SPECIES RICHNESS AND CARBON STOCK OF SHARNGAKAVU SACRED GROVE, CHENGANNUR, KERALA

by

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THESIS

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DECLARATION

I, hereby declare that this thesis entitled "**SPECIES RICHNESS AND CARBON STOCK OF SHARNGAKAVU SACRED GROVE, CHENGANNUR, KERALA**" is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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Kavya Jeevan

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LIST OF ABBREVIATIONS

CBD	Convention on Biological Diversity
CRD	Completely Randomized Design
GBD	Girth at Breast height
Mg ha^{-1}	Mega gram per hectare
$REDD^{+}$	Reducing Emissions from Deforestation and forest Degradation
SOC	Soil Organic Carbon
UNFCCC	United Nations Framework Convention on Climate Change

Dedication

To my mom, who gave me strength…

To my dad, who gave me freedom…

To the teachers, who showed me the direction…

To almighty, who made me lucky enough…

INTRODUCTION

INTRODUCTION

"Earth provides enough to satisfy every man's needs,
but not every man's greed."
-Mahatma Gandhi

The present wreckage of our planet is the result of man's greed and the urge to dominate, exploit and to slip in nature into his grasps. The decline in biodiversity and global warming are the major environmental issues the world is facing today (Saha *et al.*, 2009). Species extinction caused by human activities is at a rate of 1000 times than that of the natural rate. According to Intergovernmental Panel on Climate Change, the primary cause of global warming is the increase in the atmospheric concentrations of greenhouse gases especially carbon dioxide. International covenants like Convention on Biological Diversity (CBD) and United Nations Framework Convention on Climate Change (UNFCCC) have been developed to address these problems and to develop action plans to combat these issues. But each of them focuses only on their domain area with little effort being given for considering these issues together. In 2002, World Bank stated that there are only few efforts to explore the potential of greenhouse gas mitigating strategy (like capturing and storing of carbon for a temporal sequence) and conserving the biodiversity at the same time are very few (Saha *et al.*, 2009).

There exist a strong interest in stabilizing the concentration of atmospheric carbon and other greenhouse gases to mitigate global warming (Kerr, 2007). Deforestation and degradation of forests as one of the major causes of climate change and conservation of these as the only viable option against climate change is not only a fact understood by the experts but among the public as well. Forests are natural storehouse of carbon. They sequester and stock more carbon than any other ecosystems and are considered as natural "Brake" of climate change (Gibbs *et al.*, 2007). It has been widely accepted that in systems with lesser disturbance more

carbon is better sequestered (Six *et al.*, 2002) and also the older systems is expected to store more soil carbon than the younger ones (Fontaine *et al.*, 2007).

According to United Nations Framework Convention on Climate Change (UNFCCC) the estimates of carbon stocks and stock changes of tree biomass are necessary to study global warming and climate change (Green *et al.*, 2007). Thus climate change mitigation can be achieved by strengthening and maintaining strategies like Reducing emission from degradation and deforestation (REDD+) (Locatelli *et al.*, 2011).

Indian societies have a complex mix up of cultures, beliefs and tradition on both developed and under developed sides of the country. We had Vedic literatures, which included chapters about dealing with worshipping trees, conserving certain species as they are regarded as sacred."*Namo Vrkshebhyo Harikeshebhyo*", "*Nama parnyaya parnasathyaya*" are some sloghas mentioned in Yajurveda for worshipping trees for seeking credence from natural calamities. Trees of sacred forests in India, as a rule, should not be touched with axe unless it is required for the religious necessities. (Brandis, 1897). These trees inside the groves are considered as the "*Boodhaganas*" of the deity in the grove. Fear on God created by the ancestors often gave a reason for maintaining these natural resources up to an extent.

As having a close interaction with the nature, the ancient man recognized the need for conserving natural resources for his survival and wellbeing (Unnikrishnan, 1995). Understanding that the misuse of resources will be disastrous, nature worship was evolved as one of the way of conservation of these resources, where these resources were given a sacred or sanctified status. The concept of sacred groves might have been aroused with the spread of shifting agriculture i.e. during the Megalithic times when man transformed from the hunter-gatherer to food producer. It was believed that the groves are under the protection of the presiding deity and anyone disturbing the vegetation or animals here would be subjected to the wrath of the deity. Even the natural disasters like droughts and floods are considered as the result of the displeasure of the deity (Murugan *et al.*, 2008). According to Hughes

and Chandran (1997), sacred groves (SGs) are defined as "*segments of landscape containing vegetation, life forms and geographical features, delimited and protected by human societies under the belief that to keep them in a relatively undisturbed state is expression of an important relationship of humans with the divine or with nature.*"

The biological spectrum of Kerala's sacred groves resembles closely that of the biodiversity of tropical forests. The 230 square kilometer wide Silent valley national park is said to have about 1,682 plant species, whereas the sacred groves of Kerala which is only up to 1.5 square kilometer shelters more than 700 species (Pushpangadan *et al.*,1998). These green vegetation near the human settlements not only works as carbon sink and produce oxygen they also serve as a pollution sink and check the flow of dust and fly ash (Rawat *et al.*,1998). Taboo is often imposed on certain sets of natural resources which have greater risk of over exploitation (Colding and Folke, 2001).

About 361 sacred groves with an area greater than 0.02ha have been reported by Induchoodan (1988). Around 364 important sacred groves in Kerala with about 722 species of floristic wealth were identified by Induchoodan in1996, Sharngakavu in the Chengannur taluk of Alappuzha district is one among them.

The presiding deity of Sharngakavu is "*Vanadurga*" ('*Vana*' means forest and '*durga*' is a form of goddess Parvathi) and the *vigraha* is considered as *swayambhu* (self-manifested). No complex constructions or temple structures are present here and a belief exists that deep inside the nearby Achankovil river there is a golden temple hence no further constructions are allowed in the temple premises including the grove. During the monsoon showers, the water level of the Achankovil river rises and the water enters the temple premises and this is considered as the holy bath of the deity. The salient feature of this grove is the presence of monkeys who are said to be the children of the deity and are fed by the devotees who come to visit the grove.

This grove is said to have been maintained for more than 500 years. The people here believe that the village itself was a forest. The King Sharnga used this place for hunting and got cursed (*Sapa*) by Saint Agasthya for killing innocent

animals. As a part of repentance, the king was told to undertake strict Tapas inside the forest and worship god. Enjoying the peace and recreation of the forest, the king ordered to maintain this place as a grove and was named later as Sharngakavu.

Many groves have been encroached upon because the fear which used to be associated with them, no longer operates (Negi, 2010). With rapid and profound urbanization we are losing these treasure pots of life. According to Brody *et al.* (2008) the solution to prevent the degradation of the sacred groves is to create awareness among the local people regarding the importance of sacred groves in combating climate change and biodiversity conservation. Since the degradation of the sacred groves are associated with the knowledge and attitude of local people, studies on their perception is very important. Providing proper scientific evidences and knowledge on the floristic wealth and climate change mitigation potential of the grove will create enthusiasm among the local people and the other beneficiaries to protect and conserve these sacred sites.

It was in these backgrounds this study was proposed with the following objectives:

- Compare the floristic structure and composition of the core and buffer zones of the Sharngakavu sacred grove, Chengannur.
- Document and compare the carbon stock of the standing vegetation in both these zones.
- Assess the socio-cultural and ecological values of this sacred grove as perceived by the local community.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

2.1 SACRED GROVES

Sacred groves can be considered as the primary effort to conserve the biodiversity, valuable gene pools and preserved as sustainable resources (Brandis, 1897). Gadgil and Vartak (1976) had addressed the presence of sacred groves in continents of Asia and Africa. Later, in 1998, Hughes and Chandran reported the existence of such sites in America, Europe and Australia.

The studies on sacred groves of China revealed that they play a major role in the conservation of the local biodiversity and management. The total plant species and endemic species found in the sacred groves were higher than that of those in common forests and natural reserves (Liu *et al.*, 2000). In 2001, McWilliam reported sacred groves from Timor, which is an Indonesian island and these are called locally as 'Lulic'. These community-protected forests often are associated with or believed to house god or goddess, and are named typically after the deities (Chandrakanth *et al.*, 2004). Tibetan sacred groves conserves the different landscape, species and community hence, they are said to be ecologically unique (Salick *et al.*, 2007). Ghana, an African country lost more than fifty percentage of its forest cover and the portions surviving are 'Sacred groves'. These groves vary in size from less than a hectare to more than 30 hectares (Barre *et al.*, 2009).

Globally, sacred groves often are associated with myths and taboos on the use of some specific plants and hunting of certain animals within this area. These traditions can serve as a conservation strategy because these sacred forest fragments represent the sole remaining forests with the potential for conservation of fauna and flora. For example, the church forests in Ethiopia protect some of the last remaining fragments of the tropical afromontane forests (Aerts *et al.*, 2006). Ormsby and Bhagwat (2010) said that the sacred forests are not just cultural monuments; but are conservation areas that provide a culturally-sensitive model for the community based natural resource management. Some researches on sacred groves had concluded that

rather than formal legal frameworks an alternate view of conservation is led by taboos and norms (Kharkongor and Tiwari, 2015).

2.1.1 India

Sacred groves are found throughout the country. The presence of sacred groves have been reported in the Western Ghats, Eastern Ghats, regions of Madhya Pradesh in Central India, along the Himalayan ranges from the northwest to northeast, western Himalaya of Kumaun and Garhwal, Khasia hills of Assam, Meghalaya and tribal hill of Mizoram and also in the Aravali ranges of Rajasthan (Gadgil and Vartak, 1976; Gadgil, 1992; Burman, 1992).

In India, some sacred groves of the Western ghats area appears to be leftover of the original forest cover, which supports the rich climax vegetation including enumorous rare plants (Vartak and Gadgil, 1981). Sacred groves of Northern India contain certain species which perform key functions in nutrient conservation and could play a major role in the rehabilitation of the surrounding degraded landscapes (Ramakrishnan, 1996). The sacred forests on the southeastern coast of India are the only remnants of the dry evergreen forest habitats (Mani and Parthasarathy, 2005).

Estimates suggest that India has the highest concentration of sacred forests in the world, between 1,00,000 and 1,50,000 sacred forests are present around the country (Malhotra *et al.* 2007). In 2008, Mohapatra reported that more than 116 million tonnes of carbon dioxide is sequestered in India which contributes to reduced atmospheric carbon of the planet.

2.1.2 Kerala

Sacred groves are present throughout Kerala, in different forms, with varied cultural practices and beliefs. '*Kavu*' as in Malayalam vernacular means a consortium of trees or a garden (Unnikrishnan, 1995). The 'hotspots' of sacred groves in Kerala

are Kollam, Alapuzha and Pathanamthitta districts in the South and Kannur, Kasarkkode and Kozhikkode districts in the North (Prasad and Mohanan, 1995).

Table 1. Sacred groves of Kerala with area more than 0.02hactres (Source: Induchoodan , 1996)

Sl. No.	Districts	No. of sacred grove
1	Thiruvananthapuram	43
2	Kollam	44
3	Pathanamthitta	33
4	Alappuzha	49
5	Idukki	3
6	Kottayam	10
7	Ernakulam	7
8	Thrissur	16
9	Palakkad	3
10	Malapuram	11
11	Kozhikode	23
12	Wayanad	5
13	Kannur	54
14	Kasargod	60
	Total	361

The table 1 represents the number of sacred groves in each district of Kerala which extends more than 0.02ha as per the study conducted by Induchoodan (1996). revealed. This primitive tribal culture of pre-Dravidian era is mostly distributed from sea level to about 450 m altitude, away from forests and near to the human settlements, i.e. along the plains and lower elevations (Chandran, 1997). Kerala habours about 1500 to 2000 sacred groves whose extend varies from 0.004ha to greater than 2ha (Menon, 1997). It is estimated that about 500 ha of forest area is under SGs contributing 0.05 per cent of the total forest area of the state.

In Kerala, relatively undisturbed sacred groves were found to be similar when measures such as basal area, stem density and species diversity were compared with other forests of the same area (Chandrashekara and Sankar, 1998). In the state, Sacred groves are commonly known as '*Kavu*' but the name varies with the presiding deity, the most common one is *Sarpa Kavu* or *Naga Kavu* with serpent as the deity, if the diety is lord *Ayyapa* it is known as *Ayyappan Kavu*, if the diety is goddess it is known as *Bagavathy Kavu* , *Muthappan Kavu* if the deity is *Muthapan*, form of lord Shiva. There are also *Yakshi Kavu*, sacred groves dedicated to spirits or ancestors (Malhotra *et al.*, 2001).

2.2 SACRED GROVES IN BIODIVERSITY CONSERVATION

The sacred groves serve as a last refuge for arboreal birds and mammals, especially monkeys and also for other forest loving animals as well. It is certain that the species preserved in sacred groves possess medicinal properties and economic value if exploited and studied properly, they also represents the genetic variants of common species which is peculiar to that geographical area. These sacred groves are also regarded as the indicators of the natural productivity of the area. The presence of trees like *Alstonia scholaris, Dysoxylum binectariferum, Ficus arnottiana, Terminalia paniculata, Sterculia gutata, Mangifera indica, Memecylon umbellatum, Holigarna graham, Syzygium cuminii* and certain climbers like *Acacia rugosa, Combretum ovalifolium, Schefflera venulosa, Entada phaseoloides* and *Gnetum ula* in sacred grove of Maharashtra was also reported (Gadgil and Vartak, 1974).

Induchoodan (1996) reported 722 species belonging to 128 families and 474 genera from 361 sacred groves of Kerala. Old and magnificent specimens of climbers and trees are harbored even in the smallest groves such as *Adenanthera pavonina, Alstonia scholaris, Calycopteris floribunda, Caryota urens, Glycosmis arborea Holigarna arnotiana, Hydnocarpus pentandra, Olea dioica, Macaranga peltata, Mimusops elengi, Vateria indica,, Strycnos nux-vomica, Ixora coccinea,, and Tabernaemontana heyneana* were distributed among more than 100 sacred groves.

Also a species association of *Memecylon malabaricum – Memecylon umbellatum* and *Syzygium zeylanicum* was reported from Sharngakavu.

The presence of few threatened species like *Cleome burmanii* and *Pterospermun reticulatum* were also reported from the sacred groves of Kerala. Sacred groves conserve biodiversity in both local and regional level as they buffer against depletion of the genetically adapted native variants. Thirty percentage of the taboos are species specific taboos which ideally prohibits the use of certain threatened species, most prominently threatened mammals and reptiles (Colding and Folke, 1997). The groves play an active role in the world's biodiversity conservation outside the Protected Areas and serve as biodiversity hotspots at microlevel (Gadgil, 1998 ; Tiwari *et al.*, 1998).

The role of natural sacred sites, such as sacred groves, is attracting increased interest among international organisations and conservation organisations like UNESCO, WWF and has got significant relevance for the implementation of article 8j of the Conservation of Biological Diversity which is stressing more on the use of traditional wisdom and practices for the conservation and sustainable use of the biological diversity (Chandrashekara and Sankar, 1998).

The Sacred groves serve as refugia for the endemic species (Jamir and Pandey 2003) and the biodiversity of sacred groves often resembles with the biodiversity in the core area of some of the biosphere reserves in that region (Tripathi, 2005). Threatened tree species such as *Actinodaphne lawsonii, Hopea ponga, Pittosporum dasycaulon, Madhuca neriifolia, Michelia champaca and Syzygium zeylanicum,* were reported by Bhagwat *et al.* (2005) in the sacred groves of Kodagu district of Karnataka.

