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Assessment of Ecosystem Services for Conservation and Management of Sacred groves in Kerala part of Western Ghats (Final Technical Report of the Project KFRI 642/2012)

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Abstract

The Sacred Grove (SG) concept is one of the strategies developed by many human societies to conserve biological resources using a traditional approach. In a village landscape, compared to other forest patches, the sacred forest benefits rural societies in a better way through its ecosystem service outputs. However, the supply of ecosystem services depends on the structure and processes of ecosystems and is reduced with ecosystem degradation. In view of the fact that several SGs are being degraded, there is a necessity to identify direct and indirect drivers of forest degradation and then to develop decision support systems considering the present socio-cultural and economic dimensions to make information readily available to SG managers. With this background, the present study was conducted in five SGs (Kammadam Kavu, Karimanal Chamundi Kavu, Mani Kavu, Poyil Kavu and Valliyotu Kavu) of Kerala. Here, two approaches were taken to contribute for developing decision support systems for sacred forest conservation and management. The first approach was to assess ecosystem services of well-managed SGs as an opportunity for the conservation and management of SGs of the Western Ghats. The second approach was to identify direct and indirect drivers of degradation of SGs to compile and share useful information for planning interventions to combat forest degradation, reduce vulnerability and promote sustainable management of SGs.

The level and intensity of disturbances are qualitative in nature and thus analytical method/s to assess and compare level, intensity and diversity of disturbances in SGs had to be developed. In the present study, eight disturbance variables namely, a) loss of forest land, b) pre-mature fall of trees, c) trespass, d) Illegal collection of biomass, e) dumping of solid waste, f) anti-social activities and g) use of SG area as playground were identified. By analyzing the intensity and frequency of each type of disturbance, the frequency of disturbance and Index of Human Disturbance Value (IHD) were calculated. The frequency of disturbance in SGs ranged from 24 per cent to 58 per cent with lowest value for Kammadam Kavu and highest value for Mani Kavu. However, the level of disturbance caused due to various anthropogenic activities was more in Karimanal Chamundi Kavu followed by Mani Kavu, Poyil Kavu, Valliyottu Kavu and Kammadam Kavu.

A total of 418 angiosperm species, 36 species of Vesicular-arbuscular mycorrhiza (VAM fungi), 151 butterfly species and 106 bird species were recorded from these SGs. Among

them, sixty angiosperm species, five species of butterflies and eight species of birds were endemic to the Western Ghats. However, a negative correlation (R= - 0.945) between Index of Human Disturbance (IHD) values and total number of endemic species in these SGs was recoded. In addition, significant reduction in tree density (R= - 0.941), tree basal area (R=-0.864), biomass and carbon stock in tree biomass with increase in level of disturbance recorded.

The studies on soils of SGs thus indicated that there is a significant decrease in moisture content, OC, N, P, K, Ca and Mg with disturbances. Sustaining a good mix of tree species in the groves would supplement the soil organic matter and help sustain the ecosystem in a pristine state. Water analysis showed that the SGs maintain perennial streams with all the physical and chemical parameters within the prescribed ranges. However, all the analyzed samples indicated the presence of total coliforms and in some cases fecal coliforms, threatening the potability of otherwise good quality perennial source of water.

Comparative analysis of socio-cultural dimensions of five SGs indicated that though temple management and institutional history vary slightly across the SGs there is active participation of the local people in the affairs of the SGs. All the SGs have strong surviving social linkages and anchorages. However, further socio-cultural analysis enabled to recognise the fact that even as the social changes occur, the rejuvenation of cultural heritage - one of the important ecosystem services of SGs, can act to support the conservation and restoration of SGs. The study also identified the fact that the cultural heritage and forest vegetation are complementary to each other in determining ecosystem health of community-based biodiversity conservation institutions like SGs. Therefore, the SG managers need to plan for constituting a natural resource conservation committee in their SGs to protect and conserve forest and water bodies and also restore or enrich biodiversity. Furthermore, to promote the value of SG for biodiversity conservation, there would be a need for proper scientific assessment of SGs to demonstrate their relevance to habitat and species protection. In this context, it is suggested that an Indian National Network for Conservation of SGs (INNCSG) may be built up as a broad programme for monitoring ecosystem services of SGs.

1. Introduction

SGss represent patches of forests protected by assigning them as the abode of Godsand Goddesses. In India, in spite of increase in human population, SGs have survived under a variety of ecological situations (Ramakrishnan et al., 1998). SGs received a greater research attention from anthropological as well as biological conservation points of view (Gadgil and Vartak, 1976; Malhothra, 1998; Tiwari *et al*., 1998; Malhotra *et al*., 2001; Nair, *et al*., 2013). These studies have indicated that each SG has its own cultural, biological and ecological dimensions. In many parts of the tropics, SGs form a unit in the rural landscape. Being a landscape unit in a rural landscape, the SG performs several ecological functions, which directly or indirectly help in the maintenance of ecosystem health of all interacting landscape units. SGs can contribute to a village landscape in managing hydrological balance, availing the carbon credits under the Clean Development Mechanism (CDM) of Kyoto protocol and compensating for carbon emissions of polluting industries. Thus, conservation and management of SGs has the potential to offer direct monetary benefits to the communities besides the other ecosystem benefits.

Studies conducted in India have already highlighted the fact that well conserved SGs of the country are comparable to the regional natural forests for various ecological attributes. Importance of well managed SGs as the treasure plants and animals belonging to different conservation status is also well documented.

SGs have been maintained by the village community for both cultural and religious values. The traditional institutions have been strong to manage SGs. Because of this, several ecosystem functions and services rendered by sacred forest are directly and indirectly responsible for maintaining ecological health, economic development and sociocultural well-being of the village landscape. It is the interest of the scientific community as well as several other concerned stakeholders to have better understanding of the linkages between the function and structure of the SGs and the provision of ecosystem services therin. In this context, it is proposed to undertake a research project to demonstrate that in a village landscape, compare to other forest patches, the sacred forest benefits rural societies in a better way through its ecosystem service outputs.

The supply of ecosystem services depends on the structure and processes of ecosystems and is reduced with ecosystem degradation. It may be pointed out here that in many parts of

India, strengths of SG institutions have been eroded gradually due to changed socioeconomic scenario in the region. Consequently, vegetation and culture associated with many SGs in the country have been degraded to a greater extent. In the context of degraded or poorly managed SGs of Kerala, there is necessity to identify direct and indirect drivers of forest degradation and then to develop decision support systems considering the present socio-cultural and economic dimensions to make information readily available to SG managers. With this background, two approaches to contribute for developing decision support systems for sacred forest conservation and management are proposed. The first approach is the assessment of ecosystem services of well-managed SGs as an opportunity for the conservation and management of SGs of the Western Ghats. The second approach is the identification of direct and indirect drivers of degradation of SGs to compile and share useful information for planning interventions to combat forest degradation, reduce vulnerability and promote sustainable management of SGs.

2. Objectives

The specific objectives of the project are to

a) identify and characterize ecosystem services provided by a set of sacred forest ecosystems of Kerala,
b) assess the quantity and quality of various ecosystem services attributable to sacred forest ecosystem, and
c) study the change in quantity and quality of ecosystem services due to varying degree of management and disturbance regimes in SGs

3. Methodology

3A. Selection of SGs

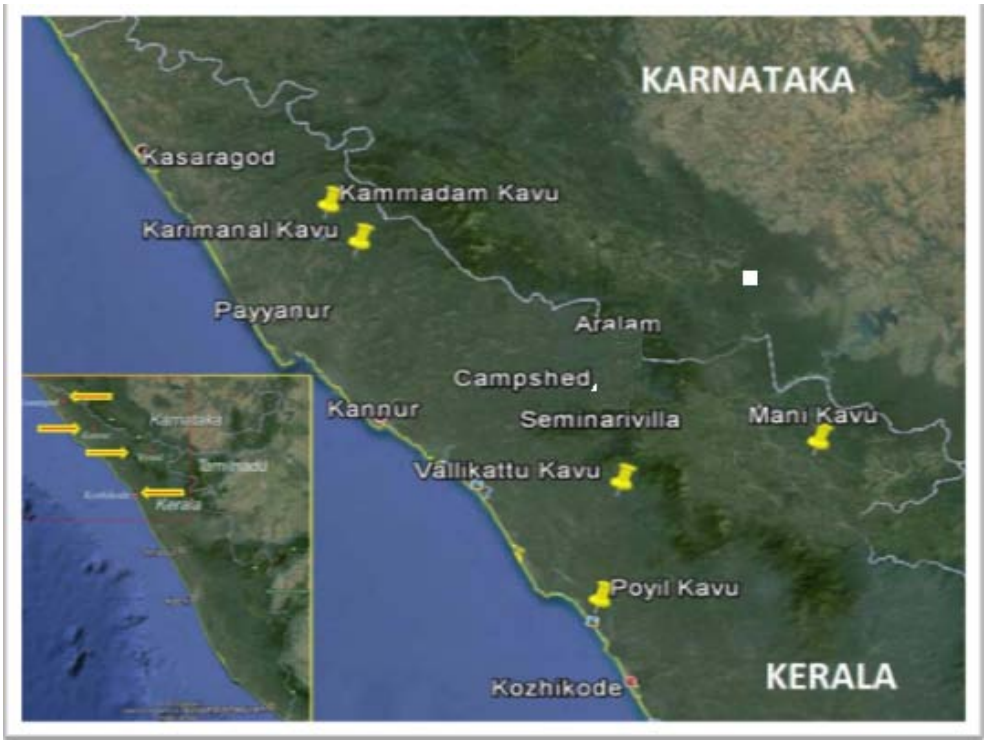
To assess the ecosystem services, five SGs associated with a stream were selected (Table 1). Before selecting the groves, the project team met different stakeholders of each SG to get their consent to carry out research in the grove. The administrative authorities of all five SGs were keen to cooperate with the project team. This was clearly shown by them by issuing formal permissions to the project team to document geographic position (using a GPS), topography, and area under vegetation and ownership and management details of SGs and also conduct studies that are envisaged in the Project.

Table 1. Location details of SGs selected in Kerala.

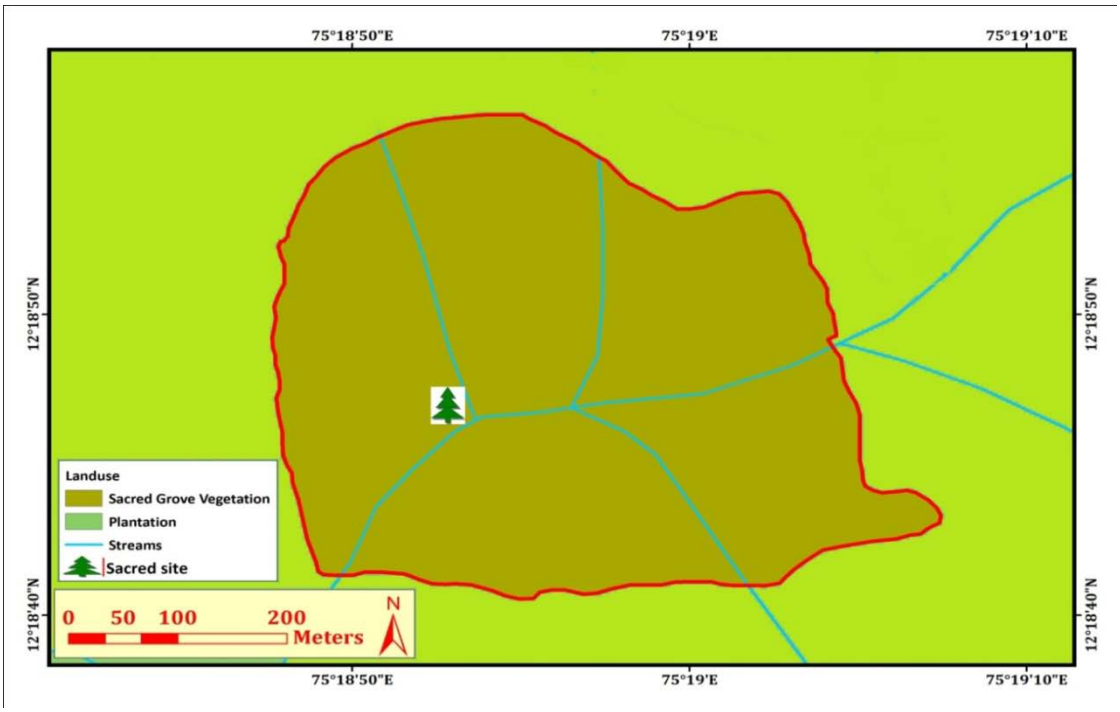
SG and its acronym	Contact details	Latitude	Longitude	Area under vegetation (ha)
Kammadam Kavu (KK)	Chairman, Board of Trustees, Kammadam Sree Bagavathi Temple, Bheemanadhi Village Kammadam, Mandapam- 571326, Kasaragodu District	12^{0}18$^{'}$30.01" N	75^{0}17'20.32" E	24.00
Karimanal Chamundi Kavu (KCK)	Secretary, Karimanal Chamundi Kavu Committee, Ponnamvayal, Vayakkara Village, Peringom Panchayath, Taliparamba Taluk, Kannur District	12^{o}15'53.02" N	75^{o}18'37.54" E	4.44
Mani Kavu (MK)	Executive Officer, Mani Kavu Devaswom Committee, Purakkadi Village, Chattupara P.O., Wayanad District.	11^{o}42'08.19" N	76^{o}09'24.19" E	11.93
Vallikkattu Kavu (VK)	Chairman, Vallikattu Kavu Management Committee, Eddakara, Kozhikode District	11^{o}23'17" N	75^{o}47'10" E	10.04
Poyil Kavu (PK)	Executive Officer, Poyil Kavu Devaswom, Poyil Viilage, Koyilandi Taluk, Kozhikode District	11^{o}24'41" N	75^{o}42'46" E	4.62

3B. Mapping of SGs

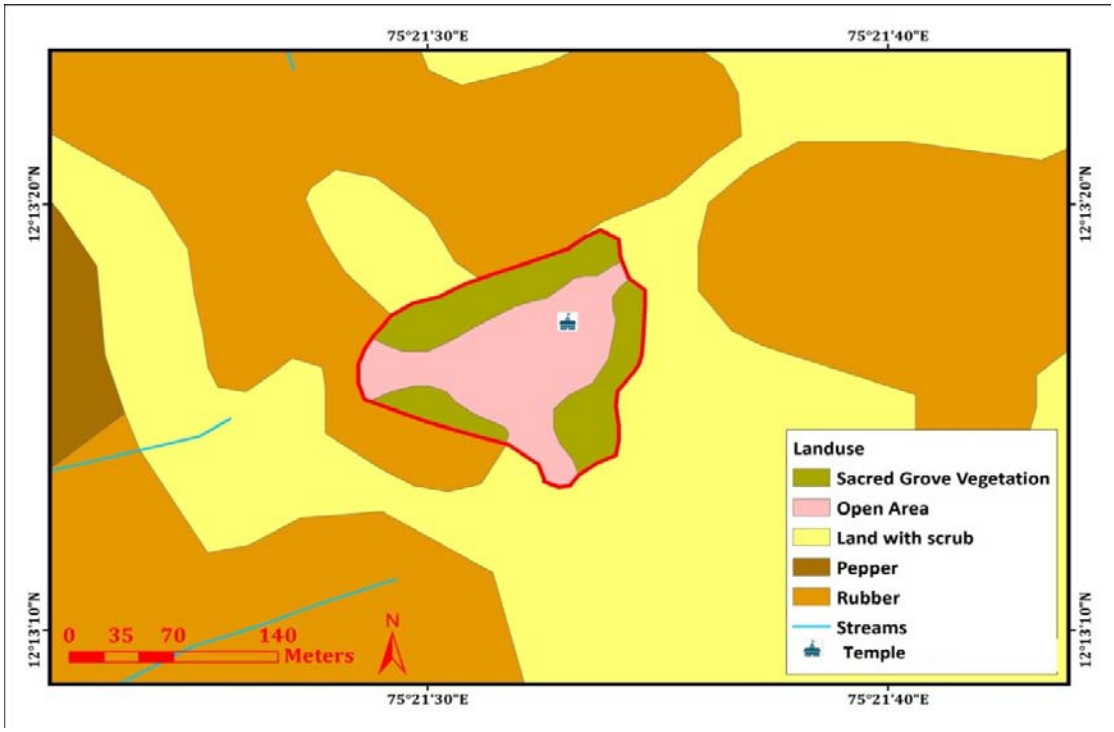
For mapping, local people were consulted to mark the boundary of their SG and then boundaries were delineated using GPS readings. Later, using Google Earth Pro imageries base map of the groves was prepared (Maps 1 to 6).



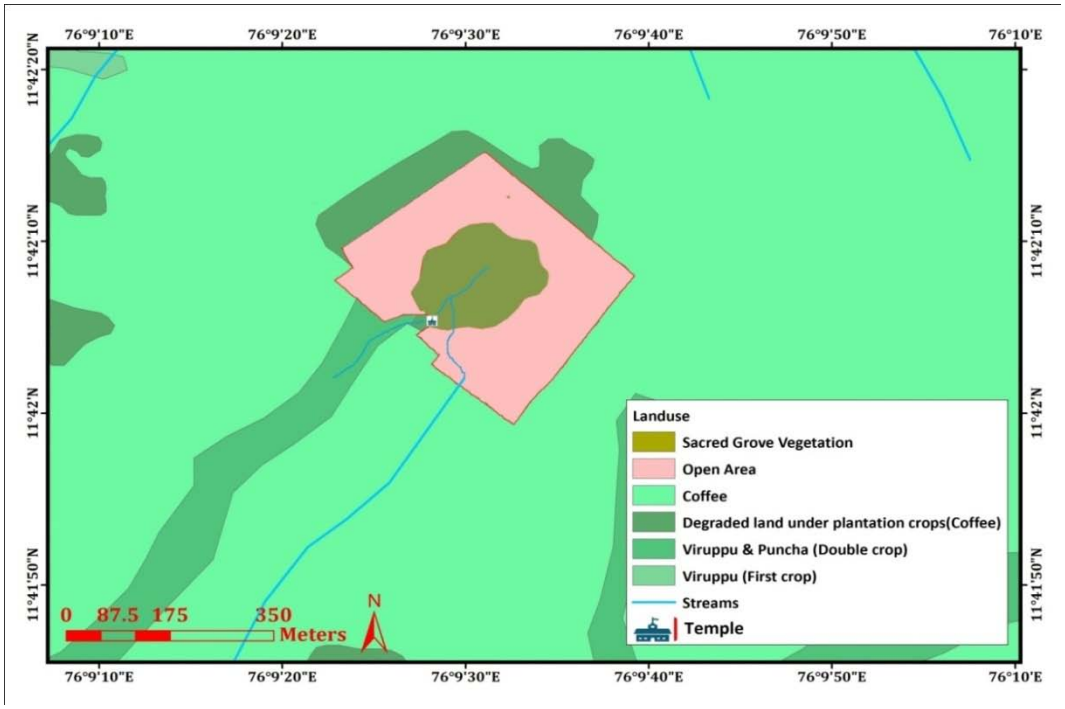
Map 1. Location map of SGs of Kerala selected for the study.



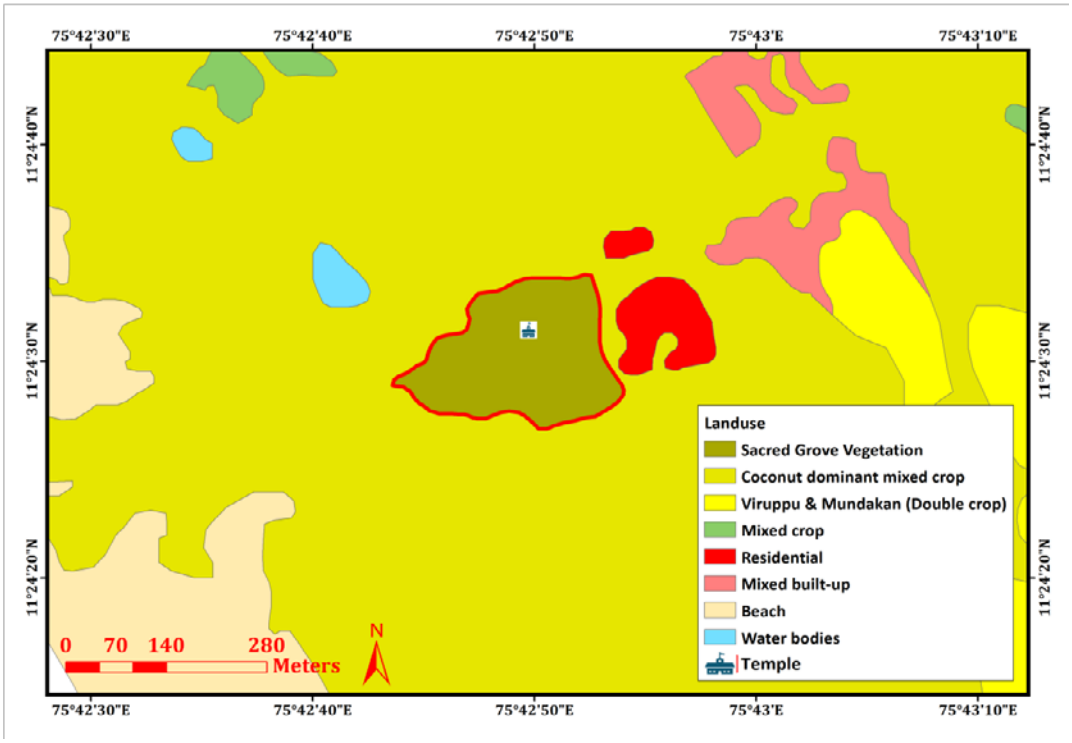
Map 2. Location map of Kammadam Kavu in Kasaragodu District of Kerala



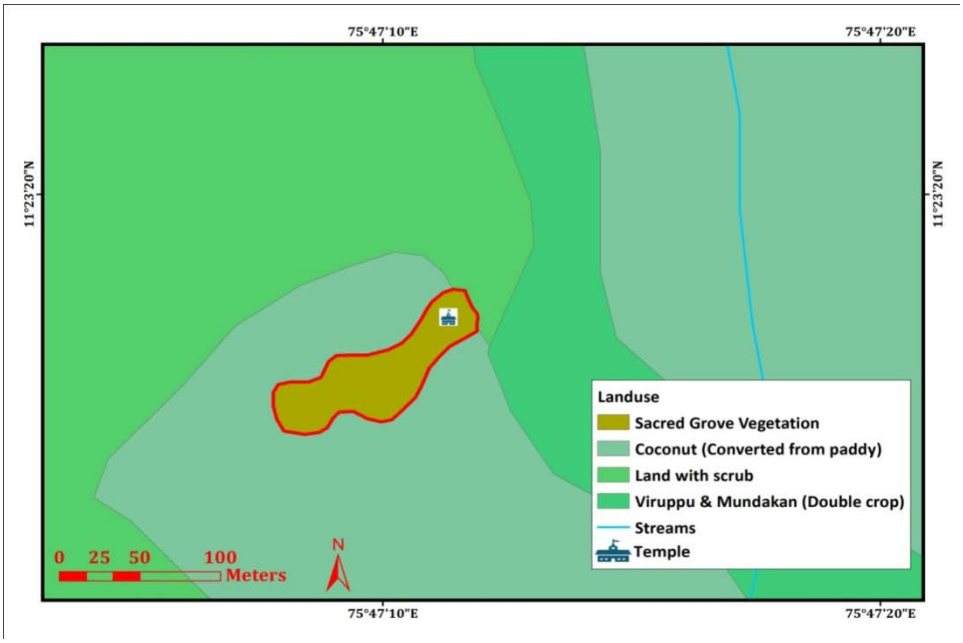
Map 3. Location map of Karimanal Chamundi Kavu in Kannur District of Kerala



Map 4. Location map of Mani Kavu in Wayanad District of Kerala



Map 5. Location map of Poyil Kavu in Kozhikode District of Kerala



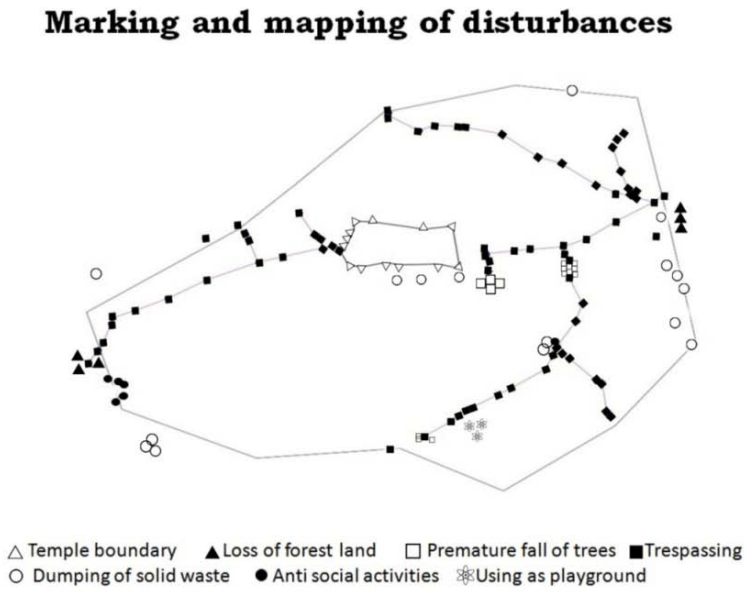
Map 6. Location map of Vallikattu Kavu in Kozhikode District of Kerala

3C. Assessment of level of disturbance in SGs

Despite the fact that the local people in general believe that their livelihood, security and prosperity are complementary to the blessings of the deity of the grove, this ancient and widespread institution of SG is showing signs of weakening in terms of both cultural and biological integrity in many parts of country. The ten major human disturbance variables in a SG are: a) loss of forest area of SGs can be due to encroachment or due to erosion of the fringe area of the forest, b) damage to understorey vegetation, particularly to the tree seedling population by trampling, c) un-authorised collection of biomass, such as, green mulch, seedlings, Non Wood Forest Products (NWFPs), fire wood and small timbers etc., d) grazing by domestic animals, e) premature fall of trees in SGs due to changes in adjacent land uses which led to the loss of windbreak to the SG, f) Poaching wild animals, g) dumping of solid waste materials such as plastic bottles, carry bags, wrappers of food/ confectionary items, kitchen wastes, old cloths etc., h) un-authorised activities, such as, consumption of alcohol, gambling among others, i) use of SG land as playground by children and adults and j) trespassing that damages regenerating plants (Chandrashekara, 2011). In general, in a SG, either one or many of these disturbance variables can be seen. Moreover, the intensity of different disturbance variables in a SG can also be different. Since the level of disturbance is qualitative in nature, it is required to measure the level of disturbance using appropriate scaling system by assigning values for different intensity level of each disturbance. When the scaling is uniform for all types of disturbance, it is easy to assess the overall level of disturbance in a SG and also compare and contrast different SGs in terms of disturbance levels. Considering these aspects, an analytical method was developed to assess the level of disturbance in SGs.

In a SG, one or many human disturbance variables can be seen. These variables may be seen in all parts or one or few parts of the SG. They may spread up to the core area (centre) of the SG or seen only in the border. Disturbance can be due to either external or internal (temple activities) activities or both. Intensity of disturbance by a given variable can be considered as high if that variable was recorded in / spread up to the central part of the SG. Therefore, it is required to divide the SG area and scoring each segment appropriately. Considering these aspects following procedures have been developed and followed.

