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MACROLICHENS FROM KERALA FORESTS

Conservation of biological diversity and sustainable utilization of our genetic resources have gained considerable importance in recent times. It is needless to emphasize that the ecosystems are subjected to intense pressure due to multifarious factors. The population of several species have been reduced and some are on the verge of extinction due to environmental degradation. Excessive exploitation, environmental pollution, climate change and invasive species are some of the factors responsible for the decline of species diversity.

The vegetation in the southern Western Ghats is typically tropical resulted by the profound influence of rainfall and temperature. Multistoried canopies of vegetation characterize these tropical forests and various synusiae are trees and shrubs, herbs, climbers, stranglers and epiphytes. Compared to the other elements in the tropical forests, epiphytes are considered as special group in terms of their morphology, adaptation and their role in a changing environment. Epiphytes being sensitive to disturbance and change in microclimate, serve as indicators or guides for careful management of the ecosystem. In the tropical forest ecosystem where atmospheric inputs are large and seasonal, the epiphyte community plays a key role in nutrient cycling.

Epiphytic community

Epiphytes, a fascinating group in the plant world, generally grow attached to the trunk and branches of trees and shrubs. The mode of life of epiphytes is highly specialized and differs widely in physiognomy and physiology from that of the herbaceous ground flora. Being a smaller group inhabiting the tropical forests and belonging to a limited number of families, epiphytes have their own importance in the tropical forest ecosystems. Epiphytes constitute an important floristic, structural and functional component of tropical rain forests (Benzing, 1983) and their spacial distribution mostly depends on phorophytic species, its age and microclimatic conditions. In different trunk diameters of the same species usually represent different ages, are correlated with the degree of epiphytic diversity (Bennett, 1986) and specific association (Catling and Lefkovitch, 1989). These epiphytes mainly include angiosperms, ferns, mosses and lichens. Their distribution and occurrence depend mainly on the microclimate, nature of substratum and their specialized morphological adaptations. The establishment, development and adaptations of epiphytes in a host tree occur very slowly, as seen in the older trees in the tropical forests inhabiting heavy growth of epiphytes.

In a single tree four epiphyte zonations can be seen:

1) The peripheral twig area - colonizing small orchids along with lichens,

2) Central area and lower part of the crown holding orchids and pteridophytes,

3) Upper trunk area with creeping herbs and pteridophytes and

4) Lower trunk with many hymenophyllaceous and trailing ferns.

In India, though a large number of floras have been published from different phytogeographic regions, very little information on epiphytes with special reference to lower plant groups is available. Emphasis has always been for documenting the vascular epiphytes and higher plants and information available on the epiphytic lower groups of plants have been scarce.

Luxuriant growth of lichen communities in High Ranges

Though the tropical forests of the Kerala part of Western Ghats is floristically rich, little effort has been taken to study epiphytes except for a few studies from certain universities under Ph.D. programmes. Kumar and Stephen (1997, 1998b) attempted to enumerate and compile information on the vascular epiphytes and data gathered about their mode of life, habitat, distribution, status, host relationship, zonation, etc. The study resulted in many new species, new records and rediscoveries (Kumar, 1998; Kumar and Stephen 1998a, 1998b, 1998c, 1999, 2000, 2001; Kumar *et al*., 2000). Muthuramkumar and Parthasarathy (2000) and Annaselvam and Parthasarathy (2001) have studied the herbaceous vascular epiphytic flora of Western Ghats. To develop a meaningful conservation strategy for the preservation of biological diversity detailed and accurate information on all the species including the epiphytic flora is essential.

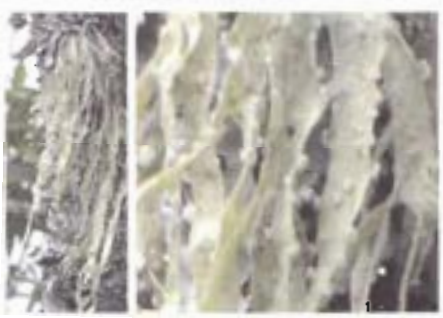
relationship of macrolichens in the tropical wet evergreen forests of Silent valley National Park, it was observed that the macrolichens prefer several host species in the west coast tropical evergreen forests, but the percentage of occurrence of macrolichens on hosts is greater in the subtropical broad leaved hill forests (Sequiera and Kumar, 2008). The study on lichens from the Kerala part of Western Ghats is far from complete and an exhaustive survey would definitely lead to discovery of more number of species from this region. At present no documentation has been carried out on the uses of lichens from this region. During the studies on macrolichens from the Kerala region, the authors gathered a few interesting records of hitherto unrecorded medicinal and other uses practiced by the local and tribal communities in Kerala. A checklist of useful macrolichens occurring in Kerala, their habitat, collection localities and uses is given in Table 1.

Coccocarpia erythroxylli

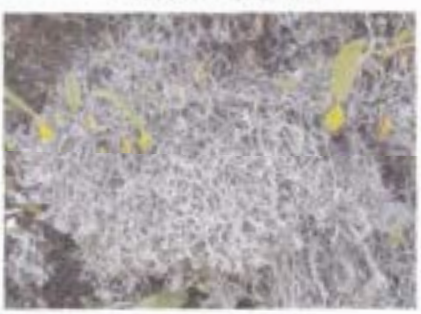
Parmotrema tinctorum

Pramotrema grayanum

Teloschistes flavicans



Roccella montagnei



Heterodermia leucomela

The most significant contribution on the epiphytic lower groups of plants from Kerala part of the Western Ghats are that of Nair and Madhusoodanan, 2002; Easa, 2003; Nair, *et al*. 2005a, 2005b; Madhusoodanan, *et al* , 2007; Manju *et al*. 2009 on the bryophytes and its vegetation. No study, apart from that of Kumar (2000), has focused on the entire lichen communities, who reported 254 macrolichens with few new species and many new reports from this part of the phytogeographic region. As many as 63 species were found to be new to peninsular India and 109 species were new records for Kerala. Among the 18 various localities surveyed during the study, some of the areas like Silent Valley Estate, Munnar, Mannavan shola, Uppupara, Periyar Tiger Reserve, of Idukki District; Siruvani Muthikulam hills, Silent Valley National Park, Nelliampathy hills, of Palakkad District hold large number of macrolichens in their microhabitat. Sequiera (2003) enumerated 159 species of macrolichens under 28 genera belonging to 12 families exclusively from the Silent Valley National Park. From the high ranges of Kerala, especially in Kannan Devan Hills including Eravikulam National Park and Mannavan Shola, 140 species of macrolichens under 36 genera belonging to 18 families were recorded (Sequiera, 2007). Recently, during a study of epiphyte host

Importance of Lichens

Lichens play varying roles in the pioneer, transition and climax ecosystem. Epiphytic lichens are well suited for studying effects of climate change because of their sensitivity to environmental changes (Nash and Olafsen, 1995; Rose, 1992).

Lichens are also widely used in monitoring the air quality and atmospheric pollution, heavy metal accumulation, climatic change and other environmental factors. When SO_2 concentration goes up in the atmosphere above a particular level lichens are the first to be affected and therefore, they act as indicators of air pollution.

Ethnolichenology from the Western Ghats region has received very little attention. The holy 'manna' food mentioned in the *Bible* is nothing but a lichen species, *Lecanora esculenta*. In Ayurveda, widely sold crude drug called "Charrila" is extracted from the species *Parmelia* (Chandra and Singh, 1971). Even though a number of lichen species are used as traditional or folk medicines and also as condiments, some are being used as vegetable by the tribals of Sikkim Himalaya and are also being utilized as a common live stock fodder. The studies from the Himalaya, north and northeastern India have

revealed that about 20 lichen species were utilized by the different ethnic groups in India for different purposes. Several species of lichens are also used against ailments. Most of the lichens reported from these regions occur in Kerala also but their uses remain unknown. During the survey of lichens in Kerala, it was observed that the many tribals in Kerala use several species of lichens as medicines and for various other purposes.

Lichens produce over 600 chemicals and synthesize numerous metabolites, the "lichen substances", which comprise aliphatic, cycloaliphatic, aromatic and terpenic compounds. Lichens and their metabolites have a manifold biological activity: antiviral, antibiotic, antitumor, allergenic, plant growth inhibitory, antiherbivore, and enzyme inhibitory. Usnic acid, a very active lichen substance, is used in pharmaceutical preparations. Large amounts of *Pseudevernia furfuracea* and *Evernia prunastri* are processed in the perfumery industry. Many species of lichens are valuable source of food. The lichen substances include pigments mostly contributed by the fungal component, toxins and antibiotics that are very useful especially as a source of dyes, perfumeries and medicines. The edible lichens are harvested and dried for human consumption or as fodder for cattle. Litmus which is widely used in chemical laboratories as an acid base indicator is also obtained from lichens. There are 27 species includes (both foliose and fruticose) macrolichen that are being used by different tribal and local people for various purposes like, food, medicine and dye. About 14 species of lichens are consumed as food, six species for various medicinal purposes and one species for making dye. It has also been observed that certain species of fruticose and foliose lichens are eaten by the Nilgiri Tahr and monkeys.

Table 1. Useful macrolichens in Kerala and their distribution

Sl. No.	Species	Uses
1.	***Coccocarpia erythroxyli* (Spreng.) Swins. & Krog** Habitat : All climatic conditions, at an altitude of 800m and above Localities: Punnamala, Silent Valley National Park - Palakkad Dist.; Mannavan Shola, Marayoor, Kattapara Shola, Uppupara, PTR - Idukki Dist.; Pakshipadalam - Wayanad Dist.	Medicine
2.	***Canoparmelia pustulescens* (Kurok.) Elix** Habitat: On rocks in the subtropical savannahs and montane grasslands between an altitude of 1000-2300m Localities: Anguinda, Koomban, Nilikkal, Poochipara, Sispara, Silent Valley National Park - Palakkad Dist.	Medicine
3.	***Dermatocarpon vellereum* Zschacke** Habitat: Subtropical lower temperate region. Prefers exposed water-dripping rocks at an altitude of 1800m Localities: Rajamalai, Munnar - Idukki Dist.	Food
4.	***Everniastrum cirrhatum* (Fr.) Hale** Habitat: Prefers exposed areas in ecotone areas at an altitude of 1800m and above Localities: Eravikulam National Park, Mannvan Shola, Marayur, Pettimudi, Anaimudi slope, Munnar - Idukki Dist.; Sispara, SVNP - Palakkad Dist.	Food/ Medicine
5.	***E. vexans* (Zahlbr.) Hale** Habitat: Prefers exposed areas at an altitude 1000m and above Localities: Pettimudi, Silent Valley estate, Munnar, Uppupara, PTR - Idukki Dist.; Upper Moozhiyar - Pathanamthitta Dist.; Pothumala, Nelliampathy, Muthikulam, Siruvani - Palakkad Dist.	Medicine
6.	***Heterodermia dissecta* var. *koyana* (Kurok.) J.C. Wei** Habitat: Prefers tree or rocks in the grassland/ evergreen/ subtropical forests between an altitude of 750-1200m Localities: Pullukuthimala, New Amarambalam RF - Malappuram Dist; Walakkad, SNVP, Muthikulam, Siruvani - Palakkad Dist.; Upper Moozhiyar, Kakki Damsite, Kakki - Pathanamthitta Dist.; Kattapara shola, Uppupara, PTR - Idukki Dist.	Food

7.	***H. pseudospeciosa* (Kurok.) W. Culb.** Habitat: Prefers open areas on trees and rocks between an altitude of 750-2100m Localities: Eravikulam National Park, Kattapara shola - Idukki Dist.; Pullukuthimala, New Amarambalam RF - Malappuram Dist.; Ranimedu, Nelliampathy, Sispara, SVNP, Siruvani - Palakkad Dist.; Kakki Damsite, Kakki, Upper Moozhiyar - Pathanamthitta Dist.	Food
8.	***Hypotrachyna adducta* (Nyl.) Hale** Habitat: Prefers shola forests at an altitude of 2300m Localities: Silent valley Estate, Munnar - Idukki Dist.	Food
9.	***H. awasthii* Hale & Patw.** Habitat: Prefers open moist areas in the forests at an altitude between 800-2300m Localities: Eravikulam National Park, Pettimudi, Anaimudi, Silent Valley Estate, Munnar, Uppupara, PTR - Idukki Dist.; Nilikkal, SVNP, Pothumala, Nelliampathy, Muthikulam, Siruvani - Palakkad Dist.; Upper Moozhiyar - Pathanamthitta Dist.	Food
10.	***H. dodapetta* Hale & Patw.** Habitat: Prefers shola forests at an altitude between 1800-2000m Localities: Pettimudi, Munnar, Mannavan Shola, Marayoor - Idukki Dist.	Food
11.	***H. osseoalba* (Vain.) Y.S. Park & Hale** Habitat: Prefers open or shady areas in the forests at an altitude between 900-2100m Localities: Eravikulam National Park, Mannavan Shola, Marayoor - Idukki Dist.	
12.	***H. infirma* (Kurok.) Hale** Habitat: Prefers open dry areas in the forests at an altitude 1500m Localities: Uppupara, PTR, Kattapara Shola, Kallar Estate, Munnar - Idukki Dist.; Pullukuthimala, New Amarambalam RF - Malappuram Dist.; Ranimedu, Nelliampathy, Muthikulam, Siruvani - Palakkad Dist.; Upper Moozhiyar, Kakki - Pathanamthitta Dist.	Food
13.	***Leptogium chloromelum* (Sw.) Nyl.** Habitat: Prefers open moist areas at an altitude of 700-2500m Localities: Eravikulam National Park - Idukki Dist.; Pakshipadalam - Wayanad Dist.; Shingampara, Siruvani - Palakkad Dist.	Medicine
14.	***L. denticulatum* Nyl.** Habitat: Prefers moist shady areas in the evergreen forests at an altitude of 800m Localities: Kakki Damsite - Pathanamthitta Dist.	Medicine
15.	***Lobaria retigera* (Bory) Trev.** Habitat: Prefers moist shaded regions in the shola forests between an altitude of 1400-2100m Localities: Mannavan shola, Marayoor, Anaimudi, Chockanad Estate, Munnar - Idukki Dist.	Medicine
16.	***Parmelinella wallichiana* (Tayl.) Elix & Hale** Habitat: Prefers trees as well as rocks in the evergreen/subtropical savannah and montane wet temperate forest between an altitude of 1000-2200m Localities: Aruvanpara, Anguinda, Kattuvaramudi, Parathode, Poochipara, Sispara, SVNP - Palakkad Dist.	Food/Dye