Sacred forests are mostly small fragments and may be the only remaining reservoirs of biological diversity outside protected areas (Bhagwat and Rutte 2006). In 2007, Punde reported some rare and climax forest tree species such as *Antiaris toxicaria, Hydnocarpus pentandra, Saraca asoca,* and *Strychnos nux-vomica* from fifteen sacred groves of Konkan region in Maharashtra. The vegetation in the groves

is highly varied viz. mangroves, fresh water swamps, or other tropical forest types (Murugan *et al.*, 2008). The exotic species dominates the tree population of the plots where the land owners have the harvesting rights while the native species dominated in the tree diversity of the culturally bounded sacred groves (Ambinakudige and Sathish, 2009). The comparison study between sacred groves and a continuous forest stand in Kodagu, showed that the groves have undergone habitat fragmentation due to human pressure, causing disappearance of half of the endemic species, and has been replaced by more ubiquitous species (Garcia *et al.*, 2010).

Sacred natural sites are considered as an additional pillar for biodiversity conservation and are examples of traditional biodiversity conservation since ancient times (Dudley *et al.*, 2010; Hangarge *et al.*, 2012). In 2013, Patel and Patel reported 43 plant species from seven different sacred groves belonging to Banaskantha district of Northeast Gujarat and the largely concentrated species were *Aegle marmelos, Azadiracta indica, Ficus benghalensis, Ficus glomerata, Ficus religiosa, Mangifera indica* and *Salvadora oleoides*. Also some rare and threatened plants like *Acacia catechu, Bombax ceiba, Butea monosperma, Calotropis gigantea, Datura innoxia* were also reported from these groves.Mild disturbance in groves may increase species richness, meanwhile the increased disturbance can lead to losses and will hamper the success of regeneration in those sacred groves (Dudley *et al.*, 2010). Singh and Garg (2014) reported about fourteen endemic, twenty six medicinal and forty Rare, Endangered and Threatened plants from Kurdi Angod sacred site of Southern Goa.

The social fencing of the sacred groves helps in the protection of biodiversity of the locality, also support diverse species of birds including threatened birds, forest birds, endemic birds, owl, raptors as well as migratory bird species. Hence these small repositories of biodiversity had to be conserved at any cost (Jyothi and Nameer, 2015). "Kavus" the sacred groves of Kerala are places where trees, reptiles, animals and birds are allowed to live without interference by human or fear of poaching (Parappurath and Paul, 2016)

2.3 SACRED GROVES AS REPOSITORIES OF CARBON

The vegetation cleanses the atmosphere naturally by absorbing the carbon dioxide emitted and converting it into biomass, which is the only way to mitigate the greenhouse gas accumulation (Varshney, 1985). Up to the soil depths of 30 cm and 1 m, the global soil organic carbon (SOC) stock has been enumerated to be in the range of 684–724 Pg and 1462–1548 Pg respectively (Batjes, 1996).

The well protected sacred groves, sequester significantly more carbon compared to other forest ecosystems because of their higher biomass. And the rate of carbon sequestration depends upon age, species composition, site quality, and the style of forest management (Schulze *et al.*, 1999). Matured and undisturbed forests retain an overall neutral carbon balance whereas regenerating or recently disturbed forests usually lose carbon from both remnant vegetation and soil (Apps *et al.*, 2000).

Soil is a potential natural sink for carbon because of being the largest terrestrial pool of soil organic carbon in addition to the relatively long residence time of organic C in the soil (Batjes, 2001). The forests sequester carbon not only in the harvestable timber but also in the other woody debris and woody plants (Wofsy, 2001). Thus the carbon sequestration potential of soil cannot be over-emphasized, and is approximately 2344 gigatone (Gt) of global organic carbon storage (Lal, 2004).

Through a series of stages in the life cycle from germination to decomposition and by processes like photosynthesis and respiration forests fix, store and emit carbon (Fukuda *et al.*, 2003). Management of tropical and temperate forests is one of the best options to stabilise the atmospheric CO_2 concentration at 550 ppm be the year 2050 (Pacala and Socolow, 2004). The reduced emission from deforestation is indicated by the amount of carbon sequestered by the sacred grove. The community-based carbon storing projects are not economically viable, meanwhile the traditional conservation faith and sequestration capacity of these types of conserved forests technically qualifies these to be viable carbon offset projects (Taiyab, 2006).

The abiotic carbon sinks will be very expensive and may have the risk of leakage, whereas the biotic techniques are cost effective processes and natural (Lal, 2008). In 2009, Lal studied the impacts of soil carbon sequestration on global climate change and suggested that organic carbon stored in soil is an extremely valuable natural resource hence, they have to be restored, improved and enhanced. Moreover carbon management policies including regulations on soil organic carbon must be developed. As addressed in Kyoto protocol the increasing emissions of carbon and their sinks are of primary concern for the entire globe (Chavan and Rasal, 2010). Deforestation and biomass burning increases the carbon concentration of the atmosphere. Sacred Groves with thick vegetation have high carbon sequestration potential which contributes to reduced concentration of atmospheric CO2. The estimation of carbon stocks are very little and there are necessary for the reporting of the Kyoto protocol (Hangarge et al., 2012).

A comparison study of four selected sacred groves of Pune district with the nearby comparable sites areas was conducted and the outcomes of the study suggests that, the sacred groves have high potential for carbon sequestration than the adjacent sites. The reason for this may be the sparse vegetation and lower soil organic contents which arised due to the activities of the local people. The study also concluded that the sacred groves with older and dense vegetation have greater potential for carbon sequestration (Kulkarni *et al.*, 2013). The research conducted by Mandal *et al.* in 2013 concluded that there is a positive relationship between the species richness and soil carbon stock, but this relationship is very weak.

A total of nineteen tree species of eighteen genera was recorded from the sacred natural forest patch of Western Odisha and the total carbon stock of the forest was accounted to be 125 Mg/ha. Being the dominat species *Shorea robusta* stored the highest amount of carbon (Antaryami *et al.*, 2016). The total organic carbon stock of the three selected sacred groves in Manipur was found to be 6802.48 Mg/ha, 6892.62 Mg/ha and 6321.58 Mg/ha. This variation in the rate of carbon sequestered

among the groves is due to the difference in the steepness of the slopes, Physico-chemical characteristics and species composition (Devi and Singh, 2016).

The carbon sequestration potential of trees increases with the increase in age, thus older trees have higher carbon content as compared to the younger trees (Kour and Sharma, 2016). The study conducted by Shrestha *et al.* (2019) on the sacred groves Quercus-Myrsine and Schima-Pyrus of Nepal revealed that the amount of carbon sequestrated in the forests varies with the type of forest and tree density. The forest's species composition is also a major factor that determines the amount of carbon assimilated in a particular forest type. Thus the Quercus-Myrsine was found to have the highest carbon stock as the grove poses more number of trees and trees with larger size.

Tadesse *et al.* (2018) in their study on climate smart landscapes in Southern Ethiopia concluded that soil carbon storage capacities vary with different land uses. Grasslands and forests have to be considered important to maximize the soil carbon stocks as the top soil of forest land use system have the higher carbon level and 20% of the world soil carbon stocks are contained in the undisturbed grasslands. The Above ground biomass and carbon storage of the largest sacred grove in Manipur was estimated to be 565.40 Mg/ha. The highest proportion of above ground biomass was contributed by the trees in the diameter range of 30-40 cm (Waikhom *et al.*, 2018). Chanderbadni sacred grove of Tehri district in Garhwal Himalaya (Temperate zone) was studied by Vikrant and Pala (2019) to assess the carbon stock and biomass. The tree density was observed to be 688 trees/ha and total carbon density estimated is 587.19 Mg/ha. *Cedrus deodara* was found to have the highest carbon density.

2.4 NEED FOR SOCIAL FENCING ON SACRED GROVES

Social taboos associated with sacred natural sites are the best example of informal institutions (Charnov, 1976). Taboos are unwritten social rule which regulate human behavior. These constraints can directly manage the constituents of

the local natural environment such as natural resources, ecosystems and many species (Johannes, 1978). Social restraints like taboos are methods of indigenous biological conservation (Berkes *et al.*, 1995). The variety of natural resource taboos which exist in the community based management systems regulate the resource withdrawal (Colding and Folke, 2001).

The degradation of the sacred groves not only reflects the loss of rich flora and fauna but also the disappearance of the culture associated with the grove, which arised due to the influence of the economic and social issues (Kushalappa and Bhagwat, 2001). The attitude of the people towards the sacred groves supports their conservation but the increasing demand for developmental activities change their attitude and is a major cause of degradation of these groves. This also leads to loss of natural resources present in this area (Khan, 2003).

Sacred groves conserve medicinal plants that may serve the health needs of the people, protect soil and water and also serve as a site for socio economic events, religious festivals and society meetings. Individual response to climate change is nearly under researched (Aiyeloja and Ajewole, 2006). For the increased management efficiency of the natural resources the perceptions of the people directly involved is very important (Brody *et al.*, 2008) and perception has been widely described as a range of beliefs, attitude and judgments (Slegers, 2008).

As reported by Kumar (2009) there is a need for revitalizing the old ethos on conservation culture of the traditional communities by supplementing with scientific knowledge on the crucial role played by these precious sites in the conservation of biodiversity and other important ecological services among the local people. For the proper implementation of carbon storage projects and Clean Development Mechanisms, it is important to include local people's participation in REDD project on a participatory basis (Lykke *et al.*, 2009). In the past two decades many researches have been conducted on the knowledge of public on climate change but,

unfortunately studies on awareness of climate change is low in developing countries as compared to the developed countries (Pelham, 2009).

The study conducted on Shivabari sacred grove of Himachal Pradesh revealed that the plant species identified from the grove represents almost two percentage of the total flowering plants of the state. The temperature inside Shivabari was significantly lower than the temperature outside. A recent shift of the local people towards a market oriented economy is a major threat to the survival of the grove (Jaryan, 2010). The solution for the degradation of the groves is to make people realize that the conservation of these groves are important for their sustenance (Khan *et al.*, 2008). People who work closely with natural resources have fairly good knowledge on the changing climate through direct experiences (Kemausuor *et al.*, 2011).

In 2011, Patil studied the community's dependence on sacred grove in Maharashtra and found that only the highly educated and well employed respondents were aware of the word 'Biodiversity'. Half of the respondents felt biodiversity is important and was aware of rare and endemic species while thirteen percentage of them felt biodiversity of the sacred grove is not important for them.

Jayant and Mehta (2013) reported that the private forests (non- governmental land supporting vegetation) are rich in biodiversity and great potential to sequester the carbon, but due to low incentives for the maintenance of these private lands people tend to use this land for any other income generating purposes. Giving proper directions and awareness among the people regarding the carbon marketing will be an inducement for the protection of these sites. REDD+ can provide a framework for registering such project in post 2012 period.

The study conducted by Krishnan (2015) concluded that the respondents near the sacred groves in the Northern Kerala had a medium knowledge on the significance of the sacred groves and also their awareness was influenced by their

gender, occupation, caste and educational qualification. Each grove have a unique oral history associated with it (Ormsby and Ismail, 2015). The groves with less human disturbance are indicator of local people with good awareness on the sacred grove as a treasured ecosystem (Reshma and Indulekha, 2016). The degradation of the sacred groves in India is due to the change in the attitude of the people and the increasing mistrust of traditional beliefs (Singh *et al.*, 2017).

The realization of the priceless ecosystem services provided by the sacred groves is expected to enhance the efforts of the local people to conserve these sites. Continuous monitoring and quantitative estimation of the services provided by the groves are essential to convince the stakeholders to protect the sacred groves without perturbations (Barik *et al.*, 2018).

2.5 SACRED GROVES-COMBATING CLIMATE CHANGE

Sacred groves certainly have an influence on making the microclimate favorable for many organisms as the transpiration from this vegetation will increase atmospheric humidity and also reduces the temperature (Khiewtam and Ramakrishnan, 1989). Brown and Adger (1994) said that forest conservation, including those under the control of local societies in developing countries, is an important constituent of a comprehensive climate mitigation strategy. In the villages of Kerala, the system of age old temples with associated water resource and sacred grove explains the ancient method of water harvesting (Induchoodan, 1996).

One of the highly cost-effective ways to immediately curtail greenhouse gases emissions is reducing deforestation mainly in lands with low opportunity costs (Sedjo, 2001). Stocking carbon in tropical forest ecosystems is the best way to mitigate climate change by promoting afforestation/reforestation (AR) and slowing down forest degradation and forest degradation (Pascala and Socolow, 2004). In 2005, Tripathi *et al.* noted faster regeneration in the sacred groves as compared to that of the other forest fragments. Also these groves are rich in biodiversity and dealt well

with climate related stresses, due to the resilience and capacity to withstand climatic shock by the indigenous biodiversity.

The norms and taboos associated with the sacred groves or sacred water bodies are a way of sustainable resource management practiced by the traditional people, and hence the utilization never exceeds the regeneration potential of the sacred natural sites (Negi, 2010). Biodiversity loss and rising in the levels of atmospheric CO_2 are the two major environmental challenges the world is facing today. Revival of traditional land use systems has the potential to move climate change mitigation and biodiversity conservation forward (Kumar, 2011).

The existence of ''sacred groves'' in many areas is a physical manifestation of the spiritual role and has contributed to the conservation of forest (Pala *et al.*, 2013). In 2014, Jantz *et al.* emphasized on the importance of Reducing Emissions from Deforestation and Forest Degradation (REDD+) as a method of mitigating the land use based climate change, as they protect forest carbon, maintain biodiversity and minimize the loss of ecosystem services.

Kihonge (2017) concluded that the sacred natural sites have the capacity to withstand the drought conditions in the dryland ecosystem. Also they contribute positively towards the resilience of the dry land ecosystem towards the effects of climate change, particularly drought. In some places the community members are allowed to move their animals near the sacred groves which provide pasture to these livestock during the drought times. The importance of creating public awareness on the significance of sacred natural sites in mitigating the adverse effects climate change was also addressed.

The study conducted by Devakumar *et al.* (2018) provide evidences to support that the sacred groves are functionally diverse as they have higher tree diversity which facilitate the efficient utilization of natural resources. Also they have higher

productivity compared to similar natural ecosystems of the region due to resilience capacity of the sacred groves that perhaps lacks in other less diverse systems.

2.6 THREATS ON SACRED GROVES

Chandran and Hughes (1997) have identified that there is an increasing tendency among the local people to relax the existing taboos associated with the groves and more support on the development of the temple structures. Sacred groves are reported to be monument forests and possibly the only remaining climax vegetation of an area, even though many are now disturbed as a result of the human actions (Tiwari *et al*., 1998).

In 2004, Chandrakanth *et al*. highlighted the loss in the area of sacred groves by the coffee plantations and further encroachment within the grove in the form of illegal timber extraction. The vegetation of the sacred groves shifted from natural vegetation to pure plantations and existence of groves devoid of vegetation is also found. The quality of the groves is deteriorating with the fast growth of the farm activities and the infrastructural facilities (Anthwal *et al.*, 2006).

In West Bengal, Bankura and Birbhum districts have lost a number of sacred groves and trees in the grove to make temple structures (Deb, 2007). The changing lifestyle and rapid urbanization are death traps for the age-old conservation practices (Murugan *et al*., 2007).

Forest Invasive Species (FIS) like *Eupatorium glandulosum*, *Lantana camara*, *Eichhornia crassipes*, *Parthenium* sp., *Mimosa* sp., *Prosopis juliflora*, *Cytisus scoparius*, *Mikania micrantha*, *Ulex enropaeus*, *Euphorbia royleana* etc poses major threats to the sacred groves (Sarabhai, 2007). Species are vanishing due to various anthropogenic perturbations like alteration of natural habitats, over exploitation, pollution, global climate change, and invasion of the nonnative species, which is so

fast that many important taxa may disappear even before they are identified, documented and their scientific value is discovered (Khan *et al*., 2008).