Using a standard GPS System (Garmine Trex 30), the boundary of the SG has been marked and a map prepared using software QGIS and Easy GPS (Trial version). GPS was also used to mark the locations within the SG where each type of disturbance variable has been noticed (Map 7). For instance, in the selected SGs the recorded disturbance variables include a) loss of forest land, b) pre-mature fall of trees, c) trespass, d) un-authorised collection of biomass, e) dumping of solid wastes, f) anti-social activities, and g) use of the SG area as playground.

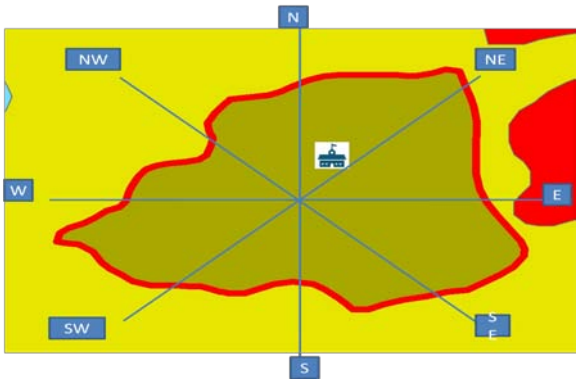


Map 7. Locations within Poyil Kavu showing different types of disturbance

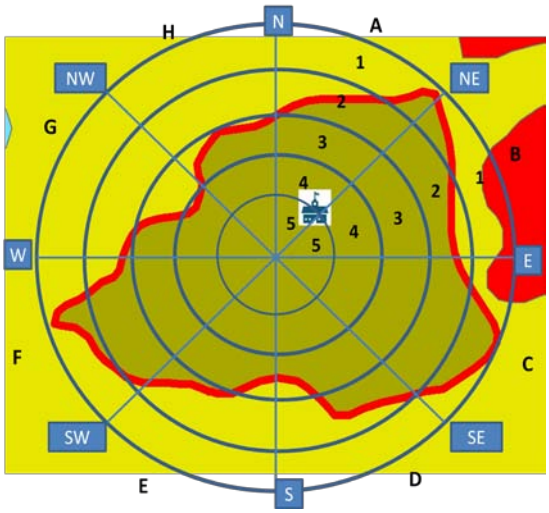
It is necessary to divide the area of SG to know the types and intensity of disturbance in different parts of the grove and then to decide necessary management options to mitigate them. Thus, based on GPS readings, the center of the SG has been determined and marked in the map. Passing through the centre, the SG has been divided into eight segments (Map 8).

Subsequently, in the boundary of the SG, a location with maximum distance from the centre has been identified. Considering this distance as radius, a circle has been drawn. Within this circle four equidistant concentric circles were drawn. Thus, in each segment, five slices have been obtained. Each slice in a segment has been assigned with a number (1 to 5) starting from the boundary to the centre of the SG (Map 9). Thus, if a SG assumes perfect circular shape, there will be 40 slices. However, the shape of a SG may not be circular and

moreover, any two SGs may not of same shape. Therefore, number of slices covered may be different for different SGs.



Map 8. Map of Poyil Kavu with eight segments.



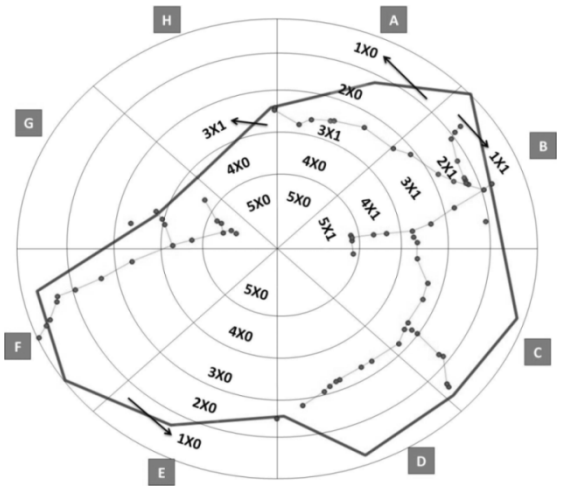
Map 9. Slices in each segment of Poyil Kavu

The number of slices showing the signs of one or more disturbance variables can vary from one grove to another grove. Thus, frequency of disturbance has been calculated by adopting the following formula

Frequency of disturbance =

$$\frac{\text{Number of slices with signs of one or more disturbance variable x 40}}{\text{Number of slices counted for the SG}}$$

Each slice in a segment has been assigned with a number (1 to 5) starting from the boundary to the centre of the SG (Map 9). These numbers also represent weighting factors that range from 1 (being less intense; a disturbance is localized to the peripheral region of the SG) and 5 (being more intense: a disturbance is even spread up to the centre of the SG; an indication of high level disregard to the sanctity of the SG and negligence in protecting and managing vegetation of the SG). In a given slice, a given type of disturbance variable may be present or absent. If a disturbance variable was noticed in a slice, the weighting factor of that slice can be multiplied by 1 and not noticed, the weighting factor can be multiplied by 0. The values obtained for one disturbance variable (trespassing) in slices of certain segments of Poyil Kavu are shown in Map 10. Sum of the values obtained for all slices in all segments gave the disturbance score for a given variable in the SG. Similarly, for each variable, disturbance score has been calculated.



Map 10. Method followed to assign value for a given variable based on its presence or absence in a given segment of Poyil Kavu.

For calculating the Index of Human Disturbance Value (IHD), the disturbance score obtained for different disturbance variables in SGs were considered. The formulae given by Mutangah (1996) were used to calculate IHD.

Individual variable index value, $Y = C/C_{max}$

Where, C is disturbance score of a given variable in a given SG, C max is the maximum disturbance score of a given variable recorded

Index of Human Disturbance Value (IHD) = $(\Sigma Y)/N) \times 100$

Where, N= Number of variables studied.

3D. Assessment of ecosystem services of SGs

3D1. Biodiversity conservation as an ecosystem service

3D1.1. Inventory of vegetation

A check-list of angiosperms in study sites has been prepared by visiting sites at a monthly interval during the reporting period. Plants were identified with the help of regional floras.

3D1.2. Inventory and diversity assessment of Vesicular-arbuscular mycorrhiza (VAM fungi)

The soil and root samples collected from all five study sites. The micro-floras from soil samples of groves, especially mycorrhizal populations were enumerated. About three kilograms of rhizosphere soil along with young roots from 10 to 20cm depth was collected from different sample plots of SGs. Care was taken to ensure that fine roots were well in samples. The soil samples along with roots were kept in polythene bags and transported to the laboratory. The soil samples were air dried and kept in tight polythene bags. Root samples were separated from rhizosphere soil and subjected to root clearing technique to detect the range of mycorrhizal association. After washing, the roots were kept moist in polythene bags and refrigerated at 5^0C. A working sample of the roots was drawn by chopping the fine roots into about 1 cm length and mixing, random sub-samples were drawn for the procedure. Clearing of mycorrhizal roots was required as structures produced by VAM fungi are not visible when fresh roots are observed, as they are obscured by natural pigments and cell contents within roots. The root bits immersed in KOH 10% w/v solution in beaker were kept in water bath for about 30-45 minutes. After clearing the roots, KOH solution drained off and the roots were thoroughly washed with tap water for 3-4 times. The roots were then neutralized with 2% HCI solution for 3-5 minutes. For staining, the roots were then immersed in Trypan blue (0.05%) and kept in water bath for 10 minutes or soak it overnight. After staining, the roots were separated from staining solution and immersed in lactic acid. The root bits were then observed under a light microscope for the presence of VAM fungal structures, arbuscules, vesicles, internal hyphae and spores. From each sub-sample, 100 root bits were observed and the percentage root colonization (RC) was calculated as the number of root bits with arbuscules and vesicles divided by number of root bits observed.

3D1.3. Inventory of Butterflies

Butterflies constitute one of the common fauna of all habitat types, and because they are responsive to change, their diversity and abundance can reflect ecological trends in other

segments of biodiversity (Furness and Greenwood, 1993). The butterfly diversity was studied by visiting the SGs three times during June-December of 2014 and 2015. The species were identified on the basis of field characters (Evans, 1932; Wynter-Blyth, 1982; Gaonkar, 1996). The entire area of the SG was sampled by walking at a constant pace for about one to three hours in the morning.

3D1.4. Inventory of Birds

In terms of indicator organisms for biodiversity studies, birds are also an excellent choice. They are common to all habitats and generally easy to observe. Many species, both common and rare, can be easily and reliably identified in the field. Thus bird diversity was also studied by visiting the SGs three times during June-December of 2014 and 2015. During each visit, the entire area of the SG was sampled by walking at a constant pace for about one to three hours in the morning. The encountered birds were identified as per Ali and Ripley (1983), while nomenclature was based on Inskipp *et al.* (1996).

3D1.5. Vegetation analysis

Tree community in the SGs were analyzed by laying out transects of convenient length in each grove. While establishing transects, a minimum of 50 m distance has been maintained between two adjacent transects in order to avoid auto-correlation. Since, the vegetation is thick, in each transect, replicate quadrats, each of 10 m x 10 m size were established. Here also 20 m distances between two quadrats were maintained. All tree (individuals with gbh more than 10.1 cm; gbh: girth at 1.37 m above ground) in each quadrat were marked and their taxonomic identification were ascertained. Number of individuals and girth of each individual of a species were recorded. In the case of trees with large buttresses, the girth was measured from above the buttressed part. Basal area and relative basal area of the all tree species was calculated. Using the data available on density, frequency and basal area of trees of each species, the species importance value (SIVI) was calculated.

Species diversity refers to number different species in the community including both abundant and rare species. Species diversity can be measured by using various diversity indices; the mathematical expression based on species abundance date. Here, we used the Shannon – Weiner index diversity.

$$\text{Species diversity index } H = -\sum [(n_i/N) \log_2 (n_i/N)]$$

Where H= Shannon – Weiner's index calculated the base 2 of species diversity; n_i number of individual of species i; N= total number of individual of all species in the community.

The Similarity Index was calculated using the formula given below

$$S = 2C/ (A+B)$$

Where S = Similarity index; A = number of species in SG A; B = number of species in SG B; C = number of species in sample common to both the SGs.

3D1.6. Biomass estimation

To estimate the aboveground biomass, the biomass value per tree (Y1 in kg) under different DBH classes were estimated using regression equation given in **Assessment of Ecosystem Services of SGs in India: A Methodology Manual** (Barik and Malhotra, 2012)

$$\text{In } (Y1) = -0.37 + 0.333 \text{ InD} + 0.933[\text{In}(D)]^2 - 0.122[\text{In}(D)]^3$$

The diameter at breast height (DBH) for each tree was measured at 1.37 m above the surface. To estimate Belowground Biomass (BGB), the aboveground biomass value of each tree was multiplied by the factor 0.29.

3D2. Water conservation as an ecosystem service

Water samples were collected from streams and wells of three SGs: Kammadamkavu (KK) in Kasragod district, Valliyottukavu (VK) in Kozhikode district and Manikavu (MK) in Wayanad district during November 2015 - October 2016 (Figure 1). The water samples were collected during pre-monsoon, monsoon and post-monsoon periods. The details of sampling locations are given in Table 2 and the acceptable limits as prescribed by BIS in Table 3.

The containers used for water sampling were pre cleaned, non reactive plastic bottles (1 liter) and sterilized bottles (100ml) for physico – chemical and bacteriological analysis respectively. For the estimation of dissolved oxygen, the samples were collected in 300ml BOD bottles. 2ml of manganese sulphate followed by 2ml of alkali – azide reagent was added to the sample collected in BOD bottles, and fixed in the field (Winkler type). Physico-chmeical and bacteriological parameters of water samples were analyzed as per the standard procedure proposed by APHA (2012). Some parameters like pH, and electrical conductivity were measured in situ.

For assessing stream discharge, the Float Method was adopted. The amount of water passing a point on the stream channel during a given time is a function of velocity and cross-sectional area of the flowing water.

$$Q = AV \quad \text{---------- Eq. 1}$$

where Q is stream discharge (volume/time), A is cross-sectional area and V is surface flow velocity.

The mean velocity was obtained using a correction factor.

$$V_{surface} = \text{travel distance/ travel time} = L/t \quad \text{---------- Eq. 2}$$

The float method velocity was repeated sufficient number of times and averaged to give $V_{mean.}$

As the surface flow velocities are typically higher than mean or average velocities

$$V_{mean} = k\, V_{surface} \quad \text{---------- Eq.3}$$

where k is a coefficient that generally ranges from 0.8 for rough beds to 0.9 for smooth beds (here we used 0.85)

In each of the selected streams, measured the stream's width and depth across at one cross section where it was safe to wade. Minimum ten depth measurements was done and averaged during each measurement. The average cross-sectional areas (A) and corrected velocity was used to compute discharge, Q using Eq. 1.

Figure 1. Collection of water samples from SGs of Kerala. a) from the stream of Vallikattu Kavu, b) from the well of Valliyottu Kavu, c) from the stream of Kammadam kavu, and d) from the stream of Mani Kavu.

Table 2. Details of water sampling stations in different SGs of Kerala.

SG and Sample Code	Details	Location	
		Latitude	Longitude
Valliyottu Kavu (VK)			
VK-01	Stream near Temple	11^0 23' 257" N	75^0 47' 164" E
VK-02	Down-stream	11^0 23' 300" N	75^0 47' 192" E
VKg-01	Well-1	11^0 23' 194" N	75^0 47' 223" E
VKg-02	Well -2	11^0 23' 354" N	75^0 47' 189" E
VKg-03	Well-3	11^0 23' 308" N	75^0 47' 264" E
Kammadam Kavu (KK)			
KK-01	Stream	12^0 18' 792" N	75^0 18' 895" E
KK-02	Stream	12^0 18' 532" N	75^0 18' 695" E
KKg-01	Well-1	12^0 18' 663" N	75^0 18' 812" E
KKg-02	Well-2	12^0 18' 640" N	75^0 18' 797" E
KKg-03	Well-3	12^0 18' 608" N	75^0 18' 655" E
KKg-04	Well-4	12^0 18' 518" N	75^0 18' 680" E
Mani Kavu (MK)			
MK-01	Stream (back side of the Temple)	11^0 23' 354" N	75^0 18' 680" E
MK-02	Stream (in front of the Temple)	11^0 23' 308" N	75^0 47' 264" E

Table 3. Acceptable limits of drinking water parameters (BIS, 2012)

Sl. No.	Parameters	Acceptable limits (BIS)	Sl. No.	Parameters	Acceptable limits (BIS)
1	pH	6.5 - 8.5	9	Calcium, mg/l	75
2	EC µS/cm	--	10	Magnesium, mg/l	30
3	Colour, Hazen units	2	11	Sodium, mg/l	--
4	Odour	Agreeable	12	Potassium, mg/l	--
5	Taste	Agreeable	13	Iron, mg/l	0.3
6	Turbidity, NTU	1	14	Dissolved Oxygen, mg/l	5
7	Total Hardness, mg/l	200	15	Biological Oxygen Demand, mg/l	5
8	Chloride, mg/l	250	16	Total Coliform, CFU/100ml	NIL
			17	E.Coli, CFU/100ml	NIL

3D3. Soil and nutrient conservation as an ecosystem service

3D3.1. Soil sample collection and analysis

Surface soil samples (0 - 0.20 m) were collected from the selected SGs by pit method. Four representative samples from randomly selected spots in each of these groves were pooled to obtain composite samples and three replications were maintained. The collected soil samples were air-dried after removing the plant remnants, slightly powdered, sieved (2-mm sieve) and stored at low temperatures for subsequent analyses.

Soil reaction (pH) was analyzed in a 1:2.5:: soil : water suspension and moisture content was estimated by gravimetric method. Oxidizable organic carbon content in soil was determined by wet oxidation method of Walkley and Black (1934). Available nitrogen content in the samples was assessed by alkaline permanganometry (Subbaiah and Asija, 1956). For available phosphorus (P), soil samples were extracted with 0.03 N NH4F + 0.025 N HCl (Bray and Kurtz, 1945) and P content in the extracts was determined by ascorbic acid method (Watanabe and Olsen 1965). Available potassium (K), calcium (Ca) and magnesium (Mg) in the soils were extracted using neutral normal ammonium acetate. Potassium in the extract was estimated using flame photometer (ELICO) and Ca and Mg using atomic absorption spectro photometer (Varian AA 240).

3D3.2. Litter collection and chemical analysis

In each SG nine litter traps, each of 1 m x 1 m, were laid and collected the litter at monthly interval. The litter was sorted into leaf litter and non- leaf litter (twigs, branches and undifferentiated litter) and washed with water to remove adhering soil particles, oven dried at 80^0 C for 48 hrs and weighed. Annual litter production was estimated by summing all the positive increments during monthly samplings. The samples were ground into fine powder and stored for nutrient analysis. For total N determination the finely ground samples were digested in a block digester with conc. H_2SO_4 using Kjeltabs as catalyst and total N was determined by distillation and titration methods (Allen *et al.,* 1974). Total phosphorus concentration was determined by molybdenum blue method (Allen *et al.,* 1974) after digestion of samples with tri- acid mixture. Potassium concentration was determined by flame photometry after digesting the plant samples with tri- acid (H_2SO_4 – $HClO_4$ – HF) mixture.

3D4. Cultural diversity of SG as an ecosystem service

The Participatory Rural Appraisal (PRA) technique was adopted to analyse the anthropological dimensions of each SG. Through this technique, information on antiquity of the SG, size of the SG, ownership pattern and management of the grove, association of the SG with different ethnic groups, the role of gender in SGs (including the gender of the deity/deities), the nature and extent of access to men and women in various rituals, festival and ceremonies that take place in the groves and the role of SGs in the lives of people and details of rituals, ceremonies and functions associated with each SG were gathered.

4. Results

4A. Comparison of level of human disturbance in SGs

As indicated in the Methodolgy (Section 4), based on GPS readings, the center of the SG has been determined and marked in the map. Passing through the centre, the SG has been divided into eight segments. Subsequently, in the boundary of the SG, a location with maximum distance from the centre has been identified. Considering this distance as radius, a circle has been drawn. Within this circle four equidistant concentric circles were drawn. Thus, in each segment, five slices have been obtained. Each slice in a segment has been assigned with a number (1 to 5) starting from the boundary to the centre of the SG (Map 9). Thus, if a SG assumes perfect circular shape, there will be 40 slices. However, the shape of a SG may not be circular and moreover, any two SGs may not be of same shape. Therefore, number of slices obtained for five SGs varied much (Table 4). The number of slices showing the signs of one or more disturbance variables (Disturbunce variables: a) loss of forest land, b) pre-mature fall of trees, c) trespass, d) un-authorised collection of biomass, e) dumping of solid wastes, f) anti-social activities, and g) use of the SG area as playground) also varied. The frequency of disturbance in SGs ranged from 24 % to 58%; Kammadam Kavu with lowest value and Mani Kavu with highest value (Table 4).

As already indicated, each slice in a segment has been assigned with a number (1 to 5) starting from the boundary to the centre of the SG (Figure 9). These numbers also represent weighting factors that range from 1 (being less intense; a disturbance is localized to the peripheral region of the SG) and 5 (being more intense: a disturbance is even spread up to the centre of the SG; an indication of high level disregard to the sanctity of the SG and negligence in protecting and managing vegetation of the SG).

Table 4. Frequency of disturbance in SGs of Kerala.

Name of the SG	Total number of slices covered the SG	Number of slices showing one or many disturbance variable	Frequency of disturbance (%)
Kammadam Kavu	38	9	24
Valliyouttu Kavu	26	8	31
Poyil Kavu	36	14	39
Karimanal Chamundi Kavu	25	13	52
Mani Kavu	36	21	58

In a given slice, a given type of disturbance variable may be present or absent. If a disturbance variable was noticed in a slice, the weighting factor of that slice can be multiplied by 1 and not noticed, the weighting factor can be multiplied by 0. The values obtained for one disturbance variable (trespassing) in slices of certain segments of Poyil Kavu are shown in Figure 10. Sum of the values obtained for all slices in all segments gave the disturbance score for a given variable in the SG. Similarly, for each variable, disturbance score has been calculated. Table 5 shows the disturbance score obtained for different variables in five SGs.

Table 5. Disturbance score obtained for different variable in SGs of Kerala.

Variables	**Disturbance Score**				
	Kammadam Kavu	**Valliyottu Kavu**	**Poyil Kavu**	**Karimanal Kavu**	**Mani Kavu**
Loss of forest land (due to conversion/ encroachment) (LL)	0	8	3	6	8
Unauthorised collection of biomass (ICB)	3	3	0	8	3
Premature fall of trees (PFT)	7	18	19	12	21
Dumping of solid waste (DSW)	3	12	18	22	25
Trespassing (TP)	3	20	50	59	57
Unauthorised activities by anti-social elements (ASA)	0	0	3	8	0
Using as playground (PG)	0	0	3	8	0
Total	**16**	**61**	**96**	**108**	**79**

The Individual Variable Index Value obtained for different variables and the Index of Human Disturbance Value obtained for five SGs are given in Table 6. The level of disturbance in SG is as follows: Karimanal Kavu > Mani Kavu > Poyil Kavu > Valliyottu Kavu > Kammadam Kavu.

Table 6. Index of Human Disturbance (IHD) values for SGs of Kerala.

Variables		Individual variable index value (Y)			
	Kammadam Kavu	**Valliyottu Kavu**	**Poyil Kavu**	**Karimanal Kavu**	**Mani Kavu**
Loss of forest land (due to encroachment/ conversion) (LL)	0.00	1.00	0.38	0.75	1.00
Unauthorised collection of biomass (ICB)	0.38	0.38	0.00	1.00	0.38
Premature fall of trees (PFT)	0.33	0.86	0.90	0.57	1.00
Dumping of solid waste (DSW)	0.12	0.48	0.72	0.88	1.00
Trespassing (TP)	0.05	0.34	0.85	1.00	0.97
Unauthorised activities by anti-social elements (ASA)	0.00	0.00	0.38	1.00	0.00
Using as playground (PG)	0.00	0.00	0.38	1.00	0.00
Sum (ΣY)	0.88	3.05	3.60	6.20	4.34
IHD	12.56	43.59	51.39	88.59	62.02

4B. Biodiversity conservation as an ecosystem service

4B.1. Angiosperm diversity

The checklist angiosperm species encountered in five SGs is given in Appendix 1. A total of 418 species belongs to 105 families of angiosperm were recorded from five SGs (Table 7). Out of 418 speceis, 203 sepceis were trees, 97 were shrubs, 94 were herbs and 24 were climbers. Among species encountered from five SGs, 9 species were endemic to peninisualr India, 21 were endemic to Western Ghats and 35 were endemic to southern Western Ghats.

Among five SGs, Vallikattu Kavu recorded highest number of species followed by Kammadam Kavu and Karimanal Chamundi Kavu (Table 8). On the other hand, when the total number of species recorded from Mani Kavu was comparatively less, total number of endemic species encountered in Karimanal Chamundi Kavu was less.

Table 7. Results of angiosperm species inventory conducted in five SGs of Kerala.

	Herbs	Shrubs	Climbers	Trees	All
Non- endemic	83	82	23	165	353
Endemic to the southern Western Ghats	6	9	0	20	35
Endemic to the Western Ghats	2	4	1	14	21
Endemic to the peninsular India	3	2	0	4	9
Total	94	97	24	203	418

Number of SGs where a given species recorded varied considerably. For instance, 299 species were observed in only one out of five SGs when 93 species in two out of five SGs and 22 species in three out of five SGs were documented. On the other hand, three species namely, *Calycopteris floribunda, Abrus precatorius and Cinnamomum malabatrum* were found in four out of five SGs. Pair-wise Jaccard Similarity Coeffificnt (in %) derived for species recorded from five SGs of Kerala ranged from 2.8 per cent to 13.3 per cent with highest being Kammadam Kavu and Mani Kavu and lowest value for Poyil Kavu and Mani Kavu (Table 9).

Table 8. Angiosperm species inventory data for five SGs of Kerala.

Details		KK*	VK	PK	MK	KCK
No. of species		138	157	90	58	122
No. of endemic species		39	22	14	10	7
a.	Endemic to the southern Western Ghats	22	7	13	5	3
b.	Endemic to the Western Ghats	12	4	7	3	2
c.	Endemic to the peninsular India	5	3	2	2	2

***, KK**=Kammadam Kavu, **VK**=Vallikattu Kavu, **PK**= Poyil Kavu, **MK**= Mani Kavu, **KCK**= Karimanal Chamundi Kavu.

Table 9. Pair-wise Jaccard Similarity Coeffificnt (in %) derived for angiosperm species recorded from five SGs of Kerala.

	KCK	PK	MK	VK
KK*	6.1	5.1	13.3	11.3
KCK		7.1	9.1	10.7
PK			2.8	11.8
MK				7.5

***, KK**=Kammadam Kavu, **VK**=Vallikattu Kavu, **MK**= Mani Kavu, **PK**= Poyil Kavu, **KCK**= Karimanal Chamundi Kavu.

Among 105 angiosperm families represented by their constituent species in the SGs, Rubiaceae, Orchidaceae and Euphorbiaceae were dominant, each with 20 or more than species. On the other hand 44 families were represented each with a single species (Table 10).

Table 10. Distribution of species into angiosperm families in SGs of Kerala.

Number of species	Number of family
30 or more than 30	1
26-30	0
21-25	1
16-20	1

Number of species	Number of family
11 to 15	4
6 to 10	18
1 to 5	80

4B.2. VAM fungal diversity

A total of 36 species of AM fungi belonging to five genera - *Glomus*, *Scutellospora*, *Gigaspora*, *Aaculospora* and *Sclerocystis* were isolated (Table 11) from the rhizosphere soil of five SGs. Among these, the genus Glomus was the most predominant and widely distributed AM fungi with 9 species.

Table 11. AM fungi recorded from soil samples of five SGs of Kerala.

No.	Species	KK*	VK	MK	PK	KCK
1	*Acaulospora brasiliensis*	P¶	P	A	P	A
2	*Acaulospora delicate*	P	A	P	A	P
3	*Acaulospora foveata*	P	P	P	A	A
4	*Acaulospora mellea*	A	P	P	A	P
5	*Acaulospora scorbiculata*	P	P	A	P	A
6	*Gigaspora albida*	P	P	A	P	P
7	*Gigaspora margarita*	P	A	P	A	P
8	*Gigospora gigantea*	P	P	P	P	P
9	*Gigospora rosea*	P	P	A	P	A
10	*Glomus canadense*	P	A	A	P	A
11	*Glomus claroideum*	P	A	A	P	A
12	*Glomus dimorphicum*	P	P	A	P	P
13	*Glomus fasciculatum*	P	A	P	P	P
14	*Glomus fulvum*	P	P	A	P	P
15	*Glomus macrocarpum*	A	P	P	A	A
16	*Glomus melanosporum*	P	A	P	A	P
17	*Glomus microcarpum*	A	A	A	P	P

¶, P: Present, A: Absent

*, **KK**=Kammadam Kavu, **VK**=Vallikattu Kavu, **MK**= Mani Kavu, **PK**= Poyil Kavu, **KCK**= Karimanal Chamundi Kavu.

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Table 11 (cont'd). AM fungi recorded from soil samples of five SGs of Kerala.

No.	Species	KK*	VK	MK	PK	KCK
18	*Glomus multicaulis*	P	A	P	A	P
19	*Glomus multisub tensun*	P	P	P	P	P
20	Glomus sp A	P	A	P	A	P
21	Glomus sp. B	P	A	P	P	A
22	*Glomus tenebrosum*	P	P	P	P	P
23	*Glomus verruculos*	P	A	P	P	P
24	*Glomus warcuppi*	P	A	P	P	P
25	*Glomus occultum*	P	P	P	P	P
26	*Sclerocystis dussii*	A	A	A	A	P
27	*Sclerocystis sinuosa*	A	P	A	A	A
28	*Scutellospora cerradensis*	P	P	P	P	P
29	*Scutellospora heterogama*	P	A	A	P	P
30	*Scutellospora nigra*	P	A	P	A	P
31	*Scutellospora persica*	P	P	P	P	P
32	*Scutellospora* sp. A	P	P	P	A	A
33	*Scutellospora* sp. B	A	P	P	A	P
34	*Scutellospora* sp. C	P	A	P	P	A
35	*Scutellospora* sp. D	P	P	P	P	P
36	*Scutellospora verrucosa*	P	P	P	P	P

¶, P: Present, A: Absent

***, KK**=Kammadam Kavu, **VK**=Vallikattu Kavu, **MK**= Mani Kavu, **PK**= Poyil Kavu, **KCK**= Karimanal Chamundi Kavu.

