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Preface

Ever since the establishment of CESS in 1978 the institute has grown from strength to strength to become one of the premier earth science research institutes in the country. The period 2010-11 was another commendable year for CESS, enhancing its reputation through R&D and consultancy activities. This year CESS recruited 5 new scientists with specializations in different field of earth sciences to strengthen the manpower requirements. The year was also notable for the approval of a major coordinated programme on climate change by the Kerala State Council for Science, Technology and Environment (KSCSTE) and initiation of two other major projects for the public sector undertakings, Indian Rare Earths Ltd., and Kerala Minerals and Metals Ltd. Establishment and maintenance of wave gauge stations in the coastal waters of the south-west coast of India with the financial support from the Indian National Centre for Ocean Information System was another important long term initiative during the year. To remain in the forefront and in tune with needs of scientific research and development we continued with zeal modernisation and upgradation of our physical and laboratory facilities. Major initiative in modernising Fluid Inclusion Laboratory with new freezing stage and advanced model of research microscope was taken up. CESS has approached the Ministry of Earth Sciences to develop this lab as a National Facility on Fluid Inclusion Research. These developments are proofs of growing coordinated and sustained efforts of dedicated team of scientists and staff at CESS for many years. I have great pleasure in presenting this Annual Report of CESS summarising achievements of 2010-11. I earnestly hope that this report will not only act as a record of financial performance but also provides a window to the growing research capabilities, expertise and reputation of CESS.

The study of earth and its processes for a sustainable development of our natural resources, environment monitoring and natural hazards management are the core themes of CESS. This demands equal importance and contributions from basic and applied research. Out of 61 projects implemented by CESS during the year 32 were funded by the central/state government departments and agencies and the remaining by internal resources. Over 55 consultancy projects, undertaken across the country, mostly for preparation of CRZ Status reports, helped CESS to generate additional funds to support the establishment and infrastructure cost and stride its research to the developmental sector. The R&D programmes are grouped under three broad themes viz., earth system dynamics, natural hazards and natural resources management.

Under the theme earth system dynamics, our research findings on the Kerala Khondalite Belt (KKB) and paleomagnetism are worth mentioning. The new geochemical and mineral chemical data on granitoids generated during the year were integrated in a petrogenic model to suggest that the lower crust of KKB formed in an arc-accretion setting. Another project on KKB to understand the tectono thermal history brought out excellent textural and geochemical evidences for the production and passage of leucogranitic melts, and the associated localised crystallisation of the U-Th-bearing minerals monazite and zircon. As part of the research programmes on continental magmatism and lithosphere evolution, the studies on Cretaceous mafic dyke swarms and the Precambrian mafic dykes were continued. Studies revealed that the 90 Ma igneous event can be linked to Marian plume activity in India which is responsible for the breakup of India-Madagascar and, the magmatism is more wide spread in India than understood earlier.

Preliminary results of the study to trace the evolutionary history of the Ashtamudi Estuary, indicate that there is a significant variation in the sediment lithological units and faunal assemblages in the area. The occurrence of littoral-marine in the northern sector and riverine-estuarine sequence in the southern sector were documented. Our studies on Quaternary geology has shown that the wetlands in the southern Kerala coast, south of Achankovil Zone, show antecedent characteristics and are seen incised on the uplifted Neogene sediments. The wetlands encompass 20-35 m thick deposit of Holocene sediments with fairly good archives of landform evolution and climate changes.

Our R & D activities under the atmospheric processes continued unabated in spite of reduction in the number of scientists. We have continued cloud studies programme with water based condensation particle counters and Cielometer measurements from Braemore station and CESS and recorded changes in particle size distribution during formation of convective cloud near the Western Ghats. Ambient atmospheric carbon monoxide at Thiruvananthapuram, a clean coastal site, was monitored continuously using a non-dispersive IR analyser. Monitoring of rain rate, drop size distribution and its vertical profile was carried out using Disdrometers and Micro Rain Radar which revealed that as rain drops come down, the number of smaller drops decrease and number of larger drops increase simultaneously.

Under the coastal processes programme, Muthalapozhi inlet re-

gion was studied through numerical modeling, supported by field data. The study showed net southward sediment transport during May to August with a reversal during the beach building period of September to April. Model results, well supported by field data, indicate significant bypassing of littoral transport into the inlet since January. We also initiated a study to evaluate performance of the first sub-merged artificial reef in the country built at Kovalam.