Measures should be taken to create awareness among the people and the stakeholders should take up the responsibility to look after the sacred groves and its conservation activities with the involvement of the local people and other beneficiaries (Bhakta, 2009). Increasing pressures on the natural resources and changing social norms and belief systems are leading to disappearance of many sacred groves that have survived for hundreds of years (Dudley *et al.*, 2010). Many Sacred groves have been encroached as the beliefs associated with them, no longer works (Negi, 2010). In 2011, Manikandan *et al.* reported that eighty percentage of the groves considered under the study had rich vegetation earlier and now it remain only as sacred places. In 2011, Patil have reported extensive removal of fallen wood, litter or twigs also threatens the survival of the sacred groves. In some sacred groves of Srinagar, Jammu and Kashmir the incidence of forest fire was also noticed (Kumar *et al*., 2011).

A social science study conducted on the attitude of the nearby residents on the conservation of the sacred groves of Meghalaya and Karnataka revealed that, in both these states the residents are aware about the existing taboos, consequences of breaking these taboos and the rituals practiced in the grove. But there are numerous factors that possess pressure on the sacred groves, these includes change in culture and increasing demand of natural resources. There is a decline in the rituals practiced in Meghalaya and in both these states there is a tremendous increase economic pressure to extract the resources from the grove, reduce the size of the grove for utilisation of the land for other income generating purposes such as coffee plantations (Ormsby, 2013).

Sacred groves are community conserved forests which plays a major role in the long term mitigation of greenhouse gas emission in the Garhwal Himalaya as the natural forests of his area is increasingly getting converted into farmlands. Trees

species growing at lower densities will be at the threat of extinction in the near future if proper protection strategies are not strengthened (Pala *et al.*, 2013). Destruction of the habitat, increased land degradation and displacement of the local people are possessing serious threats to these sacred natural resources (Konkane *et al.*, 2018).

MATERIALS AND METHODS

3. MATERIALS AND METHODS

In order to accomplish the objectives of the study, appropriate data collection tools and analytical methods were employed. The methods and procedures followed in the study are presented under the following headings:

3. 1 Locale of the study

3.2. Methodology

3.3. Socio-economic survey

3.1. LOCALE OF THE STUDY

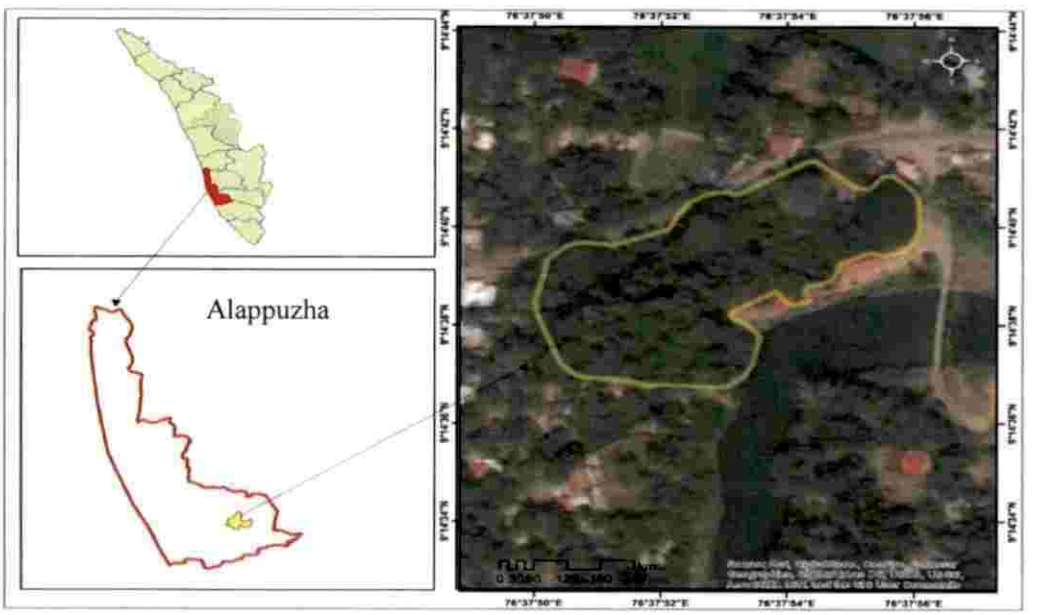

Fig 3.1. Location map of the study area

Sharngakavu is a hundreds of year old sacred grove situated in Chengannur taluk of Alappuzha district in the central zone of Kerala state, India. Frequent visit by devotees and regular ritual practices are followed here. It is located at $9^0$14'36'' and $9^0$14'41'' North latitude and between 76^0 37'44" and $76^0$37'55" East longitudes. An area of 1.3 hectare vegetation has been preserved behind the Sharngakavu temple

premises with Achankovil river as its Southern boundary and an open ground of 1.67 hectare in the east. The location map of the study area is presented as Figure 3.1.

3.2. METHODOLOGY

3.2.1. Selection of study area

To obtain the exact geographical extent of the sacred grove and associated vegetation, a GPS (GARMIN etrex 20X) survey was undertaken. Based on the visual assessment of plant species diversity and human interference, the area of the grove was delineated into core and buffer zones. The area with thicker vegetation was considered as the core zone and the area having less vegetation and more chances of human disturbances buffer zone. An area with no vegetation and share the similar topographic features was selected as control plot.

3.2.2. Floristic Analysis

Suitable quadrat size was fixed according to species area curve method. Ten quadrats of size 5m x 5m each were taken randomly on both core and buffer zones to study the vegetation.

3.2.2.1. Plant identification

Plants were identified from the grove as much as possible. Floristic diversity was found out by identifying the species with the help of standard literatures (Ramesh and Pascal, 1997) and with the help of taxonomists. For the unidentified plants, photographs were taken and identification was done with the help of local people, experts and web resources like'www.indiantreepix.com'. The vegetation data were analyzed for,

Species richness, S = Number of species in the community or sample.

The diversity of species was calculated using Shannon- Wiener Index

Shannon-Weiner's index, $H' = 3.3219(\text{Log } N\text{-}1/N \sum n_i \text{ Log } n_i)$

Where, n_i = Number of individuals of the species,

N = Total number of individuals

Simpson's evenness, E = H'/lnS, H'is the Shannon's diversity index and S is species richness.

Simpson's diversity index = $1 - \sum_{i=1}^{S}(n_i/N)^2$

Where, n_i = Number of individuals of the species,

N = Total number of individuals

The sociological structure of each tree species in the grove was understood by computing the importance value index (IVI). This was computed by summing up the relative density, relative frequency and relative basal area of that species.

IVI = Relative density+ Relative frequency + Relative basal area

$$\text{Where, Relative density} = \frac{\text{Number of individuals of the species X 100}}{\text{Number of individuals of all species}}$$

$$\text{Relative frequency} = \frac{\text{Number of occurrence of the species X 100}}{\text{Number of occurrence of all species}}$$

$$\text{Relative basal area} = \frac{\text{Basal area of the species X 100}}{\text{Basal area of all species}}$$

3.2.2.2. Analysis of vegetation

The collected data was analysed using ordination technique to get a diagrammatic representation of the species distribution in the zones.

3.2.3. Soil Analysis

3.2.3.1. Soil sample collection

Three sampling sites were selected randomly from each of the core, buffer and control cites as indicated in Figure 3.2. Soil samples were collected by making soil

profiles of one meter. The profile was further divided into horizons of 20cm depth such as 0-20cm, 20-40cm, 40-60cm, 60-80cm and 80-100cm. Composite soil samples were collected from each depth interval by mixing soils from different sampling sites (Plate 1). All the soil samples were dried under shade for 2 days, sieved (using 2mm sieve) and grinded. The prepared samples were subjected to detailed study on the various soil physico-chemical characters such as bulk density, pH, organic carbon and total nitrogen (Plate 2).

Fig 3.2: Locations of soil sample collection from Sharngakavu sacred grove, Chengannur

3.2.3.2. Soil Bulk Density

Bulk density is defined as dry weight of the soil per unit volume of the soil. Bulk density was estimated by taking a core of undisturbed soil from each 20cm depth intervals using specially designed steel cylinder (AOAC, 1995). The steel cylinder was carefully inserted to each horizon without disturbing the normal bulk density of the soil to obtain the sample core. The collected soil samples were oven dried at 105^0C for 48 hours (for complete removal of moisture) and the dry weight of the soil was found out. The volume of the core was found out by calculating the volume of the steel cylinder ($V = \pi r^2 h$). The bulk density was computed as,

Bulk density (g/cc) = Oven dry weight (g) / Volume of soil

3.2.3.3. Estimation of soil chemical properties

Soil pH

A soil-water suspension of 1:2.5 ratio was prepared. A calibrated pH meter was used for soil pH estimation.

Soil Electrical Conductivity

Soil electrical conductivity was estimated using an aqueous suspension of soil and water in ratio of 1:2.5, using a conductivity bridge.

Soil Organic Carbon

Soil organic carbon was estimated by wet digestion method. The soil samples were dried under shade and finely ground using mortar and pestle. It was then passed through 0.2mm sieve. One gram of sieved soil samples were transferred into 500ml conical flask, 10ml of $K_2Cr_2O_7$ is pipetted into it and swirled and then were kept for 30 minutes for oxidation. Then 200ml of distilled water was added to stop the reaction. The resultant solution was titrated against 0.5N $FeSO_4$ solution until the

dark green color changes to chocolate brown color. 4-5 drops of Ferroin indicator was also added prior to titration.

A blank was also run simultaneously and the values were obtained. The soil organic carbon was estimated using the following equation:

$$\text{Soil organic carbon (\%)} = \frac{\text{(Blank value-Titer value) X 10 X 0.003 X 100}}{\text{Weight of soil sample (g) X Blank value}}$$

Soil Total Nitrogen

Macrokjeldahl digestion and distillation method was used to determine the total nitrogen content of the soil sample. One gram of soil sample was taken and mixed with digestion mixture (K_2SO_4:$CuSO_4$ at a ratio 10:1) and 10ml of conc.H_2SO_4 and was kept overnight for pre-digestion and was transferred to digestion chamber. After digestion, the aliquot was made up to 100ml and was filtered using Whatman 42 filter paper. Then 10ml of the aliquot was transferred to auto N distillation Kjeldahl unit and inflamed with 40% NaOH and the liberated ammonia was collected in 4% boric acid. This solution was taken for titration against 0.01N H_2SO_4. A blank was also run simultaneously. The total nitrogen content in the samples were estimated using the following formula,

Percentage of N in soil sample=V X 0.01 X 0.014 X 100/10 X100/w

Where, V= Sample titer value – blank titer value; w is the weight of soil taken.

3.2.3. Analysis of soil properties

A 3x5 asymmetric factorial CRD with four replications was carried out, considering location (with three levels, *i.e.*, core, buffer and control) and soil depth (with five levels, *i.e.*, 0-20cm, 20-40cm, 40-60cm, 60-80cm, 80-100cm) as the 2 factors. To evaluate how the soil parameters changed across the three locations as well as the five soil depths. Interaction between those two factors was also analysed.

A) One meter deep pit for soil sampling analysis

B) Core sampling for BD

C) Composite sampling

D) Sample preparation

Plate 1. Soil sample collection and preparation from Sharngakavu sacred grove

A)Titration for carbon estimation

B) Soil sample digestion

C) Estimation of total nitrogen

E) Measuring pH and EC of the sample

Plate 2: Soil sample preparation and analysis

3.2.4. Carbon stock estimation

Woody vegetation with GBH > 10cm was considered for the carbon stock estimation. The height of trees was calculated with the help of Hega altimeter and the GBH was found out using measuring tape (1.37 m from ground level). The actual volume of the trees was calculated ($V = \pi(d^2/4)$h*0.65) and multiplied with basic density (obtained from Global Wood Density data base and standard scientific works) to get the biomass of the shoot. The below ground biomass was calculated by multiplying above ground biomass with 0.26 as the root: shoot ratio (Hangarge *et al.*, 2012). Assuming elemental carbon stock as 50 per cent of the oven dry biomass, carbon stock of the tree was calculated. The total biomass was calculated by summing up the above ground and below ground biomass.

Total Biomass (TB) = Above ground biomass + Below ground biomass.

The carbon stock of each tree species was calculated by multiplying the total biomass with a conversion factor 0.475 (Singh and Chand, 2012).

The estimated soil organic carbon was extrapolated to Mg/Ha at each depth and summed up to get the total carbon stock on core, buffer and control. Total carbon stock of the grove was also estimated using the formula;

Total carbon stock = Carbon stock of the vegetation + carbon stock of the soil.

3.3 SOCIO ECONOMIC SURVEY

The continued conservation of the grove is dependent upon the attitude of the people associated with the grove. Thus understanding people's perception on the grove and knowledge on the ability to combat climate change is very important.

3.3.1. Selection of respondents for survey

The people living in the Venmony panchayath (irrespective of religion) was considered as the local residents and the ones who are non-residents of Venmony who came to visit the grove are considered as the devotees. Thereafter, 40 local residents and 40 non-resident devotees were randomly approached for indepth discussions to understand their socio cultural beliefs and also the mores, norms and taboos associated with the sacred grove (Plate 3).

3.3.2. Collection of primary data

In consultation with experts, a detailed interview schedule (APPENDIX –I) was prepared to gather information on the people's Knowledge on climate change and the perceived effect of sacred grove on combating climate change. The schedule was pre-tested, modified and standardize based on the responses received in the pilot survey conducted in non-sampled area. Responses were collected on a three point continuum with scores three, two and one. In order to meet the objectives the interview schedule was divided into two parts as follows:

(i)Part one: Basic details of the respondents (Locality, Age, Gender, Education, Occupation, and Economic status.)

(ii)Part two: Knowledge on climate change, perception on conserving the sacred grove and its ability to combat climate change.

A) Socio- cultural survey among the local residents

B) Socio- cultural survey among the non-resident devotee

Plate 3: Socio- cultural survey among the people associated with the Sharngakavu sacred grove, Chengannur

3.3.3. Data analysis and statistical tools

3.3.3.1. Socio-economic characteristics

Age

Age was operationally defined as "the number of calendar years completed by the person at the time of study".

Education

Education indicates the "level of formal education of the respondents at the time of the investigation", which was quantified as follows in the table 2;

Table 2. Score assigned for each education category

Sl.No:	Category of response	Assigned score
1	Primary	1
2	Upper Primary	2
3	High school	3
4	Higher Secondary	4
5	Graduate	5
6	Above Graduate	6

Occupation

This refers to the nature of work from which the respondents derives major part of income. The respondents were classified into five categories and scored as follows in the table 3:

Table 3. Score assigned for each occupation

Sl.No	Occupational status	Assigned score
1	Government	5
2	Private	4
3	Wage labour	3
4	Unemployed	2
5	Others	1

Perceived knowledge on climate change and effect of Sacred grove

The response of each statement on climate change and perception on ability of sacred grove to combat climate change were assessed using Likert scale (which indicates the degree to which a person agree or disagree to a statement) on a three point scales with responses agree, neutral, disagree and scores three, two and one.

3.3.3.2. Statistical interpretation tools

The data were tabulated on MS-Excel sheet and the individual analysis was carried out. SPSS 16.0 was used for the following tests.

Chi-square test for association

Chi-square test was done to find out the association between the perception of the peoples (Local and devotee) on sacred grove and climate change based on their age group, gender, educational qualification and occupation.

Mann-Whitney U test

Man-Whitney U test is a non-parametric test, similar to the independent two-sample t test. This was carried out to check the significant difference in the perception of the local people and devotees towards the causes of climate change (Causes), impacts of climate change (Impact) and reason for the conservation of the sacred grove (Reason).

Binary logistic regression model

A binary logistic regression model was used to find out the factors that influence the attitude of the people on the role of sacred groves in combating climate change. The attitude of the respondents (towards the ability of the sacred grove to combat climate change) was taken as the dependent variable and the impacts of climate change *i.e.*, temperature rise (T), rainfall decrease (R.F), change in rainfall pattern (RFP), loss in food production (LFP), new diseases (ND), reduction in water availability (RWA),

heat stroke (HS), plant health (PH) and recurring natural calamities (RNC) as independent variables.