17.	***Parmotrema grayanum* (Hue.) Hale** Habitat: Prefers open dry areas with high wind between an altitude at 800-2300m Localities: Pettimudi, Munnar, Uppupara, PTR - Idukki Dist.; Malleswaramudi - Palakkad Dist.	Food/ Medicine
18.	***P. kamatii* Patw. & Prabhu** Habitat: Prefers open areas in the forests between an altitude at 1000-2100m Localities: Eravikulam National Park - Idukki, Dist.; Sispara, SVNP - Palakkad Dist.; Pullukuthimala, New Amarambalam RF - Malappuram Dist.	Food
19.	***P. nilgherrense* (Nyl.) Hale** Habitat: Prefers ecotone regions of Shola forests at an altitude of 2000m Localities: Chinnamala, Anaimudi, Munnar, Mannavan shola, Marayoor - Idukki Dist.	Food
20.	***P.tinctorum* (Despr.ex Nyl.) Hale** Habitat: Prefers moist or shady places in the evergreen/subtropical/sholka forests between an altitude of 750-2300m Localities: Silent valley Estate, Munnar - Idukki Dist.; Kulayalakadavu, New Amarambalam RF - Malappuram Dist.; Punnamala, SVNP, Malleswaramudi, Pothumala, Ranimedu, Karappara, Nelliampathy, Karimala, Parambikulam, Siruvani - Palakkad Dist.; Kakki damsite, Kakki - Pathanamthitta Dist.	Food/Dye
21.	***P. reticulatum* (Tayl.) Choisy** Habitat: Prefers open areas in the shola-grassland margin at an altitude of 2000m Localities: Mannavan shola, Marayoor - Idukki Dist.	Food
22.	***Roccella montagnei* Bel. em. D. D. Awas.** Habitat: Prefers open areas in the montane shola forests at an altitude of 2000m Localities: Top Station, Munnar - Idukki Dist.	Medicine/ Dye
23.	***Teloschistes flavicans* (Sw.) Norm.** Habitat: Prefers open humid areas with trees or cuttings in the ecotone regions at an altitude of 2000m Localities: Top Station, Munnar, Mannavan shola, Marayoor - Idukki Dist.	Dye
24.	***Usnea bornmuelleri* J. Steiner** Habitat: Prefers exposed areas in the shola forests between an altitude of 2000-2600m Localities: Anaimudi, Munnar, Mannavan shola, Marayoor - Idukki Dist.	Food
25.	***U. rigidula* (Stirt.) G. Awas.** Habitat: Prefers moist areas in the evergreen/subtropical/shola forests between an altitude of 1000-2300m Localities: Silent valley Estate, Munnar, Mannavan shola, Marayoor - Idukki Dist.; Sispara, Walakkad, SVNP - Palakkad Dist.	Food
26.	***U. subchalybaea* Zahlbr.** Habitat: Prefers trees in the ecotone region between an altitude of 2000-2600m Localities: Anaimudi, Munnar, Mannavan shola, Marayoor - Idukki Dist.	Food/ Medicine
27.	***U. vegae* Mot.** Habitat: Prefers upper canopy branches of trees in the evergreen/shola forests between an altitude of 1000-2300m Localities: Sispara, Walakkad, SVNP - Palakkad Dist.; Silent valley Estate, Munnar - Idukki Dist.	Food

Conclusion

Recently, studies on lichens as bio monitoring agents and bio indicators of environmental contamination and preparation of inventories of lichens of special habitats have gained importance. Western Ghats abodes a good number of lichens in its various habitats but is getting depleted due to over exploitation. Western Ghats as such has sustained extreme environmental degradation. These forests, being ecologically fragile, the damage has often been irreversible. There are many gaps in the knowledge on how the lichens function as bio indicators for air pollution and on their bioaccumulation potential for specific pollutants.

The physical and biological environments in which they are found influence the growth, reproduction and survival of lichens. The important physical influence is isolation, temperature, moisture, chemistry, soils and wind. The biological factors that affect lichens the most are the moisture and chemical characteristics of the substrate and any biological modifications of the physical environment.

Conservation implications

The International Committee for Conservation of Lichens (ICCL) has emphasized the need of lichen conservation. Some of the important points that are to be considered for lichen conservation are

1. Lichens are known to play a major role often being abundant, in habitats under threat. Lichen species that are found in such sites are inadequately known.

2. Habitat destruction throughout the world is causing widespread extinction of lichen species, mainly due to the loss of trees through both direct and indirect human interference.

3. The indiscriminate exploitation of lichens for commercial purposes leads to the impoverishment and eventual extinction of the species.

4. The extraction of lichens from its natural habitat should be judiciously handled. Large scale extraction of lichen is not economically feasible as the growth rate is very slow for lichens ranging from 1 mm to 5 mm/year.

Yearly harvesting is not possible. Sustainable harvest by careful gathering of lichens at intervals of several years has to be resorted for their long term utility. Lichens growing in their natural habitat alone provides basic raw material for economic utilization since, they cannot be cultivated *ex situ*.

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CARBON SEQUESTRATION IN SOIL
A NEW REGIME IN CDM

The rapid buildup of carbon dioxide in the atmosphere and the associated greenhouse effect has been a matter of growing concern over the last few years. The Inter Governmental Panel on Climatic Change (IPCC) visualizes an average rise of global temperature to range between 1.4 and 5.8°C by the end of 21st century.

A wide range of mechanisms for carbon reduction such as geological storage, injection to ocean bottom, carbon mineralization, etc. are proposed and experimented with. These carbon capture mechanisms, however, are constrained, particularly by health, safety and environmental risks.

The Clean Development Mechanism (CDM) is a greening up mechanism that emerged from the Kyoto Protocol (Article 12), which facilitates cooperation of the parties of the convention to reduce CO_2 emissions. It facilitates carbon capture in biomass through afforestation/reforestation projects or by reducing deforestation, so as to take advantage of economic benefits from 'carbon credits'. In the last two years, India has emerged as the world leader in making use of the CDM and reducing the greenhouse gases.

Soil, as a medium for sequestering atmospheric carbon

Apart from the above mechanisms, there is a promising possibility for storing carbon in soil, i.e., soil carbon sequestration. Soil carbon can be conceived as the residual carbon pool available in the soil over a period of several years. It is derived from the carbon originating from plant residues (input) minus the microbial decomposition, the loss from the pool (output). Clay content, depth and bulk density of the soil are important parameters that dictate the carbon storage efficiency; carbon storage efficiency is very low for sandy soil compared to clayey soil. It is also determined by the type and amount of plant residue added to the soil. Thus, proper use of fertilizers while optimizing productivity also maximizes returns to soil organic residues.

Generally the soil carbon pool is not saturated as it is dynamic, being continuously depleted by decomposition of soil organic materials to CO_2. Leaching, erosion and run off also accelerate its depletion. The soil carbon sequestration mechanism involves optimizing carbon storage in soil, beyond the existing thresholds. The underlying principle involves the transformation of atmospheric carbon (CO_2) into soil carbon through the decay of leaves, stems and roots, which are otherwise carbon sources.

Currently there has been pressure for inclusion of soil activities under the Kyoto Protocol. It provides better productivity and at the same time offers a source of income for the people in the tropics.

Methods to sequester carbon in soil

Forest plantations constitute c. 16 per cent of the total forest cover of the Kerala State. The plantations offer an excellent opportunity for carbon sequestration. Sequestering carbon by increasing organic matter level in soil is beneficial as atmospheric carbon load, soil erosion and water runoff, get reduced, thereby improving soil fertility, hydrology and water quality.

Green manure is often considered strategic in organic fertility management. Green manuring is an important practice for improving soil organic carbon as well as productivity. In China, green manure plants are commonly inter-cropped in eucalypt plantations in order to improve soil fertility. Using a legume green manure can increase soil nitrogen levels through N fixation by the bacterium, Rhizobium, associated with most legume roots. The proper choice of the green-manure species adapted to the local environment and soil characteristics is very important both from scientific and technical points of view.

Compost is an equally promising replenishment to soil carbon. Various experimental trials conducted in KFRI have shown that application of vermicompost improves soil carbon as well as productivity in teak and rosewood plantations. Similar experiments have shown that organic manures improve the supply of primary-, secondary- and micro- nutrients. Simultaneously, the physical condition, moisture status and microbial properties of the soil also get augmented which ultimately lead to enhanced productivity.

Cover crops can improve soil quality by increasing organic matter levels through the cover crop biomass over time. Dense stands of cover crops minimize the impact of rainfall on soil by preventing soil

splashing and erosive surface runoff. Additionally, vast networks of cover crop roots help to anchor the soil in place and increase soil porosity, creating suitable habitats for soil macrofauna.

Crop residue is important for replenishment of soil organic matter and can efficiently arrest the decline of soil organic matter. Allelopathic studies using four cover crops, *viz., Pueraria javanica, Calapogonium mucunoides, Centrosma pubescens, Mucuna bracteata,* showed that teak plants have no inhibitory effect on these cover crops. However, selection of the cover crop should be based on the growth habit and tolerance to shade conditions.

Chemical fertilizers have been the fuel for green revolution during the last few decades, boosting plant growth and yield. Nevertheless, it took several years to realize that chemical fertilizers are a serious threat to soil quality by deteriorating organic matter and soil structure, diminishing earthworm activity and proliferating weeds. Judicious integration of organic and inorganic manuring practices has shown promising results in sustaining productivity and increasing soil carbon pool in the long run

Mixed plantations as an alternative to monoculture plantations are tried to improve productivity, sustainability and greater carbon sequestration in the early stages of the plantations. Examples include *Acacia* with *Eucalyptus* and teak with *Leucaena.*

Enhancing soil carbon pool through improved soil and crop management is a prudent strategy for sustainable management of soil, water and environment resources. A quantification of these effects is required to evaluate soil carbon sequestration, environmental improvement and nation's welfare. As Mahatma Gandhi put it: "A technological society has two choices: first it can wait until catastrophic failures expose systemic deficiencies, distortion and self-deceptions. Secondly, a culture can provide social checks and balances to correct for systemic distortion prior to catastrophic failures".

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POTENTIAL ROLE OF BAMBOO PLANTATIONS IN AFFORESTATION / REFORESTATION CDM (Clean Development Mechanism)

Introduction

Global warming is one of the most devastating problems of the new millennium. The Kyoto Protocol is the first step towards an international strategy to limit greenhouse gas emissions which in turn helps to mitigate the global climate change. It commits the member countries to reduce the emissions of six green house gases from these countries by approximately 5 per cent below 1990 levels within the Protocol's first commitment period (2008-12). The three key mechanisms of the Protocol include international emissions trading between countries, joint implementation of emissions reducing projects and the clean development mechanism (CDM). The CDM has two purposes (a) to assist developing countries in achieving sustainable development, thereby contributing to the ultimate objective of the protocol and (b) to assist developed countries in achieving compliance with part of their quantified emission limitation and reduction commitments.

A decision was made in Marrakech Conference of Parties 7 (2001), to include the afforestation and reforestation as the only eligible activities in the CDM. According to this, "Forest" is a minimum area of land of 0.05-1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10-30 per cent with trees with the potential to reach a minimum height of 2-5 metres at maturity *in situ*). Afforestation and reforestation CDM includes establishment of woodlots on communal lands, reforestation of marginal areas with native species, e.g. riverine areas, steep slopes, around and between existing forest fragments, (through planting and natural regeneration), new large-scale industrial plantations, establishment of biomass plantations for energy production and the substitution of fossil fuels, small-scale plantations by land owners, introduction of trees into existing agricultural systems (Agroforestry) and rehabilitation of degraded areas through tree planting or assisted natural regeneration.

Role of bamboos in CDM

The giant grass bamboo which is a C4 plant has significant advantage over other biomass resources due to its species diversity, vigorous growth, early establishment, adaptability to various soil and climatic conditions, short harvesting period, sustainability in yield and its multifarious uses. Hence, it may be regarded as the best among the biomass resources. Bamboo plantations can play a significant role in CDM as it can fulfill all the criteria laid out for a CDM project and is suitable for all the type of aforesaid land uses. In order to qualify for consideration as CDM, any project activity should lead to real, measurable and long term GHG mitigation. Moreover, it should contribute to the social, economic, technological and environmental well being.

Bamboo plantations are found to be suitable for any type of land uses like clear felled forest lands, degraded lands, boundaries of agricultural lands and non-agricultural lands and other common property resources like coastal areas, road sides, canal banks, railway lines etc. Bamboo being very fast in growth produces enormous amount of biomass within a very short time. Commercially important species usually mature in 4-5 years and thereafter harvesting is possible every year. The possibility of annual selective harvesting without damaging the total stock and environment makes it a unique carbon sink compared to other woody crops.

Bamboo has several advantages over tree species in terms of sustainability and carbon fixing capacity. In a compilation done by

INBAR from the available studies conclude that bamboo biomass and carbon production may be 7-30% higher compared to the fast growing wood species. For instance tropical *Bambusa bambos* has been measured at a total above ground biomass 287 tC/ha with a mean annual production of around 47.8 t/ha/yr, almost twice that of the Eucalyptus clones. Interestingly, the total biomass of mature *Bambusa* at 6 years is in fact higher than that of teak at 40 years: 149 t C/ha versus only 126 t C/ha for teak.

