Whole plant	Leaf juice is a blood purifier. Root paste is applied on swellings and skin diseases. Plant extract is boiled with coconut oil is used as hair tonic.
2	Asparagus racemosus Willd.	Sathavari	Liliaceae	Climber	Tubers	Root is used in the treatment of throat problems, tuberculosis, leprosy, epilepsy, diseases of blood, kidney and liver and gonorrhoea. A decoction of tubers in milk is very effective in bladder problems. The root extract with a honey is given against colic.
3	Connarus monacarpus L	Kurilathali	Connaraceae	Liana	Leaves	Pounded leaves are applied to painful swellings, seeds are used to treat nervous disorders, contraceptive also. Root extract is used against sore throat, asthma, fever and skin diseases.

4	<i>Desmodium gangeticum</i> (L.) DC.	Orila	Fabaceae	Herb	Roots	Root paste is applied for chronic fever, cough, vomiting, asthma and rheumatism.
5	<i>Elephantopus scaber</i> L.	Anachuvadi	Asteraceae	Herb	Whole plant	A decoction of leaves and roots is used to treat diarrhoea, dysentery and swelling or pain in the stomach. Bruised leaves are applied to ulcers and eczema.
6	<i>Gnetum ula</i> Brongn.	Odavalli	Gnetaceae	Liana	Seeds	Decoction of seeds used for rheumatism.
7	<i>Hibiscus rosa-sinensis</i> L.	Chembarathi	Malvaceae	Shrub	Root, leaves, flower	Crushed leaves with water are used as hair tonic. Decoction of boiled flowers used for menstrual problems.
8	<i>Holigarna arnottiana</i> Hook.f.	Cheru	Anacardiaceae	Tree	Bark	Highly diluted bark decoction mixed with milk and turmeric used in mild skin problems.
9	<i>Hopea ponga</i> (Dennst.) Mabb.	Thambakam	Dipterocarpaceae	Tree	Root, Bark	Root decoction taken orally for piles. Bark paste mixed with milk taken to minimize spreading of poison during snake bite.
10	<i>Hydnocarpus pentandrus</i> (Buch.-Ham.) Oken	Marotti	Flacourtiaceae	Tree	Seeds	Seed oil applied to area affected by rheumatism.
11	<i>Ichnocarpus frutescens</i> (L.) W.T.Aiton	Parvalli	Apocynaceae	Climber	Root, leaves	Root and leaf extract is applied to backpain, skin diseases.
12	<i>Kamettia caryophyllata</i> (Roxb.) Nicolson & Suresh	Narumarathivu	Apocynaceae	Climber	Leaves, roots	Decoction of the whole plant is used for leprosy and arthritis. Leaf paste is applied on affected area for itches and scabies.
13	<i>Laportea</i>	Choriyanam	Urticaceae	Herb	Leaves,	Root is crushed and

	interrupta (L.) Chew				root, fruits.	juice taken for fever and leaves crushed and made paste is directly applied to headache.
14	Memecylon grande Retz.	Palluvirisa	Melastomatacea e	Shrub	Bark, fruits	Leaf paste used in snake bite. Root decoction is used for abnormal menstrual periods.
15	Mussaenda frondosa L.	Vellilam	Rubiaceae	Shrub	Leaves	Decoction of stem is used as a remedy for cough and decoction of root is given against white leprosy, Aqueous extract of leaves using hot water is used as shampoo.
16	Ocimum basilicum L.	Ramathulasi	Lamiaceae	Herb	Leaves	Decoction made from boiled leaves is used for headaches, coughs, diarrhea, Leaf crushed and made paste with turmeric is orally administrated for worms.
17	Ocimum tenuiflorum L.	Krishna thulasi	Lamiaceae	Shrub	Leaves	Decoction made from leaves boiled with water is used for cough, fever and leaves crushed and made paste is directly applied as antidote for insect bites.
18	Polyalthia korinti (Dunal) Thwaites	Karuvalli, Korandippanal	Annonaceae	Shrub	Leaves, bark	Decoction of bark is used for cold and cough, Leaf paste is applied as antidote for snake bite.
19	Quassia indica (Gaertn.) Noot.	Karingotta	Simaroubaceae	Tree	Bark, seeds	An infusion of leaves is used to kill lice. fleas, and white ants. Seeds are used against bilious fever and are used as a purgative and emetic. Oil from seeds is used