Another model with the same dependent variable and the basic details *i.e.*, age (A), gender (G), education (E) and occupation (O) as the independent variables was also worked out. This was done to find out whether the people's basic characteristics have a role in their attitude and which factor influence the more.

RESULTS

4. RESULTS

The present study tried to document the floristic structure and composition of the Sharngakavu Sacred Grove, Chengannur, Alappuzha district, Kerala. This study also compared the carbon stock of the vegetation in the core and buffer zones of this grove. An assessment of the cultural and ecological values of the grove as perceived by the people associated with this grove was also attempted. The results of the study are presented below.

4.1 ESTIMATION OF FLORAL WEALTH

The plant species identified from the Sharngakavu sacred grove is furnished in Table 4. A total of 67 plant species were recorded, of which 53 species were recorded from the core zone while 38 species could be identified from buffer. These included 39 tree species (table 4), 13 species of climbers, 7 shrubs, 3 herbs and some other plant forms such as ferns, palms and orchids

Table 4. List of the tree species identified from the Sharngakavu sacred grove, Chengannur

Sl. No.	Name of species
1	*Actinodaphne malabarica*
2	*Adenanthera pavonina*
3	*Aegle marmelos*
4	*Ailanthus excels*
5	*Alangium salvifolium*
6	*Alstonia scholaris*
7	*Antiaris toxicaria*
8	*Aphanamixis polystachya*
9	*Aporosa cardiosperma*
10	*Ardisia pauciflora*
11	*Azadirachta indica*
12	*Boswellia serrate*

Table 4 continued. List of the tree species identified from the Sharngakavu sacred grove, Chengannur

Sl.No.	Name of species
13	*Broussonetia papyrifera*
14	*Canarium strictum*
15	*Canthium angustifolium*
16	*Canthium coromandelicum*
17	*Carallia brachiate*
18	*Cinnamomum malabatrum*
19	*Cinnamomum verum*
20	*Drypetes oblongifolia*
21	*Ficus hispida*
22	*Grewia tillifolia*
23	*Holoptelea integrifolia*
24	*Hopea ponga*
25	*Ixora pavetta*
26	*Lagerstroemia microcarpa*
27	*Macaranga peltate*
28	*Memecylon malabaricum*
29	*Morinda citrifolia*
30	*Olea dioica*
31	*Phyllanthus emblica*
32	*Pongamia pinnata*
33	*Strebles asper*
34	*Strombosia ceylanica*
35	*Strychnos nux-vomica*
36	*Tabernaemontana alternifolia*
37	*Theobroma cacao*
38	*Vateria indica*
39	*Xanthophyllum arnottianum*

Table 5. Other plant forms found in Sharngakavu sacred grove, Chengannur

Sl. No.	Name of plant species	Vegetation type
1	*Acacia caesia*	Climber
2	*Adiathum pedatum*	Fern
3	*Liana sp.*	Climber
4	*Artabotrys zylanicus*	Climber
5	*Asparagus racemoses*	Climber
6	*Calamus rotang*	Climber
7	*Caryota urens*	Palm
8	*Calycopteris floribunda*	Shrub
9	*Chassalia curviflora*	Shrub
10	*Chromolaena odorata*	Shrub
11	*Curculigo orchioides*	Herb
12	*Cyclea pellata*	Climber
13	*Dalbergia horrida*	Climber
14	*Gastrochilus acaulis*	Orchid
15	*Geophila repens*	Climber
16	*Hibiscus rosa-sinensis*	Shrub
17	*Hydnocarpus laurifolia*	Herb
18	*Ixora coccinea*	Shrub
19	*Jasminum angustifolium*	Shrub
20	*Memecylon randerianum*	Shrub
21	*Morinda umbellate*	Climber
22	*Myxopyrum smilacifolium*	Climber
23	*Piper nigrum*	Climber
24	*Pothos scandens*	Shrub
25	*Rauvolfia serpentine*	Herb
26	*Strychnos columbrina*	Climber
27	*Vanilla walkeriae*	Orchid
28	*Wattakaka volubilis*	Climber

Figures 4.1 and 4.2 represents the species abundance in the core and buffer zones of the grove. It is evident that *Caryota urens* is the most abundant species in the core zone, followed by *Adianthum pedatum* and *Chassalia curviflora.* The buffer zone was dominated by *Adianthum pedatum* followed by *Chromolaena odorata.* Some of the important species identified from the grove included *Xanthophyllum arnottianum, Strombosia ceylanica and Antiaris toxicaria* (Plate 4).

A) *Xanthophyllum arnottianum*

B) *Strombosia ceylanica*

C) *Antiaris toxicaria*

Plate 4. Important species identified from the Sharngakavu sacred grove, Chengannur

4.1.2. Vegetation analysis

Ten sample plots each of 5m X 5m were laid on both core and buffer for the analysis of vegetation. All tree species with GBH above 0.10m were enumerated. The height and Girth at Breast Height (GBH) range of the trees in the core and buffer zones are given in Tables 6 to 9.

Table 6. Height range of trees in the core of Sharngakavu sacred grove, Chengannur

Height(m)	No. of individuals
2.5-5	8
5.1-7.5	16
7.6-10	8
10.1-12.5	7
12.6-15	1
15.1-17.5	1
17.6-20	4

Table 7. Height range of trees in the Buffer of the Sharngakavu sacred grove, Chengannur

Height(m)	No: of individuals
5-8.6	11
8.7-12.2	1
12.3-15.8	1
15.9-19.4	0
19.5-23	1

Table 8. GBH range of the trees in core zone of Sharngakavu SG, Chengannur

GBH(m)	No: of individuals
0.18-0.85	29
0.86-1.52	10
1.53-2.19	3
2.20-2.87	2
2.88-3.54	0
3.55-4.21	0
4.22-4.88	1

Table 9. GBH range of the trees in Buffer zone of Sharngakavu SG, Chengannur

GBH(m)	No: of individuals
0.25-0.88	11
0.89-1.51	3
1.52-2.14	0
2.15-2.77	0
2.78-3.4	1

The height of the trees varies from 3m to 20m in the core and in the buffer zone, the tree height ranges from 5m -23m (Tables 6 and 7). The GBH of these trees varies from 0.2 m to 4.88 m in core (Tables 8 and 9) and 0.25 m to 3.4 m in the buffer zone. Most of the trees in the core zone lies in the height range of 5.1-7.5m and in the GBH class of 0.18-0.85m. In the buffer zone, most of the trees have height between 5-8.6m and girth 0.25-0.88m.

In the core zones, sites one and three, sites five and ten, sites two, seven and eight are ecologically similar (Fig. 4.3). In the buffer zone, more species accumulation is seen in the sites 7, 10 and 5 (Fig. 4.4). Ecological similarity exists between sites 7 and 10,

sites 4,6 and 3 and among sites 9 and 8. In the plot one of core, *Caryota urens* is the most abundant species, while *Adianthum pedatum* is the most abundant species in plot six and plot nine. All the other plots have nearly equal distribution of the other species. *Adianthum pedatum* is the most common species in plot one of buffer.

Table 10. Species diversity indices of Core and Buffer zones of Sharngakavu SG, Chengannur

Location	Shannon Weiner Index	Simpson's Diversity index	Evenness
Core	1.9	0.75	0.48
Buffer	1.57	0.73	0.43

From Table 10, it is evident that the core zone has a better floral diversity (Shannon Weiner index of 1.9) as compared to the buffer zone (1.57) even though, both these zones show similar range of Simpson's Diversity index. The Shannon Weiner index of the core zone (1.9) is visibly higher than that of buffer zone. Species evenness is more in the core (0.48) than in buffer (0.43). The control site was barren in terms of other plant forms, except for the occasional grass cover

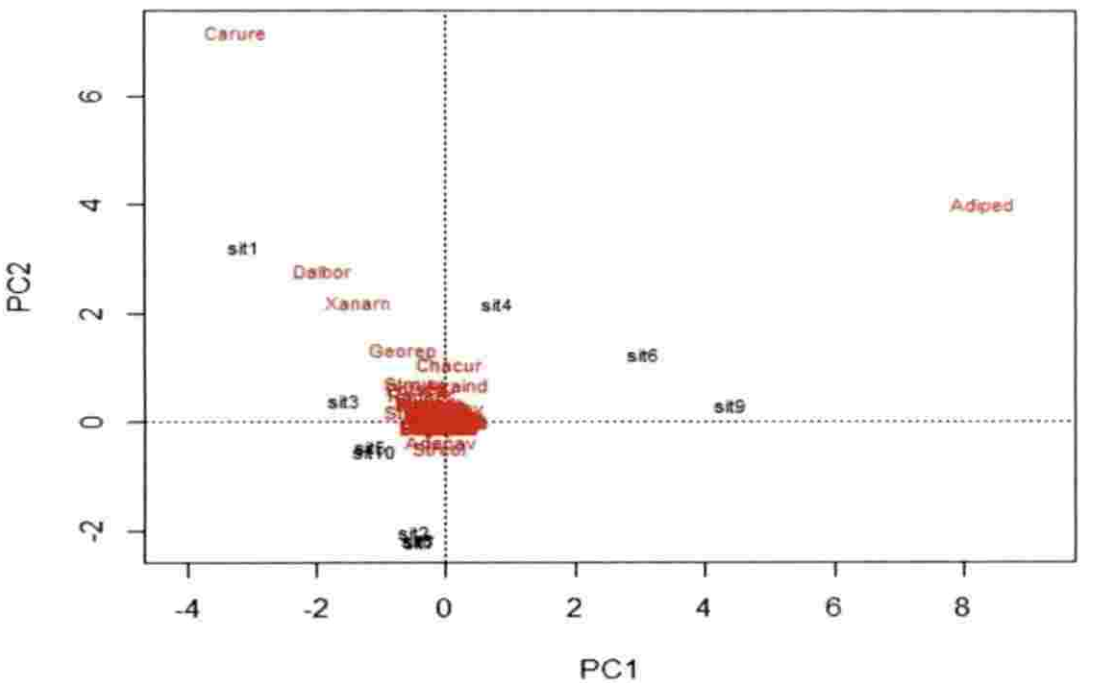

Fig 4.3. Plant species distribution of the core zone of Sharngakavu sacred grove, Chengannur

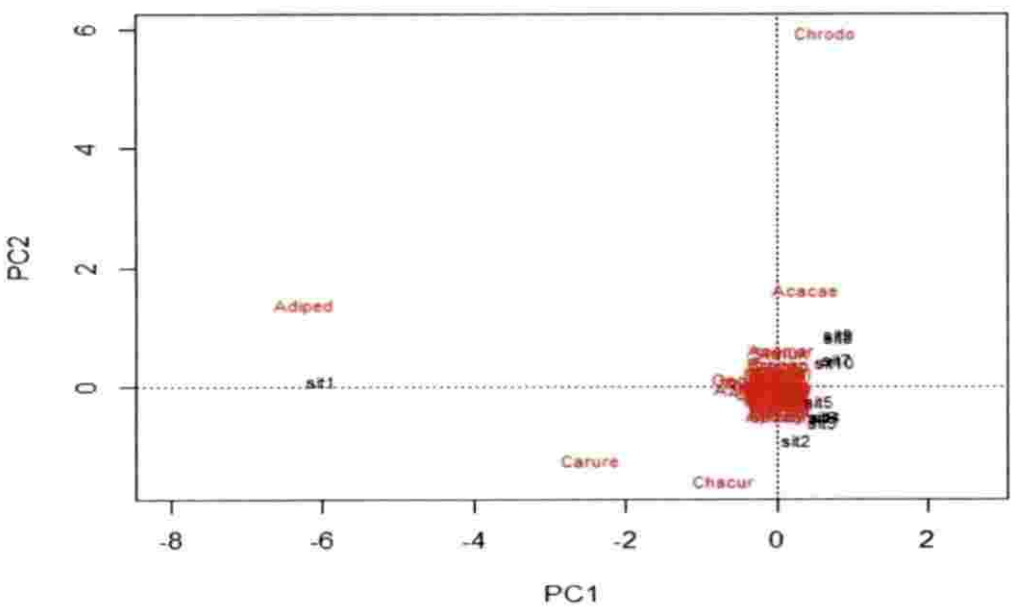

Fig 4.4. Plant species distribution of the buffer zone of Sharngakavu sacred grove, Chengannur

Table 11. Species dominance in the Core zone of the Sharngakavu SG, Chengannur

Sl.no	Species name	R.F	R.D	R.B.A	IVI
1	*Xanthophyllum arnottianum*	15.0	13.33	75.66	103.99
2	*Caryota urens*	20.0	67.08	12.22	99.30
3	*Vateria indica*	17.5	4.1	6.9	28.57
4	*Strombosia ceylanica*	12.5	5.4	0.84	18.75
5	*Lagerstroemia microcarpa*	12.5	5.8	0.18	18.51
6	*Cinnamomum malabatrum*	7.5	1.2	0.49	9.23
7	*Canarium strictum*	5.0	1.2	2.20	8.44
8	*Antiaris toxicaria*	5.0	0.83	0.08	5.91
9	*Grewia tillifolia*	2.5	0.41	0.26	4.18
10	*Aegle marmelos*	2.5	0.41	0.15	3.06
11	*Ailanthus excelsa*	1.65	0.29	0.09	2.03

Table 12.Species dominance in the Buffer zone of the Sharngakavu SG, Chengannur

Sl.no	Species name	R.F	R.D	R.B.A	IVI
1	*Caryota urens*	25.00	64.10	22.87	111.98
2	*Antiaris toxicaria*	18.75	7.69	53.01	79.46
3	*Broussonetia papyrifera*	12.50	5.12	6.41	24.03
4	*Theobroma cacao*	6.25	5.12	11.56	22.94
5	*Macaranga peltata*	12.50	5.12	1.29	18.92
6	*Strombosia ceylanica*	6.25	5.12	2.98	14.35
7	*Cinnamomum verum*	6.25	2.56	0.93	9.74
8	*Adenanthera pavonina*	6.25	2.56	0.66	9.47
9	*Ficus hispida*	6.25	2.56	0.26	9.08

From the Tables 11 and 12, it is evident that *Xanthophyllum arnottianum*is the dominant species of core zone (IVI 103.99), while *Caryota urens* is dominant in the buffer (IVI 111.98).

Table 13. Average Carbon stock contribution by each species in the Sharngakavu SG, Chengannur

Sl.No	Species	Height (m)	GBH (m)	Density (g/cm^3)	Carbon stock (Mg ha^{-1})
1	*Adenanthera pavonina*	8	0.38	0.88	1.26
2	*Aegle marmelos*	6.5	0.45	0.88	1.37
3	*Ailanthus excels*	4	0.73	0.4	1.23
4	*Antiaris toxicaria*	17.5	1.95	0.4	66.59
5	*Broussonetia papyrifera*	7.5	0.74	0.29	1.99
6	*Canarium strictum*	9.5	1.41	0.53	28.08
7	*Caryota urens*	11.2	1.91	0.31	17.59
8	*Cinnamomum malabatrum*	3.5	0.80	0.59	1.85
9	*Cinnamomum verum*	6	0.45	0.49	0.73
10	*Ficus hispida*	9	0.25	0.47	0.30
11	*Grewia tillifolia*	18	1.95	0.62	52.55
12	*Lagerstroemia microcarpa*	5.5	0.66	0.61	1.81
13	*Macaranga peltata*	6.25	0.38	0.48	0.53
14	*Strombosia ceylanica*	7.32	0.40	0.83	1.86
15	*Theobroma cacao*	7.5	1.05	0.42	4.71
16	*Vateria indica*	10.7	1.23	0.48	17.49
17	*Xanthophyllum arnottianum*	5.06	0.24	0.67	0.23

In the grove *Antiaris toxicaria* was found to have the highest average carbon stock (Table 13) considering the average carbon stock contribution by each tree species.