Green house gas mitigation

Since the emission of carbon into the ecosystem due to industrial and technological advancement, man is one of the main causal factors of the global warming, carbon sequestration plays an important role in its mitigation. The 1997 Kyoto protocol recognizes that the drawing of CO_2 from the air and sequestering into the biomass is the only practical way for mitigation of this gas from the atmosphere. Trees are proved to be the vital sinks for atmospheric carbon i.e. carbon dioxide, since 50% of their standing biomass is carbon itself (Ravindranath *et al.* 1997). Importance of forested areas in carbon sequestration is already accepted, and well documented (FSI, 1988, and Tiwari and Singh, 1987).

The carbon sequestration potential of bamboos in India is yet to be unravelled. Thorny bamboo, *Bambusa bambos* can accumulate 122, 225 and 286 t ha^{-1} dry matter at 4, 6 and 8 years (Shamnughavel and Francis, 1996) respectively, it is on par with the 10 year old fast growing *Causarina equisetifolia* or *Eucalyptus tereticornis* plantation (Mutanal *et al.* 2007). Similarly, the per hectare biomass accumulation by the *D. strictus* at the three year old plantation is very high compared to that of *Tectona grandis, Greveillea robusta* or *Acacia nilotica* of ten year age (Singh *et al.* 2004). The above and below ground biomass of bamboo is approximately in the ratio 3:1. The unique growing capacity makes bamboo a valuable sink for carbon storage. It is reported that the total carbon content comprises usually about 50% of the total biomass (Figure 1).

In the present scenario of climate change, bamboo plantations can play a major role in 'carbon trading', which is also known as "cap and trade": a method developed to reduce the carbon emissions which contribute to global warming. This will allow the developed countries to transfer the emission credits (Carbon credit) to other countries that reduce their emission more than their national target under Kyoto protocol. The CDM bamboo project execution itself creates lot of employment to the rural people during the planting and establishment period.

Even otherwise, the income generated during the selling of emission credits can be invested in the social development of the rural people which will improve their living status. Recently, The World Bank has projected a 25 million US$ bond, linked to Certified Emissions Reductions (CERs) to be generated by a Clean Development Mechanism (CDM) project in China.

Environmentally, bamboo plays a critical role in the balance of oxygen and carbon-dioxide in the atmosphere, lowers light intensity and protects against ultraviolet rays. It prevents soil erosion and creates an effective watershed by binding soil along fragile riverbanks, deforested areas and in places prone to land slides. It is an important species for landscape as bamboo provides shade, and acts as windbreak and acoustical barrier and has aesthetic beauty (INBAR, 1997). Its immense potential as a bio-energy resource helps in the retention of carbon already sequestered in the fossil fuels such as coal, oil and gas and can save the vast natural forests.

Yet another criterion for a project to be considered under CDM is the technological well being which indicate transfer of environmentally safe and sound practices that are comparable to best practices in order to assist in upgradation of the technological base. Divergent use of bamboos as for gasification, production of bamboo charcoal and activated charcoal, beers, vinegar, perfumes, medicines, boards, plywood, strip boards, particleboards etc involve technologies which are eco- friendly.

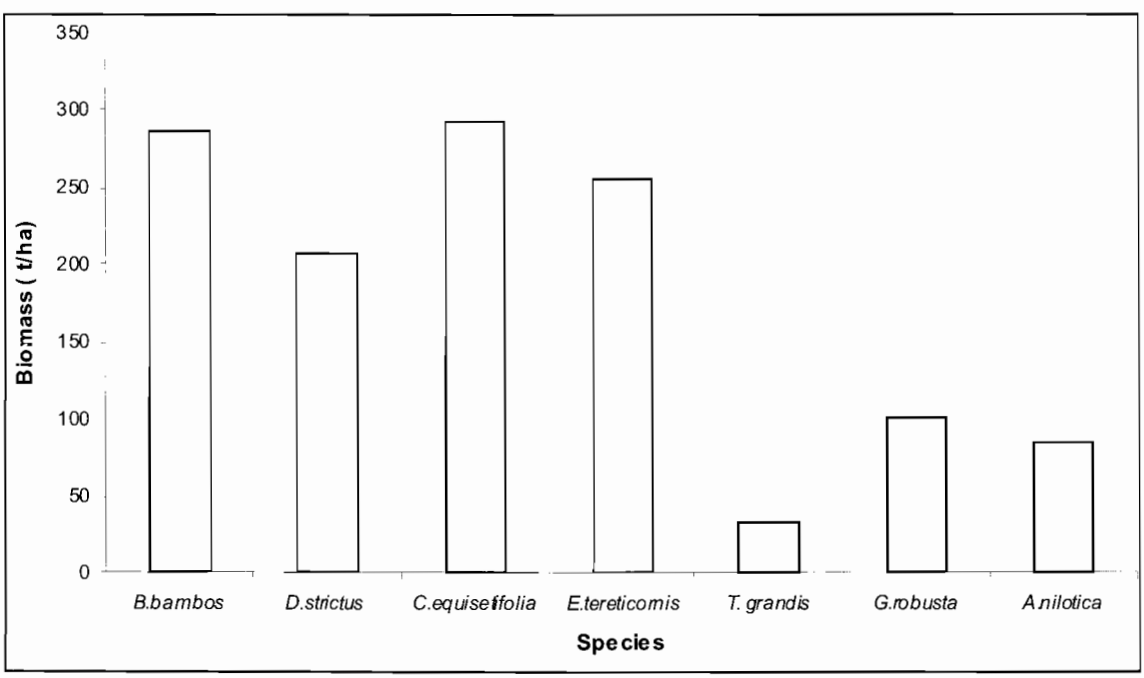

Fig. 1. Biomass production by different bamboo and tree species

Conclusion

Even though, the bamboos with their vigorous growth and sustainable yield have the potential to replace the wood in sequestering carbon, hardly any attempts have been made to investigate that potential.

Bamboo plantations can be well fitted into the CDM criteria. Afforestation and reforestation has been included in the land use practice that comes under the acceptable activities in the CDM. In order to qualify as the CDM practice an afforestation/reforestation project should mitigate the green house gas emission and contribute to social, economic, environmental and technological well being of man. It has the unique vigorous growing capacity, annual and sustained yield and a short harvesting period which helps to sequester huge amount of atmospheric CO_2, one of the causal factors of global warming. On an economic perspective, bamboo is capable for generating employment for rural poor, skilled and semi-skilled in plantation and in semi industrial and industrial activities. Bamboo and its related industries provide income, food and housing to over 2.5 billion people in the developing regions.

About 1500 documented traditional uses are recorded for bamboo which can be grouped into household, industry, weapons, transportation, fisheries, food, agriculture and construction (INBAR, 1997). The employment potential of bamboo is very high and the major work force involved are rural poor especially women.

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VARIATIONS IN SOIL PROFILES OF KERALA FORESTS

Soil is defined as a naturally occurring, unconsolidated material on the earth's surface that is capable of supporting plant growth. Soil properties and horizon development vary from place to place depending on climate, organisms, topographic position, parent material and time. Different forest ecosystems and other land covers make strong imprints on the soil beneath them and the information on these changes facilitates improved land management decisions that maintain soil productivity and therefore preserve forest sustainability and long-term ecosystem health.

The variation in morphological properties of soil beneath different forest ecosystems in the Kerala part of Western Ghats is given (Fig. 1-6).

Soil profile

Evergreen forests

Soil profile from the evergreen forests

Located at an elevation of 600 m in the Sholayar range, Vazhachal Forest Division is protected from the intense actions of weathering agents by the thick vegetation. Surface layer is enriched with organic residues and the soil column extends only up to 56 cm above the parent rock (Fig. 1a, b).

Soil profile

Shola forests

Soil profile from shola forests

Located at an elevation of 1920m in Munnar Forest Division is extra ordinarily black in colour throughout the depth due to its unique vegetation and cool climatic condition. This soil has a good reserve of organic carbon (5%) at 65cm depth (Fig.2a, b).

Soil profile

Grass land

Soil profile from grasslands

Located at an elevation of 2120m in Eravikulam National Park has 5.7 % organic carbon at 0-20cm depth. Even though the dense root mat in grasslands enriches the surface layer with organic carbon, lack of canopy cover intensify the weathering process at deeper layers giving reddish colour (Fig.3a, b).

Soil profile

Dry deciduous forests

Soil profile from dry deciduous forests

Located at an elevation of 960m in Chinnar clearly reflect the rain shadow condition of the locality with a pH of 7.3 in the surface layer and without any signs of laterisation in the deeper layers (Fig.4a, b).

Soil profile

Scrub forests

Soil profile from scrub forests

Located at an elevation of 800m in Chinnar is in the early stage of its development with plenty of weathering rock pieces and poor reserve of organic carbon (Fig.5a, b).

Soil profile

Degraded forests

Soil profile from degraded forests

Located at an elevation of 60m in Pattikkad range, Thrissur Forest Division is unique with its relatively low organic carbon throughout the depth and hard laterite beneath (Fig. 6a, b).

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COMPLETED PROJECTS

KFRI Research Reports

Strengthening and enriching the Palmetum.

KFRI Research Report No. 302 (Renuka, C. 2008).

KFRI Palmetum holds 95 species of palms belonging to 47 genera. Among them, 49 species under 16 genera are indigenous and 46 species under 33 genera are exotic ornamental palms. Data for each species contain source of the plant obtained and year of planting, description with identifying features, origin of the scientific name, common and local names, distribution, silvicultural details, flowering, uses, with their photographs. A map of the palmetum along with the list of palms is included in the report.

Quantitative Inventory of Non-Wood Forest Products in Northern Kerala.

KFRI Research Report No. 306 (Sasidharan, N., Sivaram, M. and Muraleedharan, P. K. 2008).

The quantitative inventory study of the NWFPs was carried out in the 15 Forest Divisions (11 territorial and four Wildlife Divisions) of the seven northern districts of Kerala covering an area of 4,220 km^2. A list of 137 NWFPs collected for commercial purpose from the forest was prepared. The NWFPs consist of different forms like herbs, shrubs, climbers and trees, yielding useful products such as bark, flowers, fruits, seeds, leaves and roots. Most of the NWFPs have clumped distribution, seasonal availability, rarity and occur in varied terrain conditions. Since, there was no methodology available for the quantitative inventories of NWFPs, a pilot study was undertaken to determine the sample size and the number of plots needed to be established for the estimation of NWFPs in different forest types.

For the quantification of useful products of NWFPs, software called *Invent NTFP* has been developed. The software has two major parts. The first part deals with input data. Using the data, the software quickly estimates density, abundance, relative density, relative frequency, important value index, Shannon's index and evenness index. The second part deals with yield studies such as available quantity of useful products like root, flower, bark and leave from different species. For quantification of NWFPs, a total of 11,548 sample plots were laid out in the natural forests and plantations of 15 forest divisions. Among the 137 NWFPs listed for quantification, 123 were enumerated from the sample plots. Among the 123 NWFPs recorded, the species with enough sampling intensity alone were quantified. However, structural data such as density, frequency and abundance of the species were worked out. The highest and lowest density and availability of useful part (kg/ha) were worked out for each forest division, range and vegetation type.

Among the 123 NWFPs studied 25 species belong to the Red Listed Categories such as Vulnerable (12 spp.); Low risk near threatened (4 spp.); Endangered (6 spp.) and one species (*Coscinium fennestratum)* as critically endangered. Among these *Kingiodendrum pinnatum, Strobilanthes ciliates* and *Hydnocarpus pentandra* are Peninsular Indian endemics. There are two stages in the marketing of NWFPs in Kerala, sale of collected products by the tribes to Federation through society and marketing of the collected products by the Federation. There exists different market situation in both the stages. In the first stage, the market structure is more or less similar to that of monopoly. In the second stage, the market structure of NWFPs in the product market is oligopolistic in Kerala with few firms or sellers in the market.

With no increase in the real income and standard of living, the gatherers are compelled to collect more and more of highly demanded items which will affect their availability in coming years. For conservation and better management of NWFPs, economic upliftment of the collectors, value addition of NWFPs through post harvest processing are suggested.

Establishment of a pilot scale bamboo stand for edible bamboo shoot production in Kerala.

KFRI Research Report No. 311 (Muktesh Kumar, M. S. 2009).

Results of the preliminary studies conducted on six species of edible bamboos namely, *Bambusa bambos*, *Bambusa tulda*, *Dendrocalamus brandisii*, *Dendrocalamus hamiltonii*, *Dendrocalamus longispathus* and *Dendrocalamus strictus*, are presented. It is observed that the shoot production season in Kerala is from June to September and 3-6 shoots are produced from a clump during this period. Shoots are also produced during November-December when Kerala receives northeast monsoon rains. The shoots can be harvested after 7-14 days of the shoot emergence and when the height is about 15-30 cm . It has been estimated that a freshly harvested young shoot of *Bambusa bambos* weighing 5 kg could yield 1.5-2.5 kg edible bamboo. Growth rate of bamboo is very fast and attains harvestable maturity in less than five years resulting in enhanced culm production. The average number of shoots produced in *Bambusa bambos* is 23 per annum with an approximate weight of 32-50 kg. In *Dendrocalamus hamiltonii* the average number of culm production is recorded to be 53 and weighing approximately 20-40 kg. Recently, bamboo has emerged as a cash crop to generate income for the rural communities in the bamboo shoot industry and their potential as a dietary.

Establishment of a bamboo stand for conservation and sustainable utilization of (Arayambu) *Pseudoxytenanthera bourdillonii* (Gamble) Naithani

KFRI Research Report No. 312 (Muktesh Kumar, M. S. and Seethalakshmi, K. K. 2009).