Pair-wise Jaccard Similarity Coefficicnt (in %) derived for species recorded from five SGs of Kerala ranged from 38.2% to 72% with highest being Kammadam Kavu and Poyil Kavu and lowest value for Poyil Kavu and Mani Kavu (Table 12).

Table 12. Pair-wise Jaccard Similarity Coeffificnt (in %) derived for species of AM fungi recorded from five SGs of Kerala.

	KCK*	PK	MK	VK
KK	61.8	71.0	63.6	47.1
KCK		50.0	63.3	40.6
PK			38.2	48.3
MK				41.9

***, KK**=Kammadam Kavu, **VK**=Vallikattu Kavu, **MK**= Mani Kavu, **PK**= Poyil Kavu, **KCK**= Karimanal Chamundi Kavu.

The number of arbuscular mycorrhizal spores recovered from the SG samples was the highest in the Karimanal Chamundi Kavu during the post monsoon season and the lowest was observed in Kammadam Kavu in pre-monsoon season compared to other groves in different seasons (Table 13).

Table 13. Number of AM spores per 50 g of soil in different SGs (Pre and Post monsoon samples) in Northern Kerala

Study sites	Number of spore per 10 g of soil	
	Pre-monsoon	Post-monsoon
Poyil Kavu	185	247
Karimanal Chamundi Kavu	289	356
Kammadamkavu	176	215
Vallikatukavu	179	301
Manikavu	183	256

Root samples from various SG areas revealed that roots showed VAM fungal colonization. VAM fungal structures such as Arbuscules, Vesicles, and intra-cellular hyphal coils were observed in most of the root samples. The extent of VAM fungal root colonization in SGs ranged from 27 to 47 per cent with significantly more colonization in Kammadam Kavu and no significant difference between other SGs for the fungal root colonization (Table 14). In general in all four SGs, vesicular structures are predominantly observed representing vesicular kind of mycorrhizal association. For separating VAM fungal spores from soil samples, wet sieving-decanting techniques were employed. The technique was efficient for separating VAM fungal spores from soil samples. The VAM fungal spores obtained from the soil samples of Poyil Kavu was 65±23 per 100 g soil, showing much lower spore density record may be due to some unfavorable condition.

Table 14. Root colonization by VAM fungi in root samples from different SGs of Kerala.

SG	Vesicles (V)	Arbuscule (A)	V& A	Hyphae (H)	Without V,A &H	Percentage of Root colonization
Kammadam Kavu	30±6	9±2	8±3	40±3	33±9	47±5
Karimanal Chamundi Kavu	24±3	5±4	2±1	32±4	41±7	31±3
Mani Kavu	22±8	4±6	8±14	20±11	47±32	33±7
Poyil Kavu	21±9	4±5	3±2	25±13	47±11	28±4
Vallikattu Kavu	22±12	4±3	1±2	32±10	41±5	36±4

4B.3. Butterfly diversity

Inventory of butterflies in 5 SGs recorded a total of 151 species belonging to four families (Appendix 2). The family having a maximum number of species (53 species) was Nymphalidae followed by Papilionidae (34 species), Lycaenidae (31 species) and Hesperiidae (27 species). Five species, namely *Idea malabarica*, *Pachliopta pandiyana*, *Sarangesa purendra*, *Triodes minos* and *Zipoetis satis*, are endemic to the Western Ghats. The number of butterfly species recorded from Kammadam Kavu, Karimanal Chamundi Kavu, Mani Kavu, Poyil Kavu and Vallikkattu Kavu are 110, 84, 103, 108 and 126 respectively. Pair-wise Jaccard Similarity Coefficient (in %) derived for species recorded from five SGs of Kerala ranged from 46.1% to 75.2% with highest being Poyil Kavu and Valliyottu Kavu and lowest value for Poyil Kavu and Karimanal Chamundi Kavu (Table 15).

Table 15. Pair-wise Jaccard Similarity Coeffificnt (in %) derived for species of butterflies recorded from five SGs of Kerala.

	KCK*	PK	MK	VK
KK	61.7	52.1	73.0	68.6
KCK		46.1	56.1	47.9
PK			55.1	75.2
MK				64.8

*, **KK**=Kammadam Kavu, **VK**=Vallikattu Kavu, **MK**= Mani Kavu, **PK**= Poyil Kavu, **KCK**= Karimanal Chamundi Kavu.

4B.4. Bird diversity

A total of 106 species, with 8 endemic species, were recorded from five SGs (Appendix 3). Of the 106 species, 10 species (Common Myna, Cattle Egret, Emerald Dove, Indian Treepie, Racket-tailed drongo, Brahminy Kite, Malabar Whistling Thrush, Malabar Grey Hornbill, Eurasian Golden Oriole and Common Tailorbird) were found in all five SGs. Among endemic species the Malabar Grey Hornbill was noticed in all groves, while Nilgiri Wood Pigeon was found only in Kammadam Kavu.

Total number of bird species recorded in a SG was lowest (33 species) in Karimanal Chamundi Kavu and Poyil Kavu and highest in Kammadam Kavu (86 species). Total number of bird species encountered in Mani Kavu and Vallikattu Kavu was 58 and 75 respectively. No significant correlation between the number of bird species and area under

vegetation in the SG was noticed ((R= 0.4832; P>0.05). Pair-wise Jaccard Similarity Coeffificnt (in %) derived for species recorded from five SGs of Kerala ranged from 28.2% to 62.6% with highest being Kammadam Kavu and Valliyottu Kavu and lowest value for Poyil Kavu and Karimanal Chamundi Kavu as well as for Mani Kavu and Karimanal Chamundi Kavu (Table 16).

Table 16. Pair-wise Jaccard Similarity Coeffificnt (in %) derived for species of birds recorded from five SGs of Kerala.

	KCK*	PK	MK	VK
KK	33.7	30.8	50.0	62.6
KCK		32.0	28.2	28.6
PK			28.2	35.0
MK				49.4

*, **KK**=Kammadam Kavu, **VK**=Vallikattu Kavu, **MK**= Mani Kavu, **PK**= Poyil Kavu, **KCK**= Karimanal Chamundi Kavu.

4C. Water Conservation as an ecosystem service

4C.1. Water Quality

Quality analysis of surface water samples collected from SGs during post monsoon, monsoon and pre monsoon indicated that the pH at Valliyottu kavu during post monsoon season was found to be 6.8 and dropped to 6.5 during premonsoon (Table 17). The water from the wells around Valliyottu kavu had pH of 6.3 in monsoon season and 6.0 to 6.1 in post monsoon and pre- monsoon seasons (Table 17). The pH of the ground water and the stream of Kammadamkavu showed comparatively higher value for pH during monsoon than in post and post monsoon periods (Table 18). In Manikavu the average value was 6.8 during monsoon and post monsoon periods, but was slightly acidic during premonsoon (Table 19).

Water in the streams of SGs and nearby by wells had no colour or odour during pre-monsoon, monsoon or post-monsoon periods. However, turbidity (0.22 to 1.72 NTU) was observed in the streams and well water of Valliyottu kavu, Kammadam kavu and Manikavu during the pre-monsoon and post-monsoon periods (Table 17 to 19). Total hardness was found to be in the range from 65.33 to 90.67 mg/l in the stream water of Valliyottu Kavu and from 50.00 to 103.33 mg/l in the wells located near Valliyottu kavu. In the case of the stream of Kammadam Kavu, total hardness ranged from 43.3 to 67.3 mg/l when in the

nearby wells it ranged from 83.7 to 128.8 mg/l. The water samples collected from Mani Kavu were with total hardness values ranged from 72.7 to 92.00 mg/l.

Table 17. Physico-chemical and bacteriological characteristics of water samples collected from the stream of Valliyottu Kavu from November 2015 to October 2016. Values in parantheses are for the wells located adjacent to Valliyottu Kavu.

No.	**Parameters**	Pre-monsoon	Monsoon	Post- monsoon
1	pH	6.57 (6.01)	6.75 (6.29)	6.80 (6.09)
2	EC µS/cm	136.17 (148.11)	190.08 (162.67)	113.67 (134.22)
3	Colour, Hazen	BDL (BDL)	BDL (BDL)	BDL (BDL)
4	Odour	UO (UO)	UO (UO)	UO (UO)
5	Taste	Agreeable (Agreeable)	Agreeable (Agreeable)	Agreeable (Agreeable)
6	Turbidity, NTU	0.27 (0.47)	BDL (BDL)	0.22 (0.63)
7	Total Hardness, mg/l	50.67 (65.33)	103.33 (90.67)	50.00 (74.67)
8	Chloride, mg/l	33.33 (30.67)	26.67 (32.89)	29.33 (25.78)
9	Calcium, mg/l	11.37 (16.18)	19.03 (17.31)	10.13 (18.58)
10	Magnesium, mg/l	5.18 (10.04)	11.39 (11.30)	5.99 (8.10)
11	Sodium, mg/l	2.22 (3.78)	1.62 (2.53)	1.41 (2.71)
12	Potassium, mg/l	0.85 (1.80)	0.41 (1.03)	0.58 (1.21)
13	Iron, mg/l	BDL (BDL)	BDL (BDL)	BDL (BDL)
14	Dissolved Oxygen, mg/l	7.55 (7.13)	9.82 (8.14)	7.99 (7.62)
15	Biological Oxygen Demand, mg/l	2.09 (2.44)	2.66 (3.25)	2.41(3.19)
16	Total Coliform, CFU/100ml	231.67 (243.33)	848.33 (491.67)	101.67 (271.67)
17	E.Coli, CFU/100ml	Present (Present)	Present (Present)	Present (Present)

UO, Un objectionable; BDL, Below detective level

Table 18. Physico-chemical and bacteriological characteristics of water samples collected from the stream of Kammadam Kavu from November 2015 to October 2016. Values in parantheses are for the wells located adjacent to Kammdam Kavu.

No.	**Parameters**	Pre-monsoon	Monsoon	Post-monsoon
1	pH	6.56 (6.49)	7.05 (6.82)	6.52 (6.46)
2	EC µS/cm	134.83 (139.06)	153.17 (158.42)	109.67 (120.92)
3	Colour, Hazen	BDL (BDL)	BDL (BDL)	BDL (BDL)
4	Odour	UO (UO)	UO (UO)	UO (UO)
5	Taste	Agreeable (Agreeable)	Agreeable (Agreeable)	Agreeable (Agreeable)
6	Turbidity, NTU	0.38 (0.60)	BDL (BDL)	0.26 (0.47)
7	Total Hardness, mg/l	43.33 (128.78)	67.33 (87.00)	46.00 (83.67)
8	Chloride, mg/l	32.67 (34.67)	24.00 (26.33)	28.67 (32.00)
9	Calcium, mg/l	7.80 (26.36)	15.47 (18.65)	8.80 (15.75)
10	Magnesium, mg/l	5.52 (15.25)	6.48 (9.59)	5.83 (9.64)
11	Sodium, mg/l	2.75 (3.55)	1.40 (2.54)	1.43 (3.15)
12	Potassium, mg/l	0.32 (1.13)	0.17 (1.47)	0.53 (0.93)
13	Iron, mg/l	BDL (BDL)	BDL (BDL)	BDL (BDL)
14	Dissolved Oxygen, mg/l	7.08 (7.16)	8.47 (9.07)	7.90 (6.96)
15	BOD, mg/l	3.04 (3.19)	2.29 (2.75)	1.80 (3.38)
16	Total Coliform,CFU/100ml	75.00 (325.14)	250.50 (999.72)	241.67 (393.33)
17	E.Coli, CFU/100ml	Present (Present)	Present (Present)	Present (Present)

UO, Un objectionable; BDL, Below detective level

The analysis of calcium revealed a range between 10.1 – 19.0 mg/l in Valliyottukavu, 7.8 – 26.4 mg/l in Kammadamkavu and 14.0 – 18.93 mg/l in in Manikavu. Magnesium concentrations in samples were in the range of 5.2-15.3 mg/l, in the three SGs. However, chloride concentrations in excess of about 250 mg/l can give rise to detectable taste in water and the observed range in the samples were 25.8-33.3 mg/l. in Valliyottukavu, 24.0-34.7 mg/l in Kammadamkavu,and 19.3-30.0 mg/l in Manikavu. In the present study, the maximum concentration of dissolved oxygen was observed in the monsoon season in all the SGs. Analysis of surface water samples collected from SGs basin shows that all the samples were contaminated with total coliforms and in some cases with fecal coliforms.

Table 19. Physico-chemical and bacteriological characteristics of water samples collected from the stream of Mani Kavu from November 2015 to October 2016.

No.	**Parameters**	Pre-monsoon	Monsoon	Post-monsoon
1	pH	6.63	7.23	6.81
2	EC µS/cm	120.33	175.17	118.50
3	Colour, Hazen	3.00	4.00	3.00
4	Odour	UO	UO	UO
5	Taste	Agreeable	Agreeable	Agreeable
6	Turbidity, NTU	1.72	BDL	0.80
7	Total Hardness, mg/l	75.33	92.00	72.67
8	Chloride, mg/l	30.00	19.33	23.33
9	Calcium, mg/l	14.00	18.93	16.80
10	Magnesium, mg/l	8.59	10.95	7.93
11	Sodium, mg/l	1.52	1.61	2.62
12	Potassium, mg/l	0.50	0.45	0.57
13	Iron, mg/l	BDL	BDL	BDL
14	Dissolved Oxygen, mg/l	5.17	8.18	6.72
15	Biological Oxygen Demand, mg/l	3.87	3.13	2.99
16	Total Coliform, CFU/100ml	257.50	966.67	43.33
17	E.Coli, CFU/100ml	Present in june	Present in MK02	Absent

UO, Un objectionable; BDL, Below detective level

The Water Quality Index (WQI) values ranged from 83.86 to 143.49 with comparatively lower values at exit points than at entry points of streams in Kammadam Kavu and Mani Kavu (Table 20).

Table 20. Water Quality Index (WQI) of streams in SGs of Kerala.

SGs	WQI of stream water at	
	Entry points of the stream	Exit points of the stream
Kammadam Kavu	108.56	88.70
Mani Kavu	143.49	93.79
Vallikattu Kavu	83.86	133.33

4C.2. Stream discharge from SGs

Stream discharge from three SGs was studied. In Valliyottu kavu the stream discharge varied pre-monsoon (0.19 ft^3/s) and monsoon period (0.60 ft^3/s) with slightly higher flow during post-monsoon months (0.21 ft^3/s) than in pre – monsoon months (Figure 12). In Kammadam kavu, the discharge from the stream ranged from 0.27 to 0.69 ft^3/s, and there was no significant difference between the pre – monsoon and post monsoon flow. The

stream in Mani kavu discharged nearly ten times more water during monsoon (0.52 ft^3/s) than pre and post monsoon periods.

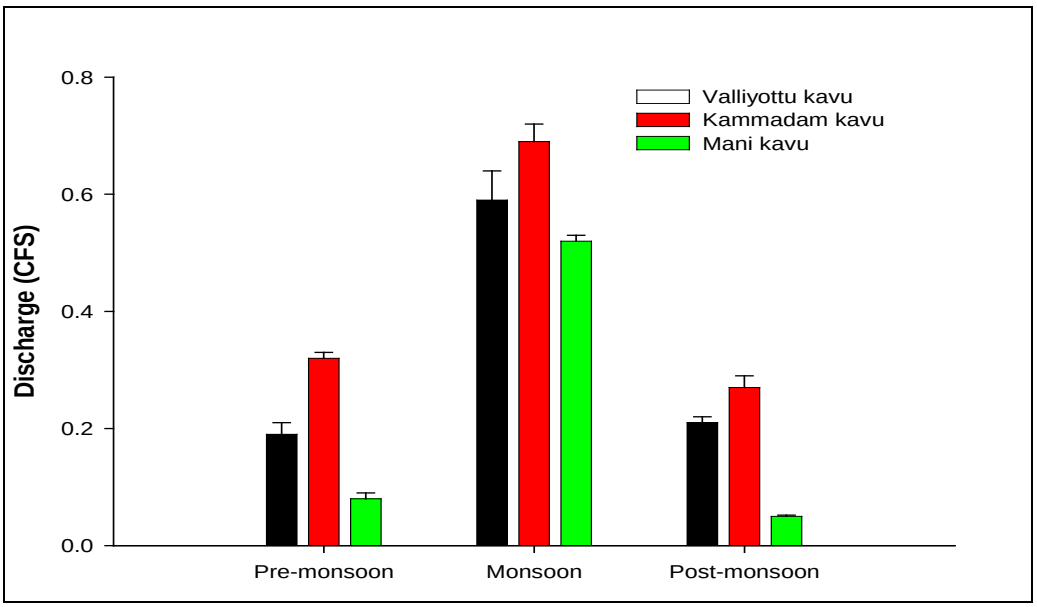

Figure 12. Stream discharge during pre – monsoon, monsoon and post - monsoon from SGs of Kerala.

4D. Nutrient conservation as a an ecosystem service

4D.1. Soil quality assessment

The pH values in the surface soils of SGs varied from 4.62-5.10 in Kammadam Kavu, 3.88-4.47 in Vallikattu Kavu, 4.75-5.16 in Mani Kavu, 4.74-5.20 in Poyil Kavu and 4.36-4.59 in Karimanal Chamundi Kavu (Table 21). There was no significant difference in soil pH between the undisturbed, moderately disturbed and highly disturbed sites of these SGs.

In each SG, there was a significant decrease in moisture content, OC, N, P, K, Ca and Mg with disturbances. Among the different SGs studied Karimanal Chamundi Kavu was found to have the highest organic carbon (6.36%) and manikavu the least (1.36 %). The N content in the soils of SGs varied from 211.56 kg/ ha in Poyil kavu to 403.02 kg/ha in Karimanal Chamundi Kavu. In general, the C:N ratios of the soil were found to be higher than 50:1 in all SGs.

The K content of the different SGs varied as Kammadam Kavu > Karimanal Chamundi Kavu > Valliyottu Kavu > Mani Kavu > Poyil Kavu. Extractable P concentrations were found to be low in all the studied samples (Table 21).

Table 21. Physical and chemical properties of soils in SGs of Kerala.

Parameters	Micro sites in SG	Kammadam Kavu *	Karimanal Chamundi Kavu	Mani Kavu	Poyil Kavu	Valliyottu Kavu
Moisture (%)	Undisturbed	19.5±0.4[a]	12.0±1.1[a]	17.0±1.0[a]	18.5±0.9[a]	18.4±0.4[a]
	Moderately disturbed	18.7±1.0[a]	10.8±0.4[a]	14.9±1.2[a]	15.3±1.4[a]	16.8±0.7[a]
	Highly disturbed	14.2±1.5[b]	9.3±0.5 [ba]	11.0±0.3[b]	14.0±0.8[b]	8.3±1.0[b]
pH	Undisturbed	5.0±0.3 [a]	4.6±0.2 [a]	4.8±0.6[a]	5.0±0.5[a]	4.3±0.3[a]
	Moderately disturbed	5.1±0.4 [a]	5.0±0.6 [a]	5.1±0.4[a]	4.7±0.3[a]	4.5±0.8[a]
	Highly disturbed	4.6±0.6 [a]	4.4±0.4 [a]	5.2±0.6[a]	5.2±0.4[a]	3.9±0.1[a]
Organic carbon (%)	Undisturbed	4.6±0.2 [a]	9.8±0.2 [a]	1.4±0.1[a]	1.8±0.1[a]	6.0±0.1[a]
	Moderately disturbed	5.1±0.2 [a]	7.7±0.4 [b]	1.5±0.2[a]	1.8±0.1[a]	4.1±0.0[b]
	Highly disturbed	2.9±0.1 [b]	1.6±0.8 [c]	1.2±0.0[a]	1.0±0.0[b]	3.1±0.1[c]
Avail. N kg/ha	Undisturbed	440.5±26.9 [a]	545.1±19.8 [a]	261.3±7.5[a]	209.1±19.8[a]	420.8±25.1[a]
	Moderately disturbed	425.6±25.9 [ab]	552.5±7.5 [a]	283.7±7.5[a]	276.3±7.5[b]	331.2±43.3 [a]
	Highly disturbed	343.5±26.9 [b]	231.5±14.9 [b]	209.1±7.5[b]	149.3±7.5[c]	284.3±20.9[ba]
Avail. P kg/ha	Undisturbed	5.9±0.1 [a]	5.4±0.3 [a]	7.4±0.5[a]	24.0±2.8[a]	4.3±0.3[a]
	Moderately disturbed	5.3±0.3 [b]	4.1±0.1 [a]	7.0±0.5[a]	21.8±2.3[a]	4.2±0.2[a]
	Highly disturbed	3.9±0.1 [c]	22.2±1.9 [b]	5.9±0.2[b]	20.1±1.1[a]	2.9±0.1[b]
Avail. K kg/ha	Undisturbed	188.1±5.9 [a]	165.3±4.4 [a]	153.2±4.2[a]	95.9±1.9[a]	156.1 ±55.3[a]
	Moderately disturbed	127.3±4.6 [b]	154.6±6.4 [a]	93.2±5.7 [b]	88.2±3.9[a]	96.3±2.8[b]
	Highly disturbed	121.1±3.6 [b]	84.8±6.4 [b]	83.9±2.5[b]	72.4±2.7[b]	90.7±3.9[b]
Avail. Mg kg/ha	Undisturbed	450.5±11.5 [a]	500.3±14.8 [a]	262.7±15.5[a]	121.9±3.6[a]	198.1±2.8[a]
	Moderately disturbed	261.7±15.0 [b]	281.4±18.5 [b]	150.9±8.4[b]	117.6±6.9[a]	180.9±10.8[a]
	Highly disturbed	241.8±15.3 [b]	97.9±2.3 [c]	93.0±2.6[c]	74.0±7.8[b]	75.8±9.0[b]
Avail. Ca kg/ha	Undisturbed	1593.9±168.4 [a]	1430.5±131.1[a]	1538.1±184.1[a]	1379.2±64.8[a]	1504.7±152.2[a]
	Moderately disturbed	1233.3±89.7[a]	1306.5±111.5 [a]	1457.4±320.5[a]	1473.5±195.3[a]	1259.3±319.4[a]
	Highly disturbed	935.8±141.3[b]	956.4±63.2 [ba]	759.1±193.6[a]	707.4±71.8[b]	919.3±111.9[a]

*, Values for a given parameter in a given SG with same alphabets in the superscript are not significantly different at the 5% level.

Soil organic matter acts as the base matrix for most of the soil chemical constituents. In the present study SOC was taken as a proxy of soil organic matter and its influence on the different studied components were worked out using Pearson's correlation matrix (Table 22). The correlation matrix shows that OC affects most of analyzed components except pH and Ca in the studied soils. It had a very high positive influence on the soil N, K and Mg. The negative correlation between OC and extractable P. Ca did not show any correlation with organic carbon.

Table 22. Pearson's correlation matrix for the soil chemical parameters in SGs of Kerala.

	OC	N	P	K	pH	Mg	Ca
OC	1	0.907**	-0.512**	0.675**	-0.168	0.698**	0.275
N		1	-0.581**	0.762**	-0.098	0.773**	0.346*
P			1	-0.503**	0.108	-0.446**	-0.105
K				1	-0.004	0.872**	0.474**
pH					1	0.044	-0.085
Mg						1	0.413**
Ca							1
**. Correlation is significant at the 0.01 level (2-tailed).							
*. Correlation is significant at the 0.05 level (2-tailed).							

4D.2. Litter production and nutrient status in litter

Average annual litter fall of the study sites ranged from 7.58 to 11.28 t/ha and of which 74.9 to 80.3% was through leaf and the rest through non-leaf litter (Table 23). High litterfall was recorded in Kammadam Kavu compared to all other SGs. There was greater litter fall was recorded in Poyil kavu in the month of February and lowest was Karimanal Kavu in the month of June (Table 24). In rainy season (June and July) litterfall was higher in Kammadam Kavu (1.03 t/ha) when compared with all other SGs. Leaf litter and non leaf litter production was greater in the month of February (0.92 and 0.29 t/ha) and lowest in May (0.40 and 0.14 t/ha) respectively.

Table 23. Annual production of leaf and non-leaf litter in different SGs of Kerala. Values are mean± SE. N=9.

SG	Leaf litter fall ($t\ ha^{-1}yr^{-1}$)	Non-leaf litter fall ($t\ ha^{-1}yr^{-1}$)	Total litter fall ($t\ ha^{-1}yr^{-1}$)
Kammadam Kavu	9.06 ±0.13	2.22 ±0.52	11.28 ±0.65
Karimanal Chamundi Kavu	5.65 ±0.07	1.90 ±0.37	7.55 ±0.44
Mani Kavu	6.34 ±0.08	2.07 ±0.53	8.41 ±0.61
Poyil Kavu	8.28 ±0.47	2.65 ±0.37	10.93 ±0.44
Vallikkattu Kavu	7.18 ±0.22	2.16 ±0.46	9.34 ±0.68

Table 24. Total monthly litter production ($t\ ha^{-1}$) in SGs of Kerala. Values are mean ± standard error. In a given species, values same alphabet in the superscripts in different months are not significant at 0.05 level.

Months	Kammadam Kavu	Karimanal Chamundi Kavu	Mani Kavu	Poyil Kavu	Vallikkattu Kavu
APRIL	0.59 ± 0.04^{ab}	0.46 ± 0.06^{a}	0.68 ± 0.06^{bc}	0.78 ± 0.06^{c}	0.57 ± 0.05^{ab}
MAY	0.57 ± 0.04^{a}	0.45 ± 0.05^{a}	0.53 ± 0.05^{a}	0.60 ± 0.05^{a}	0.53 ± 0.05^{a}
JUNE	1.03 ± 0.07^{c}	0.38 ± 0.05^{a}	0.40 ± 0.04^{a}	0.93 ± 0.04^{c}	0.66 ± 0.07^{b}
JULY	1.03 ± 0.06^{c}	0.41 ± 0.06^{a}	0.62 ± 0.07^{b}	0.97 ± 0.05^{c}	0.57 ± 0.04^{b}
AUGUST	0.55 ± 0.04^{a}	0.61 ± 0.06^{ab}	0.59 ± 0.06^{ab}	0.75 ± 0.5^{b}	0.55 ± 0.06^{a}
SEPTEMBER	0.68 ± 0.06^{b}	0.65 ± 0.04^{b}	0.57 ± 0.03^{ab}	0.64 ± 0.04^{ab}	0.51 ± 0.05^{a}
OCTOBER	0.91 ± 0.07^{c}	0.68 ± 0.03^{a}	0.66 ± 0.05^{a}	0.75 ± 0.03^{ab}	0.87 ± 0.05^{bc}
NOVEMBER	1.08 ± 0.10^{b}	0.76 ± 0.04^{a}	0.92 ± 0.07^{ab}	1.04 ± 0.04^{b}	0.80 ± 0.06^{a}
DECEMBER	1.31 ± 0.14^{c}	0.77 ± 0.05^{a}	0.88 ± 0.04^{a}	0.98 ± 0.10^{ab}	1.19 ± 0.13^{bc}
JANUARY	1.29 ± 0.10^{b}	0.94 ± 0.06^{a}	0.97 ± 0.06^{a}	1.16 ± 0.07^{ab}	1.08 ± 0.07^{ab}
FEBRUARY	1.46 ± 0.10^{b}	0.83 ± 0.15^{a}	0.77 ± 0.07^{a}	1.62 ± 0.13^{b}	1.39 ± 0.11^{b}
MARCH	0.78 ± 0.02^{b}	0.64 ± 0.06^{a}	0.81 ± 0.02^{b}	0.71 ± 0.05^{ab}	0.58 ± 0.05^{a}

The concentration of Carbon (C) Nitrogen (N), Phosphorous (P) and Potassium (K) in litter and annual nutrient return through litter fall in different sacred gorves are given in Table 25 and 26. In all the SGs, both the nutrient concentration in litter and nutrient return through litter was in the order: N>K>P.