4.2 SOIL ANALYSIS

The results of the soil analysis for different parameters are as follows:

4.2.1 Factorial analysis of soil parameters

Table 14. Mean soil carbon concentration (%) in the Sharngakavu SG, Chengannur

		Depth(cm)					
Location		0-20 cm	20-40	40-60	60-80	80-100	Average
	Core	1.30^{b}	0.87^{b}	0.62^{a}	0.56^{a}	0.50^{b}	0.77^{b}
	Buffer	1.55^{a}	1.18^{a}	0.56^{b}	0.53^{b}	0.65^{a}	0.89^{a}
	Control	0.84^{c}	0.81^{c}	0.52^{c}	0.46^{c}	0.24^{c}	0.57^{c}
	Average	1.23^{a}	0.95^{b}	0.57^{c}	0.52^{d}	0.46^{c}	
	CD L =0.01 CD D=0.01 CD L*D =0.02						

From Table 14 it can be observed that, carbon concentration is showing significant dependence between the locations ($F=1897$, $p<0.01$) as well as depth ($F=4825$, $p<0.01$). The highest carbon concentration was found in the Buffer zone (0.89%) and in the depth 0-20cm (1.23%).The pair wise interactions were studied for each depth and found that there are significant variation among each locations($F=316.80$, $p<0.01$).

Table 15. Mean soil nitrogen content (Mg ha^{-1}) in the Sharngakavu SG , Chengannur

		Depth(cm)					
Location		0-20 cm	20-40	40-60	60-80	80-100	Average
	Core	0.250^{b}	0.219^{b}	0.156^{b}	0.125^{b}	0.125^{a}	0.175^{b}
	Buffer	0.313^{a}	0.250^{a}	0.188^{a}	0.156^{a}	0.125^{a}	0.206^{a}
	Control	0.188^{c}	0.125^{c}	0.125^{c}	0.125^{b}	0.125^{a}	0.137^{c}
	Average	0.250^{a}	0.198^{b}	0.156^{c}	0.135^{d}	0.125^{e}	
	CD L=2.15		CD D=2.77			CD L*D=4.80	

Table 15 shows that the nitrogen is showing significant changes in each locations ($F=2098$, $p<0.01$) and the highest nitrogen content was found in the buffer zone (0.206 Mg ha^{-1}). A change in nitrogen content was noticed in each depth too ($F=2801$, $p<0.01$) and the depth 0-20cm had the highest nitrogen content (0.250 Mg ha^{-1}). There was also a noticeable change between same depths of different locations revealing the location- depth interactions ($F=311$, $p<0.01$).

Table 16. Mean soil pH in the Sharngakavu SG, Chengannur

		Depth(cm)					
Location		0-20 cm	20-40	40-60	60-80	80-100	Average
	Core	4.3^{c}	4.5^{b}	4.5^{c}	4.7^{c}	4.7^{c}	4.54^{c}
	Buffer	4.5^{b}	4.6^{b}	4.9^{b}	4.9^{b}	5.1^{b}	4.77^{b}
	Control	5.2^{a}	5.3^{a}	5.3^{a}	5.5^{a}	5.8^{a}	5.42^{a}
	Average	4.65^{e}	4.77^{d}	4.92^{c}	5.03^{b}	5.18^{a}	
	CD L=0.06		CD D=0.08			CD L*D=0.14	

From Table 16 it is clear that there is a visible change in the pH value with location ($F=471.796$, $p<0.01$) and the pH was found to be the highest in the control site. The pH was highest in the depth 80- 100cm and the depth wise variations was

found to be significant (F=57.85, p<0.01). The pH of each depths of the soil profile shows significant variation among the locations (F= 4.3, p<0.01).

Table 17. Mean soil EC (dSm^{-1}) in the Sharngakavu SG, Chengannur

		Depth(cm)					
Location		0-20 cm	20-40	40-60	60-80	80-100	Average
	Core	1.586^{a}	1.510^{a}	1.224^{a}	1.394^{b}	1.518^{a}	1.45^{a}
	Buffer	1.269^{c}	1.321^{b}	1.269^{a}	1.208^{a}	1.238^{b}	1.26^{b}
	Control	1.444^{b}	1.194^{c}	1.256^{a}	1.212^{ab}	1.217^{b}	1.26^{b}
	Average	1.43^{a}	1.34^{b}	1.25^{c}	1.27^{c}	1.32^{b}	
	CD L=0.02		CD D=0.03			CD L*D=0.05	

From the values shown in Table 17 the EC is showing depth wise variations (F= 77.31, p<0.01) and location wise differences (F=282.56, p<0.01). Also the samples of each depth showed significant variations among different locations (F= 43.31, p<0.01). Even though the variations were found to be significant there were only slight variations among the buffer and control locations while the core zone have the highest EC (1.45dS m^{-1}). Also the top most layer had the highest EC (1.43dS m^{-1}) and mere variations could be observed in the following layers.

Table 18. Mean soil Bulk Density (g/cc) in the Sharngakavu SG, Chengannur

		Depth(cm)					
Location		0-20 cm	20-40	40-60	60-80	80-100	Average
	Core	1.24^{c}	1.35^{c}	1.52^{c}	1.50^{c}	1.60^{c}	1.44^{c}
	Buffer	1.91^{a}	2.29^{a}	2.02^{a}	2.13^{a}	1.80^{b}	2.03^{a}
	Control	1.45^{b}	1.76^{b}	1.80^{b}	1.84^{b}	1.93^{a}	1.76^{b}
	Average	1.53^{d}	1.80^{b}	1.78^{bc}	1.83^{a}	1.77^{c}	
	CD L=0.02		CD D=0.03			CD L*D=0.05	

Table 18 shows that there are significant location wise differences in the bulk density (BD) ($F=2401$, $p<0.01$). BD differed significantly with depth ($F=240.113$, $p<0.01$). Thus the interaction between location and depth was found to be significant ($F=132.814$, $p<0.01$). The highest value for the bulk density was found in the second layer (20-40cm) of the buffer zone and the lowest bulk density was found in the top most layer of the core.

4.3 CARBON STOCK

Carbon stock by core and buffer of the grove was calculated and compared.

Table 19. Mean soil carbon stock in the three sites of Sharngakavu SG, Chengannur

Depth(cm)	Carbon Stock in Mg ha^{-1}		
	Core	Buffer	Treeless control
0-20	32.14	59.21	24.31
20-40	23.66	53.78	24.95
40-60	18.79	21.32	18.27
60-80	16.77	23.80	17.71
80-100	15.87	23.28	8.80
Total	107.23	181.39	94.04
Mean	21.45^{b}	36.28^{a}	18.81^{c}

Table 19 shows that there is significant difference (p value <0.01) in the carbon storage between the three selected locations. The soil carbon storage at 1m depth was found to be highest in the buffer region of the grove (181.39 Mg ha^{-1}), followed by 107.23Mg ha^{-1} in the core zone and 94.04 Mg ha^{-1} in the tree less control site. It is explicit that the area having vegetation cover has substantially high carbon stock as compared to the tree less control. For instance, the soil carbon stock of buffer zone has about 92.8 per cent higher carbon stock than the control site.

Table 20. Total system carbon stock (vegetation and soil) in the Sharngakavu sacred grove, Chengannur

Location	Carbon stock (Mg ha^{-1})		
	Vegetation	Soil	Total
Core	349.48	107.23	456.71
Buffer	162.97	181.39	344.36
Control	Absent	94.04	94.04

From Table 20 it can be inferred that the carbon stock contributed by vegetation was higher in the core area (349.48Mg ha^{-1}), while the carbon stock by the soil is greater in the buffer (162.97 Mg ha^{-1}). The estimated total carbon stock of the core is 456.71Mg ha^{-1} which is much higher when compared to the 344.36Mg ha^{-1} of total carbon stored in the buffer.

Table 21. Total carbon stock as function of species richness of the Sharngakavu sacred grove, Chengannur

Location	Carbon stock (Mg ha^{-1})	Species Richness (Total no: of species)
Core	456.71	53
Buffer	344.36	38
Control	94.04	Absent

From Table 21 the relationship between total carbon stock and species richness can be figured out. The highest carbon stock (456.71Mg ha^{-1}) and the highest species richness (53) were found in the core. This shows the carbon stock of a location is directly related to the species richness and vegetation wealth of the area.

4.4 SOCIO-ECONOMIC SURVEY

4.4.1. Socio-economic profile of respondents

The details of the primary data collected using interview schedule in a survey among the resident and non-resident population related to the Sharngakavu sacred grove are presented in Table 22.

Table 22. Socio-economic profile of the local residents and non-resident devotees of Sharngakavu sacred grove, Chengannur

Variable	Category	Respondent type (%)	
		Local residents	Non-resident devotees
Gender	Female	60	52.5
	Male	40	47.5
Age	Below 25	12.5	12.5
	25-40	20	27.5
	41-65	50	42.5
	66-80	10	12.5
	Above80	7.5	5
Education	Primary	2.5	0
	Upper Primary	2.5	7.5
	HS	25	25
	HSS	20	5
	Graduate	25	50
	Post graduate	25	12.5
Economic status	APL	82.5	85
	BPL	17.5	15
Occupation	Government	17.5	17.5
	Private	35	42.5
	Wage labour	7.5	7.5
	Unemployed	25	17.5
	Others	15	15

The demographic and socioeconomic status of the respondents of the study area is given in Table 22. Results from the table indicate that 60 per cent of the local resident respondents of the study area were female and half (50 per cent) of them were between the age group 41-65, followed by 20% which falls in the 25-40 age group. Majority (95 per cent) of them had education above high school levels. High school, graduate and post graduate levels of education were shared by 25 per cent each of the respondents. Higher secondary level of education was shared by slightly lower 20 per cent of respondents. There were no illiterates among the studied sample of both the categories. It is clear that in the non-resident devotee population, 52.5 per cent of the respondents were female and the remaining was male. Most respondents were from the age group of 41-65. Also 50 per cent of them were graduates. 82.5 per cent of the local residents and 85 per cent of the non-resident devotees possessed better economic status. Among the sampled population 30 per cent of the local residents and 42.5 per cent of non-resident devotees were employed in private sector.

Table 23. Distribution of respondents on their frequency of visits to Sharngakavu sacred grove , Chengannur

Category	Frequency of visit	Percentage
Local residents	First time	0
	Frequent	97.5
	Occasional	2.5
Non-resident devotees	First time	12.5
	Frequent	45
	Occasional	42.5

From Table 23 it can be found that there was no first time visitor to the grove among the residents of the area. It was estimated that 97.5 per cent of the local community visited the grove frequently (at least once in a year whereas 2.5 per cent are occasional visitors), the survey was irrespective of the religion. Among the non-

resident devotee group, majority of them are frequent (45 per cent) or occasional visitors (42.5 per cent) with the rest 12.5 per cent being first time visitors.

4.4.1.1. Climate change as perceived by the respondents

The results from Table 24 illustrate that, 92.5 per cent of the non-residents and 97.5 per cent of the residents had heard about climate change. Moreover, 82.5 per cent of the residents and 72.5 per cent of the non-residents believed that climate change could be controlled through local actions such as afforestation, conserving natural vegetation, reducing pollution and controlling unscientific developmental activities. They also suggested that implementing laws and policies which stop exploitation of nature could help to a great extent in this regard. However 17.5 per cent of the residents and 27.5 per cent of the non -residents believed that local actions could not combat climate change. Among the respondents, about 45 per cent of the resident and 47.5 per cent of the non- residents had heard about Paris Agreement and was of the view that it has to be strictly followed. Moreover, about 85 per cent of the residents and 90 per centof the non-residents believed that climate change had the capacity to endanger life or affect livelihoods.

Table 24.Distribution of respondents on knowledge of climate change

Respondent category	Response	AC-1(%)	AC-2(%)	AC-3(%)	AC-4 (%)
Non-resident devotees	Agreed	92.5	82.25	45	90
	Disagreed	7.5	18.75	55	10
Local residents	Agreed	97.5	93.75	47.5	85
	Disagreed	2.5	6.25	52.5	1

AC-1 (%) – Conscious of climate change?

AC-2(%) –Belief in the possibility to reduce climate change through local actions

AC-3(%) – Awareness of Paris Agreement

AC-4 (%) –Effect of climate change in endangering livelihoods

An evaluation of the respondents' sources of information on climate change has been presented in Figure 4.5. The result showed that mass media is the most popular source of knowledge on climate change (45 per cent). Education from school and practical experience were also other major knowledge sources.

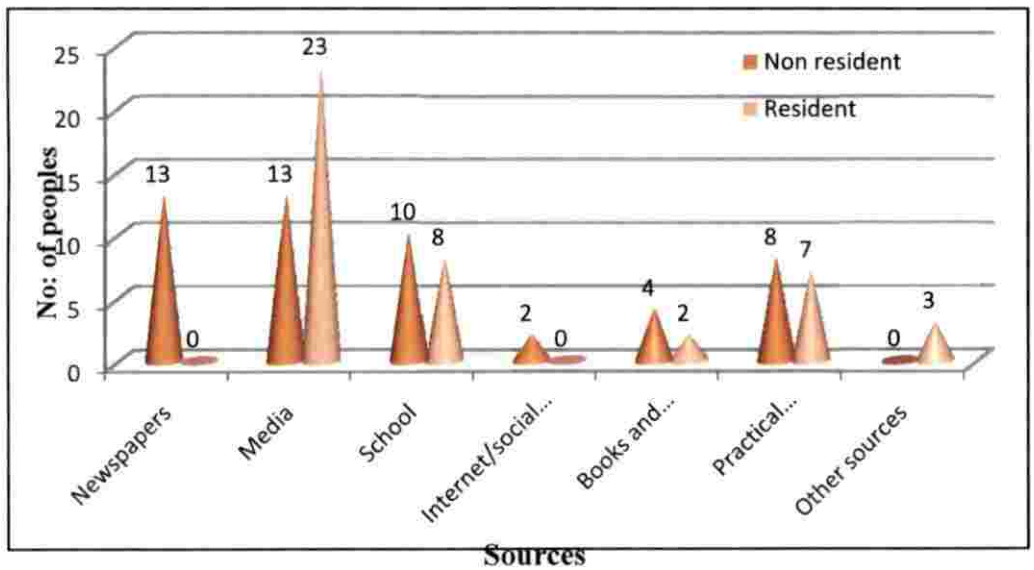

Fig4.5. Different sources of respondent's knowledge on climate change

Table 25. Perceived change in weather parameters as reported by the respondents

	Temperature		Rainfall	
	Non-resident devotee	Local residents	Non-resident devotee	Local residents
Increase	92.5	92.5	52.5	50
No change	5	7.5	22.5	40
Decrease	2.5	0	25	10

From Table 25 it is evident that 92.5 per cent of both resident and non-resident population has perceived an increase in temperature. Also a decrease in the availability of rainfall was observed by half of both the residents and non- residents.

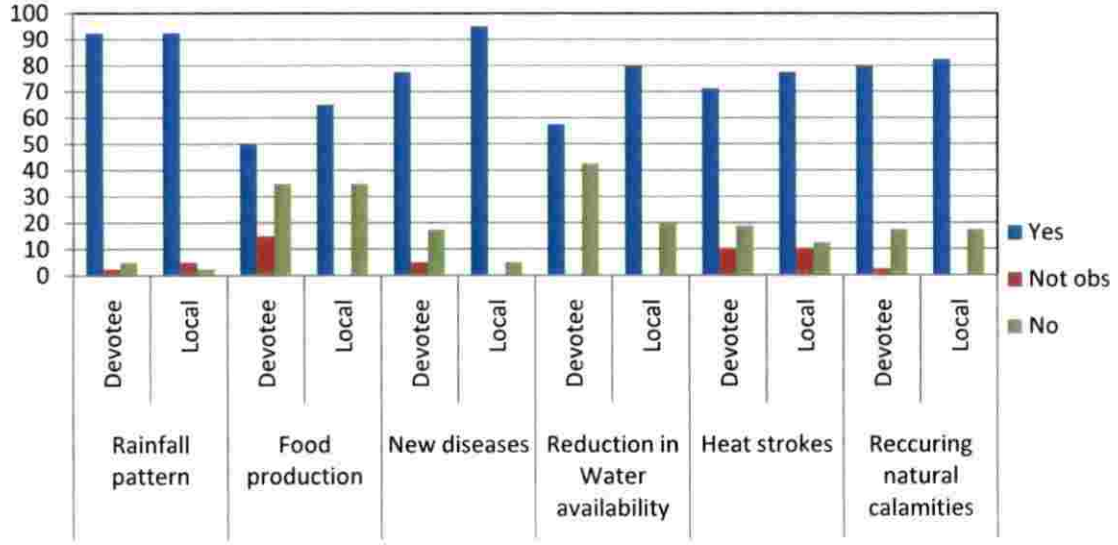

Fig 4.6. Impacts of climate change as perceived by the respondents

Figure 4.6 shows that people have observed changes in rainfall pattern, occurrence of new diseases, heat strokes, reduction in water availability and recurring natural calamities as other major issues of climate change.