Pseudoxytenanthera bourdillonii popularly known as *Arayambu* or *ponmungil* is a rare endemic bamboo of Kerala part of the Western Ghats. Over exploitation, flowering at very long intervals and death of clump after flowering have led to dwindling the population in its natural habitat. Rooting response was very poor in culm cuttings in all the treatments. No rooting was found in branch cuttings. Of the 11 treatments including GRS and control over three seasons using cuttings from three different parts, rooting was observed only in four treatments. Although there is an indication that with IBA treatments during February-May, rooting is possible, the current success rate of 10-15 percentage was not promising. Observations made show that offset planting alone is successful. Success rate, although very low in current experiments, there is an indication that rooting of culm cuttings is possible in this species. The present population is restricted to a few clumps and localised in distribution.

Establishment of a Bioresources Nature Trail in the Kerala Part of the Western Ghats.

KFRI Research Report No. 314 (Chandrashekara, U. M., Sasidharan, N. and Sajeev, T. V. 2008).

The Project was taken up to develop about 10 ha land in the Kerala Forest Research Institute (KFRI) Sub Centre, Nilambur into a Bioresources Nature Trail that can become an ex-situ conservation area for different taxonomic groups of plants with special reference to endemic and RET species and also a centre to promote nature education and ecotourism. In a span of three years, an area adjacent to the Teak Museum in the KFRI Sub Centre has been transformed into a landscaped thematic Bioresources Nature Trail which harbours 578 species of the plant kingdom, covering some rare, endangered or threatened species. Plants were collected primarily from the natural forests of Kerala while the geographic area of collection extends through natural forests of Karnataka to many locations in India as far away as Dehra Dun. All the species have been identified, labelled and presented in such a way that visitors can observe the characters of each one of them.

The Nature Trail starts with a large typical floral diagram of an orchid on ground made by planting leafy ornamental plants in front of the orchid house. The orchid house harbours over 76 species of orchids- both terrestrial and epiphytic. The house has a water course inside, starting from a cascade and ending in an underground pond. With overhead mist outlets, the house is kept humid, facilitating the survival of diverse species of orchids.

The fern house comes next which harbor about 71 species of ferns arranged in two tiers along the wall of a four armed green house. Outside the fern house is the hydrophytes garden laid out in the open space. This garden holds 80 species of water plants arranged in sunken tanks and pots. The thallophytes and bryophytes house comes next which is a green house with sunken floor from which pillars arise to facilitate the growth of a diverse variety of bryophytes and algae and for the visitors to observe them closely. Eight species of algae and eighteen species of bryophytes are represented here.

The rock garden and a green house hold the xerophytes and succulents. There are 115 species of them, of which the local varieties grow on the rock garden and those which were brought from far away places are kept in the green house. The medicinal plant garden adjoins this green house wherein 192 species of plants used in various traditional medical systems of India are planted with adequate spacing, facilitating visitor movement. The Bioresource Nature Trail also has a gymnosperm garden with 18 species planted out in a large open space with provision for addition.

The Trail was dedicated to the public on 12 February 2007 and as of now there had been good response from the general public as well as students. The Trail is being run as part of the Teak Museum which had already established itself as a destination for domestic and tourists from outside. The visitor flow had been encouraging ever since the opening of the Bioresource Nature Trail.

Conservation and Sustainable Management of Belowground Biodiversity in the Kerala part of Nilgiri Biosphere Reserve-Phase 1.

KFRI Research Report No. 316 (Chandrashekara, U. M., Balasundaram, M., Sankaran, K.V., Sujatha, M. P., Varma. R. V., Senaati, B. K. and Manvika Sehgal 2008).

The benchmark site of the Project on Conservation and Management of Belowground Biodiveristy (BGBD Project) established in the Kerala part of Nilgiri Biosphere Reserve (latitude 10°50' and 12°16'N and longitudes 76° and 77°15'E), is located in the micro-watershed of Chaliyar River. The study site covers land use systems such as primary forests, secondary forests, managed plantations, agroforestry systems and annual crop based systems. Among different land use systems, the semi-evergreen forests with 67 tree species are rich in tree species diversity. These forest patches are free from human disturbance as indicated by the RISQ value (1.16) and closed canopy nature (LAI 4.24 to 4.92). On the other hand, moist deciduous forest patches are being repeatedly disturbed and trees of smaller girth classes are lesser than those of higher girth classes and the RISQ value is significantly more (3.83) than that in semi-evergreen forest patches. Forest patches closer to the agricultural lands are

highly degraded with the total density and basal area of tree community accounting for less than 25% of that recorded in the semi-evergreen forests and 10% of that recorded in moist deciduous forests. Repeated extraction of poles and other biomass and grazing are responsible for the degradation of these patches.

Out of 171 vascular plant species recorded during the course of this study, 25 species are legumes. Wherever the contribution of leguminous shrubs is relatively more it is due to the growth of *Cassia occidentalis* and *Desmodium gangeticum*. On the other hand, wherever the contribution of leguminous herbs is relatively more it is due to the profuse growth of *Mimosa pudica, Centrosema pubescens* and *Desmodium triflorum* in poorly managed systems. In well managed systems generally *Vigna unguiculata* is being cultivated and thus it contributes much to the IVI of herb community.

The moist deciduous forest located near human habitation are highly degraded and possess sparse vegetation and nutrient poor compact soil when compared to the similar kind of forests located away from the human habitation. Though these two forests are originally similar in terms of aboveground vegetation, the degraded forests showed relatively higher value for ant density and diversity. Thus ants, particularly *Lobopelta* sp. and *Leptogenys* sp., could be considered as indicator species of forest disturbance. Absence of some of the soil faunal elements in certain landuse systems in the study area are attributed to the differences in the crop combinations and management practices. For instance, low density of earthworm in annual crops and arecanut mixed with annual crops may be attributed to the excess use of inorganic fertilizers and pesticides.

In the study area, plantations of teak, rubber and cashew are located in almost similar terrain to that of moist deciduous forest. Moreover, age of these plantations ranged from 3 to 25 years and before that they too were representing either degraded or good moist deciduous forests. Comparatively high diversity of AM fungi in soils in cashew plantations, degraded forests and teak plantations than that in moist deciduous forests situated away from human habitation indicate that conditions in these soils are highly suitable for the proliferation of a host of mycorrhizal fungi. The plant dependency on mycorrhiza is apparently more in highly degraded sites.

Studies carried out in the cultivated lands indicated that organic carbon, exchangeable calcium, magnesium and potassium were considerably lesser than the level required for the optimum crop yield. It was also recorded that the contribution of trees and understorey species maintained for green leaf manure production to the total Importance Value Index (IVI) of tree and understorey plant communities are significantly low or nil. Over-harvest of biomass without sufficient nutrient input is leading to the loss of nutrients from the crop lands. Similarly, application of heavy dose of chemical pesticides at frequent intervals into croplands can be attributed to the loss of belowground biodiversity. Studies also revealed that some of the faunal characteristics are either absent or sparsely represented in a given landuse system. It was recorded that in the unmanaged systems the root colonization of VAM fungi were more than in some of the well managed mono-cropping systems.

Results of quantitative estimation and diversity of soil legume nitrogen fixing bacterial (LNB) population in different landuse systems in the study area indicated that the rhizobial population in polyculture systems was significantly more than in annual crop based systems. Among the thirteen species of naturally growing legumes in the study area, *Desmodium triflorum* produced most profuse nodulation. Thus the wild legumes such as *Desmodium triflorum* could be a potential source of green cover crops. Conventional physiological and morphological techniques indicated that the LNB isolates belonged to five genera *viz. Rhizobium, Mesorhizobium, Sinorhizobium, Bradyrhizobium* and *Allorhizobium.* The study also revealed that most of the isolates which originated from degraded forests, teak plantation and paddy field utilized sugars better than isolates from other sites. Genetic diversity studies of inter box elements using box primers involving the eighty LNB isolates showed that 100 percent of the loci were polymorphic indicating high level of genetic diversity among the isolates. The genetic diversity studies conducted at G.B Pant University of Agriculture and Technology on 13 LNB cultures isolated from trap plants (cow pea) revealed that the LNB isolates from Kerala part of NBR are genetically more diverse than the isolates from Karnataka part of Nilgiri Biosphere Reserve and from Nanda Devi Biosphere Reserve.

As already indicated in the landscape of Chaliyar River Watershed, the study recorded a faster rate in landuse and land cover changes. From the study sites the farming community expressed the view that the conversion of one cropping system to another is more frequent resulting in the increased soil erosion and runoff rates. Considering these aspects, four strategies have been identified viz. a) application of green leaf manure, b) application of plant growth promoting microorganisms and earthworm rich compost, c) reduction of nutrient loss from the croplands, and d) growth of leguminous and/ or biomass transfer species in the crop lands for maintaining soil fertility, sustainable yield and to enhance density and diversity of soil biota in different cropping systems. During the second phase of the project on-farm participatory experiments to demonstrate the usefulness of these strategies and also disseminate information and technology to the wider user groups will be undertaken.

Forestry Sector Analysis for the State of Kerala.

KFRI Research Report No. 317 (Jayaraman, K., Anitha, V. and Sivaram, M. 2008).

Forest sector analysis was carried out under two frameworks, one purely in economic terms as measured by the Net State Domestic Product (NSDP) and the other based on the concepts of sustainable management of forests. As regards the first approach, data on NSDP relating to various sub-sectors for the State from 1960-61 to 2003-04 were subjected to time series analysis after appropriate pre-processing. The overall context was that of the developing economy of Kerala since 1986-87 in response to the liberalization policies introduced at the national level during 1980's. Although all the sectors exhibited a higher growth rate after 1987, the service sector had the maximum boost. Analysis based on

partial correlation of NSDP of forestry sector with similar values of all other sub-sectors revealed that production from forests has been proceeding more or less independently of other sectors. It was also revealed that the contribution of forest sector to the State income was to the order of 1 to 2 percent showing the inadequacy of NSDP in evaluating the sector performance.

A much larger frame for the sector analysis was that of sustainable forest management (SFM) as provided by ITTO and finalized as Bhopal India Process 2005 which consists of 8 Criteria and 43 indicators. Based on the available data for the period 1987-2003 the following indications were arrived at. With respect to forest area, the main concern was the large area diverted for non-forestry purposes so as to regularize the encroachments. There have been efforts towards forest conservation from the side of the government by bringing more area under protected class. Although there have been sporadic fires in several years, the general trend has been that of reduction in the incidence. Cattle-grazing in forests is completely banned since 1993. There has been reduction in the number of forest-related offences as well. It may be noted that although changes have been happening, they have not been uniform over the period. The progress towards SFM during 1987-2003 was also evaluated using sustainability index.

The survey on forest-based industries was directed to ecotourism and sawmilling. Ecotourism is not a market to be taken lightly considering the fact that it is the fastest growing market in the tourism industry. The tourism traffic to Kerala depicts an increasing trend over the years. The domestic tourists constitute on an average 95 percent of the total tourist flow during the period 1980-2002 and the foreign tourists constitute the rest 5 percent. The mean value of the foreign tourists who visited Kerala is 110,257 per year during the period 1980-2003. Annual increase of foreign tourists' arrival to Kerala during the given period is 11,047. The visitors' flow to the Wildlife Sanctuaries and National Parks of the State depicts an increasing trend during the period 1998-2006 with an annual average flow of 663,255. The visitor flow to the WLSs and NPs in 2006 registered a growth rate of 148 percent compared to that in 1997.

A survey of the sawmilling units in the State based on stratified random sampling indicated that the mean annual outturn of the small sized units is 806 m^3 whereas that of larger units is 1958 m^3. Together a total of nearly 1.95 million m^3 of wood gets processed through these sawmills annually. About 85 percent of the total outturn is claimed by the small units. The capacity utilization of the small units is 65 percent and that of large units is estimated as 86 percent. The major sources of the timber used in furniture- making and timber sales are homesteads (53%) and import (34%). Forest depots account for 12%. Teak (29%) pynkado (26%) and jack (15%) were the most preferred timbers used for direct sales and furniture-making by sawmill owners. The timber brought by customers for sawing mostly comes from homesteads (92%). The most common species that are brought by customers for sawing are mango (28%), jack (23%), coconut (14%), anjily (9%) and teak (6%).

The fact that the outturn is far below the installed capacity is an indication of the additional activity possible in the industry without any major structural changes. Shortage of raw material is the major constraint faced by the industry. Hence technological advancements have not made their way into the industry in a big way. Since homesteads continue to be the major source of wood, tree planting in homesteads needs to be promoted by appropriate legal and policy changes. The major timber species coming from homesteads happen to be teak, jack and mango. Pynkado is one of the preferred timbers that are imported. Since there is shortage of wood in the internal market, import could also be liberalized.

The study to evaluate the supply-demand situation of teakwood in Kerala based on econometric modelling revealed the following. The domestic consumption of teakwood in Kerala is largely influenced by the per capita income with a positive coefficient. Production from homesteads seems to follow a stable pattern with an average of 40,751 m^3 per annum but for a weak signal from previous year's production figures. The projections made of the demand and price of teakwood based on the model were on the higher side. The reason for low productivity of the model was attributable to the weak data and short time period. Since the results of modelling the time-related changes in teak price along with changes in related variables were not very encouraging, similar attempts with price of other timbers were abandoned.

Conservation of the critically endangered tree *Syzygium palghatense* Gamble (Myrtaceae) in the Western Ghats of Kerala.

KFRI Research Report No. 318 (Yesodharan, K., Mohandas, K. and Chandrasekhara Pillai, P. K. 2009).

Syzygium palghatense Gamble (Myrtaceae) is a crtically endangered evergreen tree found in the southern Western Ghats of Kerala, reported only from Parambikulam Wildlife Sanctuary in Palakkad District. The species is known only by the 17 plants (six tree, eight saplings and three seedlings) found in the Pandaravarai of Parambikulam WLS of which only two trees were found in flower during the study. The trees were found on a slope at about 1200 m.sl. Population status, pollination and reproductive biology and constraints in the natural regeneration were studied.