Table 25. Nutrient concentration (%) in the litter collected from different SGs of Kerala.

SG	C (%)		N (%)		P (%)		K (%)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Kammadam Kavu	40.57	2.30	1.76	0.25	0.035	0.005	0.265	0.039
Karimanal Chamundi Kavu	41.59	1.63	2.07	0.17	0.034	0.003	0.242	0.020
Mani Kavu	37.92	2.73	1.72	0.24	0.036	0.004	0.275	0.040
Poyil Kavu	39.47	3.21	1.60	0.29	0.035	0.006	0.248	0.030
Vallikkattu Kavu	47.29	1.49	2.60	0.44	0.030	0.002	0.267	0.021

Table 26. Annual nutrient return (kg ha^{-1} yr^{-1}) through litter falls in different SGs of Kerala.

SG	C		N		P		K	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Kammadam Kavu	4575.7	263.7	198.7	11.5	3.9	0.2	29.9	1.7
Karimanal Chamundi Kavu	3141.6	183.3	156.0	9.1	2.6	0.1	18.3	1.1
Mani Kavu	3188.7	231.3	144.2	10.5	3.0	0.2	23.1	1.7
Poyil Kavu	2931.2	173.7	118.5	7.0	2.6	0.2	18.4	1.1
Vallikkattu Kavu	4417.0	322.0	242.5	17.7	2.8	0.2	25.0	1.8

4D.3. Carbon stock in the biomass

In each SG, vegetation anlaysis or tree community (gbh≥10.1cm) was carried by following quadrat method. Total number of tree species recorded during quadrat study ranged from 16 to 81 with lowest number in Karimanal Chamundi Kavu and highest in Kammadam Kavu (Table 27). In each SG, the first three species with high values for species IVI were selected as dominant species in the tree community. When, *Xanthophyllum arnottianum* and *Knema attenuata* were the first three dominant species in Kammdam Kavu, *Hopea ponga*, *Knema attenuata* and *Xanthophyllum arnottianum* were dominant in Valliyottu Kavu. On the other hand, *Vatica chinensis*, *Holigarna arnottiana* and *Bridelia retusa* in Poyil Kavu, *Wrightia tinctoria*, *Macaranga peltata*, *Holarrhena pubescens* in Mani Kavu, and *Wrightia tinctoria*, *Macaranga peltata* and *Holarrhena pubescens* in Karimanal Chamundi Kavu were dominant. The species diversity index (H) value was also more in Kammdam Kavu (4.28)

followed by Vallikkattu Kavu (3.90), Mani Kavu (3.16) and Karimanal Chamundi Kavu (3.06).

In the SGs, the estimated tree density (individuals /ha) was between 658 and 2758, with lowest value in Karimanal Chamundi Kavu and highest in Kammadam Kavu (Table 27). The Basal cover of tree community was also high in Kammadam Kavu (65.83 m^2/ha) and low in Karimanal Chamundi Kavu (7.32 m^2/ha). However, the total biomass of tree community was comparatively more in Karimanal Chamundi Kavu (93.04 t/ha) than in Mani Kavu (76.66 t/ha). The estimated carbon stock in biomass of tree community and standing litter of SGs was between 38.9 and 385.0 t/ha (Table 28).

Table 27. Density, basal area and biomass of tree community in in SGs of Kerala.

Parameters	Kammadam Kavu	Vallikattu Kavu	Poyil Kavu	Mani Kavu	Karimanal Chamundi Kavu
No. of tree species	81	44	25	18	18
Density (Individuals/ ha)	2758	1311	1565	932	658
Basal area (m^2/ha)	65.83	17.53	12.32	8.96	7.32
Biomass (t/ha)					
Aboveground	588.22	190.35	284.97	56.86	71.43
Belowground	170.58	55.20	82.64	19.80	21.61
Total	758.80	245.55	367.61	76.66	93.04

Table 28. Carbon stock (t/ha) in biomass of tree community and and standing litter in in SGs of Kerala.

Carbon Stock (t/ha)	Kammadam Kavu	Vallikattu Kavu	Poyil Kavu	Mani Kavu	Karimanal Chamundi Kavu
Aboveground biomass	294.1	95.2	142.5	28.4	35.7
Belowground biomass	85.3	27.6	41.3	9.9	10.8
Standing litter	5.6	1.8	2.7	0.5	0.7
Total carbon stock	385.0	124.6	186.5	38.9	47.2

4E. Assessment of Cultural Services of SGs

SGs are treated as a space that has been socially rendered as a scared place through certain sets of believes system and practices associated with them. One of the salient features of SGs is that majority of them are found in the communities and societies which are under transition to the modern value systems and liberal market economy. In this context, apart from performing other ecosystems services, such as, conservation of biodiversity, soil and water, SGs also have another ecosystem service namely cultural service. Very often cultural services are non-apparent and hidden in nature. However, contribution of cultural services for the social networks and very sustenance of sacred need to be assessed while before embarking ecosystem service valuation exercises. In this present report, cultural services of five SGs namely, Kammadam Kavu, Karimanal Chamundi Kavu, Poyil Kavu Mani Kavu and Valliyottu Kavu are presented.

4E.1. Kammadam Kavu

The Kavu proper referred to in this SG is a forested land located about one kilometre from the Kammadam Sree Bhagavathy Temple. This is the actual elemental seat of the presiding deity widely known as Dandyanganathu Bhagavathy or the Kammadath Bahgavathy. Temple is a large structure with a number of the sanctum sanctorums for the principle and associate deities, such as, Vishnumoorthy, Gulikan, Bhairavar, Kutty Chathan, Kuratthy, among others. All the deities are represented as either a trident or as sword. Kammadam Kavu is having three associated SGs namely Kalicchan Kavu, Palakkunnu kavu and Chamundi Gulikan kavu.

Originary myth or Aithihyam: Originary myth of Kammadam Kavu is that a Vaniya boy who was the cow-herdsman to the Adukkath Thanthri (a local Namboothiri priest of high order) while on search of a pregnant cow which was missing from the herd was the first who saw the Bhagavathy. She provided directions to the boy for retrieving the cow and its newborn calf on the promise that her presence should not be divulged. But presence of the goddess was understood by the priest and who persuaded the goddess to reside in the temple. However, on the way to the temple the priest had broken a promise which made the goddess to choose the chief residence in the present day SG. The Bhagavathy however offered to visit the temple just for everyday rituals on the condition that she would return to the grove after each day's ritual and need to be invited every morning from grove to the

temple. This forms the basis of ritualistic processions which is repeated in the beginning of every Malayalam months and the festival days.

Rituals, Festival and Community Involvement (social embeddedness): The festival is held during the month of Dhanu according to the Malabar Calendar from the date 8th till 13th which usually falls in the last week of the Month of December every year. The temple does not have daily Pooja or offerings. The pooja and offerings are made during the festival days and during the first and last Fridays of every Malayalam month according to the Malyalam calendar besides the first day of every Malayalam months. The *putthari* of the *Thulam* month of the Malayalam calendar is another important day, which signifies the harvest, fertility, and arrival of the new grain to the storage and considered as auspicious. Along with these the *vishu* (beginning of the Malayalam Calendar and a festival signifying summer solstice whihc usually falls on the 14th of the April every year), *navarathri* (mainly the 8th, 9th and 10th days) are also celebrated. On these occasions appropriate religious texts (mostly *Purana-s* such as Ramayana) are recited at the temple. The main ritual which assume great significance among the annual rituals during the temple festival is the a procession of the chief priest, all the *koyma* or the right holders of the temple and the person who is chosen to play the Theyyam of the principle deity from the temple up to the elemental position inside the *kavu*.

The procession constitute following right holders of the temple who include:

- Chief priest (coming from Karivellur)
- *Kadayangan* (a member of the *Maniyani* community) –A family inherited position who first saw the Bhagavathy-the principle deity. This right holder (whose presence is a must for the ritual) and his family is currently located in the Kanhangad south about 30 Kilometers away from the SG.
- Nambeesan (member of a temple associated community) who carries the procession lamp
- Koyma (or the right holders) include five families Pallikki Thaavadu, Puthiyedathu Tharavadu, Karinthalam (Kalariyal) Gurukkal, Cherutta Tharavadu, Pattatthil Tharavadu.

First day all these people have to visit the Kavu after observing ablutionary rituals. On the first and concluding days of the festival as early as 2 am in the morning the vishnumoothy deity would enter the SG proper in silence and unaccompanied (after removing even the

anklets) and bring the tender coconut to the temple from the elemental loci of the Bhagavathy and break this coconut at the temple.

Following the conclusion of the pooja on these days, each day, all those who are to perform the theyyams of that day have to reach the SG with their costumes and perform ablutions inside the grove and perform the adornment inside the grove about a 100 meters distance from the place where pooja is performed inside the kavu (the elemental/originary seat of the Bhagavathy).

When the *pooja* is performed the Namboothiri (priest) provide the ritual fire to the performers and they carry out the adornments for the respective theyyam-costumes. Throughout these rituals all are expected to observe silence and for the same reason ordinary percussions that accompany the Theyyam are not allowed inside the grove, except for a soft sounding drum played gently. If at all any communication is necessary it is carried out through gestures. The percussions are played only after the performers reach the field.

Among the communities that are involved in the performance of Theyyam are *Vannan, Malaya* and *Mavila* (Thazhe kavu- *Chamundi* and *Gulikan Kolam* by Mavilas). The *Thazhe kavu* is situated slightly distantly and towards the lower portion of the temple and downstream of the *Kavu proper* on the sides of the paddy field which forms the part of property of the temple.

The Chamundi is the principal deity of the Kammadathu Bahgavathy temple. Another Chamundi of the Thazhe kavu is considered as the Steward of the properties of the principal deity of the temple. During the third day of the festival (Dhanu-10^{th}), it is believed the meeting of these two deities takes place near the small bridge near the paddy field. During this meeting, it is believed the deities exchange words which involve enquiry and report of the affairs of cultivation and management of field.

It must be noted that women has no role in these rituals though the Bhagavathy is a goddess herself. Women as well as people other than the one mentioned above are not allowed in the grove.

Main caste communities associated in the temple functioning are as below:

- Priestly services by Namboothiri community (ten Namboothiry or priestly families has rights here they include Adukkatthayar, Ovuda, Parmmeladukkam etc.)
- Kadayangan- Maniyani community

- Kalasam By Thiyya Community
- Theyyam by, Vannan, Malayan and Mavila communities
- The change cloths supplied by Vannan community
- Temple upkeep and everyday lighting of lamp by Maniyaani
- Eleven Thiyya community families called *Kootayikkar*
- Koyma by Nayar community.

There are *Janmam* rights for families of each community for performing the rituals in each of the SGs. This kinds of territorial rights, though unwritten, are very strictly observed among the communities with their own conflict resolution and decision making arrangements. This is also attended by an astrologer who on necessary occasions arranges for interpreting and reading the will and wishes of the deities for the public. Important decisions on the changes and continuance of the practices are decided based on the interpretation or the vision of the astrologer. About 1700 years of legacy is claimed for the temple during one of such astrological problem solving event. Compared to the *saktheya* system of the goddess worship in the region the practices are more brahminical or *sathvic* in Kammadathu temple.

Preparations for the festival: reinforcing institutional links: The first advance move to the festival begins by the giving the sign or *adayalam* to the chief of the family (called *neanikkam*) who has the right to perform the principle deity at the temple during the festival. This is a ritual of formal communication and reminder from temple management that the festival is scheduled as per the calendar and the person may arrange for identifying the person from his family and ensure for necessary discipline of the performer. The occasion is considered highly auspicious and graced with divine presence of the goddess. Unlike the other such groves or places of worship the sign or *adayalam* is not given to the performers of associated deities as the chief is expected to communicate this information directly to them. From the date of the *adayalam* the performers are expected to be under strict discipline including dietary restriction adhering to vegetarian diet and promising to the teetotal. The performer spends his days until the festival day by meditating the *dharma daivam* or the god of worship of the lineage/ family.

A ritual that is unique to this SG is the ritual feast served on the first day prepared and served by the Brahmin priest to the *kadayangan* and the *neanikkam* in front of the temple in the special *kalam* or the drawing on the ground. A similar and elaborate feast is served on

the concluding day to all devotees and right holders of the temple. Only after witnessing the feast the priests can proceed to SG to perform concluding rituals of the festival.

Originally the Kammadathu Bhagavathy was the presiding deity of the 18 *cherikkal* or settlements in the region. The contribution of these 18 *desam* or settlements for the conduct of the festival used to be brought as *kazhcha* or the procession of the offerings. Though most of these contribution and participation has reduced some of the *desams* continue to participate which include Moweni/ Narkkilakkad desam, Eleri, Kadumeni, among others.

There exists a customary/ ritual relation with the Thaliyil Siva temple Nileswaram town which is about 25 Kilometers away. And rituals such as *Veethu* (share offering) consisting the meat offering to deities such as Muthappan, Vishnu moorthy and Pottan Theyyam are not allowed in the locality which is often identified by a nearby kavu called Palakkunnel kavu, a two kilometers away from the Kammadathu Kavu. Kammadathu Bhagavathy being the regional presiding deity no light or processions is allowed to be brought to the Kammadathu temple. However idol/sign of the deity as light or procession may be taken to other places of worship which shows the commanding supremacy of the deity. Gun salutes to the deity is also not allowed. When the *Ayyappan velakku* is celebrated, a procession of lights and flower offerings are taken by the Ayyappa devotees from the Kammadathu Kavu to the Palakkunnu Kavu.

There will be *anndanam* or the free-meal-offering to the devotees on all days of the festival the material needed for the free-meal-offering may be amassed from the donations or offerings of the devotees and from the income of the temple.

A well acknowledged grace of the Kammadathu Bhagavathy is her ability to grant wishes of her devotees especially clearing of the mental delusions usually considered as due to possession by evil spirits and granting of children for the childless couples. So during the festival season devotees approach the Kammadathu Bhagavathy Theyyam for satisfying the wishes with offerings. Childless couples observe penance during the entire festival season by staying in the temple premises during the festival and by eating only the offerings supplied from the temple. Their desire to have baby will also have to be formally intimated to the Bhagavathy's theyyam during the festival. Apart from these, during the *navarathri* season, devotees initiate children to the world of learning through the ritual called vidyarambham as temple is abode of mother goddess who is god of the learning and

wisdom. Similarly the implements, tools, machines and instruments associated with profession are also kept for pooja by devotees on these days.

Formal and Informal Institutions: Malabar Devaswom Board a state government department has taken over the Kammadam Kavu a few years back. As the temple belongs to the group of temples classified as belonging to the low income, a trusty board of five members is appointed to mobilize funds for the celebrations for the special occasion. The trusty board members have to be people hailing from nearby localities (residing within a distance of six kilometers) and they should be free of allegations or charges against them relating to misappropriation of devaswom property or any public funds. The trusty board members are not eligible for honorarium but are eligible for travel allowance if they incur such expenses on account of disposing the devaswom related responsibilities. The trusty board for the temple is appointed by the area committee of the Devaswom Board based on a selection process involving appearing to an interview with the area committee constituted by the devaswom board. The area committee consists of people nominated by the ruling parties and it has a time period of five years. The five member trusty board in presence of the Devaswom inspector would select a member as chairman of the trusty board. The responsibility of everyday affairs of the temple and the conduct of the annual festival are with the trusty board. When the validity of a trusty board is expired devaswom board will appoint an executive officer to look after the affairs of the temple till a new trusty board is constituted. Currently the temple is under the rule of an Executive Officer as the process of constitution of the new trusty board is just initiated. In case of temples with substantial income and property, the trusty board has only limited role and responsibility of everyday affairs of the temple is with executive officer.

The salary of the regular offering of the temple is paid by the Devaswom Board while the money offering *dakshina* for the special occasions to the priest and performers of the Theyyam and special rituals is paid from the money contribution organized by the Trusty Board from devotees. The income to the Kammadam Kavu from its properties is limited to the meager income from lease of a few acres of paddy land. The last year's expenses for the festival were about two lakhs and a substantial portion of it is from contributions of the devotees. This includes the expenses towards the salary of the Theyyam performers and cost towards organizing free-meal-offering to the devotees.

A Kavu Samrakshana Samithi Grove protection committee), was formed five years back to fight against the encroachments by an adjacent landlord to the Kammadathu Kavu proper. While members of the last Trusty board included people who are also active members of the political parties as is common in most such committees of kavus, they are also simultaneously members and office bearers of organisations such as community organizations, such as, Nair Service Society (NSS), Sree Narayana Dharma Paripalana Yogam (SNDP), political parties, parent teacher's association of the local school, local voluntary environmental education groups and Art and Literature forums such as Thapasya. Researchers from various organization and institutions have made observations and full length studies here which include research students from Kerala and Calicut Universities. Members of organizations, such as, Society for Environmental Education in Kerala (SEEK), Zoological Survey of India regional centre Kozhikkode, Payyannur college and Agricultural College, Padannakkad are among the other organizations who has explored the biological richness of the Kammadam Bhagavathy kavu. When the encroachment and un-authorised felling of trees from the grove has become a concern Thapasya Art and Literature Forum has organized a procession from Kammadathu kavu to the Madayi Hill near Pazhayangadi in 1992.

4E.2. Karimanal Chamundi Kavu

Karimanal Chamundikkavu is located in Ponnamvayal in Peringome Panchayat of Taliparamba Taluk in Kannur District.

Originary Myth and Institutional History: It is said that the main goddess or *Devi* arrived from Alanthatta Pativathilkkal and proceeded to Eandy before arriving at the Karimanal Kavu. Though the kavu was owned by Ezhutthan Alakkale Tharavadu, it was with Karimanal Nair that the goddess reached the *Tharavadu*.

Originally the temple and the land belonged to the Ezhutthan Alakkale Tharavadu almost 45-50 years back. For about 15 years the temple was in an abandoned state following an incident of fire that destroyed the main structure completely. During this period an incident of un-authorised felling of a tree took place in the SG, which has lead to litigation. During this period rights over the SG and temple were vested with families such as Ezhutthan Alakkale Tharavadu, Ezhutthan Poyil Veedu and Ezhutthan Thazhatthe Veedu. The tree felling case was finally settled outside the court at the police station by a mission of a local people on the condition that the management of the temple will be transferred to the

committee of local people. The responsibility of temple and SG management was thus vested to people from seven villages/desam (Namesy Kadukkaram, Kakkara, Kadangunnu, Kundupadi, Koompuram, Mavilaru Kallu, Kutteni). All the properties both landed and non-landed assets were transferred to the people's committee formally. After people's committee taking over the management a temple was constructed, which soon proved to be inadequate and renovated again. Gradually participation from Kundupady desam has declined. A participating village with its own local committee would arrange for a procession with a collection of the materials for the festival at the temple including vegetables, paddy etc. The procession accompanied with percussions and an offering of carrying lights by girls and women called *Thalappoli*. These arrangements were a "new tradition" invented at the pretext of people taking over the management of the temple. Gradually, more villages- kutteni, Koompuram and Mavilaru Kallu- also dropped off while Perumpoyil-Puravattom desam joined the group. Therefore, there are five villages participating in the procession (i.e. Kadukkaram, Kakkara, Kadangunnu, Koovumpuram and Perumpoyil-Puravattom).

Rituals, Festival and social embeddeness: The festival is from 28th of Month of Makaram to 1st of the month of Kumbham. Besides this, 20th of the month of Medam is celebrated as the founding day. Every 10th of the month of Thulam is celebrated as *adiyanthiram* . Oil Lamps are lit every day by the *anthithiriyan.* On all Tuesday and Friday evening *Deepam*-s or ceremonial lamps attract hundreds of devotees. On the Thulam 10th the *karmi-s* (Priests) of the temple perform the *pooja* after bathing in the nearby temple ponds. The supervising priest-Tanthri- is Kalahat Tanthri. On two occasions –The foundation day and the occasion on the month of Thulam-10th)-the Thantri needs to perform these *pooja*s.

Seats of Karimanal Chamundi Bhagavathy are present in Kadamkunnu, Peruvamba, Koodom, Ponnam vayal, Kadukkaram, Kakkara, Kundupaadi and Mavilaru Kallu. The Karimanal Temple is the principal seat or locus of this deity for all these temples. One of the associated deities is Bandoor Deivam who has clear and originatory and ritualistic connection with the Payyannur Subrahmanya Swamy temple. Moreover, the Bandoor Deivam is a principal deity in one of the adjacent well-known SGs the Theyyottu Kavu (at Alappadamba) and the same head adornment of the Theyyottu kavu is used in the Karimanal Kavu by the Bandoor Deivam. All three days of the festival the first Theyyam is Bandoor Deivam. Pattuvathu Bhagavathy and Kolatthummal Kolam are the other important deities besides the Karimanal Chahmundi. As this being the *Aroodam* or principal seat of the deity, the ritual called *Thottam,* is not performed here in advance of the beginning of the Theyyam.

The ritual of giving a sign or *adayalam* is also not perfomed here unlike most other *kavus* in the region. *Theyyakkolam* is performed by the Mavila community. The *janmam* or right to perform theyyam is with *Karimanal Mavilkar* who was originally resident of Karimanal and currently residing at the Vayakkara about six kilometers from Karimanal. Their presence is also required on the day of *Adiyanthiram* in the month of Thulam when the ritual is performed on 10^{th} day of that month.

The *kazhcha* or the ceremonial procession with contributions from the five villages are organised on the same day and all the processions converge at Karimanal Kavu. Though explicit collection or campaign for the monetary contributions are not organised as part of the festival, all the requirements of the festival are met from the voluntary offerings received in cash and kind. Kazhcha from each of the five villages will have a good collection of vegetables, fruits and other agricultural products such as coconut and areca nut. Some of these items of commercial value are sold in auction to supplement the finances towards the festival. Ceremonial free-meal-feast is arranged everyday during the festival for thousands of devotees.

Preparation for the festival: reinforcing institutional links: Preparation for the festival begins with a meeting of the temple committee about two months in advance. *Kazhacha* from the villages are arranged by respective village committees. Kazhcha from the Kadmkunnu has to trvel about three kilometres before it reaches the Karimanal temple. The total expenditure for the last yers festival was about rupees three lakhs. Small Chits or revolving fund draws are run by the temple committee as a source of income. A portion of the draw is kept by the committee as commission or service charges.

Only paid employee is *anthi-thiriyan.* The present *anthi-thiriyan* is son of the previous *anthi-thiriyan* namely Palai Kunhambu. The system was introduced only 35 years back when the management was of the grove and temple was transferred to people's committee.

One of the offerings is *Thulabharam* or weighing with devotee on the balance with a chosen item as counter weight. Usually the *Thulabharam* is arranged in return to the favours received or for the prayer answered favourably. *Thulabhaaram* is arranged with tender coconut, rice, plantain or sugar. On an average 160 *thulabharam* are performed in a season. Similarly, common domestic fowl is sacrificed as a thanks giving measure. Another curious mode of offering is sponsored Theyyattam as thanks giving. This offering consists of Rs. 3001 and a rooster. On an average about 15 such offerings are made during a festival

season. Besides this the SG also facilitates dispute redressal and healing of the people possessed by the evil spirits in the presence of the Goddess.

Formal and informal institutions: There is a 14 member committee in place for coordinating the activities. People from various communities and various vocations are part of the committee. Even an affiliation with Communist/Marxist party does not stop any body from associating with the temple management and actively participating in the activities of the temple. In recent years the management committee has visibility expanded its activities by building new structures associated with the temple and increasing participation and contribution to the temple festival. Apparently people from communities other than Hindu also make offerings to the temple.

Originally the land owned by the temple was close to seven acres, which has now reduced to four and a half acres in extent owing to the road widening and similar development demands. Out of this about three acres is vegetated. The committee is currently exploring possibilities for improving the vegetation cover by planting seedlings supplied by the social forestry wing of the Kerala Forest Department. An aid is also received from Social Forestry for developing a facility for keeping drinking water for the birds.

4E.3. Poyil Kavu

The management unit of Poyil Kavu Temple mentioned in this report consists of two temples of worships – the Poyil Kavu Vana Durga Temple and the Poyil Kavu Devi Temple. These temples are referred to as *Padinjare Kavu* (Grove on the Western side) and *Kizhakke Kavu* (Grove on the Eastern Side) respectively referring to their relative location to one another. The former is also referred to as temple of Mangattoor and is believed to be the principle deity of the erstwhile Mangattoor desam. Though the word *Kavu* normally indicates presence of natural vegetation protected in the pretext of belief, here only in the former one, the Vana-Durga temple has vegetation- i.e SG. Temple inside the grove is located in the 11 acres of land which is thickly vegetated with old growth evergreen tree species, lianas and undergrowth with canopy opened up in the centre by a temple structure with all the typical features of a Kerala Temple occupying about one acre of area in extent.

The temples are placed less than a kilometre from each other and are located not very far from the sea coast. The temples are about five kilometres south of Koyilandi town and 25 km north of Kozhikode town along the National Highway (NH 17) close to the

Chemencherry Railway station. The surroundings of the temple is densely populated with high land value well above Rs.3,00,000 Lakhs /cent.

Management of both these temples now organised under the Malabar Devaswom Board and there is a management committee with hereditary trustee as a member common to both the temples who facilitates and oversees the development and annual joint organisation of festival for these two temples. The annual festival of the temple is held during the six-days in the Months of Kumbham and Meenam according to the Malayalam Calendar which approximately fall within the month of March. Through rituals and rites of the temples and management aspects both the temples and deities are closely related and managed mostly as a single unite. So a study of the SG of the Poyil-Kavu Vana-Durga temple has many things in common with the Devi temple in the east.

Originary Myth or Aithihyam: Poyil Kavu Vana Durga temple is believed to be one among the 108 Durga temples found by legendary Lord Paraurama after he reclaimed the land of Kerala from the sea by wielding his axe. This way the Vana-Durga temple is considered older than the associated Devi temple. The Vana-Durga is of *Vishanva bhava*- i.e worshipped as a form of goddess Lakshmi. And the Devi of the Eastern grove is of Saiva tradition- worshipped as a manifestation of Goddess Parvathy. This originary legend binds the temple with a powerful and universal story associated with origin of the land of Kerala and narratives of socio-political legitimisations contained in the Legend named 'Keralolpatthy', which is generally regarded as a justification for monopolising the landed property by the upper-caste priestly class of Brahmins in the Hindu society in the region. So the from the point of view of social institutions and social embeddedness of the Poyil Kavu, the kavu has a good anchorage that justifies its authority. This crucial aspect would have been the reason that the belief system and one to the underlying safety-net for the protection of the SG in the past.