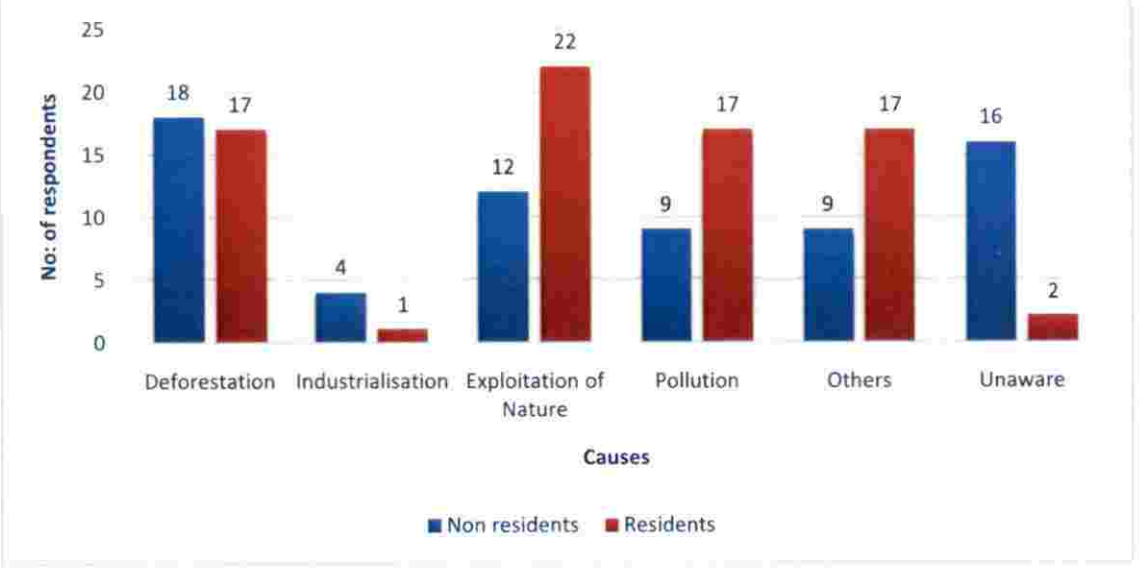

Fig4.7.Causes of climate change as perceived by the respondents

Figure 4.7 showed that deforestation and exploitation of nature was considered as the major causes for climate change by both the local residents and non-resident devotees, followed by pollution and industrialization. People seems to be less aware of the causes of climate change as some of them, mostly non-residents, said they had no idea on how climate change was happening. The residents showed a tendency to say climate change was part of natural processes.

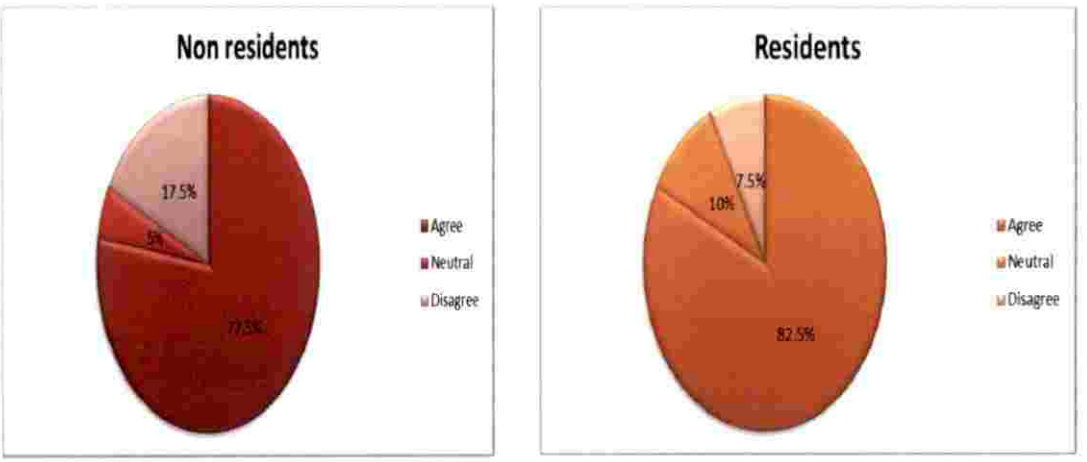

Fig 4.8. Response of local residents and non-residents on the role of human in causing climate change

Figures 4.8 illustrates that the statement "Humans have a major role in causing climate change" was supported by 77.5 per cent of the non-residents and 82.5 per cent of the residents.

4.4.1.2. Conservation of the grove as perceived by the respondents

Table 26. Respondents view on the conservation of the grove

	EC-1(%)		EC-2(%)		EC-3(%)	
	Non residents	Residents	Non residents	Residents	Non residents	Residents
Agree	100	100	62.5	75	57.5	77.5
Neutral	0	0	30	15	0	0
Disagree	0	0	7.5	10	42.5	22.5

EC-1(%) –Importance of conservation of natural vegetation

EC-2(%) – Choice of environmental conservation over development

EC-3(%) – Extent of evolution in the concept on sacred grove towards environment conservation

Table 26 gives an idea on the people's understanding of the importance of conserving the grove. It is clear from the table that the people are aware of the importance of natural vegetation as all of them (100 per cent) agreed that it is

important to conserve natural vegetation. About 75 per cent of the residents and 62.5 per cent of the non-residents were ready to accept slower economic development by giving priority on the protection of the environment.

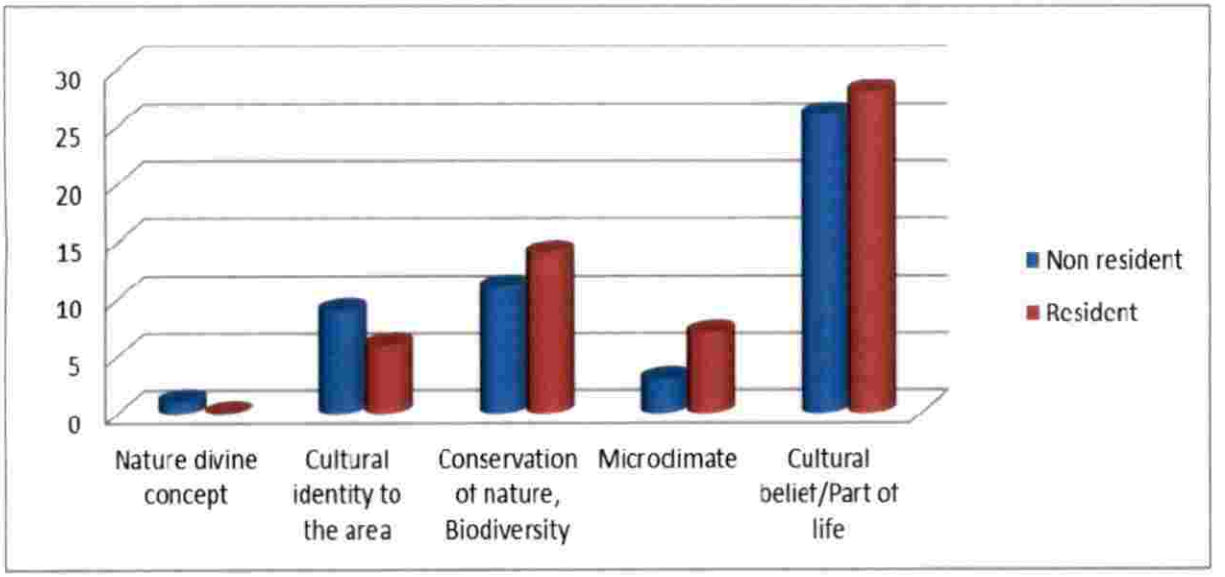

Fig 4.9. Reason for conservation of the grove as understood by respondents

Figure 4.9 reveals that majority of the population of both residents and non-residents believe that the grove has been maintained as it is a part of cultural belief or part of life as well. They also commented that conservation of biodiversity is another major reason.

4.4.2 Category wise perception study

The results of comparison of the perception on sacred grove and climate change by different age groups, Gender, Educational qualification and Peoples with different occupation is outlined in the table 27

Table 27. Perception of the respondents on the causes of climate change

Variables	Local residents		Non-resident devotee	
	Chi-square statistics	Spearman correlation	Chi-square statistics	Spearman correlation
Age	43.643**	0.722	45.116**	0.729
Education	34.839**	0.682	34.021**	0.68
Gender	19.355**	0.571	23.806**	0.759
Occupation	29.290**	0.65	51.096**	0.869

.

Table 27 showed that the people had different perceptions on the causes of climate change and was influenced by their age, education, gender and occupation. Among both devotees and local residents who were older than 75 years were aware on the causes of climate change and the awareness increased with the level of education. Male respondents could give better answers on these aspects in both the categories while the people who were not currently working could give the reasons of climate change more accurately.

Table 28. Perception of the respondents on the impacts of climate change.

Variables	Local residents		Non-resident devotee	
	Chi-square statistics	Spearman correlation	Chi-square statistics	Spearman correlation
Age	31.111**	0.544	37.986**	0.832
Education	22.222**	0.475	48.974**	0.894
Gender	2.667^{ns}	0.258	19.487**	0.694
Occupation	20.952**	0.493	24.072**	0.706

From Table 28, it is evident that age, education and occupation of both the categories have a significant influence on people's perception on the impact of

climate change. Whereas the influence of gender on their perception on the impacts of climate change was found to non-significant in case of local people, it was significant for devotees. Among the local people, respondents of age group of 25-40 seemed to be more aware on the impacts of climate change while from the devotees, people of age group 41-65 were more aware. Education of the people also had a significant influence on their response as the respondents of both category, who are graduates and above was having a better view on the impacts of climate change. The male respondents among the devotees came up with better answers while the gender showed no significant influence in the views of the local people. Occupation of the respondents also had an influence on their response as the housewives and jobless people among the devotees were more conscious on the climate change impacts while in the other category people who works in the private sector were more aware.

Table 29. Perception of the respondents on the reason for conservation of Sacred Groves.

Variables	Local residents		Non- resident devotee	
	Chi-square statistics	Spearman correlation	Chi-square statistics	Spearman correlation
Age	38.677**	0.682	33.725**	0.64
Education	32.914**	0.776	34.839**	0.718
Gender	28.571**	0.838	19.355**	0.693
Occupation	34.971**	0.768	29.290**	0.694

As indicated in Table 29, in both the categories, age, education, gender and occupation are having a significant influence on their perceived reason for the conservation of the sacred grove. The local people aged more than 75 and the devotees of the age group 66 to 75 stated the sacred grove has been conserved as a part of protection of nature and biodiversity conservation, even though they are a part of cultural belief. Education is also having a great influence on climate change as

higher the educational qualification more they believe in the biodiversity conservation aspect of the sacred grove. Male respondents of both the category seemed to be more aware on the reasons for the conservation of the sacred grove. In both the categories, people who are presently not working seemed have a better view on the reason of conservation.

Table 30. Perception change between local residents and non-resident devotee

Sl.No	Perception	Man-Whitney statistic	p-value
1	Local residents Vs Non-resident devotee(Causes)	797.00^{ns}	0.977
2	Local residents Vs Non-resident devotee(Impact)	656.5^{ns}	0.164
3	Local resident Vs Non-resident devotee(Reason)	787.00^{ns}	0.895

ns = non-significant

Table 30 shows that there does not exist any significant difference in the perception level of the respondents in both the categories.

4.4.3. Binary linear regression model

It was found that the model with the impacts of climate change as the independent variables is 58.9% fit in case of devotees and 48.1% fit in the case of local people (Nagelkerke R Square) , the correctly classified percentage is 92.5% for devotees and 75% correct for local people.

Attitude(Devotee)=-1.55**T**+1.622**R.F**-17.2**RF.P**-3.18**L.FP**-2.42**ND**-20.58**R.WA**+ 21.16**HS**+2.32**PH**-1.856**R.NC**

Attitude(Local)=77.572**T**-165**R.F**+0.4372**RF.P**+0.168**L.FP**+10.16**ND**-0.102**R.WA**-38.440**HS**+0.739**PH**+9.680**R.NC**

The other model with the basic details as the independent variables seems to have 74.3% goodness of fit in case of devotees and 45% in case of local peoples. The predicted and observed values are nearly the same as 90% is the correctly classified percentage of devotees, 92.5% for local people.

Attitude (Devotee) = 2.302**A**-5.286**G**+2.302**E**+0.775**O**

Attitude (Local) =-1.918**A**+0.218**G**-.054**E**+0.041**O**

Among the above models, the one that has been estimated by taking the basic details as the independent variables seems to be better. As physical parameters have less influence but the basic characteristics like age, gender, education and occupation have more influence on their attitude towards the importance of conservation of the sacred grove to combat climate change. The age of the respondents seems to be the best attitude defining variable ($p<0.5$) in case of the local people whereas the education seems to the most significant ($p<0.5$) independent variable in case of the devotees.

4.4.4. Taboos, Norms and Mores associated with the grove

The people here believed that the village itself was a forest. The King *Sharnga* used this place for hunting and got cursed (*Sapa*) by Saint *Agasthya* for killing innocent animals. As a part of repentance, the king was told to undertake strict *Tapas* inside the forest and worship *god*. Enjoying the peace and recreation of the forest, the king ordered to maintain this place as a grove and was named later as Sharngakavu. People are not allowed to enter the grove beyond a certain limit. The grove is famous for the presence of a large number of Bonnette monkeys who were considered as the children of the deity.

No complex constructions are allowed in this place as the people believe there is a big temple beneath the Achankovil River. The "*vigraha*" of the deity is considered as *Swayambhu* (self-manifested). During the monsoon season the water level of the Achankovil river rises and enters the temple premises covering the *Vigraha* and the

lower part of the grove. The event is considered as the '*Arattu*' meaning the holy bath of *Sharngakavil Amma*. The festival associated with Sharngakavu is the *Vishu Maholsavam* conducted during the month of April. It is believed that all the natives of the Venmony village have to visit the grove at the time of the festival.

The bare ground found in the premises of the temple is maintained as such because the people believe that thousands of years ago, *Lord Ayyappa* have stayed here and practiced Martial arts.

DISCUSSION

5. DISCUSSION

Conservation of the natural resources in the past involved many norms, taboos, and other religious practices. Sacred groves are one such traditional socio-cultural mechanism targeting on conservation of nature that knotted cultural aspects for conservation. As these are conserved for several years they can be considered as long term repositories of carbon. The results of a study to identify and record the plant species of Sharngakavu sacred grove, to enumerate its carbon stock and a social survey to understand people's attitude towards its conservation are discussed here under.

5.1 FLORISTIC WEALTH OF THE GROVE

A total of 67 plant species were identified from the grove. Fifty three species were present in the core zone, 38 species could be recorded from the buffer zone.