						as an external application in rheumatism.
20	<i>Sterculia guttata</i> Roxb. ex G.Don	Peenaari/ Kavalam	Sterculiaceae	Tree	Bark, seeds	Leaves and bark grinded using water and this paste are applied for swellings.
21	<i>Strychnos minor</i> Dennst.	Cherukanjiravalli	Loganiaceae	Climber	Bark	Leaves and roots are boiled in oil and applied to rheumatic swellings. Bark is used as antipyretic
22	<i>Syzygium lanceolatum</i> (Lam.) Wight & Arn.	Karinjavai	Myrtaceae	Tree	Fruits	Oral administration of decoction of fruits is used for piles.
23	<i>Syzygium zeylanicum</i> (L.) DC.	Poochapazham	Myrtaceae	Shrub.	Leaves, fruits	Decoction of fruits is orally taken for diarrhea and leaf paste is applied on anti-rheumatic.
24	<i>Tabernaemontana alternifolia</i> L.	Kuruttupala	Apocynaceae	Tree	Leaves	Latex from leaves directly applying on warts, wounds and other skin diseases.
25	<i>Terminalia bellirica</i> (Gaertn.) Roxb.	Thanikka	Combretaceae	Tree	Fruits, seeds	Powdered seeds and fruits with honey are used for cough and fever.
26	<i>Tiliacora racemosa</i> Colebr.	Vallikanjiram	Menispermaceae	Climber	Bark, root, leaves	Paste of bark, root and leaves used as antidote for snake bite.
27	<i>Torenia bicolor</i> Dalzell	Malatilata, Malatipusam	Scrophulariaceae	Herb	Whole plant	Juice taken from the crushed whole plant is applied for eye infections.
28	<i>Uvaria narum</i> A.DC.	Paanal	Annonaceae	Liana	Roots	A decoction of roots is used to stomachache after childbirth. External application of root extract is used for skin problems.

Table 3: Details of Ethnobotanical Plants in the Disturbed Non-Sacred Grove Land

S.No.	Name of the Species	Local Name	Family	Habit	Parts used	Medicinal Uses
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1	<i>Aerva lanata</i> (L.) Juss.	Cherula	Amaranthaceae	Herb	Whole plant	Whole plant is boiled with water and this decoction is used for the treatment of cough and urinary problems.
2	<i>Biophytum reinwardtii</i> (Zucc.) Klotzsch	Mukkutti	Oxalidaceae	Herb	Whole plant	Whole plant is crushed and juice is used for cough, asthma and oral administration of cooked whole plant with duck egg is used for piles.
3	<i>Cyathula prostrata</i> (L.) Blume	Cherukadaladi	Amaranthaceae	Herb	Whole plant	Whole plant is grinded and made paste is applied for skin diseases. Decoction of roots is given for dysentery.
4	<i>Cynodon dactylon</i> (L.) Pers.	Karuka, Karukapullu	Poaceae	Herb	Whole plant	Plant juice is applied to fresh cuts and wounds; A decoction of the root is given in cases of dropsy and secondary syphilis.
5	<i>Cyperus rotundus</i> L.	Muthanga	Cyperaceae	Herb	Rhizome	Peeled rhizome is crushed and boiled in milk is used as anti venom, liver problems and fever.
6	<i>Hydnocarpus pentandrus</i> (Buch.-Ham.) Oken	Marotti	Flacourtiaceae	Tree	Seeds	Oil from the seed is directly applied for rheumatism
7	<i>Ichnocarpus frutescens</i> (L.) W.T.Aiton	Parvalli	Apocynaceae	Climber	Root, leaves	Root and leaf extract are used to backpain, skin diseases
8	<i>Laportea interrupta</i> (L.) Chew	Choriyanam	Urticaceae	Herb	Leaves root and fruits.	Root is crushed and juice taken for fever, leaf paste is applied for headache.
9	<i>Leucas aspera</i> (Willd.) Link	Thumpa	Lamiaceae	Herb	Leaves and Flowers	The plant juice is directly applied for skin diseases and headache.
10	<i>Phyllanthus</i>	Keezharnelli,	Euphorbiaceae	Herb	Whole	Whole plant is

	amarus Schumach. & Thonn.	Kiruthaanelli			plant	grinded with milk and consumed on empty stomach for liver problems.
11	<i>Sida acuta</i> Burm.f.	Anakurunthotti, Cheruparava	Malvaceae	Shrub	Roots	A decoction of leaves and roots is given in haemorrhoids and impotence, decoction of root is used for nervous and urinary diseases.
12	<i>Sida cordifolia</i> L.	Kurunthotti	Malvaceae	Shrub	Roots	Decoction of whole plant is used for rheumatism, Root juice is used for healing wounds and fever.
13	<i>Sida rhombifolia</i> L.	Kurunthotti, Vankurunthotti	Malvaceae	Shrub	Roots	A decoction of the roots mixed with milk is used in rheumatism, arthritis and allied complaints and decoction of roots facilitate child birth.
14	<i>Tabernaemontana</i> <i>alternifolia</i> L.	Kuruttupala	Apocynaceae	Tree	Leaves	Latex from leaves directly applying on warts, wounds and other skin diseases

Table 4: Phytosociological Aspects of Ethnomedicinal Plant Species in the Sankulangara Sacred Grove

S.No.	Botanical Name	Habit	Density	Relative density	Relative frequency	Diversity Index (H')
1	<i>Abrus precatorius</i> L.	Tree	101	15.9	5.56	0.29
2	<i>Asparagus racemosus</i> Willd.	Climber	78	12.3	4.86	0.26
3	<i>Connarus monocarpus</i> L.	Liana	55	8.66	5.56	0.21
4	<i>Desmodium</i> <i>gangeticum</i> (L.) DC.	Climber	53	8.35	4.86	0.21
5	<i>Elephantopus scaber</i> L.	Climber	48	7.56	4.17	0.2
6	<i>Gnetum ula</i> Brongn.	Liana	35	5.51	3.47	0.16
7	<i>Hibiscus rosa-sinensis</i> L.	Tree	27	4.25	5.56	0.13
8	<i>Holigarna arnottiana</i> Hook.f.	Shrub	25	3.94	4.86	0.13
9	<i>Hopea ponga</i> (Dennst.) Mabb.	Tree	24	3.78	5.56	0.12
10	<i>Hydnocarpus</i> <i>pentandrus</i> (Buch.-	climber	19	2.99	4.17	0.1