Rituals and community involvement (social embeddedness): The mother goddess Vana Durga is the principle deity of the temple. As described earlier the temple is located inside the SG which has an extent of about 11 acres. The temple is a large structure with all the architectural features of a typical Kerala-temple with a sanctum sanctorum at the centre of the surrounding structure –called *nalambalam*. The temple faces westward -the sea coast- where the annual ritual of the Aarattu (Holy dip) of the Goddess marking the conclusion of six-days long annual festival is performed. The sea is about just one kilometre away from

the temple by road. Vana-Durga is the principal deity and Ganesha – or Vigneshwara is the associated deity of the temple. There is daily *pooja* in the temple. Temple is open from 6.00 to 10.00 am and 5.00 to 6.00 pm. There is an installation of Brahma-Rakshas outside the grove. This temple was believed to be under the protection of *Val-Nambi*-the clan of Brahmins who are armed. The *Brahma-rakshas* is believed to be one among the *Val-Nambi'*s of the temple.

The deity of the Devi temple in the Poyil Kavu which do not have SG is also considered in sisterly relation with the Vana Durga of the Poyil Kavu SG. However, the original myth relating to the origin says that the Devi who appeared is related to Lokanar kavu- a nearby centre of worship. While the goddess at the SG-Vana Durga is in serene mood the goddess at Poyilkavu temple is considered in the mood of combat and extermination of evil forces.

The Devi temple has a rite called Thottam that is performed every day. There is no Theyyam but a ritual dance is performed by the Theyyampadi Kurup except from of 13 of the month Dhanu-13 to 1st of the month of Meenam. Thottam is performed between 9.45 and10.00 am. This involves praise to the Goddess served in the form of a ritual song with special attire and rhythm. This is performed outside the temple while the Pooja is offered to the Goddess in the sanctum sanctorum. The thottam concludes by the Theyyampadi Kurup having and orphic import which is revealed after circling the sanctum sanctorum. One of the Ooralan- or the traditional trustee- of the temple has to be present at this. Thottam is also an offering to the deity and this can be sponsored by a devotee and is booked till month of November in 2017. The person who has booked this would also be present to listen to the message revealed to him by the Theyyampadi Kurup. The office of the Theyyampadi Kurup is a right inherited down the lineage of a family. He also accompanies in his special attire the ceremonial processions of the Goddess as *Komaram.* On the last five days of the festival a special ritual called *pattum-vilakkum* is also performed by the Kurup.

Festival as a measure of restoration of community participation: It is on the 13th of the Malayalam month of Dhanu every year the committee decides whether they want to hold the annual festival or not. Festival is not celebrated if there is an urgent need for taking up an alternate mission associated with temple such as maintenance of the temple tank or construction of a building etc. This shows that the committee has a tradition that enables them to arrive at flexible decision making.

During the six-day's long the festival staring from the last days of the month of Kumbham- and concludes by 6th of month of Meenam according to the Malayalam calendar. The beginning of the temple festival is marked by hoisting a flag on a ceremoniously brought flag staff. On the 4th of the month of Meenam the *pallivetta* the divine hunt- symbolising the warding-off of the demons and such unacceptable powers by the Goddess from the *desam* (village) is held with a lot of fanfare. It is only during these last two days of the festival that such festivities are allowed in the SG. Having too many lights and noise is considered unacceptable even during the other days. On the other days the festivities are centred at the Eastern temple. The annual festival concludes with a holy dip of the Vana-Durga in the sea which is called *Kulicch-aarattu*. During the occasion both sides of the road and houses of the devotees on each side are decorated and traditional oil lamps are lighted. Devotees welcome the goddess during the procession accompanied with percussions and a feast of fruits and such offerings. The idol of the Goddess and symbols such as *Palli Val*- decorated Sword made of Bell Metal and other signs- arrives at a temporary structure is erected at the seashore accompanied by large number of devotees who arrive from various localities in the region. Devotional music with instrumental accompaniments is played throughout the forenoon up to completion of the function by groups of singers who come together as *Poyil Kavu Durga Temple Bhajan Group*. Besides this various youth clubs, self-help groups etc. are actively involved in organising of the function. After the *Kulicch-aarattu* the Goddess proceeds as procession back to the SG and temple, and welcomed by an elaborate *Pandi melam*-a grand traditional ensemble of percussions and wind/pipe instruments including *Chenda*. The grandeur of the *Pandi-melam* in festival of 2016 is remarkable because the fact that it was lead by a celebrity percussionist called Kalloor Raman Kutty Asan. This is indicative of the great fanfare associated with the event and the grandeur of the function. The *pandi-melam* lasting about two and half hours is performed inside the SG and it is referred to as taking place in 'Vana-Madhyatthil' i.e. in the midst of forest, in the festival programmes.

The official beginning of the annual festival is marked by hoisting of flag at the Vana-durga temple inside the grove in the evening. The flag hoisting in the Devi temple takes place after this in the same evening. This indicates the primacy attached to the temple grove. The second day the holy dip-*Kulicch-arattu*- is performed for the goddess in the eastern temple. When this ritual is progressing, the Goddess of the SG arrives on a ceremonial processesion a top an elephant to the eastern temple and holy dip-*arattu*-of Vana-Durga is also held

subsequently. Upon completion of this ritual a joint procession is held by both the Goddess. During the circum ambulation after the third circling the Vana-Durga roceeds back to the SG. The festival concludes by the *Arattu* of the Vana-Durga at the sea on the sixth day of hoisting the festival flag.

Despite the festivities associated with the annual festival such as the popular cultural shows and percussion ensembles by celebrity performers the highlight of the festival that attracts biggest crowd and participation of the people is the day of the Arattu of the Goddess Vana-Durga at the sea. The same day the road leading to the sea from the temple is cleaned and washed with water, houses on both sides welcome the procession with ceremonial lamps and offerings such as flower decorations and fruits. Devotees are served with butter milk, sweets and fruits. The goddess is taken on ceremonial procession for *arattu* is by the Thanthri, his assistants accompanied by the *Oorlan*-s- the traditional trustees of the temple. Goddess arrives back from the sea after the *arattu* on top of a caparisoned tusker accompanied by two more elephants. Goddess is welcomed at the grove with an ensemble of percussions, wind pipes etc. played by a large and well trained artists performing under the guidance of a celebrity percussionist of excellence. This is called *pandi-melam*.

As the festival here takes place with elaborate rituals, cultural programmes and rituals along with the festival of the Poyil Kavu Devi Temple, a considerably large crowd assembles during the festival and elaborate rituals and rites are performed in both the temples during the period. The originary legend associated with Poyil Kavu Devi Temple and appearance of the deity there has a number of versions pointing at a real life event. These stories point towards appearance of a young lady who was protected by an elderly lady whose whereabouts were unknown and later found to be of a divine presence of the Goddess. The young lady was also subsequently accepted to a powerful family. The whole episode and subsequent lineage starting from the lady forms the origin of the traditional trusteeship managing both the temples.

Formal and informal institutions: Both the temples belong to the members of nine *tharavadu*-s i.e extended kiship group who belonged to an extended family of the matriarch-who is the young lady. The two daughters of her and families of their nine daughters' have inherited the right over the management of the two temples. Out of these nine families only four are active in the management of temple now. Each of these traditional trustees is called an *Ooralan*. One among them is member of the trustee board of the Devaswom committee

governing the temples. However the first among the nine Ooralan's have special privileges. All the decisions have to get ratification of the first *Ooralan*. At the time of *Pattum-Vilakkum* an important ritual during the festival a sign for its beginning has to be granted by the first *Ooralan*. Similarly the rituals such as flag hoisting which marks the beginning of the festival and Arrattu all require a consent and presence of the first Ooralan. This is a restoration of the primacy of the kinship and originary legend associated with the temples through ritualisation.

Apart from the annual festival a still larger event- called Thalappoly is held. The Thalappoli is a mega procession held only during once in five years. The last it held was in the year 2013. This event has a clear division of labour involving rights and regulations with the nine *Ooralan*-s and representatives of 41 different communities from the *desam.* This ritualisation and creation of rights creates a sense of belonging among all the castes and creeds of the society and it also forges a sense of home territory called desam. In the last thalappoli except for just three right holders all the other traditional community representatives have turned up and this shows in a way the tradition is still active. A bunch of coins are given as gift to these right holders and each one of them counting the amount he /she got will return the same along with an equal amount as their contribution to the committee.

Despite the involvement of Malabar Devaswom board, the role played by the board in organising the festival is minimal. The whole event is planned and executed by a popular committee formed for organising the festival under the aegis of the traditional trustees of the temple. Malabar Dewasom board assumed the management from 1998 onwards. However the role of Devaswom board in everyday management and financial administration is only nominal. The grant received from the board is mainly towards the maintenance of the temple (Last year's grant amount from the Board was Rs. 2,15,000 which was used partially for maintenance of the temple tank). Festival expenses are met from the donations and sponsorships of the people, the surplus collection during the festival season would make up for the deficit in organising the day to day activities.

Participation of communities: As mentioned earlier the role of the Devaswom board is minimal in organising the venets such as Thalappoly and annual festival. The elaborate arrangement needed to organise rituals, festivities, mobilisation of resources etc. are organised by the popular committee including the traditional trustee families. Various caste

community and kinship groups are involved in the organisation. Though the society is under the spell of modernisation from the early decades of the 20th century (say from 1900s) though reorganisation of the production, reassignment of landed properties in the later decades, reconfiguration of the traditional relations of productions and accumulation the modernisation is has taken place by burying the traditional structures but not by annihilating these structures or relations especially that of caste communities. The division of labour once in place through the caste system has become obsolete however the traditional ritualistic enactments restores the memory of these remnant caste based community commitment in the organisation of the festival.

Poyil Kavu Vana Durga Temple is a *Desa Kshethram* i.e. temple of the deity officially protecting the Chengottu Kavu region. The present head of rituals and special priest of the temple- the Thanthri - is Karumaratthillathu Parameswaran Namboothiri at Kannur. This is a traditional hereditary office. This and the daily pooja are offered by Nampoothiri Brahamins. However the Brahmin priest's is not a hereditary office. However there are other offices which are right based and hereditary in nature. The traditional trusteeship of the temple is held by the Nair community. The Marar who holds the right to accompany the ceremonial processions during the festival is reserved to partcilar family. Similarly the the family of Dhobi's who supply the purified cloths called -Mattu is supplied by particular family who holds the right. The balck smith has an important role of maintaining the armoury of the Goddess and the particular black smith is sent for maintenance and repair. Where the black smith is officially welcomed and entrusted the work and the armoury is duly returned by him officially with the occasion marked ritualistically. The potter family-Kumbharan-who has the right to supply the pottery and Carpenter who has to oversee cutting of Areca-tree for flag post for festival are traditional right holders. The members of the Pulaya community were to supply Matt necessary for the festival hwihc is a tradition almost discontinued now. The ceremonial palm leaf-Umbrella is being supplied by *Panan* community. Member of a Thandan community supplies the coconut leaves and coconut bunch besides the cutting the areca pole ceremoniously for flag post under the supervision of the Carpenter. Each of these community members belong to the *desam* and they also holds the traditional rights in return for their services in the form of money, rice and vegetables. The event of *thalappoly* also restores the originary legend as it is necessary that a woman from the valloppilli Tharavad has to lead the procession of *thalappoly*. Valloppilli is a Nair tharavadu. Devotees from faraway places arrive for performing their obeisance and

fulfilling their vows to their Goddess during the festival. Poyilkavu has many celebrity devotees including one of the previous chief secretaries of the state who used regularly sponsor the Prasada Ootu (meals for the devotees).

4E.4. Mani Kavu

Manikavu is located near the Choothupara in the Meenangadi Panchayat of in Wayanadu district. The Manikavu is a temple of Lord Shiva and the sign of worship here is considered of self originated. In general, like other districts which are located predominantly in the hilly tracts, Wayanadu has only less number of SGs. It is located right within a vegetated and well defined watershed with a perennial first order stream and a spring. However the natural growth of vegetation in the 32 acrealand owned by the temple is residual in nature and there are joint initiatives of the various governmental and non-governmental agencies for restoring the vegetation cover in the watershed here.

Legend, worship and societal embeddings: The principal deity is Lord Shiva and the other associated deities are Ganapathy, Ayyappan, devi and Maha Vishnu besides the brahma Rakshas, the Serpent lord-the Nagar, nandikeswarar and Gulikan. The temple here is referred to as Manikavu Swayam Bhoo Shiva Ganga Kailasa Kshethram. It has also been found that presence of more number of deities is confirmed by means of the recently organised astrological query. The name of the temple could a recently sanskritised and attributed to what is perhaps an ancient site of worship for the structure or sanctum sanctorum of the temple appears to be ancient by the style of architecture. The term swayam bhoo (literally means self originated) refers to the orginary legends of finding the sign inside the sanctum sanctorum located right in the lowest point of a perennial stream flowing through a marshy bottom of the watershed area. The sanctum sanctorum and the platform are built around this natural sign which is in place of the installation. The stream is equated to river Ganga (or Ganges), in the name of the temple which according to the mythology is the consort o the lord Shiva as well. The place is also thus equated to Kailasa -the abode of lord Shiva with his consort Ganga. Thus the name captures all that is mythologically attributed to the Lord Shiva with the Manikavu SG and the associated ecological features. In a way the social construction of the place is so thick and multilayered with popular imaginaries it has a very deep seated socio-psychological anchorage.

The temple is under the management of Devaswam board and has a committee of devotees which overseas and organises the annual temple events and festival. The temple have

regular offerings and ritual worships organised one-time (morning time) everyday. An analysis of the routine rituals and offering indicate that the temple has a traditional brahmanical worship systematised according to the system of worship followed in most Kerala Temples. Along with the Kerala hindu priestly class – the Namboothries other traditional temple communities (*Ambalavasi*-s) are also associated with the routine activities in the temple. The oil that is poured over the main deity –shiva- is considered to have curative properties against skin diseases.

Past ten years have witnessed increased popularity to the temple and associated with this there were efforts to renovate the temple. Accordingly, a committee of enthusiasts for renovation of the temple came into existence and the committee made elaborate resource mobilisation efforts. Temple is well known in the southern Wayanadu and the Wayanadu district in general. The temple enjoys popularity in Kozhikkode and southern parts of the Kannur district to some extent. The seasonal pilgrims heading to Sabarimala (a very popular destination of the Hindu pilgrims in the southern Kerala) also has brought the Manikavu temple in the Sabarimala pilgrim circuit. As part of the renovation the temple also found new patrons who were liberally contributing to the renovation efforts. There are also individuals who have been contributing to the temple renovation who hails as far as from Ernakulam district. Ithas also been learned that the temple is being considered to be recognised as a heritage site by UNESCO owing to the long history of its existence.

During the year 2016, associated with the Mahasivarathi in the month of February, the temple witnessed 11 days long Rudra-yagam where devotees were given a chance to directly participate by making offerings. This event witnessed phenomenal flow of devotees to the temple. The event also had other attractions like dance and devotional talks by well-known figures as in previous years.

Under the aegis of the Community Biodiversity centre of the MS Swaminathan Foundation located in the Kalpetta a programme for enriching the vegetation named ‘Punyavanam’ (literally meaning sacred forest) were being implemented from 2015. Agencies such as State and Central Medicinal Plant’s Boards are partners in this programme. However, this is not the first time that the Manikavu and the associated watershed is attracting attention of the agencies who are interested in conservation of the ecological well being, biodiversity values and ecosystem services. A similar programme focussing on the 30 acre land available with temple was chosen for augmentation of the vegetation earlier by the Menangadi Panchayat

with a wider objective of revegetating the watershed, planting the selected areas with fruit trees for developing a fruit orchard for establishing fruit processing unit. Agencies such as social forestry wing of the state forest department are also co-operating with the programme.

4E.5. Vallikkattu Kavu

The grove is located on a steep slope of the Eliyode hill in a small watershed. Eliyode hill is a midland lateritic hill located within less than 10 kilometres of areal distance from the seaboard of the Arabian sea at Edakkara desam, Thalakkulathur revenue Village in the Kozhikkide district. The grove is on the foothills of the eastern slopes of the Wyanadu plateau in the western ghats. At Edakkara, Vallikkattu Kavu which has more than 10 acres of land under thick natural vegetation has a site of worship of Goddess Vana Durga, just inside the boundaries with divine signs and installations. These are along a perennial spring which flows out of the grove as a stream. The stream flows out through a fresh water marshy land with thick growth of Myristica trees. The grove is about 9.5 hectares in extent and is under the management of Malabar Devaswom board. Vallikkattu Kavu Management Committee with representatives of the hereditary trustees and the Devaswom board takes lead in organising the annual events.

The grove has a profusion of lianas and vines and the term Valli in Malayalam indicates this profusion of vines in the grove. Outside the bounds of vegetation, the water from stream is collected into a pond which is considered sacred. The waters of which flows out as a stream through a narrow stretch of wet paddy land and further into the small home gardens and farm lands downstream.

The Kavu has a natural site identified as the seat of the presiding deity the Goddess Durga. Durga here is a mood of supreme mother goddess. The mother goddess is also considered as ‘prakriti’ the creative power of the supreme un-manifest. The universe and nature are considered manifest both in subtle and gross forms. Thus the prime and virgin form of the nature is chosen as the abode of goddess. The seat of the godess here is not an installed one but considered self-manifest here and is referred to as Swayam Bhoo. There exists a constellation of associated deities such as Ganapathy, Ayyappan, Bhadrakali and Paradevta. The entry to the site marked with presence of these deities is restricted to priests and their assistants only. A small stream, which is considered holy, originating from a spring inside the SG flows beside this seat of deities. Devotees and pilgrims take dips in the water from the stream which is collected in a pond just outside at the entrance of the grove. Another

pond which is considered sacred and restricted for the use during the rituals of the grove is also present. The forest abounding flowering creepers is considered pouring the flowers on the diety Sree Durga who likes to be bathed in the rain and sun and vary of having a temple or sanctum sanctorum constructed. Thus vallikkattu has a special feel of divinity associated with trees, creepers, vegetation, water and the stream flowing through it.

Legend, worship and societal embeddings: The grove has worship and offerings done every day. The worship rituals for the evenings are conducted only on special days and festival season. The rituals are carried out by the priests hailing from two Brahmin families - Karakkattu Illam and Vallikkattu Illam. The representatives from these families conduct the affairs of the grove take six-monthly alternate turn. Small collective of women is also active during the festival and holy seasons in organising the events.The grove also attracts pilgrims heading towards sabarimala temple located in the southern district of Kerala.

The important events of the temple are:
The most auspicious day celebrated is the day of confirming the presence of the presiding deity Goddess Durga at the SG. This is celebrated on the Makam day of the Malayalam Month of Kumbham every year; which roughly occurs in the month of February and March. The nine days of celebration of the mother goddess is called Navarathri, which is also traditionally the season for initiation to formal education for the children. Similarly the month of Karthika is also considered auspicious to worship the mother godess and the temple attracts large number of devotees. The 41 days of the pilgrimage season to Sabarimala, the prominent temple of Ayyappan in the south central Kerala, is called mandala masam whence large number of devotees come to organise worship in the temple.
Entry to most part of the grove is forbidden to humans. Even priests are not allowed to spent time inside the grove once the daily worship is completed. Entering and moving inside by devotees are viewed as a taboo and is strictly observed. The monkeys present in the grove are fed (with what is called Kadukka Choru) as an offering mostly by childless couple to win a boon of child from the deity.

A small office structure which is also used as store room by the SG management is located inside the SG close to the seats of the deities. The temple/ SG is administered by the Malabar Devaswom Board for many decades now. There is a committee of representatives of Devaswom board and the traditional trustees. The traditional or hereditary trustee of the

grove are three Kuruppu families (who are Nairs by caste hierarchy) which are Varodi Ponnarambathu Kurup, Kainolikkal Kuttiyadippurathu Kurup and Vazhappadathil Kuruppu.

5. Discussion

The local people in rural landscapes of Kerala believe that their livelihood, security and prosperity are complementary to the blessings of the deity of their SG. In general, they also recognise the role of SGs in maintaining cultural and biological integrity of the region. However, this ancient and widespread institution of SG is showing signs of weakening in many parts of tropics (Ryan et. al., 2016). For instance, an array of site- specific human disturbance regimes was reported from SGs of Kerala (Chandrashekara, 2011). In addition, the intensity of different disturbance variables in a SG can also be different. However, since the level and intensity of disturbances are qualitative in nature, analytical method/s to assess and compare level, intensity and diversity of disturbances in SGs had to be developed. In the present study, for each SG, the frequency of disturbance and Index of Human Disturbance Value (IHD) were calculated. Among five SGs studied, Mani Kavu showed a wide spread disturbance caused by several factors. The include vegetation loss due to conversion of forested ares for vehicle parking and temple related activities, premature fall of trees in the SG due to land use changes in adjacent areas, and dumping of solid waste throughout the grove. However, value for the Human Disturbance Index was comparatively high for Karimanal Chamundi Kavu suggesting that illegal collection of biomass, trespassing, un-authorised activities of anti-social elements and use of certain parts of the grove as play grounds. Among five groves, Kammadam Kavu found to be free from many types of disturbances. However, a small area of the grove found to be used to dump wastes and occasional ro collect biomass.Thus, five SGs of the present study represent at different postions of a human disturbance matrix and consequently, ecosystem services rendered by them are expected to vary. In the following section, ecosystem services of sacred gorves which show different degree and inteintisity of disturbance will be discussed.

Several studies indicate that SGs contribute comsiderably to the preservation of wild plant species (Ramakrishnan et al., 1998) and thus, conservationists emphasise the need of using SGs for *in situ* conservation. Analysis of floristic wealth of the 364 SGs (> 200 m^2) covering an area of 1.44 km^2 in Kerala comprises about 720 species of angiosperms belonging to 472 genera and 126 families (Induchoodan, 1998). A total of 670 angiosperm species belonging to 120 families were recorded in another inventory conducted in 28 SGs of Kerala

(Chandrashekara, 2011). Occurrence of a total of 418 angiosperm species in the five SGs selected for the present study indicates the richness of plant species in these groves and their role biodiversity conservation. It may also be pointed here that the value obtained for Pair-wise Jaccard Similarity Coefficient derived for species recorded from five SGs of Kerala is less than 13.3%. Low similarity between SGs may indicate the need of protection and conservation of more number of SGs to ensure conservation of rich plant diversity. At the same, a negative correlation (R= - 0.7421) between Index of Human Distubance (IHD) values and total number of species also indicate a moderate impact of human disturbance on species concentration in these SGs.

Well managed SGs are also the treasure of rare and endemic species (Verschuuren et. al., 2010). For example, analysis of the phytogeographical elements of SGs of Kerala indicated that out of 720 angiosperm species recorded 154 are endemic to Western Ghats (Induchoodan, 1998). In another study it was reported that about 20% (133 out of 670 speices) of the total number of species recorded from the SGs are endemic (Chandrashekara, 2011). However, in the present study, only 16% (65 speceis) of total number of species found to be fall under endemic species category; with a large number of them (35 speceis) are endemic to the southern Western Ghats. It may be pointed out here that anthropogenic disturbance is one of the causes for reduction in richness of endemic species in SGs. Thus, a negative correlation (R= - 0.945) between Index of Human Distubance (IHD) values and total number of endemic species in these SGs was recorded.

Available publications (Nayar, 1997; Sasidharan, 2004; Irwin and Narasimhan, 2011) indicated that Rubiaceae, Acanthaceae, Balsaminaceae, Asclepiadaceae, Lamiaceae, Poaceae and Orchidaceae are the families rich in endemism in peninsular India. In the present study, Acanthaceae, Rubiaceae, Lauraceae and Melastomataceae were found to be rich in endemic species.

It is reported that in the humid tropical evergreen and semi-evergreen forests of the Western Ghats of India, for example, the range of stem density of trees (gbh $\geq$ 10.1cm) is from 270 ha^{-1} to 3341 ha^{-1}, while the range of basal area is from 24.7 m^2 ha^{-1} to 83.8 m^2 ha^{-1} (Pascal, 1988; Chandrashekara and Ramakrishnan, 1994; Chandrashekara and Sankar, 1998; Chandrashekara and Jayaraman, 2002). Tree density in five SGs that were studied under this project ranged beween 658 to 2758 ha^{-1} and these values are within the range of tree density recorded in the humid tropical forests of the Western Ghats. However, tree basal area (7.3

to 65.8 m^2 ha^{-1}) in four out of five SGs of the present study are below the value obtained for the humid tropical forests of the region. Moreover, a negative correlation between Index of Human Distubance (IHD) values and tree density (R= - 0.941) and tree basal area (R=-0.864) in these SGs was recorded. Consequently, biomass and carbon stock in tree biomass also reduced as the level of disturbance is increased R value between IHD value and tree biomass (total)/ carbon stock is -0.891).

SGs of Kerala also support rich bird and butterfly fauna. Available literature indicate tha more than half of the about 400 species of birds recorded from Kerala have been cited in the SGs of State (Jyothi and Nameer, 2015). Even in the present study conducted in selected five SGs, a total of 106 species, with 8 endemic species, were recorded. The present study also demonstrated the fact that more than the size of the SG, the level of anthropogenic disturbance determines the bird and butterfly species deiversity in the groves. For instance, significantly negative correlation (R= -0.806) between number of bird species and IHD values in SGs was noticed. However, a weak negative correlation (R= 0.695) between number of butterfly species and IHD values in SGs was recorded.

According Skinner and Bowen (1974) and agriculture systems contained fewer species of AM fungi than natural grasslands. Even in the semi-evergreen and moist deciduous forests also the number of AM spores and infective propagules can also be low (Schenck *et al*., 1989), as exemplied from this study in forest patches of SGs. Comparatively low value obtained for number of AM spores and infective propagules may indicate inherently fertile and less dependent on mycorrhizae for their plant growth.

The factors affecting the distribution of AM fungi are poorly understood except in a few cases and it is believed that AM fungal population varies with the climatic conditions and edaphic environment as well as ecosystems. The present study clearly indicates that the correlation between AM fungal populations and IHD values in SGs is not significant. However, in some of the groves a significant increase in AM spores during the post monsoon is apparently due to an increase in soil moistures. In others, where as spore count were not higher during post monsoon, soil moisture may not have been adequate or other factors may have been limiting for inducing any significance change.

Root colonization per cent by AM fungi was more in Karimanal Chamundikavu. The present observation is attractive since plants with tap root are known to be more independent

on mycorrizae than those with fibrus root system (St. John, 1980). The high root colonization in Chamundi Kavu may be due to the fact that level of disturbance and stand quality are more dependent and attract on mycorrizae for growth. However, Kammadam Kavu had the lowest root colonization per cent which indicates that the semi evergreen and moist deciduous forest show their inherent fertile soil property and less dependent on mycorrhizae for plant growth.

In all five SGs, soil reaction of the soils could be placed in extremely strong to strongly acidic. There was no significant difference in soil pH between the undisturbed, moderately disturbed and highly disturbed sites of these SGs. The effect of disturbance on soil pH is minimal due to the inherent soil buffering capacity. Soil pH is suitably buffered by the soil mineral and organic components and hence expected to change much slowly. The low pH is essentially due to the leaching of bases under high rainfall conditions. Under such basic leaching conditions, silica may get dissolved and leached out leaving the entire horizon rich in Fe and Al sesquioxides. Under undisturbed conditions organic matter will prevent this chemical degradation to a great extend and at the same time replenish the soils with sufficient cations and help maintain the soil reaction from drastic changes. Though the Ca and Mg values were on the high in the soils their effect on soil pH was not prominent.

Several studies have reported that over the pH range 4.0–6.5, there is a close relationship between soil buffering capacity and organic matter content, and to a lesser extent with clay content (Helyar *et al*., 1990; Aitken and Moody, 1994; Dolling *et al*., 1994; Noble *et al*., 2002). SG soils with its high soil organic matter could buffer the pH changes, hence the results were found to be in concurrence with the earlier observations.