The species identified from the core included species like *Adenanthera pavonina, Aegle marmelos, Alstonia scholaris, Antiaris toxicaria, Azadirachta indica, Caryota urens, Cinnamomum malabatrum, Hopea ponga, Ixora coccinea, Macaranga peltata, Olea dioica, Strychnos nux-vomica and Vateria indica* which has been reported from other sacred groves of India as well in various studies(Gadgil and Vartak, 1974; Induchoodan, 1996; Colding and Folke, 1997; Bhagwat *et al.*, 2005; Punde, 2007; Patel and Patel, 2013). This grove also harbour other rare, endangered and threatened species such as *Alangium salvifolium, Aporosa cardiosperma, Asparagus racemose, Canarium strictum, Canthium angustifolium, Canthium coromandelicum* and *Strombosia ceylanica*. Some species that are endemic to Western Ghats are also hosted in this grove, for example *Actinodaphne malabarica* and *Xanthophyllum arnottianum.*

In the study conducted by Induchoodan (1996) on the sacred groves of Kerala, species such as *Xanthphyllum arnottianum, Adenenthera pavonina, Hopea ponga,*

Calamus rotang and *Vateria indica* have been classified as species common in groves near the coastal region. And the species such as *Antiaris toxicaria, Hopea ponga, Strombosia ceylanica, Strychnos nux-vomica* and *Lagerstroemia malabarica* are regarded as species found in the evergreen ecosystem. A species association of *Memecylon malabaricum – Memecylon umbellatum* and *Syzygium zeylanicum* was reported from Sharngakavu by Induchoodan in this same study but *Memecylon umbellatum* and *Syzygium zeylanicum* could not be identified during the time of this study. This may indicate the fast disappearance of important species from the grove.

The other species that has been identified from the core of the grove includes evergreen and semi-evergreen species such as *Aphanamixis polystachya, Ardisia pauciflora, Carallia brachiate, Cinnamomum malabatrum, Cinnamomum verum, Lagerstroemia microcarpa, Morinda citrifolia, , Pongamia pinnata and Strebles asper.* Some deciduous tree species such as *Alangium salvifolium, Grewia tillifolia* and *Boswellia serrata* were also seen here.

Meanwhile, the buffer zone has some of the large trees which are also seen in the core and some of the common species such as *Macaranga pelata, Theobroma cacao, Calycopteris floribunda, Drypetes oblongifolia, Ficus hispida, Broussonetia papyrifera, Acacia caesia* and *Chromolaena odorata.* Gracia *et al.* (2010) has reported that the disturbed fragments of the vegetation losses its native species and get replaced by ubiquitous species. The remnants of the large trees in the buffer establish that the area taken as buffer once had similar characteristics of the core and the disturbances caused the establishment of the common species. Most of these ubiquitous species was found in their regenerating stage hence, these change in the species composition had only occurred recently.

The core of the grove was dominated by *Xanthophyllum arnottianum* which is a species recorded as endemic to Western Ghats by Induchoodan (1996). The buffer region was dominated by *Caryota urens* which is a native species of Kerala. Even

though only very few trees of the species *Antiaris toxicaria* were recorded from buffer, the Importance Value Index of the species was found to be high in this zone. This may be due to the presence of a giant tree of *Antiaris toxicaria* with height of 23 meters and GBH of 3.4 meters.

Most of the area under buffer has been covered with of *Acacia caesia* and *Chromolaena odorata*. As reported by Macdonalds (1983), *C.odorata* has been considered as a major weed throughout the world as they spread effectively due to its fast dispersal of seeds in short and long distances. Pure strands of *C.odorata* will get established in disturbed forest areas. These invade the natural vegetation and poses serious threats. As observed from the site of study *Acacia caesia* has spread widely in the buffer with their wines climbing on the regenerating saplings, thus preventing them to grow further. These might be the reasons for the poor regeneration rate in the buffer region. The occurrence of *Macranga peltata* is an indicator of disturbance in the ecosystem as they are commonly found in the secondary succession period (Jayant and Mehta, 2013).

It is evident from the previous studies that the species richness of the groves that has been kept away from disturbances have a good number of plant species present in them and those fragments that are exposed to human interferences or any such disturbances in an increased rate will lack in the species richness (Garcia *et al.*, 2006; Murugan *et al.*, 2007; Khan *et al.*, 2008; Dudley et al, 2014). The species richness of the buffer was found to be much less than that of the core which suggests the buffer area that constitutes the major portion of the grove is under great pressure. Even though the cutting of plants and construction works are restricted in the grove, the developmental activities such as road constructions, absence of strict delineation of the grove from the nearby human habitats and threats possessed by the invasive species are major issues faced by the Sharngakavu sacred grove.

During the door to door survey some people denied the decrease of the vegetated area but some people seemed to have noticed current changes and this was found to be true when the present vegetation cover of the grove was assessed. The people are also aware that many economically important and medicinal plants are present inside the grove and some have noticed the disappearance of those species. As understood by the people the spreading up of *Acacia caesia* is the major problem of the grove. They also reported that some attempts were made to remove these climbers but was found to be less effective.

5.2 SOIL CHARACTERISTICS OF THE GROVE

Soil is regarded as the largest terrestrial pool of carbon. The soil characteristics of Sharngakavu was analysed primarily for estimating the difference in carbon concentration in the core, buffer and also the soil collected from the control site. In all the sites the carbon concentration was decreasing with depth. As reported by Saha *et al.* (2009) this trend in common is a reflection of the deposition of higher quantities of organic materials such as litter on the surface soil and rapid decomposition of them.

When the soil organic carbon (SOC) concentration of each location was compared, the soil collected from core was expected to have the highest carbon concentration but buffer recorded the highest SOC. This can be justified by the increased incidence of solar radiation in the buffer zone as compared to the thickly vegetated core. This justification is supported by the findings of Toth *et al.* (2007) and Baughman *et al.*(2015), who states that the distribution of SOC depends on the incidence of solar radiation, decreased temperature conditions slows down the decomposition of soil organic matter that also decrease the rate of SOC accumulation. Meanwhile the elevated soil temperature would result in increased soil respiration rate which act as a positive feedback mechanism for global warming. Hence, the

reason for decreased concentration of SOC in the control site is the lack of vegetation cover that contributes to the formation of soil organic carbon.

The total nitrogen content of soil in the study area was also following the same trend of the SOC. The relationship between the carbon and nitrogen is well acknowledged, the total nitrogen content and carbon concentration are positively correlated as both are function of the aboveground organic matter (Stevenson, 1959).

The pH of the soil is the measure of acidity or alkalinity of the soil. The pH of the soil varies with the decomposition rate; the zones with slower decomposition rate of the organic matter will be more acidic due to the presence of humic acid. The pH of the soil decreases with depth as the deeper soils are in less contact with the acidic organic matter (Papritz and Flühler, 1992). Thus the reason for decreasing trend of the pH with depth in the study area and variation of the pH range with locations can be understood. In the study area, acidity of the core is greater than that of buffer. This is also a proof for the conclusion that more accumulation of organic matter and slower decomposition of them is taking place in the core. The pH value of the control site was much greater than the core and buffer proving the soil of this zone lacks in this humic acid content.

In general, the bulk density of the soil profile increases with depth due to change in organic matter content and compaction (Chaudhari *et al., 2013)* which has been followed by the core and the control sites. But there was a visible change from the general trend of bulk density in the buffer region. This may be due to the mineral deposits contributed by the nearby stream and increased soil erosion in these sloppy areas. The mineral deposits increase the bulk density of the soil (Liu *et al.*, 2018).

5.3 CARBON STOCK OF THE GROVE – INDICATOR OF REDD+ POTENTIAL

Each biochemical process of the vegetation growth includes carbon fixing. Undisturbed vegetation is considered as long term repositories of carbon. A 1.3ha of

standing vegetation that has been conserved against deforestation and degradation implies a significant amount of locked up carbon for ages. Hence this hundreds of year old grove can be considered as an ancient old REDD+ mechanism. The United Nations collaborative programme on Reducing Emissions from Deforestation and forest Degradation in developing countries was initiated in 2008 with aims to check the reduction in existing carbon sinks by sustainable management of forests and enhancement of forest carbon stocks in developing countries. The documentation of the present carbon stock of the grove will serve as a reference level of the REDD+ potential of the grove and give a scientific support for its continued conservation.

The carbon stock of the vegetated area was visibly much higher than that of the treeless control sites. It was visible that the SOC of the deepest soil layer of control site was much less than that of the vegetated area which was attributed by the fine roots of the large trees in the vegetated area. The total organic carbon captured and stored by the Sharngakavu sacred grove was enumerated to be 456.71 Mg ha^{-1} in the core and 344.36 Mg ha^{-1} in the buffer. This can be correlated with the species richness of the core and buffer area. The core seems to have more carbon stock as compared to the buffer. The species richness of the core which is visibly greater than that of the buffer is the reason for this difference. Species richness and carbon stock are positively correlated (Mandal *et al.*, 2013). This shall also emphasis the increased disturbance in the buffer zone. Well protected and undisturbed groves are considered to store more carbon than the disturbed or regenerating systems (Schulze *et al., 1999,* Apps *et al.*, 2000).

Thus the core can be considered as the heart of the grove which is a gene pool and have the capacity to store more carbon. The buffer zone constitutes more area of the grove but have less species recorded from there. According to Saha *et al.* (2009), more the number of species the more will be the utilization of the resources, thus increasing the net primary productivity of the system and elevates it's potential for

carbon sequestration. Thus the core of the grove will be having a greater productivity than the buffer. Thus a careful management of the grove can extend the core area, which increases the productivity of the grove and its carbon storage.

5.4. PERCEPTION AND CONCERNS ABOUT THE SACRED GROVE

For the increased management efficiency of Sharngakavu sacred grove the perception of the people who are directly involved in the activities of the grove are important. Thus understanding the views of the local people near the grove and those devotees who come to visit the grove is important for finding out the existing issues and future conservation strategies.

The study revealed that majority of the respondents from both the category (local and devotee) have heard about climate change and have experienced it directly. As understood by the people human activities such as deforestation and over exploitation of nature are the major causes of climate change and they strongly believe that the natural vegetation has to be conserved. A similar study conducted by Patil (2011) in Maharashtra reported that some people were least concerned about the conservation of such groves and believed that sacred groves are not an important aspect for them. Thus the attitude of the people changes with region and depends on their conceived benefits from the grove. The people's knowledge on the reasons for climate change increased with their educational qualification, which proves education makes people more environmental conscious. In addition to the need for protecting the existing forest cover the need of local actions for mitigating climate change was well addressed by the people. The local people seemed to have an increased concern on the environmental conservation than development.

The respondents said that there is a tremendous increase in temperature in the recent years with irregularities in the rainfall pattern. New disease outbreaks in addition to the chances of sunburn and heat strokes during hot season are major issues

of climate change. Recurring natural calamities and reduction in water availability possess a great risk for the vulnerable community such as those who depends on the natural resources for their livelihood. Studies have already revealed that a large number of forest dependent communities, people who depend on natural resources as part of their livelihood have understood that the climate has become hotter and there is an increased uncertainty in the rainfall (Vidya *et al.*, 2015). Thus the people believe that climate change can endanger their livelihood and has to be considered as a serious issue. The answers of most people were in agreement with the findings of Intergovernmental Panel on Climate Change (IPCC).

Impacts of climate change were noticed well by the younger respondents (25-40) among the category of local people as they are more exposed to the outer environment experiencing these changes directly. In the other category, the people of age group 41-65 found to have more knowledge on the impacts of climate change as they are comparing the changes in climate with that of their younger ages when urbanization was low.

Among the devotees, the awareness on climate change decreased with better occupation, the jobless people including housewives gave better response. But among the local people the awareness on climate change was found to be increasing with better occupation. Thus a conclusion can be arrived that people who live away from the grove are more exposed to climate change and those people who are having better occupation have increased responsibilities and have less time to observe these changes around them. Whereas the people who live near the grove derive benefits from the ecological services provided by the grove and experience a better microclimate. Hence, the jobless/ housewives who have fewer chances to move outside the residence are less aware of such changes. Similar trends were observed by Krishnan (2014) in his study on the sacred groves of Northern Kerala.

In both the categories better educated people have gained more knowledge on climate change and its impacts. But when the impacts of climate change in the immediate vicinity was considered people who are more exposed to the open environment had experienced these changes directly. This statement can be proved with the support of results that the respondents who has more chances of dealing with the outside environment came up with better answers in both the categories. No gender based changes were found in the answers of the local people as they are not much exposed to such changes in their microclimate but such changes are found among the devotees here male respondents had better observations on climate change. Krishnan (2014) had reported that the perception of the people on the conservation of sacred grove depends on their gender, educational qualification and occupation. This was found to be true also in case of the people associated with Sharngakavu, in addition to that age of the respondents was also recognized as a factor that influences their perception.

A previous study had concluded that the perception of the local people on the conservation of the sacred grove depends on their caste. The caste group which is more dependent on the resources from the grove urges for its continued conservation and those who have less association with the activities of the grove are less interested in it. But here in the case of Sharngakavu all the local residents of this region are interested in the continued conservation of the grove regardless of their caste or religion.

Reduction in the size of sacred groves and utilisation of these areas under groves for other income generation activities are common among the private sacred groves in some districts (Ormsby, 2013). In Sharngakavu, the activities of grove is run by a group of Brahmin families, hence any unauthorized utilization of the natural resources and any violation of the norms of the grove will be strictly controlled. Thus the grove proves to be a success of community based management system of natural

resources. Even though felling of trees and converting the grove area for other purposes was under thorough check issues such as trespassing fragmentation and pollution activities (plastic deposition by man or those have been carried into the grove my the monkeys) exists which can be attributed to the degradation of the grove.

Proper fencing of the boundaries of the grove is important as the rate of degradation was found to be more near the edges of the grove which are nearer to the human habitats. The developmental activities such as road constructions are also causing the degradation in some edges as there is tendency among the workers to disturb the grove by depositing the construction materials in the grove area. Sparse or very few underground vegetation was found in the edges of the grove and the tree species have started getting degraded which will later on reduce the vegetated area. Chances of encroachment will also be encouraged.

All sacred groves play a vital role in maintaining the environment. The vegetation present in these groves checks the soil erosion and increases the water holding capacity. There are also evidences of the better microclimate of the region was attributed by these groves (Mahajan and Patil, 2018). Thus the disappearance or absence of the Sharngakavu sacred grove will result in alterations of microclimate in this region including increased temperature, increased rate of soil erosion in these sloppy area and reduction in availability of fresh water. But in a global concern a large quantity of carbon will remain in the atmosphere which attributes to climate change. In an ecological concern, a number of endemic and evergreen species will vanish along with the supported biodiversity including birds, animals, reptiles and the microorganisms. These green islands also have an influence on the mental health of the people. The fresh air, oxygen and recreation provided by the grove are priceless. Even though the people admire these benefits provided by the grove the existence value of the grove was only an issue of mere concern among them and comes only after the religious value.

The cultural believes surrounding the grove have a major role in the conservation of the grove since ages. The sacred groves are warehouse of natural resources including many timber species. As stated by Chandran and Hughes (1997) one of the major reason for the vanishing of the existing sacred groves is the relaxing of the existing norms on the conservation of the grove and utilization of these resources for the construction and maintenance of the temple structures. But in Sharngakavu, the existing taboo against any constructional activities or building complex temple structures in the premises stop the people from cutting trees from the grove for such activities. Unless the periodic cutting of the climbers that threatens other species of the grove (such as *Acacia caesia*) no removal of any flora from the grove was allowed. This can be considered as an informal mechanism imposed by the ancient people to control deforestation activities understanding the chances of clearing this natural vegetation in the upcoming years.

The belief of the local people is that a huge temple is present deep inside the Achankovil River flowing beside the Sharngakavu. This controls the setting up of any industrial activities near the river stream that reduces the chances of pollution of this fresh water resource.