The scientific data gathered on population studies along with climatic factors enabled to determine the causal factors responsible for reduction of the population in its natural habitat which subsequently led to the rarity of species. Understanding climatic and edaphic requirements *in situ* will be of use while implementing the restoration of the species.

Since *S. palghatense* is critically endangered species vegetative propagation technique such as rooting of stem cuttings and seed propagation technique can be adopted for its multiplication. Planting seedlings of the species in its natural habitat, in botanical gardens and including the species in the rehabilitation programmes are suggested for the recovery of the species.

Establishment of an Arboretum of rare and characteristic species of the Moist Deciduous Forests of Kerala.

KFRI Research Report No. 319 (Nair, K. K. N., Yesodharan, K. and Unni, K. K. 2008).

The Arboretum was established in the main campus of Kerala Forest Research Institute at Peechi, in an area of about five hectares. The area is covered by moist deciduous forests represented by 34 species and 726 individual trees. By supplementing the existing stand by filling tree gaps present, the live collection was organised. In order to systematically organize the arboretum, initially, the plot was demarcated into grids of 25 x 25 m size and the positions of all the existing trees were marked and gaps for planting were identified. Seeds of different arborescent species were collected from the moist deciduous forests of the state along with those of a few endemic species from the adjoining semi evergreen, evergreen and dry deciduous forests. The collected seeds were germinated in the nursery at the Field Research Station, at Veluppadam. When the seedlings attained suitable size, they were planted in the Arboretum plot in the tree gaps already identified with appropriate spacing. The Arboretum is maintained with necessary casualty replacements, weeding and watering, whenever required. The present holding of the Arboretum is 3089 accession belonging to 170 species under 50 families and 122 genera, with about 50 taxa endemic to southern Peninsular India. Arboretum is maintained with the details on location and grid map. The Arboretum has obtained the Index Seminum ID No.1518 and is also enlisted in the National Network of Botanical Gardens in India.

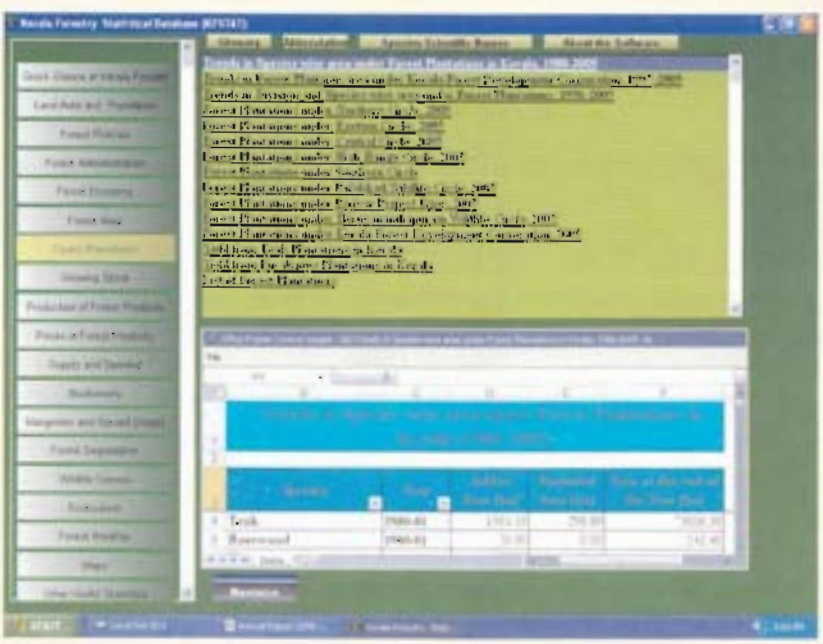
Computerized database on Kerala Forest Resources and data retrieval system Research .

KFRI Research Report No. 320 (Sivaram, M. 2008).

A computerized database and data retrieval system on forest resources of Kerala State, India was developed (Fig.1). The database contains the spatial-temporal data covering themes such as forest area, forest plantations, production, supply, demand and prices of forest products. The data in the database are stored in popular file formats such as Excel (xls), Word (doc) or Acrobat (pdf). The database has an interface developed using 'Microsoft Visual Basic'. It helps to retrieve the required data in a few clicks. The graphical representation of the data, data source and glossary are also integrated in the system. The highlights of the important statistical data and the following two major applications of the database are also presented.

i. Projection of availability of teak wood from forest plantations was undertaken under different scenarios, taking into account the factors such as species-mix, age structure, rotation age, productivity and planting rates. The projections indicated that the promotion of teak outside the forests such as home gardens and farmlands would help to bridge the gap between future demand and supply.

ii. The long-term trends in the real prices (deflated current prices) of teak wood in different girth classes for the period 1956 to 2005 were analysed by fitting different spline models. The analysis indicated that there was a declining trend in real prices since 1995 probably due to increased availability of substitute materials in the market. However, of late, the prices of teak wood have been increasing. The short-term price forecasts of teak wood were made using artificial neural network and auto-regressive integrated moving average models. The forecasts indicated that the quality teak wood would fetch high returns. Therefore, efforts should be made to produce quality teak wood.



Main menu of the database and retrieval system

The Raw Drugs Requirements of Ayurvedic Medicine Manufacturing Industry in Kerala.

KFRI Research Report No. 322 (Sasidharan, N. and Muraleedharan, P. K. 2009).

The annual consumption of raw drugs by the Ayurvedic medicine manufacturing industry in Kerala was assessed in the study. Although, about 400 raw drugs are used in the manufacture of various medicines, 230 items which are consumed at the rate of over one thousand kg per year were selected for the present study. There are 706 pharmaceutical units having drug license from the Industries Department. The study focuses on the consumption/requirement of the licensed units. Based on the annual turnover, the medicine manufacturing units were classified into small, (below 1 crore) medium (1-3 crores) and large (over 3 crores). The annual consumption of the 230 raw drugs studied is 20,517 tonnes, of which 48 per cent is consumed by the large units, 37 per cent by small units and 15 per cent by medium units. Annual consumption of 24 items of raw drugs is over 200 tonnes; 20 items between 200-100 tonnes; 42 items between 100-50 tonnes; 44 items between 50-25 tonnes and 62 items between 25-10 tonnes; 39 items below 10 tonnes. *Kurumthotti* (1,194 tonnes) and *Nellikkai* (860 tonnes) are most abundantly consumed items. The raw drugs consumption is highest in Thrissur (6,276 tonnes) and Malappuram (4,433 tonnes) districts, as some of the larger units are located here. The lowest consumption is in Wayanad (133 tonnes).

There is marked variation with regard to consumption of raw drugs in small, medium and large units, as the quantity and type of medicines prepared by them differ. Annual consumption with regard to plant/parts viz., roots/tubers/rhizomes constitutes 45 per cent of the total quantity. Fruits and seeds constitute 18 per cent; whole plants (herbs) 12 per cent; leaves 7 per cent; bark 6 per cent; Stem 5 per cent; wood 5 per cent; flowers and resin 1 per cent each. The raw drugs are traditionally grouped as *Pettimarunnu* and *Pachamarunnu*. The former consists of items used in the dried form, which include several raw drugs obtained from North India. *Pachamarunnu* are used fresh and are locally available. Forests are the main source of medicinal plants. Out of the 230 raw drugs studied, 40 per cent are obtained from forest. Only 8 per cent raw drugs are from cultivation, which include items also used as spices.

Medicinal plants trade in Kerala is a very prospective one and price of most of the items is on the increase. The price increase is partially due to an imbalance between supply and demand. Marketing agents play a major role in the trade. The medicinal plants collected by the tribes are marketed through the society and the federation. Those collected from outside the forests, private gardens, homesteads, waste lands and common properties are sold directly or through agents to the dealers and medicine manufacturing companies.

Comparison of the consumption of 125 major items based on a study in the year 2000 and in 2006 (present study) reveals that there is an overall increase of 1,943 tonnes. The highest increase is noticed in the case of *Sathavari* (243 tonnes), followed by *Kurumthotti* (131 tonnes), *Nellikkai* (124 tonnes), and *Kayyunni* (116 tonnes). The items which show decrease in the consumption are *Raktachandanam* (52 tonnes), *Maramanjal* (17 tonnes) and *Chuvannaratha* (10 tonnes). The collection of these items from wild is banned. Non-availability may be the reason for the decrease in their consumption. The overall increase in the consumption of raw drugs indicates the growth of Ayurvedic medicine Industry in the State. Considering the increase in the demand of raw drugs, requirement can be met only through cultivation. Item-wise consumption of medicinal plants in each district has been worked out, so that farmers can select the species which are in high demand for cultivation. Awareness on good agricultural practices, post-harvest processing and storage of medicinal plants among farmers is needed for production of quality raw drugs.

Use of bioprotectant for the control of sapstain on rubberwood.

KFRI Research Report No. 327 (Maria Florence, E. J. 2009).

Rubber wood is one of the widely used timber in wood-based industries in Kerala. One problem of utilization of rubber wood is its susceptibility to moulds, sapstain and decay fungi, and insect borers. Among various fungi, *Botryodiplodia theobromae* Pat. is the dominant fungus causing sapstain on rubber wood. Among the several microorganisms screened, a bacterium, *Bacillus subtilis B2* and an actinomycete *Streptomyces* sp. SA18 were identified as possible. The inhibition of *Bacillus* by the *Streptomyces* sp. SA18 was by producing chitinase enzyme and thereby degradation of the fungal cell wall chitin. The antibiotic, Iturin A produced by *B. subtilis B2* was also inhibiting the fungal growth. When compared to actinomycete, the bacterium was more effective against the sapstain fungus in the field. Open stacking reduced the fungal infection than close stacking.

NEW PROJECTS INITIATED

Sponsored Projects

KFRI 418a/2007: Conservation and sustainable management of belowground diversity in the Nilgiri Biosphere Reserve: Phase-2 (U. M. Chandrashekara, April 2007 -December 2009) TSBF-SARNET, JNU, New Delhi.

KFRI 544/2008: Forestry sector analysis for the state of Kerala –Phase II (K. Jayaraman May 2008 - April 2009) Ministry of Statistics and Programme Implementation, GOI, New Delhi.

KFRI 558/2008: Natural enemies of the Red Palm Mite in India (K. V. Sankaran, September 2008 - August 2009) CABI, Europe, U K.

KFRI 559/2008: Developing appropriate technology and establishing a plant for activated carbon production from coconut shells for community based organizations (T. K. Dhamodaran, November 2008 - June 2012) ICAR, NAIP, GOI, New Delhi.

KFRI 560/2008: Planting stock production of selected commercial species of bamboos (C. K. Soman, December 2008 - November 2009) BTSG, National Bamboo Mission, New Delhi.

KFRI 561/2008: Impact of Industrial activities on soil and water qualities in Koratty Panchayat area (M. Balagopalan, January 2009 - December 2011) Kerala State Council for Science Technology and Environment, Thiruvananthapuram.

KFRI 562/2009: Bamboo resource development and utilisation in Karassery Panchayath (V. P. Raveendran, January 2009 - December 2011) Karassery Panchayath.

KFRI 567/2009: Species recovery of selected endangered rattan species of the Western Ghats (C. Renuka, April 2009 - March 2012) Kerala Forest Department, Thiruvananthapuram.

KFRI 568/2009: Floristic Studies in Aralam Wildlife Sanctuary (N. Sasidharan, May 2009 -October 2011) Kerala Forest Department, Thiruvananthapuram.

New Extension Projects

KFRI Ext. 146/2008: National Seminar on Grass Root Innovators and Intellectual Property Rights, (V. V. Sudheendrakumar, 26 – 27 September 2008, 2 days) KSCSTE, Thriruvananthapuram.

KFRI Ext. 147/2008: Propagation, Cultivation, Management and Post Harvest Technology of Bamboos, (K. K. Seethalakshmi, 21 - 27 September 2008, 7 days) Department of Horticulture, Rajasthan.

KFRI Ext. 148/2008: Information Kerala Mission Computer Training for Councillors of Malappuram Municipality, (Programme Coordinator, Ext. & Training, 23 – 26 August 2008, 4 days) Information Kerala Mission.

KFRI Ext. 149/2008: Information Kerala Mission Computer Training for Councillors of Vadakara Municipality, (Programme Coordinator, Ext. & Training, 28 - 31 August 2008, 4 days) Information Kerala Mission.

KFRI Ext. 150/2008: Information Kerala Mission Computer Training for Municipal Councillors (Programme Coordinator, Ext. & Training, 3 - 6 October 2008, 4 days) Information Kerala Mission.

KFRI Ext. 151/2008: Conventional and molecular methods of tropical tree improvement for higher productivity, (E. P. Indira, K. C. Chacko, 18 - 27 November 2008, 10 days) ITTO.

KFRI Ext. 152/2008: Collection, processing and storage of seeds of forestry and medicinal plants under FRLHT programme, (R. C. Pandalai , K. C. Chacko, 20 - 21 November 2008, 2 days) Kerala Forest Department, Thiruvananthapuram.

KFRI Ext. 153/2008: Intra-districts training programme for farmers under the agricultural technology management agency (ATMA) scheme. (K. C. Chacko, K. K. Seethalakshmi, K. Mohanadas, E. J. Maria Florence, 5 – 6 December 2008, 2 days) ATMA and BTSG, National Bamboo Mission, New Delhi.

KFRI Ext. 154/2009: Study tour on teak (K. C. Chacko, K. Mohanadas, 11 - 14 January 2009, 4 days) Myanmar Forest Department, Myanmar.

KFRI Ext. 155/2009: National Workshop on Global warming (K. K. Seethalakshmi, January 2009, 1 month) EMA, Kerala and KFDC.

KFRI Ext. 156/2009: Training workshop on prevention, control and management of forest invasive species – strategies (K. V. Sankaran, K. C. Chacko, E. J. Maria Florence, K. Mohanadas, 28-29 January 2009, 2 days) MOEF, New Delhi.