	Ham.) Oken					
11	<i>Ichnocarpus frutescens</i> (L.) W.T.Aiton	Herb	18	2.83	2.78	0.1
12	<i>Kametia caryophyllata</i> (Roxb.) Nicolson & Suresh	Shrub	17	2.68	4.17	0.1
13	<i>Laportea interrupta</i> (L.) Chew	climber	16	2.52	4.17	0.09
14	<i>Memecylon grande</i> Retz.	Tree	14	2.2	4.86	0.08
15	<i>Mussaenda frondosa</i> L.	Shrub	13	2.05	4.17	0.08
16	<i>Ocimum basilicum</i> L.	Herb	12	1.89	4.17	0.07
17	<i>Ocimum tenuiflorum</i> L.	Climber	12	1.89	2.08	0.07
18	<i>Polyalthia korinti</i> (Dunal) Thwaites	Tree	12	1.89	4.17	0.07
19	<i>Quassia indica</i> (Gaertn.) Noot.	Herb	11	1.73	4.17	0.07
20	<i>Sterculia guttata</i> Roxb. ex G.Don	Shrub	11	1.73	2.78	0.07
21	<i>Strychnos minor</i> Dennst.	Herb	10	1.57	2.08	0.07
22	<i>Syzygium lanceolatum</i> (Lam.) Wight & Arn.	Herb	6	0.94	2.08	0.04
23	<i>Syzygium zeylanicum</i> (L.) DC.	Shrub	5	0.79	2.08	0.04
24	<i>Tabernaemontana alternifolia</i> L.	Tree	4	0.63	2.08	0.03
25	<i>Terminalia bellirica</i> (Gaertn.) Roxb.	Tree	4	0.63	2.08	0.03
26	<i>Tiliacora racemosa</i> Colebr.	Liana	2	0.31	1.39	0.02
27	<i>Torenia bicolor</i> Dalzell	Herb	2	0.31	1.39	0.02
28	<i>Uvaria narum</i> A.DC.	Tree	1	0.16	0.69	0.01
TOTAL			635	29.9	28.8	2.89

Table 5: Phytosociological Aspects of Ethnomedicinal Plant Species in the Disturbed Non-Sacred Grove Land

S.No.	Botanical name	Family	Density of plants	Relative density	Relative frequency	Diversity Index (H')
1	<i>Aerva lanata</i> (L.) Juss.	Herb	30180	47.5	10.26	0.354
2	<i>Biophytum reinwardtii</i> (Zucc.) Klotzsch	Herb	9133	14.4	10.26	0.279
3	<i>Cyathula prostrata</i> (L.) Blume	Herb	7545	11.9	10.26	0.253
4	<i>Cynodon dactylon</i> (L.) Pers.	Herb	4765	7.49	8.974	0.194

5	Cyperus rotundus L.	Herb	3574	5.62	7.692	0.162
6	Hydnocarpus pentandrus (Buch.-Ham.) Oken	Herb	3177	5	6.41	0.15
7	Ichnocarpus frutescens (L.) W.T.Aiton	Herb	2780	4.37	7.692	0.137
8	Laportea interrupta (L.) Chew	Herb	2383	3.75	6.41	0.123
9	Leucas aspera (Willd.) Link	Shrub	14	0.02	7.692	0.002
10	Phyllanthus amarus Schumach. & Thonn.	Shrub	13	0.02	7.692	0.002
11	Sida acuta Burm.f.	Shrub	12	0.02	6.41	0.002
12	Sida cordifolia L.	Climber	9	0.01	3.846	0.001
13	Sida rhombifolia L.	Tree	5	0.01	3.846	0.0007
14	Tabernaemontana alternifolia L.	Tree	3	0.005	2.564	0.0005
TOTAL			63593	28.7	26.26	1.66