Vishu Maholsavam is the major festival celebrated in the Sharngakavu devi temple every year during the month of April. As believed by the people all the natives of the Venmony village has to visit the grove at the time of Vishu Maholsavam. This norm was found to be followed by them without fail. Such a mandatory periodic visit to the grove and the native place build up strong social bonding among people and strengthens the existing cultural believes. A major support to the livelihood of small scale merchants of this region is also ensured during this period.

Bonnet macaque is a macaque species endemic to Southern India. Sharngakavu is famous for the monkey population residing inside the grove which is

considered as the children of Sharngakavilamma. The people who visit the grove are not allowed to hurt these animals and they often offer food such as banana and rice flakes to these monkeys. Thus the Sharngakavu sacred grove serves as a safer habitat for these endemic species.

As the educational qualification of the people increases they seem to understand that these taboos imposed on the grove are ancient old informal mechanisms for the conservation of biodiversity. During the study it was evident that the people have realized the importance of sacred groves for the conservation of biodiversity.

Attitude of the people associated with the grove is very important for the continued conservation of the grove to combat climate change. The stakeholders of this grove revealed that they are getting highly benefited from the ecosystem services provided by the grove which includes, influence on microclimate (the decreased temperature experienced in this region), availability of fresh air and also the regulation of local hydrology. They also stated that they are ready to give economic support for the conservation activities of the grove. Similar findings came out during the study of Vasudevan (2005) on the sacred groves of Kerala which reported the people living closer to grove are enjoying the ecosystem services provided by the groves to a great extent and this was their major reason for supporting the conservation of the grove. The native people of the village who migrated to other places (such as women who got married to other places and people who moved out of the village for educational and occupational purposes) acknowledged the role of the sacred grove in altering the microclimate of the region and the revitalizing power of the grove.

Physical parameters of climate change such as temperature rise and the recurring extreme events such as flood in the recent years were well understood by the people, but these experiences seemed to have a less influence on their attitude.

Whereas, the demographic characteristics of the people such as age, gender, occupation and education can be considered as the parameters that influence their attitudes.

Attitude of the local people seem to be changing with age, the older people have an increased attitude disposition to climate change. This says that the experience that they gained as residents of that area is influencing them to conserve the grove for the future generations. The impact of the grove on controlling their microclimate is well understood by the people. Education of the people was the parameter which had a positive correlation with the attitude of devotees on the conservation of the grove. This confirms with the theoretical disposition that, education determines a person's knowledge and attitude.

Taboos and cultural believes are the invisible fencing which has been laid around the sacred groves. Decreased trust on these believes are one of the major reasons for the vanishing of the sacred groves. When people move towards the modernized era people lack traditional knowledge and move away from these ancient old laws imposed on them. The increased demand for development and improved infrastructural facilities may drive them towards the utilization of these treasure pots and build up the economic wealth. People who thinks that the existence of life is much important than the improvement of life are decreasing with generations.

The developing countries are the ones who are more fragile to this condition, as the developmental activities get done at the cost of natural resources. A recent example for this is the complete destruction of Shanthi vanam sacred grove in Cochin, Kerala for the setting up of electrical lines. Electricity has been considered as a major aspect of livelihood nowadays and thus the development as understood by the people is better living standards. But here the local people living near the grove and the public strongly protested against the activity. The reason which they more

emphasized on was the ecological services provided by them and the biodiversity the grove harboured.

Thus creating awareness among the people and making people realize the critical role of the grove in biodiversity conservation and more importantly in combating climate change is the most important measure to conserve these natural sites. Education increases awareness on biodiversity but at the same time people has chances of losing their belief on these traditional norms. Directing this knowledge towards the conservational aspect of the grove and the necessity of mitigating climate change is the major challenge for preserving these sacred natural sites for future generations.

SUMMARY

SUMMARY

A study titled "Species richness and carbon stock of Sharngakavu sacred grove, Chengannur, Kerala" was undertaken in a hundreds of year old sacred grove named Sharngakavu in Venmony village, Alappuzha district Kerala. The objectives of the study were to document and compare the species richness of the core and buffer zones of the grove and to compare the carbon stock of both these zones. A socio cultural survey was also conducted to understand the perception of the people associated with the grove on climate change and the grove's ability to combat it. The major findings of the study are summarised below:

- The grove harboured about 67 plant species including various evergreen and semi evergreen plants species that are endemic to the Western Ghats. Fifty three plant species was recorded from the core zone, while the buffer zone recorded 38 plant species.

- The species that are found in coastal groves such as *Xanthophyllum arnottianum*, *Vateria indica* and *Adenenthara pavonina* and some evergreen species like *Aphanamixis polystachya*, *Ardisia pauciflora*, *Cinnamomum malabatrum* and Cinnamomum verum were identified from the core. The buffer zone constituted some species like *Antiaris toxicaria*, *Caryota urens* and few commonly found species like *Macranga peltata and Broussonetia papyrifera*. But most of the buffer zone has been inhabited by *Chromolaena odorata* and *Acacia caesia.* The grove also provides a safer habitat for a number of Bonnet macaque which is endemic to Southern India

- The presence of *Chromolaena odorata* over a vast area and *Macranga peltata* in the buffer zone indicates the occurrence of disturbances in this zone..

- Carbon concentration significantly varied between core and buffer zones. The SOC of the buffer is more than the core zone. This could be due to the increased solar insolation in the buffer zone because of the comparatively sparser underground vegetation.

- The total nitrogen content of the soil was also found to be decreasing with depth, showing the same trend of that of the SOC.

- The soil pH increased with depth. The top soil layers are more acidic due to the increased humic acid content. The pH was also increasing in the order Core< Buffer< Control.

- The Electrical conductivity of the soil showed less variation with depth. However slight variations were observed between locations.

- The soil carbon stock of the core and buffer zones were 107.23Mg ha^{-1} and 181.39Mg ha^{-1} respectively while C stock was only 94.04Mg ha^{-1} in the control site.

- The carbon stock of the standing vegetation in the core zone was 349.47 Mg ha^{-1} while it was 162.97 Mg ha^{-1} in the buffer zone.

- The total carbon stock (Sum of carbon stock of soil and standing vegetation) is 456.71 Mg ha^{-1} for the core zone while it was 344.36 Mg ha^{-1} for the buffer zone.

- The highest carbon stock (456.71Mg ha^{-1}) and the species richness (53) were found in the core. This shows the carbon stock of a location is directly related to the species richness and vegetation wealth of the area.

- Both the local residents of the Venomony village and non-resident devotees who came to visit the grove are interested in the continued conservation of the grove. However, there were no significant variations among their perceptions on climate change.

- The majority of the respondents from both the categories was aware of climate change and had experienced it directly. Ninety per cent of the non-resident devotees and eighty five percent of the local residents believe that climate change will endanger their livelihoods. About 82.25% of the non-resident devotees and 93.75% of the local residents agreed that the climate change can be reduced through local actions

- The respondents reported that mass media was reported their major source of knowledge on climate change, followed by, education and experiences.

- The impacts of climate change as noticed by the respondents included increase in temperature and changes in rainfall pattern. The recurring natural calamities, incidence of new diseases, decreasing food production through yield loss and increasing risk of heat strokes was also reported as the impacts of climate change by the people.

- The people who are more exposed to the outside environment seemed to be more aware on the impacts of climate change.

- The causes of climate change as understood by the respondents are mainly deforestation and over exploitation of nature. About 82.5 per cent of the local residents and 77.5 per cent of the non- resident devotees believes that humans have a major role in causing climate change.

- The respondent's perception on the causes of climate change and the reason for conserving the grove was found to be influenced by their age, gender, education and occupation.

- In the case of both categories of respondents, the respondents who are older than 75 years were aware of the causes of climate change. The impacts of climate change were well understood by the respondents in the age group 25-40 (local residents) and people of age group 41-65 (non-residential devotees). The reason why the sacred grove has been conserved till now is the cultural belief associated with it. But it was evident that the local people aged more than 75 and the devotees of the age group 66 to 75 have understood the sacred grove has been maintained as a part of protection of nature and biodiversity conservation.

- The awareness on the impacts, causes of climate change was found to be increasing with the level of education. The education also positively influenced the view of the respondents on the conservation of biodiversity through sacred groves.

- Among both the categories, the male respondents could give better answers on the causes and the reasons for conservation of the grove. Better answers were given by the male respondents on the impacts of climate change in the case of non-residential devotees, but, gender showed no significance in the people's response on the impact of climate change among the local residents.

- Among the devotees the people who are not currently working could answer on the causes of climate change correctly but from the category of local

residents the answers were rightly said by those who work in private sectors. In both the categories, the causes of climate change and the reason for conservation of the sacred grove was better understood by the people who are presently jobless or not working.

- The knowledge gained through education and the experiences of the people were the major factors influencing their attitude on the conservation of the grove.

- Even though the ability of the natural vegetation like sacred groves to combat climate change was well appreciated by 100 per cent the respondents in both the categories only 62.5 per cent of the non-resident devotees and 75 per cent of the local residents opted the choice of environmental conservation over development.

- The view of the people on the grove has started changing from a cultural entity to a mechanism of biodiversity conservation. But still it was evident that the major reason for continued conservation of the grove is the cultural belief associated with it.

- The absence of a proper fencing around the grove and the increased disturbances on the boundaries are the major threats faced by the grove. The plastic wastes (used bottles of oil and plastic covers of offering materials) were often carried into the grove by the monkeys and these pollute these sacred sites.

Future scope of the grove and continued conservation:

- Making people more aware of the importance of the conservation of the grove with scientific evidences will ensure a more serious approach on this aspect.

- The projects like carbon neutral village and REDD+ mechanisms with economic support can be implemented. So the proper conservation of the grove can be ensured along with the sustainable development of the locality.

- A detailed documentation of the ecosystem services provided by the grove and the people's willingness to pay for the grove's conservation will help to understand people's readiness to conserve the grove.

- The influence of the grove on water conservation and controlling the microclimate, thus acting as a "green island" of this region can be studied for documenting the evidences of the ecosystem services provided by the grove.

- The grove has to be protected against trespassing of people who use the grove as a shortcut. Hence it should be properly fenced and protected properly from the nearby residential area to decrease the human disturbances. The proper management of the *Chromolaena odorta* and *Acacia caecia* which possess major threats to the regeneration of the grove has to be ensured. The temple authority should ensure the proper management of the plastic wastes.

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APPENDIX- I

Interview schedule used for socio-cultural survey at Sharngakavu sacred grove, Chengannur.

Title of the study: Species richness and carbon stock of Sharngakavu sacred grove, Chengannur, Kerala

INTERVIEW SCHEDULE

Respondent no:

Date:

PART -1

1. Name :

2. Address :

3. Name of the Panchayath :

4.District :

5.Local person /Devotee/Migrated/NRI

6.First time visitor/Frequent visitor/Occasional visitor

7. Gender : Male/Female/Others

8. Age :

9. Education :Illiterate/Primary/High school/SSLC/HSS/Graduate/PG

10. Economic Status : BPL/APL

11. Major occupation :

PART-2

1. I strongly believe in Climate change/Global warming?	Agree	Not decided	Disagree

2.From where have you heard about climate change (source of knowledge on climate change)

i)Newspapers

ii)Media

iii)School

iv)Internet/Social media

v)Books and Journals

vi)Practical experience

vii)Other sources (Mention).....

3. What changes do you think,happening due to climate change

Sl.N	Observation	Yes	No	Not observed
1	Increase in temperature			
2	Decrease in temperature			
3	Increase in rainfall			
4	Decrease in rainfall			
5	Changes in rainfall pattern (Advanced/Delayed)			
6	Food production loss			
7	New diseases			
8	Reduction in water availability (wells,lakes,rivers)			
9	Heat strokes			
10	Plant health			
11	Reccuring natural calamities			
12	Any others,.....			

4.I believe that climate change can endanger life or affect livelihood ?

Agree	Not decided	Disagree

If Agreeing,How?

i)Food availability

ii)Water availability

iii)Air quality

iv) Diseases

v)Loss of biodiversity

vi)Others (Mention).....

5. According to you, what might be the causes of these changes ?

i)Defforestation

ii)Industrialisation

iii)Pollution

iv)Others(Mention) .....

6.Local actions cannot reduce climate change

Agree	Not decided	Disagree

(if disagreeing, how?)

i).....

ii).....

iii).....

7.Conservation of natural vegetation through Kavu have an important role ?

Agree	Not decided	Disagree

(Why?)

8.Protecting the environment should be given priority, even if it causes slower economic development.

Agree	Not decided	Disagree

(Reason)

9.Human activities are the major causes of climate change

Agree	Not decided	Disagree

(Reason)

10.Paris agreement has to be strictly followed

Agree	Not decided	Disagree

11. What could be the social/cultural reason for maintaining this sacred grove?

i) All creation of nature are divine and hence must be protected.

ii)This grove asigns a cultural identity to this neighbourhood.

iii)By protecting the grove,we are protecting the nature.

iv)Disturbing the grove will disturb themicroclimate.

v)Cultural belief, part of life

vi)Others ,.....

SPECIES RICHNESS AND CARBON STOCK OF SHARNGAKAVU SACRED GROVE, CHENGANNUR, KERALA

by

KAVYA JEEVAN

(2014-20-114)

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirements for the degree of

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FACULTY OF AGRICULTURE

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ABSTRACT

Global warming and biodiversity loss are the major environmental issues faced by the planet today. The "sacred groves" are repositories of woody vegetation that successfully and efficiently conserve these "trees outside the forests". Documentation of the species present in such C sinks will help to document the native species that are conserved here. Estimation of carbon locked up in these vegetated areas will help to further understand the potential of these sacred natural sites in mitigating climate change. With this background, a study titled "Species richness and carbon stock of Sharngakavu sacred grove, Chengannur, Kerala" was attempted on Sharngakavu sacred grove, Aalapuzha during 2018- 2019. The objectives of the study were to document the floristic wealth of the grove, enumerate the carbon stock of the grove and to understand the people's perception on the role of conservation of this sacred grove in combating climate change. The grove was delineated into core zone and buffer zone for detailed vegetation analysis and estimation of carbon stock. Fifty three plant species were recorded from the core zone of the grove, while from the buffer zone, 37 species could be identified. *Actinodaphne malabarica* and *Xanthophyllum arnottianum* which is endemic to Western Ghats were observed in the core region. Other species identified, included some major evergreen and semi- evergreen species such as, *Aphanamixis polystachya, Ardisia pauciflora, Carallia brachiata, Cinnamomum malabatrum, Cinnamomum verum, Lagerstroemia microcarpa, Morinda citrifolia, Pongamia pinnata and Strebles asper.* Some deciduous tree species such as *Alangium salvifolium, Grewia tillifolia* and *Boswellia serrata* were also found. The Shannon Weiner index value of the core was about 1.9, which suggests the grove inhabits a fairly good number of species. The core zone was dominated by *Xanthophyllum arnottianum* while the buffer was dominated by *Caryota urens*. The carbon stock of the soil was found to be decreasing with depth. The carbon stock of the standing vegetation was found to be the highest in the core which could be attributed to the species richness. The total carbon stock was also found to be the highest in the core zone (456.71 Mg ha^{-1}), while 344.36 Mg $ha^{-1}$was recorded total C of the buffer zone, even though in terms of area, this constituted

the major portion of the grove. Perception studies revealed that majority of the respondents are strongly interested in the conservation of the grove. They also considered deforestation and exploitation of nature as the major causes of climate change. It was also clear that the people's perception on the causes and impacts of climate change was highly influenced by their age, gender, education and occupation. Among the local residents, people's interest to conserve the grove was influenced by their age, while among non-resident devotees, education levels was observed to influence their attitude. Traditional beliefs certainly had an influence on the existence of the grove. Even though the grove has been conserved as a part of cultural belief, its role in biodiversity conservation was well understood by the people. Strengthening the people's knowledge on the importance of value of the grove in both biodiversity conservation and climate change mitigation will help to conserve this Important Plant Area (IPA).