There was a significant decrease in moisture content, OC, N, P, K, Ca and Mg with disturbances. Irrespective of the disturbance the organic carbon was found to be high and N and K in the medium ranges in the soils. The high litter fall and ensuing mineralization would be helping to maintain a steady supply of OC, N and K in these systems. However, the C:N ratios of the soil were found to be higher than 50:1 indicating a low rate of mineralization. Several studies have reported mineralization of organic matter as the key component in maintaining nutrient cycles in soil (Verma et al., 2010; Sandeep et al., 2016). The high C:N ratio of the added liiter explains the moderate levels of N and K even with high OC status in the soils.

Extractable P concentrations were found to be low in all the studied samples. Tropical soils rich in 1:1 soil minerals provide a favourable environment for P fixation and hence restricted availability of this element. Further, in the acidic soils of the humid tropics, a major part of P is typically associated with Al and Fe hydroxides rendering them unavailable (Wood et al., 1984; Fernandez and Struchtemeyer, 1985; Sherman et al., 2006). Nevertheless, the high OC content may negate some of these effects by chelation or solubilization mechanisms.

The studies on soils of SGs thus indicated that there is a significant decrease in moisture content, OC, N, P, K, Ca and Mg with disturbances. But irrespective of the disturbance the organic carbon found to be high, available N and K in the medium ranges and extractable P concentrations low in the soils. Organic carbon in these soils was found to affect most of soil parameters except pH and Ca. Sustaining a good mix of tree species in the groves would supplement the soil organic matter and help sustain the ecosystem in a pristine state.

Water samples collected from streams and wells of three SGs: Kammadam Kavu, Valliyottu kavu and Mani Kavu were analysed different physico-chemical and biological parameters. Using the maximum permissible range of 6.5-8.5 as limit for pH (BIS) as benchmark, stream water from the SGs were comfortably within safe limits. Conductivity is an indicator of the amount of dissolved salts in water**.** The electrical conductivity value was found to be higher during the pre monsoon season in all the studied streams. Dilution of the salts was observed during monsoon period in all the water samples from the SGs and ground water collected from the surrounding wells. In and around the SGs, water in the streams had no colour or odour during premonsoon, monsoon or post monsoon periods. Though turbidity was observed in the streams and well water during the premonsoon period, it was within the permissible limits.

Hardness is an important parameter in decreasing the toxic effect of poisonous element. Total hardness in SGs was found to be in the range from 40 to 84 mg/l in pre monsoon. The hardness of water increases in the polluted water by the deposition of calcium and magnesium salts. Hardness caused by calcium and magnesium usually results in excessive soap consumption and subsequent “scum” formation. The results indicate that though the hardness limits are well within the critical permissible ranges, cumulative effects over the period may result in loss of water quality.

The analysis of calcium revealed a range between 4.0 and 20.0 mg/l. The W.H.O standard of drinking water indicates that the taste threshold for the calcium ion is in the range of 100–300mg/l, depending on the associated anion. Magnesium concentrations in samples were in the range of 4-18mg/l, in the three SGs. Chloride in drinking-water originates from natural sources, sewage and industrial effluents, saline intrusion etc. No health-based guideline value is proposed for chloride in drinking-water in WHO standard of drinking water. However, chloride concentrations in excess of about 250 mg/l can give rise to detectable taste in water and the observed range in the samples (12-36 mg/l) were well below the limit.

Dissolved oxygen is a very important parameter of water quality and an index of physical and biological processes in water. In the present study, the maximum concentration of dissolved oxygen was observed in the monsoon season in all the SGs.

All natural waters can also be populated by transient bacteria. Among these are the human pathogens that gain entry to water from fecal contamination. Thus contaminated water is a potential transmitter of any of a number of intestinal diseases. The direct isolation of intestinal pathogens is impractical; instead the number of indicator bacteria is determined. *Eshcerichia coli* which are in the large intestine of virtually all people have been used as the indicator of human fecal contamination of water and food. Analysis of surface water samples collected from SGs basin shows that 100 per cent of the samples were contaminated with total coliforms and in some cases with fecal coliforms.

In Valliyottu Kavu and Mani Kavu, seasonal variation in stream discharge was recorded with more during monsoon period (0.52 to 0.60 ft^3/s) and less during pre-monsoon period (0.05 to 0.27 ft^3/s). However, in Kammadam Kavu, the discharge from the stream ranged from 0.27 to 0.69 ft^3/s and there was no significant difference between the pre – monsoon and post monsoon flow. Water analysis showed that the SGs maintain perennial streams with all the physical and chemical parameters within the prescribed ranges. However, all the analyzed samples indicated the presence of total coliforms and in some cases fecal coliforms, threatening the potability of otherwise good quality perennial source of water.

Comparative analysis of socio-cultural dimensions of five SGs indicated that though temple management and institutional history vary slightly across the SGs there is active participation of the local people in the affairs of the SGs. All the SGs have strong surviving social linkages and anchorages characterised by:

- Participation and collective action of all the sectors of the local Hindu communities
- People who are part of the management of the kavu/temple are also members or office bearers of the civil society organisations, local panchayat and community organisations.
- The temple management is considered as a serious affair and the committees innovate the traditions which increasingly contribute towards the social anchorage of the institutions.
- Social catchments of the beneficiaries and devotees of are fairly wide for all the SGs. Non-apparent social linkages and stakes stretch beyond the boundaries of the villages and integrate even distantly located temples and the kavus as part of the network of traditions woven with fine threads of myths and beliefs.

There is a general awareness of the ecological values of the SGs apart from the religious perceptions associated with the grove. Even then, the SGs are facing threats of varying intensity. Thus, location-specific protection and conservation activities have to be undertaken by preparing management plan through adopting participatory approach. It may also be pointed out here that most SG custodians worry that, the ancestral wisdom behind protection of the groves is no longer respected. Thus, they felt that the funding agencies should support them with physical support (boundary posts, compound wall, chain- link or barb wire fence) to protect the groves. Even though the social barrier is more appropriate, the custodians of many groves are of the opinion that in the present day sociocultural context, physical barriers such as fencing and compound wall are needed to protect SGs till the attitude of stakeholders towards SGs becomes positive.

6. Conclusions and Recommendations

Due to changing socio-economic and cultural scenario, some of the SGs in the State of Kerala are showing various degrees of disturbance. Even then, the local people are attempting to maintain the groves as a part of their culture. The stakeholders view that their SG should be a model grove for effective conservation of biological and cultural diversity through participation of all stakeholders to overcome all the existing threats and weaknesses. In this context, grove-specific management options need to be identified and the objectives of such management activities should be to: a) ensure that all activities which adversely affect the conservation and management of forest vegetation of the SG are effectively curtailed, and b) enhance the biodiversity and the ecological and cultural values

of the grove. Considering these aspects, certain management options; both grove-specific and common, are discussed below.

Awareness creation activities

To ensure the positive attitude of all stakeholder groups for sustainable management and conservation of SGs and also to uphold and sustain the cultural, biological and ecological values of SGs and transfer it to the coming generations, the awareness creation programmes need to be targeted at all stakeholder groups. Therefore, the main management option, applicable to all SGs, is conduct of awareness creation programme for different sections of people. The aim of each programme should be to disseminate information such as ecological, cultural, biological and social dimensions of groves and also ways and means by which different stakeholder groups can contribute for the conservation and management of groves. Apart from the scheduled awareness creation programmes, necessary support should be provided for the visits and camps by nearby colleges and schools to appreciate the multi-fold importance of SGs.

Protective measures

The participants of many groves stressed the need of physical barriers to protect the SGs from encroachment, trespassing and forest degradation. For instance, the the stakeholders of Mani Kavu, Poyil Kavu, Karimanal Chamundi Kavu and Valliyottu Kavu opted for chain-link fence around the groves to prevent trespassing, grazing, illegal collection of biomass and other activities which are affecting the ecological health of groves. However, to prevent encroachment of forest land of Kammadam Kavu, it was suggested that area should be declared as an ecologically fragile land and boundary demarcation structures (posts) should be constructed all around the kavu. The members of the Kammadam Kavu Protection Committee also suggested to recruit watchers to prevent trespassing in the forest fringe, encroachment of the forest land, poaching of wild animals and collection of biomass. In Mani Kavu, establishment of a fire line all along the boundary of the grove to protect forest from anthropogenic fire has been identified as the major management option.

Forest restoration measures

Due to anthropogenic disturbance and fragmentation, many SGs are showing different degrees of degradation. The ecological restoration measures identified for groves are different. For instance, removal of climber and weeds, particularly exotic species, is identified as the major restoration activity in groves such as Kammadam Kavu, Karimanal

Chamundi kavu and Mani Kavu. Re-vegetation of disturbed areas, by reintroduction of species characteristic to the given grove, is another strategy for ecological restoration of Karimanal Chamundi Kavu. Enrichment planting around temples is another strategy to be considered in the case of Mani Kavu. In many groves, the local management committees are ready to raise seedlings locally with the technical know-how and financial assistance from the concerned departments.

Measures for restoration of water bodies

In all five SGs, existing water bodies need to be effectively managed for making them functional. For instance, in Poyil Kavu, `Thirikuzhi' is a natural pond and regarded as a holy pond. However, due to silt deposition and lack of management for several decades the ponds are unable to store water. Removal of silt and deepening are the suggested measures to make the pond functional. The ponds of Valliyottu kavu and Mani Kavu are covered with algal bloom and partially filled with silt and debris. Thus cleaning, de-silting and repairing are suggested for their restoration. Devotees consider the pond situated in front of the Temple of Vallikkattu Kavu as a holy water tank (Theertha Kulam). However, the tank is now damaged and unable to store water. Thus the tank needs to be repaired.

The rejuvenation of cultural heritage - one of the important ecosystem services of SGs is needed to support the conservation and restoration of groves. Thus, processes of building institutions to strengthen the cultural heritage need to undertaken. It may also be pointed out here that the cultural heritage and forest vegetation are complementary to each other in determining ecosystem health of community-based biodiversity conservation institutions like SGs. Imbalance of these two components can severely affect all other ecosystem services. Therefore, in each SG, a natural resource conservation committee should be constituted to protect and conserve forest and water bodies and also restore or enrich biodiversity. Furthermore, to promote the value of SG for biodiversity conservation, there would be a need for proper scientific assessment of SGs to demonstrate their relevance to habitat and species protection. In this context, it is suggested that an Indian National Network for Conservation of SGs (INNCSG) may be built up as a broad programme for monitoring ecosysytem services of SGs.

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Appendix 1. List of angiosperm species recorded in Kammadam Kavu (KK), Karimanal Chamundi Kavu (KCK), Mani Kavu (MK), Poyil Kavu (PK) and Vallikattu Kuvu (VK) of Kerala.

Sl. No.	Species	Habit	Number of SGs of occurrence and acronym of the SGs	
			Number	Acronym of the SGs
	ACANTHACEAE			
1.	*Acanthus ilicifolius*	S	1	PK
2.	*Asystasia gangetica*	S	1	KCK
3.	*Eranthemum capense*	S	1	PK
4.	*Gymnostachyum febrifugum*[a]	H	1	KK
5.	*Gymnostachyum latifolium*[b]	S	1	KK
6.	*Lepidagathis keralensis*[c]	H	2	PK, VK
7.	*Rostellularia japonica*	H	1	KCK
8.	*Rungia parviflora*	H	1	VK
9.	*Strobilanthes barbatus*[a]	S	1	KK
10.	*Strobilanthes foliosus*[a]	S	1	KK
11.	*Strobilanthes gracilis*[a]	S	1	KK
12.	*Strobilanthes heyneanus*[a]	S	1	KK
	ALANGIACEAE			
13.	*Alangium salvifolium*	T	1	KCK
14.	*Alangium salvifolium* ssp. h*exapetalum*	S	1	PK
	ALOEACEAE			
15.	*Aloe vera*	H	1	PK
	AMARANTHACEAE			
16.	*Achyranthes aspera*	H	1	KCK
17.	*Aerva lanata*	H	1	KCK
18.	*Cyathula prostrata*	H	1	VK
	AMARYLLIDACEAE			
19.	*Crinum sp.*	H	1	PK
	ANACARDIACEAE			
20.	*Holigarna arnottiana*[a]	T	3	KK,VK, MK
21.	*Holigarna beddomei*[a]	T	1	VK
22.	*Holigarna nigra*[a]	T	2	KK, PK
23.	*Lannea coromandelica*	T	1	VK
	ANACARDIACEAE			
24.	*Mangifera indica*	T	3	KK, VK,KCK
25.	*Spondias pinnata*	T	1	KCK
	ANCISTROCLADACEAE			
26.	*Ancistrocladus heyneanus*	C	1	KK
	ANNONACEAE			
27.	*Annona squamosa*	T	2	PK, KCK
28.	*Goniothalamus cardiopetalus*[a]	T	1	VK
29.	*Meiogyne ramarowii*[a]	T	1	PK
30.	*Miliusa tomentosa*	T	1	VK
31.	*Polyalthia coffeoides*	T	1	KK
32.	*Polyalthia fragrans*[a]	T	1	KK
33.	*Polyalthia korintii*	S	1	VK
34.	*Uvaria narum*	S	1	VK

Plant name with superscript, a = endemic to the southern Western Ghats, b=endemic to the Western Ghats, c=endemic to the Peninsular India.

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Appendix 1 (cont'd). List of angiosperm species recorded in Kammadam Kavu (KK), Karimanal Chamundi Kavu (KCK), Mani Kavu (MK), Poyil Kavu (PK) and Vallikattu Kuvu (VK) of Kerala.

Sl. No.	Species	Habit	Number of SGs of occurrence and acronym of the SGs	
			Number	Acronym of the SGs
	APOCYANACEAE			
35.	*Parsonia spiralis*	S	1	VK
36.	*Aganosma cymosa*	C	1	KK
37.	*Allamanda cathartica*	S	1	KCK
38.	*Alstonia scholaris*	T	2	KK, VK,
39.	*Ichnocarpus frutescens*	C	2	VK,KCK
40.	*Plumeria alba*	T	1	KCK
41.	*Rauvolfia serpentina*	H	1	KCK
42.	*Tabernaemontana alternifolia*	T	3	VK,KCK, MK
43.	*Wrightia tinctoria*	T	2	VK, KCK
	ARACEAE			
44.	*Amorphophallus bulbifer*	H	1	PK
45.	*Amorphophallus commutatus*	H	1	PK
46.	*Amorphophallus nicolsonianus*[a]	H	2	PK, VK
47.	*Amorphophalus paeoniifolius*	H	1	KCK
48.	*Anaphyllum wightii*[a]	H	1	PK
49.	*Cryptocoryne spiralis*	H	1	PK
50.	*Pothos scandens*	H	1	VK
51.	*Remusatia vivipara*	H	1	VK
52.	*Rhaphidophora pertusa*	S	1	VK
	ARALIACEAE			
53.	*Schefflera racemosa*[b]	T	1	MK
54.	*Schefflera venulosa*	S	1	KK
	ARECACEAE			
55.	*Areca catechu*	T	1	KCK
56.	*Arenga wightii*[b]	T	1	PK
57.	*Calamus rotang*	C	1	VK
58.	*Calamus thwaitesii*	C	1	KK
59.	*Caryota urens*	T	1	VK
60.	*Cocos nucifera*	T	1	KCK
61.	*Phoenix humilis*	T	1	MK
62.	*Pinanga dicksonii*[b]	T	1	KK
	ARISTOLOCHIACEAE			
63.	*Thottea siliquosa*	S	1	KK
	ASCLEPIADACEAE			
64.	*Calotropis gigantea*	S	1	KCK
65.	*Ceropegia candelabrum*	H	1	VK
66.	*Gymnema sylvestre*	S	1	KK
67.	*Hoya pauciflora*	C	1	KK,MK
68.	*Hoya wightii*[a]	S	1	PK
69.	*Tylophora asthmatica*	C	1	VK

Plant name with superscript, a = endemic to the southern Western Ghats, b=endemic to the Western Ghats, c=endemic to the Peninsular India.

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Appendix 1 (cont'd). List of angiosperm species recorded in Kammadam Kavu (KK), Karimanal Chamundi Kavu (KCK), Mani Kavu (MK), Poyil Kavu (PK) and Vallikattu Kuvu (VK) of Kerala.

Sl. No.	Species	Habit	Number of SGs of occurrence and acronym of the SGs	
			Number	Acronym of the SGs
	ASTERACEAE			
70.	*Ageratum conyzoides*	H	1	PK
71.	*Chromolaena odorata*	S	1	PK
72.	*Eclibta alba*	H	1	KCK
73.	*Elephantopus scaber*	H	3	KK, PK, VK,
74.	*Emilia sonchifolia*	H	1	VK
75.	*Mikania micrantha*	S	1	PK
76.	*Vernonia arborea*	T	1	KK
77.	*Vernonia cinerea*	H	1	VK
	BALSAMINACEAE			
78.	*Impatiens chinensis*[c]	H	1	KCK
	BIGNONIACEAE			
79.	*Stereospermum colais*	T	1	MK
	BOMBACACEAE			
80.	*Bombax ceiba*	T	1	MK
	BORAGINACEAE			
81.	*Cordia obliqua*	T	1	VK
	CAESALPINIACEAE			
82.	*Acrocarpus fraxinifolius*	T	1	PK
83.	*Bauhinia malabarica*	T	1	KCK
84.	*Bauhinia racemosa*	T	1	MK
85.	*Peltophorum pterocarpum*	T	1	KCK
86.	*Saraca asoca*	T	1	VK
87.	*Tamarindus indica*	T	1	KCK
	CAPPARACEAE			
88.	*Cleome viscosa*	H	1	PK
	CARICACEAE			
89.	*Carica papaya*	H	1	PK
	CELASTRACEAE			
90.	*Celastrus paniculatus*	S	1	KK
91.	*Euonymus crenulatus*[a]	T	1	KK
92.	*Lophopetalum wightianum*	S	2	KK, VK
93.	*Losneriella arnottiana*	T	1	KK
94.	*Microtropis stocksii* [a]	S	1	KK
	CLUSIACEAE			
95.	*Calophyllum inophyllum*	T	1	KK
96.	*Garcinia gummi-gutta*	T	1	VK
97.	*Mesua ferrea*[a]	T	1	KK
	COCHLOSPERMACEAE			
98.	Cochlospermum religiosum	T	1	MK

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Appendix 1 (cont'd). List of angiosperm species recorded in Kammadam Kavu (KK), Karimanal Chamundi Kavu (KCK), Mani Kavu (MK), Poyil Kavu (PK) and Vallikattu Kuvu (VK) of Kerala.

Sl. No.	Species	Habit	Number of SGs of occurrence and acronym of the SGs	
			Number	Acronym of the SGs
	COMBRETACEAE			
99.	*Calycopteris floribunda*	C	4	KK, PK, VK, KCK,
100.	*Terminalia bellerica*	T	3	VK, KCK , MK,
101.	*Terminalia catappa*	T	1	VK
102.	*Terminalia elliptica*	T	2	VK, MK
103.	Terminalia panicualta	T	3	VK, KCK, MK
	COMMELINACEAE			
104.	*Murdannia simplex*	H	2	PK, KCK
	CONNARACEAE			
105.	*Connarus monocarpus*	S	2	KK, VK,
106.	*Connarus paniculatus*	C	2	KK, VK
	CONVOLVULACAE			
107.	*Merremia umbellata*	H	1	VK
108.	*Aniseia martinicensis*	H	1	VK
109.	*Ipomoea mauritiana*	C	2	PK, VK
110.	*Ipomoea obscura*	C	1	PK
111.	*Ipomoea pes-caprae*	H	1	PK
	CORNACEAE			
112.	*Mastixia arborea*[b]	T	1	VK
	CYPERACEAE			
113.	*Hypolytrum nemorum*	H	2	PK, VK
	DATISCACEAE			
114.	Tetrameles nudiflora	T	2	KK, MK
	DICHAPETALACEAE			
115.	*Dichapetalum gelonioides*	S		KK
	DILLENIACEAE			
116.	*Dillenia pentagyna*	T	2	KCK,MK
	DIOSCOREACEAE			
117.	*Dioscorea bulbifera*	S	1	VK
	DIPTEROCARPACEAE			
118.	*Hopea parviflora*[a]	T	2	KK, VK
119.	*Hopea ponga*[b]	T	2	KK, VK,
120.	*Vateria indica*	T	1	VK
	DRACAENACEAE			
121.	*Dracaena terniflora*	S	1	VK
	EBENACEAE			
122.	*Diospyros bourdillonii*[a]	T	2	KK, PK
123.	*Diospyros buxifolia*	T	1	VK
124.	*Diospyros malabarica*	T	1	VK
125.	*Diospyros oocarpa*	T	1	KK

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----Cont'd----

Appendix 1 (cont'd). List of angiosperm species recorded in Kammadam Kavu (KK), Karimanal Chamundi Kavu (KCK), Mani Kavu (MK), Poyil Kavu (PK) and Vallikattu Kuvu (VK) of Kerala.

Sl. No.	Species	Habit	Number of SGs of occurrence and acronym of the SGs	
			Number	Acronym of the SGs
	ELAEAGNACEAE			
126.	*Elaeagnus kologa*	T	1	PK
127.	*Elaeocarpus serratus*	T	1	VK
128.	*Elaeocarpus tuberculatus*	T	1	KK
	ERIOCAULACEAE			
129.	*Eriocaulon sp.*	H	1	VK
130.	*Scleria lithosperma*	H	1	VK
131.	*Ipomoea mauritiana*	C	2	PK, VK
	EUPHOBIACEAE			
132.	*Agrostistachys indica*	T	1	KK
133.	*Antidesma acidum*	T	1	PK
134.	*Antidesma alexiteria*	T	1	VK
135.	*Antidesma montanum*	T	2	PK, VK
136.	*Aporosa lindleyana*	T	3	KK,VK,MK
137.	*Baccaurea courtallensisa*	T	1	KK
138.	*Breynia retusa*	S	1	KCK
139.	*Briedelia retusa*	T	1	KCK
140.	*Briedelia scandens*	S	2	KK, MK
141.	*Cyclostemon confertiflorus*	T	1	KCK
142.	Excoecaria indica	T	1	PK
143.	*Flueggea virosa*	T	1	VK
144.	*Glochidion velutinum*	T	1	KK
145.	*Homonoia riparia*	S	1	KK
146.	*Jatropha curcas*	S	1	KCK
147.	*Macaranga peltata*	T	3	VK, KCK, MK
148.	*Mallotus philippensis*[c]	T	2	KK, MK
149.	*Mallotus tetracoccus*	T	1	MK
150.	*Saurpus androgynus*	S	1	KCK
151.	*Tragia involucrata*	H	1	KCK
	FABACEAE			
152.	*Abrus precatorius*	S	4	KK,PK, VK,KCK
153.	*Butea* monosperma	T	1	KK,
154.	*Clitoria ternatea*	C	1	KCK
155.	*Dalbargia horrida var. horridaa*	S	3	KK, PK, VK
156.	*Dalbergia latifolia*	T	3	KK,KCK,MK
157.	*Derris trifoliata*	S	1	PK
158.	*Desmodium gangeticum*	S	1	KCK
159.	*Mucuna pruriensa*	C	2	PK, VK
160.	*Pithecellobium gracile*	S	1	KCK
161.	*Pongamia pinnata*	T	2	VK,KCK,
162.	*Pterocarpus marsupium*	T	2	KCK, MK
163.	*Vigna sublobata*	C	1	VK
164.	*Zornia gibbosa*	H	1	VK

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Appendix 1 (cont'd). List of angiosperm species recorded in Kammadam Kavu (KK), Karimanal Chamundi Kavu (KCK), Mani Kavu (MK), Poyil Kavu (PK) and Vallikattu Kuvu (VK) of Kerala.

Sl. No.	Species	Habit	Number of SGs of occurrence and acronym of the SGs	
			Number	Acronym of the SGs
	FLACOURTIACEAE			
165.	*Casearia rubescens*	T	1	VK
166.	*Flacourtia indica*	T	2	KK, MK
167.	*Flacourtia montana*[c]	T	1	PK
168.	*Hydnocarpus alpina*	T	2	PK, VK
169.	*Hydnocarpus pentandra*	T	2	KK,KCK,
	FLAGELLARIACEAE			
170.	Flagellaria indica	S	1	PK
	GESNERIACEAE			
	HIPPOCRATEACEAE			
171.	*Salacia reticulata*	S	1	VK
	HYPERICACEAE			
	HYPOXIDACEAE			
172.	*Curculigo orchioides*	H	3	PK, VK, KCK
	ICACINACEAE			
173.	*Gomphandra polymorpha*	T	1	PK
174.	*Gomphandra tetrandra*	T	1	KK
175.	*Sarcostigma kleinii*	S	1	VK
	LAMIACEAE			
176.	*Colebrookea oppositifolia*	S	1	KK
177.	*Leucas aspera*	H	1	KCK
178.	*Leucas eriostoma*[c]	S	1	KCK
179.	*Ocimum sanctum*	S	1	KCK
180.	*Scutellaria discolor*	H	1	KCK
	LAURACEAE			
181.	*Actinodaphne malabarica*[a]	T	1	KK
182.	*Cinnamomum malabatrum*[a]	T	4	KK,PK, VK, MK
183.	*Cinnamomum verum*	T	2	PK, VK
184.	*Litsea bourdillonii*[a]	T	1	KK
185.	*Litsea floribunda*[b]	T	1	PK
186.	*Litsea insignis*[b]	T	1	KK
187.	*Litsea laevigata*[a]	T	1	MK
188.	*Litsea sp.*		1	VK
189.	*Persea macrantha*	T	2	VK,MK
	LECYTHIDACEAE			
190.	*Careya arborea*	T	3	VK, KCK,MK
	LEEACEAE			
191.	*Leea crispa*	S	1	KCK
192.	*Leea indica*	T	2	VK,KCK
193.	*Leea sambucina*	T	1	KK
	LEMNACEAE			
194.	*Wolffia globosa*	H	1	VK

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----Cont'd----

Appendix 1 (cont'd). List of angiosperm species recorded in Kammadam Kavu (KK), Karimanal Chamundi Kavu (KCK), Mani Kavu (MK), Poyil Kavu (PK) and Vallikattu Kuvu (VK) of Kerala.

Sl. No.	Species	Habit	Number of SGs of occurrence and acronym of the SGs	
			Number	Acronym of the SGs
	LENTIBULARIACEAE			
195.	*Utricularia graminifolia*	H	1	VK
	LILIACEAE			
196.	*Asparagus racemosus*	S	1	VK
197.	*Gloriosa superba*	S	2	KK, VK
198.	*Urginea indica*	H	1	VK
	LINACEAE			
199.	*Hugonia mystax*	S	1	VK
	LOGANIACEAE			
200.	*Fagraea ceylanica*	T	2	PK, VK
201.	*Strychnos cimamomea*	S	2	KK, MK
202.	*Strychnos involucra*		1	VK
203.	*Strychnos nux-vomica*	T	2	KCK, MK
204.	*Strychnos vanprukii*	S	1	KK
	LYTHRACEAE			
205.	*Lagerstroemia lanceolata*[b]	T	2	KK, VK
206.	*Lagerstroemia microcarpa*[b]	T	2	KCK, MK,
	MAGNOLIACEAE			
207.	*Michelia champaca*	T	1	VK
	MALPIGHIACEAE			
208.	*Hyptage madablotta*	C	1	PK
	MALVACEAE			
209.	*Abelmoschus moschatus*	S	1	KCK
210.	*Hibiscus hispidissimus*	S	2	PK, VK
211.	*Hibiscus rosa-sinensis*	S	1	KCK
212.	*Sida cordifolia*	H	1	VK
213.	*Sida fryxellii*	S	1	VK
214.	*Sida rhombifolia*	S	1	KCK
215.	*Urena lobata*	S	1	KCK
	MELASTOMATACEAE			
216.	*Melastoma malabathricum*	S	2	PK, VK,
	Memecylon depressum[a]	T	1	KK
217.	*Memecylon edule*[c]	S	3	KK, PK,MK
218.	*Memecylon randerianum*[a]	T	1	VK
219.	*Memecylon umbellatum*	T	2	KK, VK
220.	*Osbeckia leschenaultiana*	S	1	MK
221.	*Sonerila rheedei*[a]	H	1	KCK
	MELIACEAE			
222.	*Aglaia barberi*	T	1	PK
223.	*Aglaia elaeagnoidea*	T	1	VK
224.	*Aglaia lawii*	T	1	KK

Plant name with superscript, a = endemic to the southern Western Ghats, b=endemic to the Western Ghats, c=endemic to the Peninsular India.