KFRI Ext. 157/2009: Training workshop on taxonomy and ecology on Soil flora and fauna (U. M. Chandrasekhara, 12 - 13 February 2009, 2 days) Kerala State Biodiversity Board, Thiruvananthapuram and TSBF - SARNet & JNU, New Delhi.

KFRI Ext. 158/2009: Crash Course for M.Sc., Wood Science and Technology students of Kannur University, (E. J. Maria Florence, K. Mohanadas, 16 - 21 March 2009, 6 days) Kannur University.

Publications

Papers in journals

Anto, P. V., Renuka, C. and Pradeep, A. K. 2008. Demographic and conservation studies on two solitary species of *Calamus* in the Western Ghats of Kerala, India. *Journal of Non Timber Forest Products* 15(4): 225-234.

Krishnankutty, C. N. and Chundamannil, M. 2008. Moisture content of bamboo (*Bambusa bambos*) in the forests and conversion factors for determining the weight of standing bamboo from the weight of harvested bamboo. *International Journal of Forest Usufructs Management* 9(2): 41-46.

Mahiba Helen, S., Sajeev, T. V. and Sudheendrakumar, V. V. 2008. An improved method of extraction of nucleopolyhedrovirus from soil with reference to *Hyblaea puera* NPV. *Journal of Biological Control* 22 (2): 479-481.

Muraleedharan, P. K., Krishnankutty, C. N. and Anitha, V. 2008. An assessment of bamboo resources in agroforestry home gardens of Kerala. *Journal of Non-Timber Forest Products* 15(3):141-145.

Pramod N. Nair, Indira, E. P., Sabna Prabha, S. and Rajalakshmi, R. 2008. Impact of human disturbance on genetic diversity in teak- an assessment through nuclear gene markers. *In:* A. K. Mandal, S. A. Ansari and C. Narayanan (Eds.) *Forest Biotechnology in India*. Delhi, Satish Serial Publishing House, Delhi, India, 31-36.

Sivaram, M. 2008. Forestry statistical database and data mining: A case study of Kerala State. *Envis Bulletin* 8 (2). Forest Research Institute, Dehradun.

Sreejith, K. A., Chandrashekara, U. M. and Jose Kallarackal (2008). Determination of the successional status of tropical evergreen species using chlorophyll fluorescence technique, *Indian Journal of Forestry* 31(2): 257-259.

Sudheendrakumar, V. V., Sajeev, T. V. and Biji, C. P. 2008. A new insect rearing container for in vivo mass multiplication of NPV of *Hyblaea puera*. *Journal of Biological Control* 22 (1): 217-219.

Sudheendrakumar, V. V., Sajeev, T. V. and Biji, C. P. 2008. Optimization of in vivo mass production of HpNPV in teak defoliator, *Hyblaea puera* (Cramer). *Entomon* 33 (3): 171-180.

Rugmani, P. and Jayaraman, K. 2009. Intrinsic units of growth for teak trees. Trees- Structure and Function 23: 51-58.

Papers in Books/ Proceedings/ Newsletters

Bhat, K. M., Balasundaran, M., Bhat, K. V., Muralidharan, E. M. and Thulasidas, P. K. 2008. Processing and Marketing of Teak Wood Products of Planted Forests. *Proceedings of the Regional Workshop* held during 25 - 28 September 2007, Kerala Forest Research Institute, Peechi, India, 336pp.

Chandrashekara, U. M. 2008. Participatory vegetation analysis in a forest landscape in the Nilgiri Biosphere Reserve. *In: Sustainable Forest Management and Poverty Alleviation: Roles of Traditional Forest-related Knowledge*. John A. Parrotta, Liu Jinlong and Sim Heok-Choh (Eds.). IUFRO World Series No. 21. IUFRO, Vienna. 19 – 22p.

Chandrashekara, U. M. and Sankar, S. 2008. Ecological and socio-economic dimensions of homegardens of Kerala, India. *In: Contribution of Gardens, City life and Culture: A World Tour.* M. Conan and Chen Wangeng (Eds.) Dumbarton Oaks and Harvard University Press. 247 – 258p.

Indira, E. P., Pramod N. Nair, Sabna Prabha, S. and Hugo Volkaert. 2008. Genetic diversity and contemporary gene flow in teak. *In*: Bhat, K. M. *et al.* (Eds.) *"Processing and Marketing of Teak Wood Products of Planted Forests, Proc. of the International workshop* at KFRI, Peechi, Kerala, India during 25 - 28 September 2007. 205 – 213p.

Jayaraman, K. and Rugmini, P. 2008. Optimum thinning schedule for teak plantations. *In*: Bhat, K. M. *et al.* (Eds.) *Processing and marketing of teak wood products of planted forests. Proceedings of the Regional workshop* 25-28 September 2007. Kerala Forest Research Institute, Peechi and International Tropical Timber Organization, Yokohama, 168 – 172p.

Sasidharan, N. 2008. Regeneration of Trees in the Teak Plantations of Parambikulam Wildlife Sanctuary, Kerala, India. *In:* Bhat K. M. *et al.* (Eds.) *Processing and Marketing of Teak Wood Products of Planted Forests.* Kerala Forest Research Institute, Peechi and International Tropical Timber Organization, Japan: 178-187p.

Sivaram, M. 2008. A database on forest resources and its applications: A case study of Kerala State, India. *Proceedings of the International Workshop on Figures for Forests.* Forest Research Institute, Freiburg, Germany.

Seminar/ Workshops attended

Dr. C. N. Krishnankutty, gave a lecture as a special invitee, on Wood-based industries in Kerala and future wood availability, in the State-level committee meeting of the Central Empowered Committee appointed by the Hon' able Supreme Court, chaired by Mr. T. M. Manoharan IFS, Principal Chief Conservator of Forests, at Government Guest House, Aluva, 9th April 2008.

Dr. C. N. Krishnankutty, presented the *'Methodology of the Wood-balance study in Kerala'* in the two-day Expert consultation Meeting on *'Production and consumption study of wood'* organised by the Forest Survey of India (Ministry of Environment & Forests, Government of India) at NASC Complex, ICAR Campus, New Delhi, 28 - 29 April 2008.

Dr. N. Sasidharan, participated in the National Seminar on medicinal plants, and presented a paper on *In situ* Conservation of medicinal plants in Kerala, organized by the Ayurveda Research Institute, Poojapura, Thiruvananthapuram, 24 - 25 May 2008.

Dr. N. Sasidharan, participated in the workshop on medicinal plants cultivation, and presented a paper on Cultivation Practices of the 11 prioritized medicinal plants for cultivation by the Kerala Forest Department, at Kerala Forest Research Institute, Peechi, 25th August 2008.

Dr. N. Sasidharan, participated in the meeting organized by the Botanical Survey of India to finalize the list of plants which are on the verge of extinction or likely to become extinct under section 38 of the Biological Diversity Act 2002, gave a presentation on the critically endangered species recorded from Kerala, 22nd September 2008.

Dr. U. M. Chandrashekara, presented the Ecological and Socio-cultural dimensions of sacred groves of Kannur and Kasaragode Districts. National Seminar on Coastal Wetland Ecosystems of Kerala, held at Department of Botany, Sree Narayana College, Kannur, 16 -17 October 2008.

Dr. N. Sasidharan, participated in the Training Programme on Capacity Building in Plant Taxonomy, as a resource person and gave lectures on i) Computer aided tree identification programme and ii) Electronic checklist on the flowering plants of Kerala, at Shillong, Meghalaya, 10 - 11 November 2008.

Dr. K. K. Seethalakshmi, participated in National Seminar on Progress, Prospects and Problems in Bamboo Research and presented a paper on Potential of bamboo and bamboo industries, at Mercy College, Palakkad, Kerala, 18th November 2008.

Dr. U. M. Chandrashekara, presented the Ethno-medicine of the Panian tribes in Vaniampuzha forests, Kerala. Seminar on Medicinal and Insecticidal properties of Botanicals Marthoma College, Chungathara (Nilambur), 28 - 29 November 2008.

Dr. N. Sasidharan, participated in the Brain Storming Session on Plant Taxonomy and Biodiversity, gave a presentation on Interactive Identification package for plants, at National Bureau of Plant Genetic Resources, New Delhi, organized by NBPGR and Botanical Survey of India, 16th December 2008.

Dr. V. V. Sudheendrakumar, attended National Seminar on Ecofriendly approaches in pest management, as an invited speaker and gave a lecture on Biocontrol of teak defoliator using baculovirus, at M. E. S College Mampad, 18th December 2008.

Dr. K. K. Seethalakshmi, participated in a National Workshop on Global Warming and its Implication for Kerala. Presented two papers: Bamboo Plantations: An Approach to Carbon Sequestration; *Recent developments in the bamboo sector,* at Thiruvananathapuram, 19 -21 January 2009.

Dr. M. P. Sujatha, attended a National workshop on Global Warming and its implications for Kerala and presented a poster paper on Strategies for enhancing soil carbon sequestration and productivity of forest plantations in Kerala, at Thiruvananthapuram, 19 - 21 January 2009.

Dr. C. K. Soman, participated in the National workshop on Global Warming and its implication for Kerala organised by Kerala Forest Department, at Thiruvananthapuram, 19 - 21 January 2009.

Dr. E. J. Maria Florence, attended Career in Science for Women - Challenges & Opportunities at Thiruvananthapuram, 17 - 18 March 2009.

Extension activities

Dr. N. Sasidharan, evaluated the progress of project *Poverty alleviation and rehabilitation of tribes and farmers by raising medicinal plants in Wayanad* funded by National Medicinal Plant Board, during 7 - 8 April 2008.

Dr. M. Sivaram, served as the Course Coordinator of the Training Workshop on 'Collection, compilation, validation and dissemination of Forestry Statistics' for Indian Forest Service (IFS) Officers, at Kerala Forest Research Institute, Peechi. He also delivered a lecture on 'Computerized database on Kerala Forest Resources and its applications', during 21 - 25 April 2008.

Dr. S. Sankar, served as the Course Coordinator of the Training Workshop on Tree farming in Agro forestry systems and wastelands, during 20 - 29 May 2008.

Dr. K. K. Seethalakshmi, served as the Course Coordinator of the Training Workshop on Propagation, Cultivation, Management and Post Harvest Technology of Bamboos, during 22 - 28 June 2008.

Dr. K. K. Seethalakshmi, served as the Course Coordinator of the Training Workshop on Priority Species, Resource Estimation, Plantation Development, Post Harvest Technology and Socio-economic Livelihood Potential of Bamboos, during 22 - 27 September 2008.

Dr. K. V. Sankaran, served as the Course Coordinator of the Training Workshop on Prevention, Control and Management of Forest Invasive Species - Strategies, during 28 - 29 January 2009.

Dr. E. J. Maria Florence, served as the Training Coordinator for a Crash course for M.Sc Wood Science and Technology students of Kannur University, during 16 - 21 March 2009.

Guest Lecture/ Classes taken

Dr. N. Sasidharan, gave lectures on concept of plant taxonomy, plant nomenclature and computer aided tree identification program to the M.Sc., students of Govt. Victoria College, Palakkad, 5th February 2008.

Dr. K. Jayaraman, delivered a lecture on 'Data needs for forest sector analysis' in the Training Workshop on 'Collection, compilation, validation and dissemination of Forestry Statistics' for Indian Forest Service (IFS) Officers, at Kerala Forest Research Institute, Peechi, 21 - 22 February 2008.

Dr. K. Jayaraman, delivered a lecture on 'Data needs for sustainable forest management' in the Training Workshop on 'Collection, compilation, validation and dissemination of Forestry Statistics' for Indian Forest Service (IFS) Officers, at Kerala Forest Research Institute, Peechi, 21 - 25 April 2008.

Dr. N. Sasidharan, gave a lecture on plant identification methods to the students and research scholars of Amala Cancer Research Centre, Thrissur, 19th May 2008.

Training Imparted

Dr. C. N. Krishnankutty, served as a resource person to handle the Session on Wood-balance study: Methodology and data base, during the *one-week compulsory training* of Indian Forest Service Officers *on* 'Collection, compilation, validation and dissemination of forest statistics', 21 - 25 April 2008.

Dr. P. K. Thulasidas, served as resource person and handled wood anatomy lecture classes and practical training in the Wood Science laboratory for 11 M.Sc Wood Science & Technology students of Kannur University, during 9 – 19 June 2008.

Dr. E. P. Indira, Training conducted for two Myanmar officials under ITTO funding during 18 - 27 November 2008.

Dr. C. N. Krishnankutty, served as a resource person to handle the Session on 'Estimation of bamboo resource in farm lands' as part of the training for Field Functionaries under the National Bamboo Mission Bamboo Technical Support Group for South Zone, during 4 - 11 January 2009.

Dr. U. M. Chandrashekara, organised a Training Workshop on Taxonomy and Ecology of Soil Flora and Fauna, at KFRI Sub Centre with the financial support from Kerala State Biodiversity Board Thiruvananthapuram and TSBF - SARNet, New Delhi, 12 - 13 February 2009.

Ph. D. Awarded

Mr. P. K. Thulasidas was awarded doctorate degree in Wood Science & Technology by the FRI University, Dehra Dun, in 2008 for his work on, "**Timber Properties of Teak (*Tectona grandis* L. f.) grown in the Homesteads of Kerala**" under the guidance of Dr. K. M. Bhat, Programme Coordinator, Forest Utilisation Division, KFRI.

The wood quality attributes of 35-year old teak from two home-gardens in the district of Ernakulam (wet site-high rainfall area) and Palakkad (dry site-low rainfall area) in Kerala were compared with those of forest plantations at Nilambur- famous for Malabar teak in the trade. Of the 96 home-garden teak logs (aged 35-years) graded from wet and dry sites, 59% belonged to timber Grade II-IV and the rest fell under pole classes. Faster grown teak in the wet site produced large diameter logs with average dbh of 39.6 cm, which was comparable to that of site quality I (SQ I) as per the All India Yield Table (FRI, 1970). Contrastingly, the average dbh for teak grown in the dry site was 24 cm, qualifying only for SQ II or III as compared to the average dbh of 31 cm recorded from the same aged forest plantation in Nilambur. It was found that only 10 logs belonged to Grade II timber and the rest fell under grade III- IV with more frequent visual defects. The sawn timber out turn was therefore significantly higher from homesteads of wet sites than dry and plantation sites. The sawn timber recovery percentage was lower for the dry site (66.8%), whereas there was no significant difference between wet (76.5%) and forest plantation sites (78.8%).