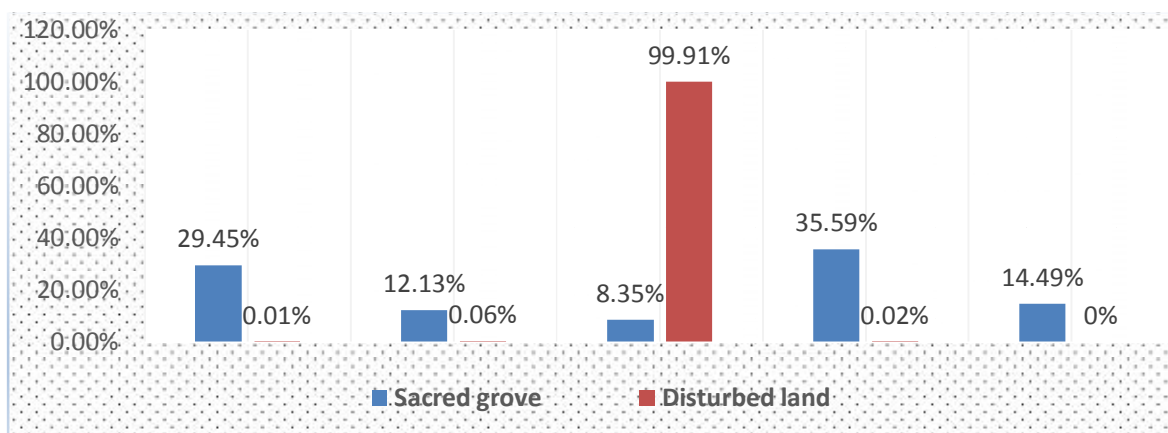


Figure 1: Population Wise Distribution of Ethnomedicinal Plants of Different Groups in Sankulangara Sacred Grove and in the Disturbed Non-Sacred Grove Land

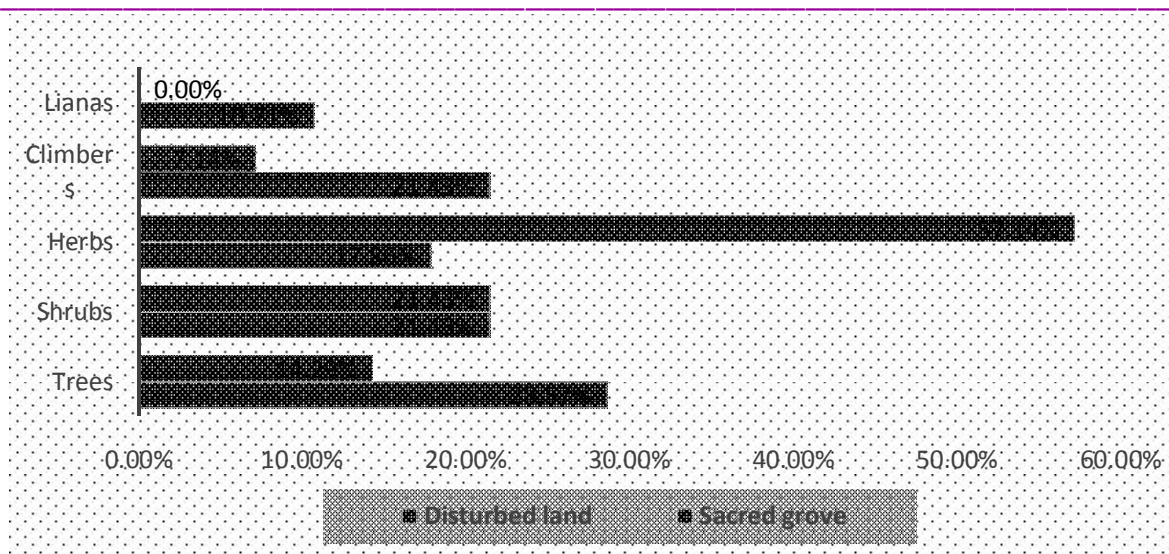


Figure 2: Diversity in the Species Distribution of Ethnomedicinal Plants of Different Plant Groups in Sankulangara Sacred Grove and Disturbed Non-Sacred Grove Land

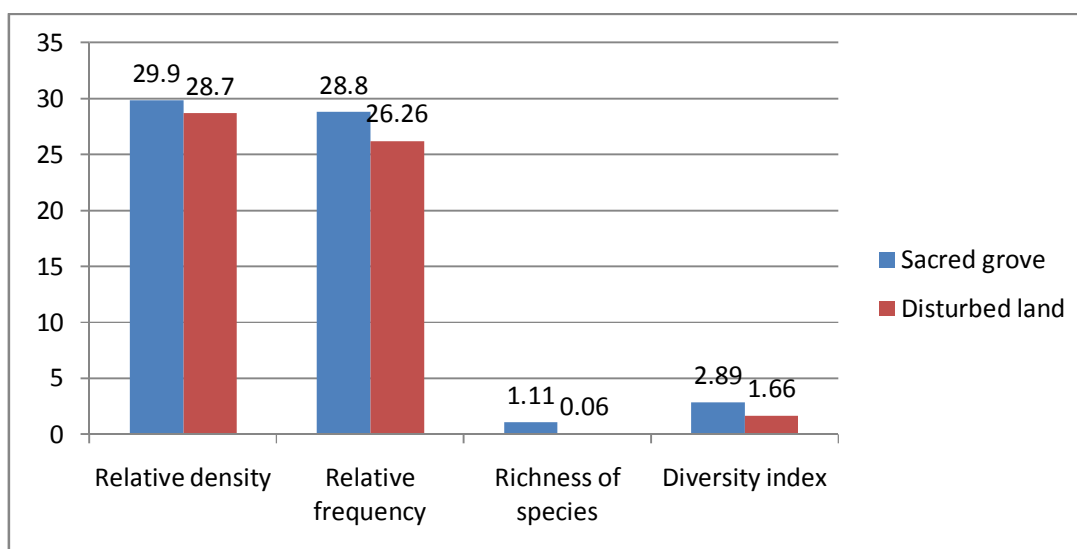


Figure 3: Comparative Evaluation on Relative Density, Relative Frequency, Richness of Species and Diversity Index of Ethnomedicinal Plants in Sankulangara Sacred Grove and Disturbed Non-Sacred Grove Land