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Appendix 1 (cont'd). List of angiosperm species recorded in Kammadam Kavu (KK), Karimanal Chamundi Kavu (KCK), Mani Kavu (MK), Poyil Kavu (PK) and Vallikattu Kuvu (VK) of Kerala.

Sl. No.	Species	Habit	Number of SGs of occurrence and acronym of the SGs	
			Number	Acronym of the SGs
	MELIACEAE			
225.	*Azadirachta indica*	T	2	PK, KCK
226.	*Chukrasia tabularis*	T	1	PK
227.	*Dysoxylum ficiforme*	T	1	PK
228.	*Naregamia alata*[c]	H	2	KK, VK
229.	*Trichilia connaroides*	T	1	PK
	MENISPERMACEAE			
230.	*Anamirta cocculus*	C	2	KK, VK
231.	*Cyclia peltata*	C	3	KK,KCK, MK
232.	*Diploclisia glaucescens*	C	1	VK
233.	*Tiliacora acuminata*	S	1	VK
234.	*Tinospora malabarica*	S	1	VK
	MIMOSACEAE			
235.	*Acacia caesia*	S	2	KK,MK
236.	*Acacia nilotica*	T	1	KCK
237.	*Adenanthera pavonina*	T	2	PK, VK
238.	*Albizia chinensis*	T	1	VK
239.	*Albizia odoratissima*	H	2	PK, MK
240.	*Mimosa pudica*	H	2	PK, KCK
241.	*Xylia xylocarpa*	T	3	VK, KCK, MK
	MORACEAE			
242.	*Antiaris toxicaria*	T	2	KK, VK,
243.	*Artocarpus heterophyllus*	T	1	KCK
244.	*Artocarpus hirsutus*[a]	T	2	VK,MK
245.	*Ficus asperrima*	T	2	PK, KCK
246.	*Ficus beddomei*[b]	T	1	KK
247.	*Ficus callosa*	T	1	MK
248.	*Ficus hispida*	T	2	PK, KCK
249.	*Ficus microcarpa*	T	1	PK
250.	*Ficus nervosa*	T	2	KK, PK
251.	*Ficus religiosa*	T	2	PK, KCK
252.	*Ficus* sp.	T	1	PK
253.	*Ficus tsjahela*	T	2	VK, KCK
254.	*Streblus asper*	T	1	KCK
	MORINGACEAE			
255.	*Moringa oleifera*	T	1	KCK
	MUSACEAE			
256.	*Musa paradisiaca*	H	1	KCK
	MYRISTICACEAE			
257.	*Myristica dactyloides*	T	1	PK
258.	*Knema attenuata*[b]	T	1	KK, VK
259.	*Myristica malabarica*[b]	T	1	KK, VK,

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Appendix 1 (cont'd). List of angiosperm species recorded in Kammadam Kavu (KK), Karimanal Chamundi Kavu (KCK), Mani Kavu (MK), Poyil Kavu (PK) and Vallikattu Kuvu (VK) of Kerala.

Sl. No.	Species	Habit	Number of SGs of occurrence and acronym of the SGs	
			Number	Acronym of the SGs
	MYRSINACEAE			
260.	*Ardisia pauciflora*	T	1	KK
261.	*Ardisia solanacea*	T	1	KK,MK
262.	*Embelia tsjeriam-cottam*	S	1	VK, KCK
263.	*Maesa indica*	T	1	KK, PK
	MYRTACEAE			
264.	*Eugenia bracteata*	T	1	KK
265.	*Euginea mooniana*	T	1	KK
266.	*Syzygium caryophyllatum*	T	1	VK
267.	*Syzygium cumini*	T	1	KCK
268.	*Syzygium hemisphericum*	T	1	KK
269.	*Syzygium travancoricum*[a]	T	1	VK
270.	*Syzygium zeylanicum*	T	1	VK
271.	*Psidium guajava*	T	1	KCK
	NYCTAGINACEAE			
272.	*Boerhaavia diffusa*	H	1	PK
	NYMPHAEACEAE			
273.	*Nymphaea stellata*	H	1	KCK
	OLACACEAE			
274.	*Strombosia ceylanica*	T	1	VK
	OLEACEAE			
275.	*Chionanthus mala-elengi*[c]	T	1	KK
276.	*Jasminum malabaricum*[b]	S	2	PK, VK
277.	*Jasminum multiflorum*	S	1	KCK
278.	*Olea dioica*	T	1	MK
279.	*Olea polygamaa*	T	1	VK
	ORCHIDACEAE			
280.	*Acampe praemorsa*	H	1	VK,
281.	*Aerides crispa*[b]	H	1	VK
282.	*Bulbophyllum aureum*[a]	H	2	KK, MK
283.	*Cottonia peduncularis*	H	1	KK
284.	*Dendrobium haemoglossum*	H	2	KK, PK
285.	*Dendrobium heyneanumc*	H	1	KK
286.	*Dendrobium macrostachyum*	H	1	KK
287.	*Dendrobium ovatumc*	H	1	MK
288.	*Epidendrum tenuifolium*	H	1	KK
289.	*Gastrochilus flabelliformisb*	H	1	KK
290.	*Geodorum densiflorum*	H	1	PK
291.	*Malaxis rheedei*	H	1	KK
292.	*Malaxis versicolor*	H	1	KK
293.	*Nervilia crociformis*	H	1	VK

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Appendix 1 (cont'd). List of angiosperm species recorded in Kammadam Kavu (KK), Karimanal Chamundi Kavu (KCK), Mani Kavu (MK), Poyil Kavu (PK) and Vallikattu Kuvu (VK) of Kerala.

Sl. No.	Species	Habit	Number of SGs of occurrence and acronym of the SGs	
			Number	Acronym of the SGs
	ORCHIDACEAE			
294.	*Nervilia infundibulifolia*	H	1	VK
295.	*Nervilia prainiana*	H	2	KK, KCK
296.	*Oberonia santapauia*	H	1	KK
297.	*Pholidota pallida*	H	1	KK
298.	*Porpax reticulatab*	H	2	KK, VK
299.	*Schoenorchis nivea*	H	1	KK
300.	*Seidenfia rheedei*	H	1	VK
301.	*Zeuxine longilabris*	H	1	KK
	OXALIDACEAE			
302.	*Biophytum sensitivum* var. *candolleanum*	H	2	KK, KCK
303.	*Biophytum sensitivum* var. *sensitivum*	H	1	PK
	PANDANACEAE			
304.	*Pandanus furcatus*	T	1	MK
305.	*Pandanus odoratissimus*	S	1	VK
	PASSIFLORACEAE 1			
306.	*Passiflora foetida*	S	1	KCK
	PERIPLOCACEAE			
307.	*Hemidesmus indicus*	S	2	VK, KCK
	PIPERACEAE			
308.	*Peperomia pellucida*	H	1	KK
309.	*Peperomia tetraphylla*	H	1	MK
310.	*Piper argyrophyllum*	S	1	KK
311.	*Piper hymenophyllum*	S	2	KK,MK
312.	*Piper longum*	S	1	KCK
313.	*Piper nigrum*[a]	S	3	KK, VK, KCK
314.	*Piper wightii*[a]	S	1	KK
	POACEAE			
315.	*Chrysopogon aciculatus*	H	1	PK
316.	*Cynadon dactylon*	H	1	KCK
	RANUNCULACEAE			
317.	*Clematis smilacifolia*	S	2	KK,MK
318.	*Naravelia zeylanica*	S	3	KK, VK, KCK
	RHAMNACEAE			
319.	*Zizyphus oenoplea*	C	1	VK, KCK
320.	*Zizyphus rugosa*	S	3	VK,KCK, MK
	RHIZOPHORACEAE			
321.	*Carallia brachiata*	T	2	PK, VK

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Appendix 1 (cont'd). List of angiosperm species recorded in Kammadam Kavu (KK), Karimanal Chamundi Kavu (KCK), Mani Kavu (MK), Poyil Kavu (PK) and Vallikattu Kuvu (VK) of Kerala.

Sl. No.	Species	Habit	Number of SGs of occurrence and acronym of the SGs	
			Number	Acronym of the SGs
	ROSACEAE			
322.	*Prunus ceylanica*	T	1	KK
323.	*Rosa damascene*	S	1	KCK
	RUBIACEAE			
324.	*Anthocephalus cadamba*	T	1	KCK
325.	*Benkara malabarica*	T	1	PK
326.	*Canthium* angustifolium	S	1	PK
327.	*Canthium dicoccum*	T	1	KCK
328.	*Canthium rheedei*[c]	T	1	KK
329.	*Catunaregam spinosa*	T	1	VK
330.	*Geophila reniformis*	H	1	KK
331.	Geophila repens	H	3	PK, VK, KCK
332.	*Haldina cordifolia*	T	1	KCK
333.	*Hedyotis auricularia*	H	2	PK, VK
334.	*Ixora brachiata*[b]	T	1	KK
335.	*Ixora coccinea*	S	1	KCK
336.	*Ixora elongata*[b]	S	1	KK
337.	*Ixora nigricans*	T	2	KK, VK
338.	*Ixora parviflora*	T	1	KCK
339.	*Lasianthus dichotomous*	S	1	KK
340.	*Mitragyna parviflora*	T	1	KCK
341.	*Mussaenda bellila*	S	1	KCK
342.	*Mussaenda frondosa*	S	1	VK
343.	*Oldenlandia auricularia*	H	1	KCK
344.	*Ophiorrhiza hirsutula*	S	1	KCK
345.	*Pavetta indica*	T	2	VK, KCK,
346.	*Pavetta tomentosa*	T	1	KCK
347.	*Pavetta zeylanica*	S	2	KK, VK
348.	*Psychotria anamalayana*[a]	T	1	KK
349.	*Psychotria macrocarpa*[a]	S	1	VK
350.	*Psychotria truncata*[b]	T	1	KK
351.	*Randia sp.*	R	1	VK
352.	*Saprosma glomerata*[b]	S	1	KK
353.	*Spermacoce pusilla*	H	1	KCK
	RUTACEAE			
354.	*Acronychia pedunculata*	T	1	VK
355.	*Aegle marmelos*	T	1	KCK
356.	*Atalantia racemosa*	T	2	KK,MK
357.	*Atalantia wightii*	T	2	PK, KCK

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Appendix 1 (cont'd). List of angiosperm species recorded in Kammadam Kavu (KK), Karimanal Chamundi Kavu (KCK), Mani Kavu (MK), Poyil Kavu (PK) and Vallikattu Kuvu (VK) of Kerala.

Sl. No.	Species	Habit	Number of SGs of occurrence and acronym of the SGs	
			Number	Acronym of the SGs
	RUTACEAE			
358.	*Citrus medica*	T	1	KCK
359.	*Glycosmis arborea*	T	1	KCK
360.	*Glycosmis pentaphylla*	T	2	KK, KCK
361.	*Murraya paniculata*	T	2	KK, MK
362.	*Naringi crenulata*	T	1	VK
	RUTACEAE			
363.	*Toddalia asiatica*	C	2	VK, MK
364.	*Zanthoxylum ovalifolium*	T	1	KCK
365.	*Zanthoxylum rhetsa*	T	1	VK
	SANTALACEAE			
366.	*Scleropyrum pentandrum*	T	2	KK, KCK
	SAPINDACEAE			
367.	*Allophyllus cobbe*	T	1	VK
368.	*Cardiospermum halicacabum*	H	1	KCK
369.	*Filicium decipiens*	T	1	PK
370.	*Harpullia arborea*	T	1	PK
371.	*Lepisanthes umblellatus*	T	1	KK
372.	*Sapindus laurifolius*	T	1	KCK
373.	*Sapindus trifoliata*	T	1	MK
374.	*Schleichera oleosa*	T	3	KK, KCK,MK
	SAPOTACEAE			
375.	*Madhuca longifolia*	T	1	VK
376.	*Madhuca neriifolia*	T	1	VK
377.	*Mimusops elengi*	T	2	PK, VK
	SIMAROUBACEAE			
378.	*Quassia indica*	T	1	VK
	SMILACACEAE			
379.	*Smilax wightii*	S	1	KK
380.	*Smilax zeyalnica*	C	2	KK, MK
	SOLANACEAE			
381.	*Capsicum frutescens*	H	1	KCK
382.	*Solanum nigram*	H	1	KCK
383.	*Solanum torvum*	S	1	KCK
	STAPHYLACEAE			
384.	*Turpinia malabarica*	T	1	KK
	STERCULIACEAE			
385.	*Helictres isora*	T	2	VK, KCK
386.	*Pterospermum reticulatum*[a]	T	3	KK, VK, KCK
387.	*Sterculia guttata*	T	3	KK, VK, KCK

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Appendix 1 (cont'd). List of angiosperm species recorded in Kammadam Kavu (KK), Karimanal Chamundi Kavu (KCK), Mani Kavu (MK), Poyil Kavu (PK) and Vallikattu Kuvu (VK) of Kerala.

Sl. No.	Species	Habit	Number of SGs of occurrence and acronym of the SGs	
			Number	Acronym of the SGs
	SYMPLOCACEAE			
388.	*Symplocos racemosa* var *racemosa*	T	1	KK
	TILIACEAE			
389.	*Grewia tiliifolia*	T	3	VK, KCK, MK
390.	*Grewia umbellifera*[b]	C	1	MK
391.	*Grewia microcos*	T	1	PK
392.	*Grewia nervosa*	T	1	VK
	ULMACEAE			
393.	*Holoptelea integrifolia*	T	1	MK
	URTICACEAE			
394.	*Elatostema lineolatum*	S	1	KK
395.	*Pellionia heyneana*	H	1	KK
	VERBANECEAE			
396.	*Premna latifolia*	T	1	VK
397.	*Callicarpa tomentosa*	T	2	KK, VK
398.	*Clerodendrum paniculatum*	S	1	KCK
399.	*Clerodendrum viscosum*	T	2	PK, MK
400.	*Lantana camara*	S	1	MK
401.	*Premna tomentosa*	T	1	VK
402.	*Tectona grandis*	T	1	KCK
403.	*Vitex altissima*	T	1	VK
404.	*Vitex trifolia var.subtrisecta*	S	1	VK
405.	*Duranta repens*	S	1	KCK
	VIOLACEAE			
406.	*Hybanthus enneaspermus*	H	1	VK
	VITACEAE			
407.	*Cayratia trifolia*	C	2	KK, VK
408.	*Cissus arnottiana*	S	1	KK
409.	*Cissus heyneana*	S	1	PK
410.	*Cissus latifolia*	S	1	KK
411.	*Cissus trilobata*	S	2	PK, VK
	XANTHOPHYLLACEAE			
412.	*Xanthophyllum arnottianum*	T	1	KK
	ZINGIBERACEAE			
413.	*Amomum pterocarpum*	H	2	KK,MK
414.	*Curcuma amada*	H	2	PK, KCK
415.	*Curcuma caesia*	H	1	KK
416.	*Curcuma neilgherrensis*[b]	H	2	PK, KCK
417.	*Curcuma oligantha*	H	2	PK, VK
418.	*Curcuma oligantha var. lutea*[a]	H	1	VK

Plant name with superscript, a = endemic to the southern Western Ghats, b=endemic to the Western Ghats, c=endemic to the Peninsular India.

Appendix 2. List of butterfly species recorded recorded in Kammadam Kavu (KK), Karimanal Chamundi Kavu (KCK), Mani Kavu (MK), Poyil Kavu (PK) and Vallikattu Kuvu (VK) of Kerala.

Sl. No.	Species	Common Name	Number of SGs of occurrence and acronym of the SGs	
			Number	Acronym of the SGs
	Family: Hesperiidae			
1.	*Ampittia discorides*	Bush Hopper	4	KK, VK,KCK,MK
2.	*Badamia exclamationis*	Brown Awl	2	KK, PK
3.	*Baracus vittatus*	Hedge Hopper	2	PK,VK,
4.	*Bibasis sena sena*	Orange Tail Awl	2	*PK, MK*
5.	*Borbo cinnara*	Rice Swift	4	KK, PK, VK, MK
6.	*Caprona procris*	Commander	1	VK
7.	*Celaenorrhinus ambareesa*	Malabar Spotted Flat	2	KK, KCK
8.	*Celaenorrhinus leucocera*	Common Spotted Flat	5	KK, PK,VK, KCK, ,MK
9.	*Gangara thyrsis thyrsis*	Giant Red Eye	4	KK, PK,VK,KCK
10.	*Hasora badra*	Common Awl	4	KK, PK,VK, MK
11.	*Hasora chromus*	Common Banded Awl	4	KK,PK,VK, KCK,
12.	*Hasora taminatus*	White banded Awl	1	VK
13.	*Hasora taminatus*	White Banded Awl	4	KK,PK,VK, MK
14.	*Hasora vitta*	Plain Banded Awl	1	VK
15.	*Lambrix salsula*	Chestnut Bob	4	KK, PK,VK, MK
16.	*Notocrypta curvifascia curvifascia*	Restricted Demon	4	KK,PK,VK,MK
17.	*Pelopidas Inathias*	Small Branded Swift	5	KK, PK,VK, VK,MK
18.	*Psedocoladenia dan*	Fulvous Pied Flat	4	KK, PK,VK, MK
19.	*Psolos fuligo subfasciatus*	Coon	5	KK,PK,VK,KCK, MK
20.	*Sarangesa dasahara*	Common Small Flat	3	PK,VK, MK
21.	*Sarangesa purendra pandra* *	Spotted Small Flat	4	PK,VK, KCK, MK
22.	*Spialia galba*	Indian Grizzled Skipper	3	PK,VK,MK
23.	*Suastus gremius*	Indian Palm Bob	2	KK,KCK
24.	*Tagiades gana silvia*	Immaculate Snow Flat	4	KK, VK,KCK, MK
25.	*Tagiades litigiosa*	Water Snow Flat	5	KK,PK,VK, KCK, MK
26.	*Taractrocera maevius sagara*	Common Grass Dart	3	KK, PK, VK
27.	*Telicota ancilla bambusae*	Dark Palm Dart	4	KK,PK, KCK, MK

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Appendix 2 (con'd). List of butterfly species recorded recorded in Kammadam Kavu (KK), Karimanal Chamundi Kavu (KCK), Mani Kavu (MK), Poyil Kavu (PK) and Vallikattu Kuvu (VK) of Kerala.

Sl. No.	Species	Common Name	Number of SGs of occurrence and acronym of the SGs	
			Number	Acronym of the SGs
	Family: Lycaenidae			
28.	*Abisara echerius prunosa*	Plum Judy	5	KK, ,PK,VK, KCK, MK,
29.	*Actolepis puspa felderi*	Common Hedge Blue	5	KK,PK,VK,KCK, MK
30.	*Arhopala atrax*	Indian Oakblue	2	PK,VK
31.	*Arhopala pseudocentaurus*	Western Centaur Oak Blue	1	PK
32.	*Bindahara phocides*	The Plane	2	PK,VK
33.	*Caleta caleta desidia*	Angled Pierrot	5	KK, PK,VK,KCK,MK
34.	*Castalius rosimon*	Common Pierrot	3	KK, VK, MK
35.	*Catochrysops Strabo*	Forget-Me-Not	1	VK
36.	*Cheritra freja*	Common Imperial	3	KK, VK,MK
37.	*Curetis thetis*	Indian Sunbeam	3	KK,VK, KCK
38.	*Discolampa ethion vavasanus*	Banded Blue Pierrot	4	KK,PK,VK,KCK
39.	*Euchrysops cnejus*	Gram Blue	4	KK, VK, KCK, MK
40.	*Freyeria trochylus*	Grass Jewel	2	PK,VK
41.	*Iraota timoleon*	Silver Streak Blue	4	PK,VK, KCK,MK
42.	*Jamides alecto*	Metallic Cerulean	1	VK
43.	*Jamides bochus*	Dark Cerulean	2	PK, MK
44.	*Jamides celeno aelianus*	Common Caerulean	5	KK, PK,VK, KCK,MK
45.	*Lampides boeticus*	Pea Blue	5	KK,PK,VK,KCK, MK
46.	*Leptotes plinius*	Zebra Blue	5	KK,PK,VK, KCK, MK
47.	*Loxura atymnus*	Yamfly	3	KK, VK, MK
48.	*Neopithecosps zalmora dharma*	Quaker	4	KK, VK,KCK, MK
49.	*Prosotas nora*	Common Line Blue	4	KK,PK,VK,MK
50.	*Pseudozizeeria maha ossa*	Pale Grass Blue	5	KK, PK,VK, KCK, MK
51.	*Rapala manea schistacea*	Slate Flash	5	KK, PK,VK ,KCK,MK
52.	*Rathinda amor*	Monkey Puzzle	4	PK,VK,KCK, MK
53.	*Spalgis epius epius*	Apefly	3	PK,VK,MK
	Spindasis vulcanus	Common Silver Line	3	PK,VK, MK
54.	*Spindasis lohita lazularia*	Long Banded Silver Line	1	MK
55.	*Tajuria cippus*	Peacock Royal	3	KK,VK, MK
56.	*Talicada nyseus*	Red Pierrot	5	KK,PK,VK, KCK, MK
57.	*Thaduka multicaudata*	Many Tailed Oak Blue	2	KCK, MK
58.	*Zesius chrysomallus*	Red Spot	3	KK, VK, MK

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Appendix 2 (con'd). List of butterfly species recorded recorded in Kammadam Kavu (KK), Karimanal Chamundi Kavu (KCK), Mani Kavu (MK), Poyil Kavu (PK) and Vallikattu Kuvu (VK) of Kerala.

Sl. No.	Species	Common Name	Number of SGs of occurrence and acronym of the SGs	
			Number	Acronym of the SGs
	Family: Nymphalidae			
59.	*Acraea Violae*	Tawny Coster	5	KK,PK,VK,KCK, MK
60.	*Ariadne ariadne indica*	Indian Angled Castor	5	KK, PK,VK, KCK, MK
61.	*Ariadne merione*	Common Castor	1	VK
62.	*Athyma perius*	Common Sergeant	4	KK,VK,KCK, MK
63.	*Athyma ranga karwara*	Blackvein Sergeant	3	KK,VK, KCK
64.	*Byblia ilithyia*	Spoted joker	2	PK,VK
65.	*Charaxes dolon*	Black Rajah	4	KK,PK,VK, MK
66.	*Cirrochora thais*	Tamil yeoman	4	KK, PK,KCK, MK
67.	*Cupha erymanthis*	Rustic	4	KK,PK,VK,MK
68.	*Cynthia cardui*	Painted Lady	5	KK,PK,VK, KCK, MK
69.	*Danaus chrysippus*	Plain Tiger	3	KK,VK,MK
70.	*Danaus genutia*	Common tiger	5	KK,PK,VK,KCK,MK
71.	*Dophla evelina laudabilis*	Redspot Duke	4	KK, PK,KCK,MK
72.	*Elymnias hypermnestra caudata*	Common Palmfly	4	KK,VK, KCK,MK
73.	*Euploea core*	Common Crow	5	KK,PK,VK,KCK, MK
74.	*Euploea klugii*	Brown King Crow	4	KK,PK, KCK,MK
75.	*Euploea sylvester coreta*	Double Branded Crow	1	PK
76.	*Euthalia aconthea meridionalis*	Baron	2	PK, KCK
77.	*Euthalia lubentina*	Gaudy Baron	2	PK,VK
78.	*Euthalia lubentina arasada*	Gaudy Baron	3	KK, VK,MK
79.	*Hypolimnas bolina*	Great Eggfly	5	KK, PK,VK,KCK,MK
80.	*Hypolimnas misippus*	Danaid Eggfly	4	KK,PK,VK, KCK,
81.	*Junonia atlites*	Gray Pansy	4	KK, PK,VK, KCK
82.	*Hypolimnas septentrionis*	Dark Blue Tiger	1	VK
83.	*Idea malabarica**	Malabar Tree Nymph	3	KK, KCK, MK
84.	*Junonia almana*	Peacock Pansy	4	KK,VK,KCK,MK
85.	*Junonia hierta*	Yellow Pansy	4	KK,PK, VK, KCK,
86.	*Junonia iphita pluvia*	Chocolate Pansy	3	KK,VK, MK
87.	*Junonia lemonias*	Lemon Pansy	5	KK, PK,VK, KCK,MK
88.	*Junonia orithya*	Blue Pansy	4	KK,PK,VK,MK
89.	*Kaniska canace*	Blue Admiral	1	PK, VK
90.	*Lethe europa ragalva*	Bamboo Tree Brown	3	PK,KCK,MK

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Appendix 2 (con'd). List of butterfly species recorded recorded in Kammadam Kavu (KK), Karimanal Chamundi Kavu (KCK), Mani Kavu (MK), Poyil Kavu (PK) and Vallikattu Kuvu (VK) of Kerala.

Sl. No.	Species	Common Name	Number of SGs of occurrence and acronym of the SGs	
			Number	Acronym of the SGs
	Family: Nymphalidae			
91.	*Libythea lepita lepitoides*	Common Beak	2	PK,MK
92.	*Limenitis procris undifragus*	Commander	5	KK ,PK, VK, KCK,MK
93.	*Melanitits leda leda*	Common Evening Brown	4	PK,VK,KCK, MK,
94.	*Mycalesis mineus polydecta*	Dark-Brand Bush Brown	4	KK PK,VK,MK
95.	*Mycalesis patnia junonia*	Glad Eye Bush Brown	5	KK, PK,VK, KCK,MK
96.	*Mycalesis perseus typhlus*	Common Bush Brown	3	KK,PK,VK
97.	*Neptis hylas varmona*	Common Sailer	5	KK PK,VK, KCK,MK
98.	*Neptis jumbah*	Chestnut Streaked Sailer	3	VK, KCK, MK,
99.	*Orsotrioena medus mandata*	Nigger	5	KK, PK,VK, KCK, MK
100.	*Pantoporia hardonia*	Common Lascar	4	KK, VK, KCK,MK
101.	*Parantica aglea aglea*	Glassy Blue Tiger	4	KK, VK, KCK, MK
102.	*Parthenos sylvia*	Clipper	4	KK,PK,VK,MK
103.	*Phalanta phalantha*	Leopard Butterfly	5	KK, PK,VK,KCK,MK
104.	*Polyura athamas*	Common Nawab	4	KK, VK, KCK,MK
105.	*Tanaecia lepidea miyana*	Grey Count	3	KK,VK,MK
106.	*Tirumala limniace exoticus*	Blue Tiger	3	KK, VK,MK
107.	*Tirumala septentrionis*	Dark Blue Tiger	3	KK, KCK, MK
108.	*Vindula erota*	Cruiser	2	KK,*VK*
109.	*Ypthima baldus*	Common Five Ring	5	KK,*PK,VK*, KCK,MK,
110.	*Ypthima ceylonica*	Ceylon Four Ring	2	KK,KCK
111.	*Ypthima huhebneri*	Common Four Ring	5	KK,PK,VK, KCK,MK
112.	*Zipoetis satis*	Tamil Catseye	4	KK,PK,VK, KCK
	Family: Papilionidae			
113.	*Anapheis aurota*	Caper White	4	KK, VK, KCK, MK
114.	*Appias indra*	Plain Puffin	2	PK,VK
115.	*Appias lyncida latifasciata*	Common Albatross	4	KK, PK, KCK,MK,
116.	*Catopsilia pomona*	Lemon Emigrant	5	KK,PK,VK, KCK, MK
117.	*Catopsilia pyranthe*	Mottled Emigrant	2	VK, MK,
118.	*Cepora nerissa phryne*	Common Gull	4	KK,VK,KCK, MK

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Appendix 2 (con'd). List of butterfly species recorded recorded in Kammadam Kavu (KK), Karimanal Chamundi Kavu (KCK), Mani Kavu (MK), Poyil Kavu (PK) and Vallikattu Kuvu (VK) of Kerala.