CESS continued its R & D activities in the field of natural hazards more vigorously with the increase in demand for our inputs from the Disaster Management and other Departments of the Government of Kerala. The digital Broadband Seismic Observatory (Station Code: PCH) at Peechi continued to provide high quality data for study of local, regional and distant/global seismic events. Our scientists investigated landslides and land subsidence incidents at a number of locations. Under the tsunami inundation modelling project, the vulnerability maps for the northern Kerala coast was prepared and field measurements were completed for the Karnataka coast. The work under the oil spill modelling project attained further momentum, and hydrodynamic models were set up for hypothetical cases of oil spill off Cochin and Vizhinjam.

The projects under natural resources and management theme dealt with various issues ranging from terrain, land quality and geochemistry to environmental remote sensing. CESS continued to painstakingly carry out sand auditing for the rivers. The action research programme on rain water harvesting and ground water recharge in Chadayamangalam block warrant special mention as it directly addressed societal concern. A couple of projects focused on issues related to terrain, landuse and geomorphology. Some projects were executed in the realm of environmental impact assessment and management, like SoE studies for Kochi metropolitan region, impact of river sand mining, interrelationship between incidents of poverty and environmental degradation, ecological studies in selected swamps in the Madathara area to reconstruct the past history of these swamps, environmental degradation of Muvattupuzha river basin, etc. Sampling and analysis of water and sediment samples from coastal waters of Kochi identified estuarine discharges as a significant source of oceanic methane and nitrous oxide in the coastal regions. Work under the ongoing national programme on Coastal Ocean Monitoring and Prediction System (COMAPS) made significant contributions with the continued monitoring at three hotspot areas viz., Kochi, Mangalore and Kavaratti. As a result of our activities in monitoring water and sediment quality of estuaries, the study results of the Kochi estuary and Periyar river showed high values of total mercury in water and sediment samples. Chemical loading into reservoirs was another important study completed during the year.

CESS continued to be in the forefront of development and application of remote sensing techniques for various purposes. Multi-spectral imaging techniques were developed to remotely sense biological systems such as corals and vegetation. With a view to apply these technologies to the benefit of mankind, CESS initiated an Indo-Bulgarian collaborative program with the support of DST, Govt of India. Several clinical studies were carried out in the Govt. Dental College, Trivandrum to treat periodontal infections. Several projects in natural resources management, utilizing satellite remote sensing and GIS were carried out. Notable among them are the Agricultural atlas of Kerala, Resource atlas of Kerala, cadastral level decision support system for management of natural resources, development of Tribal Information System etc.,

On the publication front, our performance was creditable. 27 papers in national/international journals, and a special issue of the Indian Journal of Geo-Marine Sciences on Coastal processes, Resources and Management with N.P. Kurian & K.V. Thomas as Guest Editors and a book entitled 'Photo diagnosis of oral malignancy - Basic, translational and clinical' authored by R. Mallia and N. Subhash were published. These were in addition to 22 research papers in proceedings/books and 44 Technical/Project Reports. Dr. Subhash was conferred as the Senior Fellow of Head and Neck Optical Diagnostic Society and Dr. Nandakumar was awarded the INSA Royal Society Fellowship to visit Scotland. Ms. M. Vandana won second position in the Prof. N.P. Ayyer Young Geographer Award and Mr. George Thomas received the Best Performer Award in the SERC School of Global Warming and Climate Change organised by DST (Govt. of India) and IITM. Many of our scientists participated in several national/international conferences and also gave invited talks.

Through our consistent efforts and strengthening of our academic programmes, the number of Ph.D. students increased to 29. 51 students carried out their M.Sc., M.Tech. & B.Tech. dissertation work, out of which 12 were provided with studentship.

CESS successfully organized the 23rd Kerala Science Congress. This was a major event attended by over 800 delegates with presentation of about 190 papers. The Congress was inaugurated by the Hon'ble Chief Minster Shri. V.S. Achuthanandan. Several national luminaries like Dr. K.K. Kasturirangan, Prof. Madhav Gadgil, Prof. Prabhat Patnaik, Prof. J. Srinivasan were invited speakers and guests of honour. This year's Prof. C. Karunakaran Endowment Lecture, ninth in the series, was delivered by Prof. T. Padmanabhan, Inter-University Centre for Astronomy and Astrophysics, Pune. A workshop on Interdependency between rivers and backwaters: Consequences for water quality, ecology, economy and environmental governess was organized in collaboration with ZMT, Bremen. CESS also observed the National Technology Day and Earth Day.