REFERENCES

- Akhtar Husain. (1992). Dictionary of Indian Medicinal Plants, Central Institute of Medicinal and Aromatic Plants, Lucknow.
- Alejandro Loydi, Kerstin Lohse, Annette Otte, Tobias Donath, & Lutz Eckstein. (2014). Distribution and effects of tree leaf litter on vegetation composition and biomass in a forest-grassland ecotone. Journal of Plant Ecology, 7 (3), 264-275.
- Kaufman, P.B., Cseke, L.J., Warber, S., Duke, J.A., & Briemann, H.L. (1999). Natural products from plants. CRC Press, Boca Raton, FL.

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- Krishnan Nambiar, V.P., Sasidharan, N., Renuka, C., & Balagopalan, M. (1985). Studies on the medicinal plants of Kerala forests. KFRI Research Report 42, KFRI, Peechi, Thrissur, 200.
 - Khare, C.P. (2007). Indian Medicinal Plants. An Illustrated Dictionary. Springer-Verlag Berlin/Heidelberg edition, USA.
 - Laloo, R.C., Kharlukhi, L., Jeeva, S., & Mishra, B.P. (2006). Status of medicinal plants in the disturbed and the undisturbed sacred forests of Meghalaya, northeast India: population structure and regeneration efficacy of some important species. *Curr. Sci.*, 90, 225-232.
 - Menhinick, E. F. (1964). A comparison of some species diversity indices applied to samples of field insects. *Ecology*, 45, 859-861.
 - Shannon, C. I., & Wiener, W. (1963). The mathematical theory of communication. University Illinois Press, Urbana, Ill., USA.
 - The Ayurvedic Pharmacopoeia of India. (2004). Part I., Volume I to IV, (API), Ministry of Health, Govt. of India, New Delhi.
 - Xiong, S., & Nilsson, C. (1999). The effects of plant litter on vegetation: a meta-analysis. *J Ecol.*, 87, 984-994.

**SACRED GROVES UNDER THREAT- A CASE STUDY OF NAMBIYATH SACRED GROVE
LOCATED IN THE COASTAL BELT OF THRISSUR DISTRICT, KERALA**

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Abstract

Introduction: Sacred Groves are patches of forest vegetation conserved by the villagers and local people by dedicating them to the local deity. These groves are rich in biodiversity and consist of rare, endemic and medicinally important plant species. Now a days these natural patches of forest face severe threats due to various human interference.

Objectives: Analysis on the plant diversity, floristic richness and ethnomedicinal status of plants present in Nambiyath sacred grove in Thalikulam, belonging to the coastal belt of Thrissur district, Kerala; to highlight the threats faced by the grove and the necessity for its preservation.

Methodology: Identification and distribution of different plant groups, evaluation of ethnomedicinal plants, Species Richness Index (Menhinick 1964) and Diversity Index (Shannon, 1963), IUCN status.

Results: Sacred grove is rich in vegetation and biodiversity. It also consists of many ethnomedicinal, endemic and vulnerable species of plants. Different anthropogenic factors are depleting the biodiversity of the sacred grove. So it is very necessary to protect and maintain these remnants of natural forest for the future.

Keywords: Nambiyath sacred grove, floristic richness and diversity, ethnomedicinal wealth, human interference and depletion of vegetation

Introduction

Nature worship is an integral part of human beings mainly in India. Sacred groves, one form of nature worship, are patches of forest vegetation conserved by the villagers and local people by dedicating them to the local deity and cultural and religious beliefs (Rajesh, 2016). These groves are rich in biodiversity with rare, endemic and medicinally important plant species. However, the most serious problem now a day we face is the large scale destruction of vegetation including the patches of forest vegetation the so called sacred groves, due to various anthropogenic activities. The weakening of traditional values and socio-cultural practices among the people is one major reason for the depletion of these groves. The present study was carried out to collect information on floristic richness, diversity, ethnomedicinal wealth and relevance in the conservation of sacred groves, based on the analysis of a selected sacred grove. The study also aims to analyze various reasons which lead to the degradation of groves and to create awareness among the people on the relevance of conserving these treasure houses for the future.

Materials and Methods

Study area

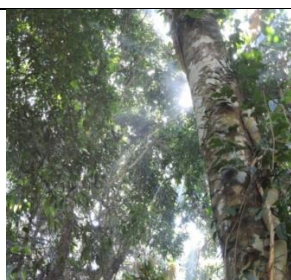
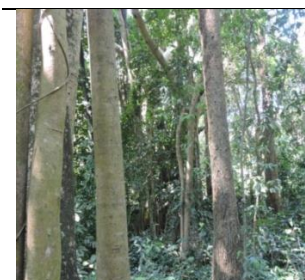
The study area is Nambiyath sacred grove of about 30 cents (1214.05sq.m) in size located at Thalikulam Panchayath which belongs to the Coastal Belt of Thrissur District, Kerala. The study was conducted during the period January 2016 - March 2017. This sacred grove is worshipped mainly for the serpent God "Naga".