Sl. No.	Species	Common Name	Number of SGs of occurrence and acronym of the SGs	
			Number	Acronym of the SGs
	Family: Papilionidae			
119.	*Delias eucharis*	Common Jezebel	4	KK, VK, KCK, MK
120.	*Eurema hecabe simulata*	Common Grass Yellow	4	PK,VK, KCK,MK
121.	*Eurema blanda silhetana*	Three Spot Grass Yellow	4	KK,PK,VK,MK
122.	*Eurema brigitta rubella*	Small Yellow	3	KK,*VK*, MK
123.	*Eurema hecabe*	Common Grass Yellow	1	*PK*
124.	*Eurema laeta*	Spotless Grass Yellow	1	*VK*
125.	*Graphium agamemnon menides*	Tailed Jay	5	KK,PK,VK,KCK,MK
126.	*Graphium antiphates*	Five bar swordtail	1	PK
127.	*Graphium doson*	Common Jay	4	KK,PK, KCK,MK
128.	*Graphium sarpedon teredon*	Common Blue bottle	4	KK,VK, KCK,MK
129.	*Hebomoia glaucippe australis*	Giant Orange Tip	5	KK, PK,VK, KCK,MK,
130.	*Leptosia nina*	Psyche	4	KK,VK,KCK,MK,
131.	*Pachliopta aristolochiae*	Common Rose	4	KK, PK,VK,MK
132.	*Pachliopta hector*	Crimson Rose	5	KK, PK,VK, KCK,MK
133.	*Pachliopta pandiyana* *	Malabar Rose	2	PK,VK
134.	*Papilio buddha*	Buddha Peacock	3	KK, VK,MK
135.	*Papilio clytia*	Common Mime	3	KK, VK, MK,
136.	*Papilio demoleus*	Lime butterfly	4	KK, PK,VK, MK
137.	*Papilio dravidarum*	Malabar raven	4	KK, PK,VK, MK
138.	*Papilio helenus*	Red Helen	3	KK,PK,MK
139.	*Papilio liomedon*	Malabar Banded Swallowtail	4	KK, PK, VK, MK
140.	*Papilio paris tamilana*	Paris Peacock	5	KK, PK,VK,KCK,MK
141.	*Papilio polymnestor*	Blue Mormon	4	KK,PK, KCK, MK
142.	*Papilio polytes*	Common Mormon	5	KK, PK,VK, KCK,MK
143.	*Parenonia valeria*	Common Wanderer	4	KK, PK,VK, MK
144.	*Prioneris sita*	Painted Sawtooth	5	KK, PK,VK, KCK, MK
145.	*Troides minos**	Southern Birdwing	5	KK,PK,VK,KCK,MK
146.	*Zipoetis satis*	Tamil Catseye	4	KK,PK,VK, KCK
147.	*Troides minos**	Southern Birdwing	5	KK,PK,VK,KCK,MK
148.	*Pachliopta pandiyana* *	Malabar Rose	2	PK,VK
149.	*Idea malabarica**	Malabar Tree Nymph	3	KK, KCK, MK
150.	*Sarangesa purendra pandra* *	Spotted Small Flat	4	PK,VK, KCK, MK

Appendix 3. List of bird species recorded recorded in Kammadam Kavu (KK), Karimanal Chamundi Kavu (KCK), Mani Kavu (MK), Poyil Kavu (PK) and Vallikattu Kuvu (VK) of Kerala.

Sl. No.	Species	Common Name	Number of SGs of occurrence and acronym of the SGs	
			Number	Acronym of the SGs
1.	*Accipiter badius*	Shikra	3	KK , MK, VK
2.	*Acridotheres fuscus*	Jungle Myna	4	KK, KCK,MK ,VK
3.	*Acridotheres tristis*	Common Myna	5	KK, KCK, MK, PK,VK
4.	*Alcedo athis*	Small Blue Kingfisher	2	KK, VK
5.	*Anthus rufulus*	Paddyfield Pipit	4	KCK, MK, PK,VK
6.	Ardeola grayii	Indian Pond Heron	3	KK, PK,VK
7.	*Bubulcus ibis*	Cattle Egret	5	KK, KCK, MK, PK,VK
8.	*Butorides striatus*	Little Green Heron	2	KK, MK
9.	*Cacomantis sonneratii*	Banded Bay Cuckoo	2	KK, KCK
10.	*Caprimulgus asiaticus*	Common Indian Nightjar	3	KK, MK,VK
11.	*Caprimulgus indicus*	Indian Jungle Nightjar	2	KK,VK
12.	*Casmerodius albus*	Large Egret	2	MK, VK
13.	*Chalcophaps indica*	Emerald Dove	5	KK, KCK, MK, PK,VK
14.	*Chloropsis cochinchinensis*	Blue-winged leafbird	1	MK
15.	*Columba elphinstonii*	Nilgiri Wood Pigeon *(E)*	1	KK
16.	*Copsychus saularis*	Oriental Magpie Robin	4	KK, MK, PK, VK
17.	*Copsychus malabaricus*	White-Rumped Shama	1	KK
18.	*Coracina melanoptera*	Black-headed Cuckoo-Shrike	2	KK,VK
19.	*Corvus macrorhynchos*	Jungle Crow	4	KK, KCK,MK, VK
20.	*Corvus splendens*	House Crow	3	MK, PK,VK
21.	*Cuculus micropterus*	Indian Cuckoo	3	KK, MK ,VK
22.	*Culicicapa ceylonensis*	Grey-headed Flycatcher	4	KK, MK , PK,VK
23.	*Cyornis rubeculoides*	Blue-throated Flycatcher	4	KK, KCK, MK, VK
24.	*Cyornis tickelliae*	Tickell's Blue Flycatcher	4	KK, KCK, MK, VK
25.	*Dendronanthus indicus*	Forest Wagtail	4	KK, KCK, PK, VK
26.	*Dendrocitta vagabunda*	Indian Treepie	5	KK, KCK,MK, PK, VK
27.	Dendrocitta vagabunda	Rufous treepie	2	VK, KCK
28.	*Dendrocopos mahrattensis*	Yellow -Fronted Pied Woodpecker	4	KK, MK, PK, VK
29.	*Dendrocopos nanus*	Brown-capped Pygmy Woodpecker	2	KK, VK
30.	*Dicaeum agile*	Thick-billed Flowerpecker	1	KK
31.	*Dicaeum concolor*	Plain Flowerpecker	3	KK, KCK,VK
32.	*Dicaeum erythrorynchos*	Tickell's Flowerpecker	2	KK,VK
33.	Dicrurus caerulescens	White bellied drongo	1	PK
34.	*Dicrurus leucophaeus*	Ashy Drongo	3	KK, MK , VK
35.	*Dicrurus paradiseus*	Greater Racket-tailed Drongo	3	KK,VK, MK
36.	*Dicrurus paradiseus*	Racket-tailed drongo	5	KK, KCK,MK, PK, VK

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Appendix 3 (cont'd). List of bird species recorded recorded in Kammadam Kavu (KK), Karimanal Chamundi Kavu (KCK), Mani Kavu (MK), Poyil Kavu (PK) and Vallikattu Kuvu (VK) of Kerala.

Sl. No.	Species	Common Name	Number of SGs of occurrence and acronym of the SGs	
			Number	Acronym of the SGs
37.	*Dinopium benghalense*	Black-rumped woodpecker	3	KK, MK, PK
38.	*Dinopium benghalense*	Lesser Golden-backed Woodpecker	3	KK, MK ,VK
39.	*Dinopium javanense*	Common Golden-backed Woodpecker	4	KK, KCK, PK, VK
40.	*Ducula aenea*	Green Imperial-Pigeon	1	VK
41.	*Egretta garzetta*	Little Egret	2	KK, MK
42.	*Eudynamys scolopacea*	Asian Koel	2	KK,VK
43.	*Eumyias albicaudata*	Nilgiri Flycatcher (E)	3	KK, MK ,VK
44.	*Ficedula nigrorufa*	Black-and-Orange Flycatcher (E)	4	KK, MK ,PK,VK
45.	*Gallus sonneratii*	Grey Junglefowl	4	KK, KCK , PK,VK
46.	*Garrulax delesserti*	Wynaad Laughingthrush *(E)*	4	KK, MK, PK,VK
47.	*Gracula religiosa*	Southern Hill-Myna	4	KK, KCK,MK, VK
48.	*Halcyon smyrnensis*	White-breasted Kingfisher	3	KK,VK,PK
49.	*Haliastur indus*	Brahminy Kite	5	KK, KCK, MK, PK,VK
50.	*Hemicircus canente*	Heart spotted woodpecker	4	KK, KCK, MK ,VK
51.	*Hierococcyx varius*	Common hawk cuckoo	1	MK
52.	*Hirundo rustica*	Common Swallow	1	VK
53.	*Hypothymis azurea*	Black-naped Monarch Flycatcher	2	PK,VK
54.	*Hypsipetes leucocephalus*	Black Bulbul	2	VK,MK
55.	*Iole indica*	Yellow-browed Bulbul	1	MK
56.	*Lonchura kelaarti*	Blach -Throated Munia	4	KK, KCK , PK,VK
57.	*Lonchura mlacca*	Balck-headed Munia	3	KK,PK,VK
58.	*Lonchura striata*	White-rumped Munia	2	MK,VK
59.	*Luscinia brunnea*	Indian Blue Robin	3	KK, KCK, MK
60.	*Megalaima haemacephala*	Crimson breasted barbet	2	KK,VK
61.	*Megalaima viridis*	White cheeked barbet	3	KK, MK ,VK
62.	*Megalaima zeylanica*	Brown-headed Barbet	1	VK
63.	*Merops leschenaulti*	Chestnut-headed Bee-eater	3	KK, KCK , PK
64.	*Merops orientalis*	Small Bee-eater	2	KK, KCK
65.	*Merops philippinus*	Blue-tailed Bee-eater	2	KK,VK
66.	*Monticola solitarius*	Blue Rock Thrush	1	KK
67.	*Motacilla cinerea*	Grey Wagtail	2	KK,VK
68.	*Muscicapa dauurica*	Asian Brown Flycatcher	2	PK,VK
69.	*Muscicapa muttui*	Brown-breasted Flycatcher	2	PK, MK

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Appendix 3 (cont'd). List of bird species recorded recorded in Kammadam Kavu (KK), Karimanal Chamundi Kavu (KCK), Mani Kavu (MK), Poyil Kavu (PK) and Vallikattu Kuvu (VK) of Kerala.

Sl.	Species	Common Name	Number of SGs of occurrence and

No.			acronym of the SGs	
			Number	Acronym of the SGs
70.	*Muscicapa ruficauda*	Rusty-tailed Flycatcher	1	MK
71.	*Myophonus horsfieldii*	Malabar Whistling Thrush	5	KK, KCK,MK, PK,VK
72.	*Nectarinia asiatica*	Purple Sunbird	2	KK, PK
73.	*Nectarinia lotenia*	Loten's Sunbird	1	VK
74.	*Nectarinia minima*	Small Sunbird (E)	3	KK, KCK, MK
75.	*Nectarinia zeylonica*	Purple-rumped Sunbird	3	KK, MK ,VK,
76.	*Nycticorax nycticorax*	Black-crowned Night Heron	1	KK
77.	*Nyctyornis athertoni*	Blue-bearded Bee-eater	2	KK, VK
78.	*Ocyceros griseus*	Malabar Grey Hornbill (E)	5	KK, KCK,MK,PK, VK
79.	*Oriolus oriolus*	Eurasian Golden Oriole	5	KK, KCK,MK,PK, VK
80.	*Orthotomus sutorius*	Common Tailorbird	5	KK, KCK,MK,PK, VK
81.	*Pericrocotus cinnamomeus*	Small Minivet	3	KK, MK ,VK
82.	*Pericrocotus flammeus*	Scarlet Minivet	3	KK, MK ,VK
83.	Phaenicophaeus viridirostris	Blue-faced malkoha	2	KK, KCK
84.	*Phaenicophaeus viridirostris*	Small Green-billed Malkoha	2	KK, MK
85.	*Phalacrocorax carbo*	Great Cormorant	3	KK,PK,VK
86.	*Phalacrocorax niger*	Little Cormorant	3	KK, MK, PK
87.	*Phylloscopus affinis*	Tickell's Leaf Warbler	2	KK,KCK
88.	*Picus chlorolophus*	Small Yellow-naped Woodpecker	3	KK, MK ,VK
89.	*Pitta brachyura*	Indian Pitta	3	KK, MK ,VK
90.	*Psittacula columboides*	Blue-winged Parakeet (E)	2	KK,VK
91.	*Psittacula cyanocephala*	Plum-headed Parakeet	2	KK,VK
92.	*Pycnonotus cafer*	Red-vented Bulbul	3	KK ,MK,VK
93.	*Pycnonotus melanicterus*	Black-crested Bulbul	1	KCK
94.	*Pycnonotus priocephalus*	Grey-headed Bulbul (E)	3	KK, MK ,VK
95.	*Rhopocichla atriceps*	Black-headed Babbler	1	KK
96.	*Spilornis cheela*	Crested Serpent Eagle	4	KK, MK ,PK, VK
97.	*Streptopelia chinensis*	Spotted Dove	3	KK, KCK ,VK
98.	*Surniculus lugubris*	Drongo Cuckoo	1	KK
99.	*Terpsiphone paradisi*	Asian Paradise Flycatcher	3	KK, MK ,VK
100.	*Turdoides affinis*	White-headed Babbler	1	KK
101.	*Turdoides affinis*	Yellowbilled babbler	1	MK
102.	*Turdoides striatus*	Jungle Babbler	3	KK, MK ,VK,
103.	*Turdoides subrufus*	Indian Rufous Babbler	2	KK,VK
104.	*Zoonavena sylvatica*	White-rumped Needletail-Swift	1	VK
105.	*Zoothera citrina citrina*	Orange-headed Thrush	1	KK
106.	*Zoothera citrina cyanotus*	White-throated Ground Thrush	3	KK, KCK,MK

Appendix 4. Stand density, frequency, basal area and Importance value index (IVI) of tree community (gbh ≥10.1cm) recorded in Kammadam Kavu

Sl no	**Plant Name**	**Density (Individual /ha)**	**Frequency (%)**	**Basal area (cm^2/ha)**	**IVI**

1	*Acronychia pedunculata*	3	3	211	0.35
2	*Aegle marmelos*	3	3	72	0.33
3	*Aglaia apiocarpa*	1	1	26	0.17
4	*Aglaia lawii*	14	9	1670	1.57
5	*Agrostistachys indica*	14	13	435	1.73
6	*Albizia amara*	1	1	2231	0.50
7	*Albizia lebbeck*	1	1	8	0.16
8	*Alstonia scholaris*	17	16	1339	2.19
9	*Antiaris toxicaria*	69	35	8542	6.88
10	*Antidesma montanum*	5	5	108	0.66
11	*Aphanamixis polystachya*	14	14	896	1.91
12	*Artocarpus heterophyllus*	3	1	201	0.24
13	*Artocarpus hirsutus*	47	27	4102	4.72
14	*Briedelia retusa*	4	4	132	0.50
15	*Carallia brachiata*	12	10	10673	2.96
16	*Caryota urens*	3	3	2598	0.72
17	*Chrysophyllum cainito*	5	5	93	0.66
18	*Chukrasia tabularis*	8	8	140	0.99
19	*Cinnamomum malabatrum*	91	58	41456	14.73
20	*Cinnamomum riparium*	21	16	1079	2.29
21	*Cinnamomum verum*	43	35	1226	4.83
22	*Citrus sp*	22	14	435	2.12
23	*Croton persimilis*	3	3	23	0.33
24	*Dalbergia latifolia*	8	8	465	1.04
25	*Diospyros assimilis*	18	14	514	1.99
26	*Diospyros buxifolia*	9	8	2345	1.37
27	*Diospyros sylvatica*	18	13	365	1.86
28	*Ficus beddomei*	1	1	58	0.17
29	*Grewia tiliifolia*	19	16	704	2.18
30	*Heritiera papilio*	1	1	61	0.17
31	*Hevea braziliensis*	5	5	74	0.66
32	*Holigarna arnottiana*	71	39	28745	10.38
33	*Hopea parviflora*	26	18	22735	5.99
34	*Hopea ponga*	8	6	14936	3.12
35	*Hydnocarpus pentandra*	149	62	23123	14.41
36	*Ixora brachiata*	104	52	5774	9.21
37	*Ixora nigricans*	26	21	3122	3.24
38	*Knema attenuata*	422	88	54655	31.37
39	*Lagerstroemia microcarpa*	5	5	233	0.68
40	*Litsea bourdillonii*	1	1	8	0.16
41	*Litsea floribunda*	1	1	92	0.18
42	*Lophopetalum wightianum*	34	23	69151	13.78
43	*Macaranga peltata*	39	23	3931	4.07

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Appendix 4 (cont'd). Stand density, frequency, basal area and Importance value index (IVI) of tree community (gbh ≥10.1cm) recorded in Kammadam Kavu

Sl no	Plant Name	Density (Individual /ha)	Frequency (%)	Basal area (cm^2/ha)	IVI

44	*Mallotus philippensis*	4	4	4266	1.13
45	*Mallotus tetracoccus*	1	1	1848	0.44
46	*Mangifera indica*	12	9	623	1.32
47	*Melia dubia*	3	3	566	0.41
48	*Memecylon sisparense*	12	9	125	1.24
49	*Memecylon umbellatum*	66	40	1474	6.17
50	*Mimusops elengi*	9	5	755	0.90
51	*Myristica malabarica*	48	23	15431	6.14
52	*Naringi crenulata*	42	26	6044	4.71
53	*Pamburus missionis*	14	8	3413	1.72
54	*Persea macrantha*	3	3	68	0.33
56	*Polyalthia fragrans*	5	4	3114	1.00
57	*Pongamia pinnata*	9	6	157	0.92
58	*Pterospermum diversifolium*	3	3	240	0.36
59	*Pterospermum reticulatum*	3	3	949	0.47
60	*Pterospermum rubiginosum*	18	8	3202	1.83
61	*Pterygota alata*	77	34	5127	6.53
62	*Sapindus trifoliata*	4	4	65	0.49
63	*Saraca asoca*	3	3	39	0.33
64	*Sterculia guttata*	21	17	4502	2.92
65	*Stereospermum colais*	4	4	74	0.50
66	*Strychnos nux-vomica*	4	4	57	0.49
67	*Swietenia macrophylla*	1	1	8	0.16
68	*Syzygium cumini*	6	6	983	0.96
69	*Syzygium travancoricum*	3	1	2064	0.52
70	*Tabernaemontana alternifolia*	32	19	543	2.97
71	*Terminalia paniculata*	13	12	3507	2.03
72	*Tetrameles nudiflora*	13	10	174650	27.91
73	*Toona ciliata*	17	16	384	2.04
74	*Trema orientalis*	5	4	198	0.56
75	*Discospermum apiocarpum*	5	4	64	0.54
76	*Vateria indica*	3	3	113	0.34
77	*Vernonia arborea*	4	1	1749	0.52
78	*Vitex altissima*	13	12	10225	3.05
79	*Xanthophyllum arnottianum*	858	97	89538	53.29
80	*Xylia xylocarpa*	17	10	12014	3.35
81	*Zanthoxylum rhesta*	32	25	1143	3.52
		2758		**658302**	**300.00**

Appendix 5. Stand density, frequency, basal area and Importance value index (IVI) of tree community (gbh ≥10.1cm) recorded in Poyil Kavu

Sl. No.	**Plant Name**	**Density (Individual /ha)**	**Frequency (%)**	**Basal area (cm^2/ha)**	**IVI**

1	*Acronychia pedunculata*	55	40	1210	11.58
2	*Adenanthera pavonia*	15	15	142	3.73
3	*Annona squamosa*	10	5	21	1.54
4	*Areca catechu*	5	5	27	1.23
5	*Artocarpus hirsutus*	80	50	1113	14.86
6	*Briedelia retusa*	125	50	3463	19.65
7	*Caryota urens*	105	50	10791	24.31
8	*Chrysophyllum cainito*	5	5	12	1.21
9	*Carallia brachiata*	5	5	225	1.39
10	*Diospyros sylvatica*	5	5	87	1.28
11	*Grewia tiliifolia*	5	5	35	1.23
12	*Holigarna arnottiana*	145	60	3869	23.02
13	*Hydnocarpus pentandra*	10	5	35	1.55
14	*Mangifera indica*	25	15	101	4.33
15	*Mimusops elengi*	30	25	1187	7.30
16	*Myristica sp.*	15	15	6945	9.25
17	*Pterygota alata*	5	5	338	1.48
18	*Sterculia guttata*	45	30	1058	9.04
19	*Strychnos nux-vomica*	5	5	77	1.27
20	*UnPk 1*	95	50	7633	21.11
21	*UnPk 2*	10	5	93	1.60
22	*UnPk 3*	5	5	618	1.71
23	*UnPk 4*	10	5	5256	5.79
24	*Vateria indica*	60	5	3790	7.79
25	*Vatica chinensis*	690	100	75111	122.74
		1565		**123238**	**300.00**

Appendix 6. Stand density, frequency, basal area and Importance value index (IVI) of tree community (gbh ≥10.1cm) recorded in Vallikattu Kavu.

Sl. No.	**Plant Name**	**Density (Individual/ha)**	**Frequency (%)**	**Basal area (cm^2/ha)**	**IVI**

1	*Actinodaphne tadulingamii*	15	15	179	4.13
2	*Aegle marmelos*	7	7	216	2.14
3	*Agrostistachys borneensis*	4	4	35	1.03
4	*Alstonia scholaris*	37	15	1445	6.55
5	*Artocarpus hirsutus*	7	7	33	2.03
6	*Briedelia retusa*	22	19	466	5.58
7	*Carallia brachiata*	7	4	249	1.43
8	*Caryota urens*	15	11	492	3.58
9	*Cinnamomum malabatrum*	81	37	4093	15.80
10	*Cinnamomum riparium*	4	4	8	1.01
11	*Cinnamomum verum*	4	4	65	1.04
12	*Croton persimilis*	11	11	182	3.13
13	*Fabaceae sp.*	4	4	1972	2.13
14	*Ficus hispida*	4	4	54	1.04
15	*Grewia tiliifolia*	4	4	10	1.01
16	*Holigarna arnottiana*	48	33	10328	16.09
17	*Hopea ponga*	363	44	31547	54.37
18	*Hydnocarpus pentandra*	93	33	4097	15.92
19	*Ixora brachiata*	56	22	1177	9.26
20	*Knema attenuata*	226	30	52834	53.17
21	*Lagerstroemia microcarpa*	4	4	332	1.20
22	*Macaranga peltata*	19	15	1428	5.13
23	*Madhuca neriifolia*	4	4	3033	2.74
24	*Meliaceae sp.*	4	4	30	1.02
25	*Memecylon talbotianum*	4	4	42	1.03
26	*Mimusops elengi*	11	11	1192	3.70
27	*Myristica malabarica*	26	15	805	5.34
28	*Pterospermum reticulatum*	4	4	42	1.03
29	*Pterospermum rubiginosum*	4	4	23	1.02
30	*Santalum album*	7	4	70	1.33
31	*Sapindus trifoliatus*	4	4	225	1.14
32	*Sterculia guttata*	4	4	512	1.30
33	*Stereospermum colais*	4	4	1590	1.91
34	*Strychnos nux-vomica*	33	11	3467	6.69

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Appendix 6. Stand density, frequency, basal area and Importance value index (IVI) of tree community (gbh ≥10.1cm) recorded in Vallikattu Kavu.

Sl. No.	**Plant Name**	**Density (Individual /ha)**	**Frequency (%)**	**Basal area (cm^2/ha)**	**IVI**

35	*Syzygium travancoricum*	4	4	7152	5.09
36	*Tabernaemontana alternifolia*	19	19	867	5.53
37	*Tetrameles nudiflora*	7	7	26631	17.21
38	*Unknown*	7	4	48	1.32
39	*Unknown 1*	15	15	4217	6.43
40	*Unknown 2*	7	4	475	1.56
41	*Unknown 3*	7	7	50	2.04
42	*Xanthophyllum arnottianum*	89	41	12574	21.92
43	*Zanthoxylum rhesta*	15	11	1016	3.88
	Total	**1311**		**175305**	**300.00**

Appendix 7. Stand density, frequency, basal area and Importance value index (IVI) of tree community (gbh ≥10.1cm) recorded in Karimanal Chamundi Kavu.

Sl. No.	**Plant Name**	**Density (Individual/ha)**	**Frequency (%)**	**Basal area (cm^2/ha)**	**IVI**
1	Adenanthera pavonina	2	2	152.5	1.0
2	Careya arborea	2	2	236.0	1.1
3	Cassia fistula	6	4	43.6	1.9
4	Cochlospermum religiosum	12	10	76.3	4.3
5	Dillenia pentagyna	7	4	13565.2	26.0
6	Grewia tiliifolia	8	12	2607.0	8.5
7	Holarrhena pubescens	143	74	3220.7	46.8
8	Macaranga peltata	188	76	7792.0	55.0
9	Mallotus philippensis	2	2	14.5	0.8
10	Miliusa tomentosa	14	14	355.8	6.0
11	Phyllanthus emblica	2	2	744.3	1.8
12	Sterculia guttata	14	12	2748.6	8.7
13	Strychnos nux-vomica	4	4	76.3	1.7
14	Terminalia bellirica	10	10	13147.7	21.5
15	Terminalia paniculata	32	22	7356.3	19.8
16	Tetrameles nudiflora	4	4	25.4	1.6
17	Wrightia tinctoria	176	88	12795.5	71.6
18	Xylia xylocarpa	32	26	8231.4	22.0
	Total	658		73189.1	300.0

Appendix 8. Stand density, frequency, basal area and Importance value index (IVI) of tree community (gbh ≥10.1cm) recorded in Mani Kavu.

Sl. No.	**Plant Name**	**Density (Individual/ha)**	**Frequency (%)**	**Basal area (cm^2/ha)**	**IVI**
1	Artocarpus hirsutus	26	16	4598.4	13.5

2	Cinnamomum malabatrum	11	8	1771.1	6.0
3	Diospyros oocarpa	6	4	803.3	2.9
4	Elaeocarpus tuberculatus	20	12	4124.0	11.0
5	Holigarna arnottiana	117	46	13820.6	44.5
6	Hydnocarpus pentandra	14	10	3972.2	9.5
7	Knema attenuata	396	82	27464.1	103.7
8	Mallotus philippensis	3	2	31.6	1.0
9	Myristica dactyloides	26	12	907.7	7.8
10	Myristica malabarica	266	50	23963.1	74.8
11	Persea macrantha	3	2	607.2	1.7
12	Prunus ceylanica	9	6	1046.8	4.2
13	Pterospermum reticulatum	3	2	281.5	1.3
14	Sterculiaguttata	3	2	53.8	1.0
15	Symplocos racemosa var racemosa	11	8	1261.9	5.4
16	Syzygium sp.	9	6	3703.4	7.3
17	Turpinia malabarica	6	4	1056.3	3.2
18	Vitex altissima	3	2	132.8	1.1
		932		89600.0	300.0