No significant differences were noticed in wood basic density, moisture content and volumetric shrinkage values, measured by standard methods, among the homesteads of wet and dry localities as well as the plantation site in Nilambur. This implies that teakwood grown in homesteads has almost the same dimensional stability as the plantation grown teak of forest sites. Excepting slightly higher longitudinal compressive stress of dry site home-garden teak, no significant variation was noticed in timber stiffness (modulus of elasticity), air-dry density and bending strength among the wood samples from the three sites studied.

The microfibrillar angle (MFA) did not vary significantly between the wet, dry and plantation localities and the values are 13° for wet site and 12.5° each for dry and plantation (P=0.05) sites. The analysis of radial pattern of variation revealed that fibril angle decreased from the juvenile inner portion near the pith towards the periphery of wood in all the three localities. The results of the present study proved that teakwood harvested from the homesteads at the age of 35-years is strong and dimensionally stable for any structural use as the MFA 12.5° was quite small and strength values did not differ significantly between the two homesteads when compared to plantation teak.

The accelerated laboratory tests for decay resistance revealed that natural decay resistance significantly differed between wet and dry localities. The weight loss in wet site samples due to the attack of brown-rot fungi, viz., *Polyporus palustris* to the extent of 43% brings down the teakwood to the category of Class III (Moderately Resistant Timbers). The dry and plantation site samples belong to the same durability class; they were more resistant than wet site samples. White-rot fungi did not cause any damage to the timber as the percentage weight loss was in the range of 1.7-3.0% which is much less than the threshold value of 10% for durability Class I. In general, *P. palustris* was the most aggressive fungus followed by *Gloeophyllum trabeum*, both causing brown-rot. The tests results of durability imply that the wet site sample is more susceptible to brown-rot fungi and one must be cautious when the timber is put to exterior use in structural applications. The HPTLC analysis of purified ethanol extract showed that the amount of tectoquinone was highest in dry site (0.34%), the difference between the dry and plantation sites was not statistically significant (P=0.05) in comparison to the lowest amount (0.23%) in the wet site sample. In contrast, the amount of naphthoquinone consistently decreased from dry (1.26%) to wet site (0.62%) samples with intermediate value for forest plantation site (0.97%), correlating negatively with the weight loss percentage from dry to wet site and plantation site values. More than the total extractive content and tectoquinone, the amount of naphthoquinone was correlated with higher decay resistance from the wet to dry planted sites implying that naphthoquinone is the single most important compound which imparted decay resistance to teakwood against the two brown-rot fungi, viz., *P. palustris* and *G. trabeum*.

Mr. K. A. Sreejith was awarded doctorate degree by the Forest Research Institute (FRI) University, Dehra Dun, in 2008 for his work on "**Ecological and ecophysiological studies on the successional status of tree seedlings in tropical wet evergreen and semi-evergreen forests of Kerala**", under the guidance of Dr. U. M. Chandrashekara, Scientist & Head, KFRI Sub Centre, Nilambur.

In the wet evergreen and semi-evergreen forests of Kerala, 35 tree species were studied to determine their light adaptation strategies under different light regimes. The study indicated that in a given species, the chlorophyll fluorescence is related to the quantum use efficiency of photosynthetic system. The study also indicated that the species are in a continuous gradient in terms of light adaptation. Even then these species can be categorized into different successional groups based on ecological and ecophysiological studies. The photosynthetic efficiency showed significant difference between successional groups when studied under different light regimes.

In 10% light regime, primary and late-secondary species recorded significantly higher value than that by early-secondary species (P=0.05). However, no such difference was noticed under 25% light regime (P=0.05). On the other hand, when the light was more than 50%, the photosynthetic efficiency of secondary species was significantly higher than that of primary species (P=0.05). The quantum use efficiency of photosynthetic system of a given category of tree species under different light regimes was also compared.

Consistent reduction in the quantum use efficiency of photosynthetic system value increase in light intensity (P=0.05) in primary species is an indication of their shade loving nature. In the case of secondary species, the quantum use efficiency remained same up to 50% light regimes showing their light demanding nature. Subsequent decline in the value in these species could be attributed to photoinhibition. The study also revealed that in all light regimes except in 10% light, quantum use efficiency of photosynthetic system of *Mallotus tetracoccus*, *Croton malabaricus*, *Macaranga peltata*, and *Leea indica* is significantly better than that of all other species. Since these four species perform well in relation to other as the light availability increases, they can be considered as indicator species of forest disturbance.

Mr. K. C. Rajesh Kumar was awarded doctorate degree by the Forest Research Institute (FRI) University, Dehra Dun, in 2009 for his work on the "**Biodiversity of Plant Pathogenic Fungi in Natural Forests in the Kerala part of Western Ghats**", under the guidance of Dr. C. Mohanan, Scientist & Head, Forest Pathology Department, KFRI.

Considering the importance of natural forests in the Kerala State as one of the centres of mega diversity in the world, a systematic exploration of plant pathogenic fungi was undertaken to assess the biological diversity. Comprehensive disease surveys were conducted in four selected forest types in natural forests viz., West coast tropical evergreen forests (EF), Southern montane wet temperate forests or Shola forests (SF), West coast tropical semi-evergreen forests (SEF), South Indian moist deciduous forests (MDF). Stratified random sampling was employed for sampling. A total of 2326 disease specimens were collected from 501 host plant species belonging to 112 host families. The semi-evergreen forest is found vulnerable to 22 per cent of diseases with high severity. Also, the fungal diseases in natural forests exist in an equilibrium state in the study area.

In the systematic treatment, 184 species of plant pathogenic fungi belonging to 88 genera were collected from the study area. Plant pathogenic fungi belonging to Deuteromycotina-Hyphomycetes dominated in the study area with 75 species belonging to 29 genera. Deuteromycotina-Coelomycetes constituted 70 species belonging to 34 genera and were next to Hyphomycetes. Under Basidiomycotina, 29 species of plant pathogenic fungi belonging to 16 genera were identified. Fungi belonging to Ascomycotina include nine species and seven genera. Fifteen dominant plant pathogens were identified. Oomycotina and Deuteromycotina-Agonomycetes were rarely recorded from natural forests. A large number of fungal taxa were non-sporulating. The host to plant pathogenic fungi ratio in natural forests was determined based on fungal isolates identified from each host plant. South Indian moist deciduous forest recorded the highest ratio of 1:5.21. The overall host to pathogenic fungi ratio recorded in natural forests in the Western Ghats was 1: 7.38. Highest host to plant pathogenic fungi ratio of 1: 20 was recorded in the host plant *Aporusa lindleyana*.

Spatial diversity of the plant pathogenic fungi was assessed in higher and lower altitudes of West coast tropical evergreen forests (EF), Southern montane wet temperate forests or Shola forests (SF), West coast tropical semi-evergreen forests (SEF) and South Indian moist deciduous forests (MDF). Differences in the diversity of the plant pathogenic fungi were higher and prominent in lower altitudes (<500 m a.s.l.) compared to higher altitudes (>500 m a.s.l.) in South Indian moist deciduous forests. In Shola forests of high altitudes the diversity of plant pathogenic fungi were comparatively less, however, the lower altitude Shola forests supported more fungal pathogens.

Biodiversity analysis revealed that the species richness and evenness was high in semi-evergreen forests with the Menhinick's index 3.82 and evenness index 0.72. Shannon Wiener diversity index of 3.47 was also higher in Semi-evergreen forests followed by MDF. The Simpson's index was low in Semi-evergreen forests compared to MDF and EF. These observations clearly indicate that the heterogeneity of fungi was more in semi-evergreen forests. In Shola forests, even though the species diversity was less, the plant pathogenic fungi were more evenly distributed. Species ordination studies in different forest types revealed that *Colletotrichum gloeosporioides* was the characteristic species of tree, shrub and climber microhabitats of EF, MDF and SEF. However, a number of species like *Colletotrichum gloeosporioides*, *Colletotrichum* sp., *Phomopsis* sp. preferred tree microhabitat in Shola forests. The distribution of various plant pathogenic fungi in natural forests is depicted in the distribution maps prepared for the Kerala part of the Western Ghats.

Mrs. S. Sabna Prabha was awarded doctorate degree by the Forest Research Institute (FRI) University, Dehra Dun, in 2009 for her work on the "**Analysis of mating system and contemporary gene flow in natural teak forests and plantaions through DNA markers**", under the guidance of Dr. E. P. Indira, Scientist & Head, Forest Genetics Department and Dr. M. Balasundaran, Programme Coordinator, Biotechnology Department, KFRI.

The study was undertaken to trace the pollen and seed dispersal using parentage analysis, to analyse the mating system and to compare the contemporary gene flow in plantation and natural teak forests with different levels of human impact using DNA markers. To compare the contemporary gene flow and mating system in teak populations with different levels of human interference, two natural teak forests, one highly disturbed and another undisturbed and a teak plantation were selected in the Peechi- Vazhani Wildlife Sanctuary of Thrissur District in Kerala State. All the adult trees in the selected sites and progenies of nine trees from each of the populations were DNA fingerprinted using 7 microsatellite markers to study the pollen dispersal. Seedlings on the forest floor were also fingerprinted to analyse the seed movement. The total number of alleles for all the loci obtained was 40, 45 and 42 in disturbed and undisturbed natural teak forests and plantation respectively. The average value for Polymorphic Information Content (PIC) of all the loci together, in each of the selected populations, was higher than 0.5 ensuring the highly informative nature of the markers.

The allelic richness and the average PIC value of the selected populations confirm that the resolving power of the loci is sufficient and the output is suitable for unbiased estimation of individual reproductive success and for tracing parentage. Various genetic diversity measures were estimated namely heterozygosity, gene diversity and inbreeding, population differentiation between parents and progeny and gene flow in the populations. The study revealed that all the teak populations harbour good amount of gene diversity and it was lower in disturbed teak forest

population (0.563) than the undisturbed natural teak forest (0.614) and plantation (0.651). With regard to inbreeding coefficient (*Fis*), 7 per cent (0.070) inbreeding or heterozygote shortfall was observed in the disturbed plot whereas in undisturbed plot it was only 1.8 per cent (0.018). In teak plantation, no inbreeding was found and the *Fis* value obtained was negative (-0.033).

In disturbed population, genetic differentiation (*Fst/Gst'*) between parents and progenies was high (0.024) compared to the value of 0.010 obtained for both undisturbed population and plantation. The indirect estimation of gene flow (*Nm*) between the parents and their respective progenies (seeds) estimated from the corresponding *Fst* value in the selected plots showed that the gene flow was low (10.17) in the disturbed population than in the undisturbed population and plantation where same value of 24.75 was estimated. In the disturbed population, gene flow was less (10.17) leading to a substantial shortfall of heterozygotes (7%) and a higher differentiation between parents and progeny (0.024), compared to other two populations. The contemporary gene flow was evaluated through the components of pollen and seed dispersal. The main range of pollen dispersal distance was found to be 151-200 m in disturbed plot, 101-150 m in undisturbed plot and 50-100 m in teak plantation. The pollen dispersal analysis from three teak populations showed that the pollen dispersal was mainly in the distance of below 200 m. It indicated that the pollen dilution zone in seed orchards/seed stands must be more than 200 m to restrict the entry of pollen from outside.

The analysis on seed dispersal in natural teak population showed that the dispersal was mainly in the distance range of 50-100 m. This indicated that, in natural teak population, the distance of pollen flow is more than the seed movement.

The results of the study showed that the selected teak populations are genetically diverse and disturbance in natural forests leads to decrease in gene diversity, lower gene flow as well as higher population differentiation between parents and their progenies and increased inbreeding. The study has not only analysed the reasons for the high gene diversity seen in the teak population but also estimated the distance of the pollen and seeds transferred. The findings of this study are useful for the scientific and sustainable management of teak seed orchards/seed stands as well as for the preparation of efficient and comprehensive strategies for the conservation of natural teak populations and germplasm bank.

Sports and Games Meet 2008

Winners of Forest Sports and Games Meet 2008

KFRI participates every year in the annual Kerala Forest Sports and Games meet organized by the Kerala Forest Department, as a separate circle - the KFRI Circle. The *Kerala Forest Sports and Games Meet 2008* was held at Palakkad form 18-20 of October 2008. Thirty six staff members (including project staff) from KFRI participated in the meet in items like Volley Ball, Cricket, Power Lifting, Weight Lifting, Swimming, Table Tennis, Rifle Shooting and other track and field events. KFRI secured 2 Gold medals, 3 Silver medals, and 6 Bronze medals in the Meet as given below.

Ms. Swapna Francis bagged four medals.

One *Gold Medal* for Shuttle Badminton. One *Silver Medal* for Caroms. Two *Bronze Medals for* Chess and Shuttle Mixed Doubles

Mr. Shanthakumar, S. B won *Gold Medal* for Weightlifting (Under 56Kg).

Dr. Mamman Chundamannil bagged *Two Silver medals* for Table Tennis Open and Doubles.

Dr. K. Mohanadas obtained *One Silver Medal* for Table Tennis Doubles and *One Bronze Medal* for 1500 m. walking competition.

Mr. Biju, K.P. obtained *Silver Medal* for Swimming (Back Stroke)

Mr. Sathish.C won *Bronze Medal* for Rifle Shooting Competition.

Mr. Saiju obtained *Bronze Medal* for 5000 Mt. Running Competition.

Mr. Vincent C.K. obtained *Bronze Medal* for Power Lifting.