Figure 1: Certain views from the Nambiyath sacred grove

Vegetation in the Nambiyath sacred Grove

Worshipping the serpent
Naga inside the grove

Worshipping sacred tree
in the grove - *Alstonia
scholaris*



Identification and distribution of plants

The plant species were identified based on the plant key characters and Flora of the Presidency of Madras (Gamble & Fischer, 1915-1936), field keys devised by Balasubramanyan et al. (1985) and other relevant Floras, Manuals, Revisions etc. The floristic richness and diversity index of plants in the sacred groves have been recorded.

1. Species richness index (Menhinick, 1964)

Species richness index = $S/\sqrt{N}$, where S - total number of a species and N - total number of individuals in a sample

2. Diversity Index of plants- based on Shannon Wiener Index (Shannon & Wiener, (1963)

Shannon Wiener Index (H') = $-\sum \{(n/N) \ln (n/N)\}$

Analysis on the ethnomedicinal plant wealth

The details of ethnomedicinal plants and related information were collected through survey, discussions and interviews with local people and traditional healers in the area. The identification and other required information on ethnomedicinal plants were done with the help of referred books and reports (Akhtar, 1992; The Ayurvedic Pharmacopoeia of India, 2004; Khare, 2007).

Analysis and identification of IUCN listed plant

The details of IUCN status of plant species were collected with the help of referred book- Flowering Plants in Kerala (Sasidharan, 2012) and other relevant books and reports (Daniels et al., 1915).

The destruction factors visually observed and recorded

Various man made activities were observed to have contributing to the depletion and destruction of the grove.

Results and Discussions

The floristic study conducted in Nambiyath sacred grove identified 30 species of Trees which comprises of 29 genera belonging to 20 families, 17 species of Shrubs which comprises of 15 genera belonging to 10 families, 16 species of Herbs which comprises of 16 genera belonging to 12 families, 13 species of climbers which comprises of 13 genera belonging to 10 families and 5 species of liana or woody climbers which comprise of 5 genera belonging to 5 families (table 1). *Alstonia scholaris* is the worshipping sacred tree in the grove but most dominant tree is *Artocarpus hirsutus* of Moraceae then immediately followed by *Pterygota alata* of Sterculiaceae. Most dominant shrub is *Ixora coccinea* of Rubiaceae which is followed by *Bridelia stipularis* of Euphorbiaceae whereas the most dominant herb is *Panicum notatum* of Poaceae which is immediately followed by *Emilia sonchifolia* of Asteraceae. *Abrus precatorius* of Leguminosae and *Ichnocarpus frutescens* of Apocynaceae are the most dominant species of climbers while most dominant woody climber is *Gnetum ula* of Gnetaceae which is immediately followed by *Uvaria narum* of Annonaceae. *Acampe praemorsa* of Orchidaceae and the Pteridophyte *Drynaria quercifolia* of Polypodiaceae are the two epiphytes present in the sacred grove. *Dendrophthoe falcata* and *Helicanthes elastica* of Loranthaceae are the two parasitic plants observed in the sacred grove. Six species of plants are found endemic to Western Ghats and two species are endemic to Peninsular India (table 3). According to IUCN plant list *Ixora malabarica* of Rubiaceae and *Saraca asoca* of Leguminosae are reported as vulnerable, *Tabernaemontana alternifolia* of Apocynaceae reported as near threatened. Total of 85 species of plants are identified in the Nambiyath sacred grove and out of which 25 species of plants are identified as ethnomedicinal (table 3). The ethnomedicinal plant species in the grove are found constituted 29.4% of the total plant species present in the grove. The sum of the diversity index of all the plant groups in the grove is 18.07 and species richness is 67.34 (table 1). The diversity index and species richness of the entire grove is 4.15 and 30.18 respectively.

Better distribution of vegetation and higher diversity of plant species particularly ethnomedicinal species, from diverse groups of plants such as trees, climbers, lianas, shrubs and herbs in the studied sacred grove compared to the distribution of vegetation in the nearby areas of the grove may be attributed to comparative low human interference and conducive environmental factors in the grove area such as physical and chemical properties of soil and microclimate. However the study observed that certain construction works, farming activities, over exploitation, dumping of domestic wastes and plastics, invasion of exotic species like *Lantana camara* and *Mikania micrantha* are the main threatening factors of Nambiyath sacred grove. All these factors are found contributing to the gradual but progressive destruction of vegetation and diversity of plants in the grove. If this trend continues, it may lead to complete disappearance of such treasure houses in the near future. So necessary action should be taken to prevent the destructing factors effectively.

Figure 2: Some of the threatening factors of sacred grove



Table1: Distribution of plant groups in Nambiyath sacred grove

Plant Groups	No. of species	No. of Genera	No. of family	Total no. of plants	Diversity index	Species richness
Trees	30	29	20	178	3.1125	13.3433
Shrubs	17	15	10	216	2.7387	14.7038
Herbs	16	16	12	205	2.7306	14.3254
Climbers	13	13	10	148	7.9663	12.1710
Lianas	5	5	5	164	1.5267	12.8025
Total	81	78	40	911	18.0748	67.3460

Table 2: Details of Ethnobotanical plants in Nambiyath Sacred Grove

Botanical Name	Local Name	Family	Habit	Parts Used	Medicinal Uses
<i>Abrus precatorius</i> L.	Kunni	Leguminosae	Climber	Whole	Leaf juice is a blood purifier. Root paste is used for swellings and skin diseases, Plant extract is boiled with coconut oil is used as hair tonic.
<i>Aerva lanata</i> (L.) Juss.	Cherula	Amaranthaceae	Herb	Whole plant	Whole plant is boiled with water and this decoction is used for the treatment of cough and urinary problems.
<i>Alstonia scholaris</i> (L.) R. Br.	Ezhilampala	Apocynaceae	Tree	Bark	Bark is used in the treatment of diarrhea, dysentery, liver complaints, skin diseases and rheumatic pains. Milky juice is applied to ulcers
<i>Biophytum reinwardtii</i> (Zucc.) Klotzsch	Mukkutti	Oxalidaceae	Herb	Whole plant	Whole plant is crushed and juice is used for cough, asthma and oral administration of cooked whole plant with duck egg is used for piles.

<i>Boerhaviadiffusa</i> L.	Thazhuthama	Nyctaginaceae	Herb	Whole plant	Oral administration of decoction of whole plant is useful for asthma, dysentery and diarrhea.
<i>Cissuslatifolia</i> Lam.	Chunnambuvali	Vitaceae	Climber	Root, stem	Root and stem of the plant is crushed and administered orally to cure bone fractures, weak bones (osteoporosis).
<i>Connarusmonocarpus</i> L.	Kurilathali	Connaraceae	Liana	Leaves	Pounded leaves are applied to painful swellings, seeds are used to treat nervous disorders, contraceptive also. Root extract is used against sore throat, asthma, fever and skin diseases.
<i>Cyathulaprostrata</i> (L.) Blume	Cherukadaladi	Amaranthaceae	Herb	Whole plant	Whole plant is crushed and ground into a paste is applied for skin diseases. Decoction of roots is given for dysentery.
<i>Cyperusrotundus</i> L.	Muthanga	Cyperaceae	Herb	Rhizome	Powdered rhizome is mixed with milk is used for digestive disorders and renal problems.
<i>Desmodiumgangeticum</i> (L.) DC.	Orila	Leguminosae	Herb	Roots	Root paste is applied for chronic fever, cough, vomiting, asthma and rheumatism.
<i>Diospyrosmalabarica</i> (Desr.) Kostel.	Panachi	Ebenaceae	Tree	Bark, seeds	Infusion of fruits is used as gargle for sore throat. Fruit juice is applied for wounds and ulcers. Oil of the seeds is given in diarrhea & dysentery.
<i>Dracaena terniflora</i> Roxb.	Manjakantha	Liliaceae	Shrub	Root	Root extract is applied for skin diseases, consumption of aqueous extract is useful for jaundice.
<i>Emilia sonchifolia</i> (L.) DC. ex DC.	Muyalcheviyan	Asteraceae	Herb	Whole plant	Decoction of whole plant used to treat tonsillitis, bleeding piles and fever. Whole plant is crushed and made paste is applied on throat is beneficial for sore throat.
<i>Garciniagummi-gutta</i> (L.) Roxb.	Kudampulli	Clusiaceae	Tree	Roots, Leaves, fruits.	A decoction of the fruit rind is used for the treatment of rheumatism, bowel complaints, piles and disorders in the womb.

<i>Gnetumula</i> Brongn.	Odavalli	Gnetaceae	Liana	Seeds	Seed oil is externally applied on area affected by rheumatism.
<i>Ichnocarpus frutescens</i> (L.) W.T. Aiton	Parvalli	Apocynaceae	Climber	Root, leaves	Root and leaf extract is applied to back pain, skin diseases.
<i>Kamettia caryophyllata</i> (Roxb.) Nicolson & Suresh	Narumarathivu	Apocynaceae	Climber	Leaves, roots	Decoction of the whole plant is used for leprosy and arthritis. Leaf paste is applied on affected area for itches and scabies.
<i>Laportea interrupta</i> (L.) Chew	Choriyanam	Urticaceae	Herb	Leaves, root, fruits.	Root is crushed and juice taken for fever and leaves crushed and made paste is directly applied to headache.
<i>Mimusops elengi</i> L.	Elanji	Sapotaceae	Tree	Bark, fruit	A decoction of the bark forms good gargle in odontalgia, oral administration of ripe fruit pulp is used against dysentery.