Congratulations!

KFRI participants

Ms. Swapna Francis

Mr. S. B. Shanthakumar

Evergreen congratulates the winners on their grand success.

Farewell

Since the establishment of the Kerala Forest Research Institute in 1975, the first generation of its staff has started in the preceding year extended over the coming 4-5 years, the maximum number retiring between 2009 and 2012. Six of our staff has superannuated recently and the process will continue over the coming years. KFRI bids them a fond farewell hoping that they will have a happy retired life and will continue to take interest in the activities and development of the Institute.

Dr. K. K. N. Nair, Senior Scientist, Botany Discipline, Forest Ecology & Biodiversity Conservation Programme Division retired from the service of the institution on 31st August 2008. He joined in KFRI during 26th August 1982. His area of specialization is Taxonomy and ecology of flowering plants, floristic studies of specific areas/ regions, impact assessment with reference to indigenous flora and endemic and endangered plants, artificial regeneration and conservation of indigenous and endemic tree species and medicinal plants, wasteland rehabilitation technology using medicinal plants and other NTFP species, biodiversity documentation, evaluation, conservation, training and editorial and publication works related to books, journals, abstract volumes of international conferences, brochures etc. He has served as the Deputy Coordinator of IUFRO Working Groups for 'Tropical and subtropical Silviculture' and 'Silviculture and management of threatened and endangered species'. He has over 60 publications in professional journals, 14 Research Reports, 10 (authored/edited) Books, 9 Information Bulletins and 21 proceedings/Chapters in books to his credit. KFRI looks forward his guidance and support in the future.

Shri. K. Sankarapillai, Librarian. He joined in KFRI during 5th July 1980 and retired from the service of this institution on 31st May 2008. He was responsible for initiating the computerization and digitalization of the library. He was involved in several activities in connection with the BIC-INDIA project sponsored by INBAR, Beijing, P. R-CHINA. He has published information bulletin and directory on Bamboo and Cane researchers. His involvement during the publication of Bamboo Compendium, the Bibliography of Bamboos of South and Southeast Asia is worth mentioning. He has participated in several national and international workshops on bamboos. KFRI look forward his guidance and support in the future.

Shri. T. Prabhakaran, Clerical Assistant, he joined in KFRI during 23rd October 1976 and retired from the service of this institution on 31st May 2008.

Shri. P. Mohandas, Driver, he joined in KFRI during 5th June 1982 and retired from the service of this institution on 30th June 2008.

Shri. K.R. George, Attender, he joined in KFRI during 18th July 1978 and retired from the service of this institution on 30th June 2008.

Shri. P. S. Raman, Attender, he joined in KFRI during 2nd April 1980 and retired from the service of this institution on 31st July 2008.

Obituary

It is with profound sadness that we announce the untimely death of our colleagues

K. RAJENDRAN

Shri. K. Rajendran, Poolakai House, Chulliyode P.O., Nilambur, who was in KFRI Service as Assistant Office Manager, since 04-01-1982 and served Nilambur Sub Centre from 1987 onwards, died on 6th September 2008. He was a sincere and diligent employee and served KFRI with extreme devotion. KFRI fraternity deeply mourn the death of Shri Rajendran and pray to GOD to grant peace to the departed soul, strength and fortitude to the bereaved family members.

KANTHILA MAHABALA BHAT

Dr. Kanthila Mahabala Bhat, the renowned researcher in the area of Wood Science and Technology, died on 2 January 2009 after a brief illness of fighting with prostrate cancer. He was born in Puthoor, Karntaka, India, on 19 June 1950. After post graduation, he worked as Lecturer in Botany at the St: Aloysius College, Mangalore and later joined as Research Assistant in the Forest Research Laboratory (the present Institute of Wood Science and Technology, ICFRE) Bangalore. In 1979 he joined Kerala Forest Research Institute (KFRI), Peechi, India as Scientist in the Division of Wood Science. He was awarded L.Sc. (Licentiate of Science in Wood Technology) and D.Sc in 1981 by the University of Helsinki, Finland. He was serving as Programme Coordinator (Scientist-F) of Forest Utilisation Division until his sad demise. He was also the Network Coordinator of the Asia Pacific Teak Information Network (TEAKNET) presently based in KFRI supported by the FAO- RAP, Bangkok.

Dr. Bhat had distinguished career as a wood scientist and had made significant contributions in his field of expertise. He was an expert both in tropical and temperate hardwood and non-wood forest products, their management and utilisation including reed bamboos.

He was a consultant to the International Network for Bamboo & Rattan (INBAR) for standardisation of rattan grading rules, to the Amazon Teak Foundation, to the British Overseas Development Administration (ODA) and to Indufor Oy, Helsinki, International Cooperation Centre for Agriculture Education (ICCAE), Nagoya University, Japan. He was appointed as Regional Coordinator for International Academy of Wood Science (IAWS) in the Indian sub-continent in 1996. He was IUFRO Convenor of the Teak Wood Working Party, as a member of the Teak 2000 Technical Foundation Committee and also a member of IUFRO Enlarged Executive Board and Deputy Coordinator of IUFRO Division 5 (2000-2010). He was honoured with the Rising Personalities of India award as well as a Medal instituted by the Bamboo Society of India, Institute of Wood Science & Technology and Karnataka Forest Department in 1999, for outstanding contributions to rattan development in India and Asia Pacific Region.

He was the founder Coordinator of IUFRO 5.06.02 (Teak Wood) Working Party while being a Deputy Coordinator of IUFRO Division 5: Forest Products (2000-2010). In 2000, he was awarded the lifetime IUFRO Scientific Achievement Award with Gold Medal in Forest Products.

He has carried out collaborative research programmes in Finland, France, Germany and Japan. He was responsible for major conferences and workshops such as International Teak Conference (2003) and Regional Teak Wood Workshop (2007) that attracted much international attention. He was a regular participant in many international events and Conferences, World Forestry Conferences etc. and presented several invited papers.

Dr. Bhat was also an elected Fellow of International Academy of Wood Science (1991) and Indian Academy of Wood Science (1999). He has more than 190 publications including books, refereed papers, monographs, articles and reports to his credit. The KFRI fraternity will always miss the creative genius of Dr. K. M. Bhat in the various forestry scientific programmes being undertaken.

He is survived by wife, Kusuma Bhat and two children- daughter, Divya and son, Shyamal. Every Staff of KFRI deeply mourn the death of Dr. K. M. Bhat and pray to GOD to grant peace to the departed soul, strength and fortitude to the bereaved family members

Journal of Bamboo and Rattan

The Journal of Bamboo and Rattan is an international peer reviewed scientific journal hitherto published by VSP/E.J. Brill, The Netherlands, has been taken over by the Kerala Forest Research Institute, Peechi, Thrissur, Kerala. The journal from volume 5 (2006) on wards is being published by KFRI. Volumes 5-7 (2006-2008) have already been brought out.

The scope of the journal encompasses the following broad areas of Bamboo and Rattan:

- Biology and Genetic resources
- Propagation
- Management of natural stands and plantations
- Utilization, value addition and Engineering applications
- Marketing and socio-economics
- Policy issues

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Weather data

from KFRI operated Automated Weather Stations for the year 2008

KFRI operates four automated weather stations (AWS) in its three centers and another in Kanthalloor in the Western Ghats. Each station measures temperature, relative humidity, rainfall, wind velocity and solar radiation, all at hourly intervals. Monthly averages of the weather parameters for 2008 are provided in following tables. Hourly data is made available for researchers, on request.

MONTHLY WEATHER DATA FOR 2008 AT PEECHI

LATITUDE -10° 31'47'' N LONGITUDE- 76° 22'7.5'' E ALTITUDE- 45 msl

Month	Max.Temp Deg C	Min.Temp Deg C	Max. rh %	Min. rh %	Rainfall mm	WindVelocity km/h	Solar Radiation kw m^{-2}
Jan	33.27	18.75	100.00	30.52	0.00	6.20	152.43
Feb	35.07	21.35	100.00	21.89	19.40	3.79	153.27
Mar	35.21	20.53	100.00	13.84	226.00	4.75	161.14
Apr	35.47	21.35	100.00	37.79	84.80	1.48	155.09
May	34.56	22.02	100.00	48.38	50.60	1.67	148.56
Jun	33.08	21.47	100.00	56.06	625.20	1.55	106.36
Jul	32.01	22.02	100.00	57.24	483.00	1.30	104.46
Aug	32.30	22.08	100.00	64.51	313.80	1.30	116.77
Sep	31.93	21.96	100.00	59.65	146.60	1.49	132.95
Oct	33.96	21.50	100.00	53.71	460.60	2.95	129.04
Nov	32.68	21.90	100.00	45.03	14.60	3.50	128.63
Dec	31.40	17.95	100.00	33.59	1.60	8.56	143.54
Tot/Avr	33.41	21.07	100.00	43.77	2406.20	3.21	136.09

MONTHLY WEATHER DATA FOR 2008 AT KANTHALLOOR

LATITUDE-10° 12'09'' N **LONGITUDE-** 77° 11'9.1'' E **ALTITUDE-** 1520 msl

Month	Max.Temp	Min.Temp	Max. rh	Min. rh	Rainfall	WindVelocity	Solar Radiation
	Deg C	Deg C	%	%	mm	km/h	kw m^{-2}
Jan	N.R	N.R	N.R	N.R	N.R	N.R	N.R
Feb	N.R	N.R	N.R	N.R	N.R	N.R	N.R
Mar	N.R	N.R	N.R	N.R	N.R	N.R	N.R
Apr	N.R	N.R	N.R	N.R	N.R	N.R	N.R
May	N.R	N.R	N.R	N.R	N.R	N.R	N.R
Jun	N.R	N.R	N.R	N.R	N.R	N.R	N.R
Jul	27.14	15.19	100.00	41.78	280.60	1.74	1.11
Aug	26.05	14.54	100.00	48.84	260.20	1.37	1.22
Sep	32.05	15.22	100.00	52.17	201.40	1.32	87.10
Oct	25.70	12.56	100.00	37.89	279.20	1.05	0.93
Nov	23.91	11.56	100.00	39.68	196.00	1.38	0.88
Dec	21.87	6.70	100.00	35.33	110.20	1.22	1.04
Tot/Avr	**26.12**	**12.63**	**100.00**	**42.62**	**1327.60***	**1.35**	**15.38**

MONTHLY WEATHER DATA FOR 2008 AT VELUPADAM

LATITUDE-10° 26' 7.4'' N **LONGITUDE-** 76° 21'32.9'' E **ALTITUDE-** 45 msl

Month	Max.Temp	Min.Temp	Max. rh	Min. rh	Rainfall	WindVelocity	Solar Radiation
	Deg C	Deg C	%	%	mm	km/h	kw m^{-2}
Jan	N.R	N.R	N.R	N.R	N.R	N.R	N.R
Feb	N.R	N.R	N.R	N.R	N.R	N.R	N.R
Mar	N.R	N.R	N.R	N.R	N.R	N.R	N.R
Apr	N.R	N.R	100.00	38.04	76.80	0.99	137.43
May	34.21	21.91	100.00	50.07	51.00	1.16	135.02
Jun	33.25	21.75	100.00	58.06	627.40	0.79	102.49
Jul	31.85	22.00	100.00	59.14	467.60	0.79	105.37
Aug	32.64	21.63	100.00	69.68	481.80	0.79	113.15
Sep	32.78	21.79	100.00	52.17	323.40	0.68	126.41
Oct	34.54	21.45	100.00	71.42	383.00	0.58	127.14
Nov	34.30	20.24	100.00	71.94	50.00	0.55	115.30
Dec	N.R	N.R	100.00	47.26	8.20	0.89	133.89
Tot/Avr	**33.37**	**21.54**	**100.00**	**57.53**	**2469.20***	**0.80**	**121.80**

MONTHLY WEATHER DATA FOR 2008 AT NILAMBUR

LATITUDE-11° 17'28.5'' N **LONGITUDE-** 76° 15'36.3'' E **ALTITUDE-** 37 msl

Month	Max.Temp	Min.Temp	Max. rh	Min. rh	Rainfall	WindVelocity	Solar Radiation
	Deg C	Deg C	%	%	mm	km/h	kw m^{-2}
Jan	34.48	17.45	100.00	45.62	0.00	0.35	49.90
Feb	37.88	16.42	98.92	17.11	0.00	0.62	132.56
Mar	38.27	14.89	100.00	13.47	247.40	0.84	87.55
Apr	37.54	21.55	100.00	50.59	118.40	0.51	155.14
May	36.51	21.07	100.00	48.03	100.60	0.54	154.47
Jun	33.47	22.25	100.00	59.55	653.80	0.40	106.10
Jul	34.79	21.25	100.00	56.32	503.60	0.36	119.21
Aug	34.14	21.07	100.00	59.75	452.00	0.31	115.99
Sep	33.18	21.79	100.00	52.17	292.00	0.62	131.66
Oct	34.58	18.92	100.00	51.25	496.80	0.36	127.02
Nov	34.50	18.42	100.00	43.21	54.20	0.40	105.19
Dec	34.21	15.01	100.00	40.76	0.00	0.38	116.61
Tot/Avr	**35.30**	**19.17**	**99.91**	**44.82**	**2918.80**	**0.47**	**116.78**

* partial data for the year; NR- Not Recorded

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Tree Physiology Department, SFM Division.

KERALA FOREST RESEARCH INSTITUTE

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		Price	
Bamboo		**Rs.**	**US$**
1.	An Annotated Bamboo Bibliography. KFRI CD 4	200.00	20.00
2.	Bamboo: A Crop (CD-ROM)	250.00	25.00
3.	Bamboos of India	2250.00	100.00
4.	Edible Bamboo Shoot Recipes	30.00	10.00
5.	Edible Bamboo Shoots: Collection and Processing (Malayalam)	10.00	10.00
6.	Information Resources for Bamboo and Cane Development in Kerala	75.00	10.00
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