Table 3: IUCN listed plant species in the Nambiyath Sacred grove

Plant Name	IUCN Status				
	Endemic	Endangered	Vulnerable	Threatened	Rare
<i>Briedelia stipularis</i> (L.) Blume	Peninsular India	-	-	-	-
<i>Holigarna arnottiana</i> Hook.f	Southern Western Ghats	-	-	-	-
<i>Hydnocarpus pentandra</i> (Buch.-Ham.) Oken	Western Ghats	-	-	-	-
<i>Ixora malabarica</i> (Dennst.) Mabb	Southern Western Ghats	-	Vulnerable	-	-
<i>Kamettia caryophyllata</i> (Roxb.) Nicolson & Suresh.	Southern Western Ghats	-	-	-	-
<i>Mussaenda frondosa</i> L.	Peninsular India	-	-	-	-
<i>Pinangadicksonii</i> (Roxb.) Blume.	Western Ghats	-	-	-	-
<i>Saraca asoca</i> (Roxb.) de Wilde		-	Vulnerable	-	-
<i>Tabernaemontana alternifolia</i> L.	Southern Western Ghats	-	-	Near Threatened	-

Conclusion

The present study found richness in vegetation and plant diversity in the sacred grove area compared to nearby areas of the grove. This grove is maintained basically for religious practices and worship of the deity by

the farmers and the local people. Certain plant species of the grove are threatened, endemic and vulnerable which are economically and medicinally very important and not commonly found in the nearby premises. The conservation of such plant species is very essential for the future generation, but found threatened by various human interventions. Therefore, it is necessary to create awareness among the local people regarding the conservation of these kind of natural forest patches. Further, Government should declare such areas as 'protected land' and stringent laws should be enforced for their protection. Scientific documentation and creating awareness in the present and future generations on the need and importance of conservation and management of the sacred groves as a treasure house of biodiversity is to be initiated.

References

- Akhtar Husain. (1992). Dictionary of Indian Medicinal Plants, Central Institute of Medicinal and Aromatic Plants, Lucknow.
- Amirthalingam, M. (2005). Conservation strategy for sacred groves of Tamilnadu, C.P.R. Environmental Centre, Chennai.
- Balasubramanyan, K., Swarupanandan, K., & Sasidharan, N. (1985). A field key to the identification of indigenous arborescent species of Kerala Forests. Research Report, No. 33 KFR I. Peechi.
- Bhakat, R. K., & Pandit, P. K. (2003). "Role of a sacred grove in conservation of medicinal plants." Indian Forester, 129:224-232.
- Bhandary, M. J., & Chandrashekar, K. R. (2003). Sacred Groves of Dakshina Kannada and Udupi Districts of Karnataka. Current science, 85: 1655-1666.
- Daniels R. J. R., Kumar N. A., & Jayanthi M. (1995). Endemic, rare and threatened flowering plants of South India. Current Science 68: 493-495.
- Gamble, J. S., & Fischer, C. E. C. (1915-1936). Flora of the Presidency of Madras. Vols. 1-3, Adlard & Son Limited, London. 2017 pp.
- Induchoodan, N. C. (1998). Ecological Studies on the Sacred Groves of Kerala. Ph. D Thesis, Pondicherry University, Pondicherry. 156 pp.
- Khare, C. P. (2007). Indian Medicinal Plants. An Illustrated Dictionary. Springer-Verlag Berlin/Heidelberg edition, USA.
- Menhinick, E. F. (1964). A comparison of some species diversity indices applied to samples of field insects. Ecology, 45, 859-861.
- Rajesh, B. (2016). Sacred Groves: Floristic Diversity and their Role in Conservation of Nature. Forest Res 5: 161. doi:10.4172/2168-9776.1000161.
- Sambandan, K., & Dhathanamoorthy, N. (2012). Studies on the Phytodiversity of a sacred grove and its traditional uses in Karaikal dist. UT. Puducherry. J. Phytology 4: 16-21.
- Sasidharan, N. (2012). Flowering Plants in Kerala, Kerala Forest Research Institute, Peechi.
- Shannon, C. I., & Wiener, W. (1963). The mathematical theory of communication. University Illinois Press, Urbana, III., USA.
- The Ayurvedic Pharmacopoeia of India. (2004). Part I., Volume I to IV, (API), Ministry of Health, Govt. of India, New Delhi.

**IMPACT OF HUMAN INTERFERENCE ON ETHNOMEDICINAL PLANT
WEALTH AND DIVERSITY- A COMPARATIVE STUDY OF SANKULANGARA
SACRED GROVE AND A DISTURBED NON-SACRED GROVE LAND LOCATED
AT S.N.PURAM, THRISSUR DISTRICT, KERALA**

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Abstract

Since ancient times, a wide variety of plants have been used to treat various kinds of diseases based on the traditional knowledge. But now a days the major threat to this kind of treatment is the disappearance or scarcity of many valuable medicinal plants due to large scale destruction of vegetation for various reasons. Whatever be the reason, the fact that is often neglected is the pharmacological importance of this safer, cheaper and reliable source of drugs and its preservation for the future. Comparative analysis on the ethnomedicinal plant wealth and diversity between the Sankulangara sacred grove and the near by disturbed non-sacred grove land. Study includes identification and distribution of ethnomedicinal plants and their uses (through survey & interviews), analysis on the phytosociological aspects such as relative density and relative frequency of plant species, dominance of ethnomedicinal family and species, Species Richness Index (Menhinick, 1964) and Diversity Index (Shannon, 1963). The ethnomedicinal plant wealth and diversity is significantly higher in the grove area compared to disturbed non-sacred grove area. It is very necessary to protect and maintain these remnants of natural forest for the future.



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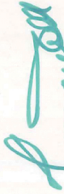
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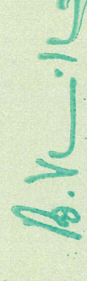
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