I take pride in presenting this Annual Report before you. The guidance and support received from the KSCSTE, Research Council and the Management Committee of CESS, and the co-operation and support extended by scientists and staff in all endeavours have all contributed immensely in our success.

Dr. N.P. Kurian
Director

1.1 Crustal Evolution and Geodynamics

1.1.1 Metasedimentary rocks of the Kerala Khondalite belt: petrology and Geodynamics of their formation

The Kerala Khondalite Belt (KKB) is an important lower crustal segment of the southern Indian granulite terrain. Dominant rock types (except sillimanite bearing gneisses) are classified as tonolitic (tonalite-trondhjemite) and potassic (granite-granodiorite) granitoids. Most studies consider KKB to be of supracrustal origin. Tectonomagmatic framework is not well-constrained due to lack of comprehensive datasets for the entire KKB. This project was conceived as an extension of our earlier studies on aspects related to general understanding of lithounits of the belt. Main focus of our present study is to revisit on aspects concerning inter-relationship between rock types, origin, PT conditions of formation and geochemistry and generate new data on major- and trace-element composition and REE systematic on dominant (> 70%) lithounits of the belt. Significant contributions expected from this work, by evaluation of new results and data available so far from long term research, for over two decades in this region, are on understanding of deposition, metamorphism evolution and pre-

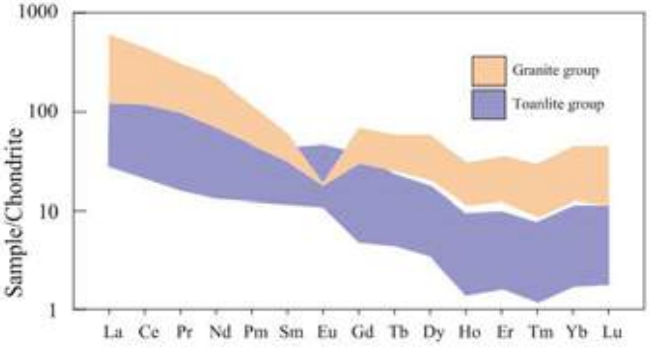


Fig. 1.1.1.1 Chondrite-normalized REE distribution patterns for the tonolite and granite group of rocks of KKB

metamorphic geodynamic settings of precursor rocks of Kerala Khondalite Belt (KKB). During the period of project we have carried out extensive field studies to document field relations between various rock types. Vast amount of data pertaining to field and geochemistry, with detailed quarry scale studies from over three hundred fresh outcrops and trace and REE analysis, have helped in assessing the tectonomagmatic framework. As a first step in data processing we used geochemistry and compositional variations of biotites from different groups of granitoids to document igneous parentage and examine biotite as a potential indicator of nature of the magma and the physical conditions during crystallization. Following is a summary of our results, first in the series, on granitoids of KKB.

The granitoids of KKB have been classified as tonolite and granite groups based on K_2O/Na_2O ratios. The tonolite group has geochemical affinity to Archaean tonalities with low-K, calc-alkaline, metaluminous to peraluminous chemistry. Compositionally contrasting K-rich rocks are essentially of granitic composition. Most oxides in both the groups, with exceptions of K_2O and Na_2O, show negative correlation with SiO_2. The tonolite

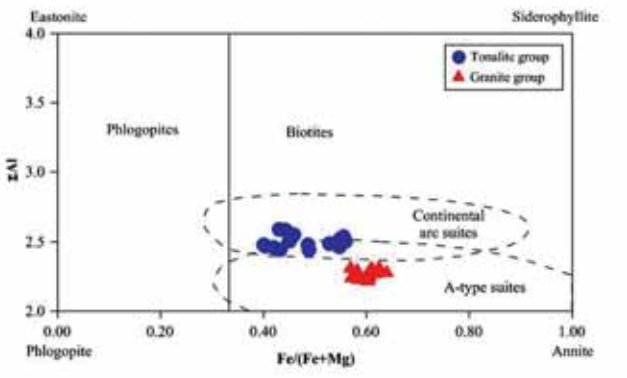


Fig. 1.1.1.2 Fe/Fe+Mg vs ΣAl diagram for biotites in tonalite and granite groups of KKB

group is enriched in Sr and depleted in Rb and Th. They exhibit geochemical features similar to those of Archaean tonalite and trondhjemite with enriched LREE and depleted HREE with positive and/or no Eu anomaly (Fig 1.1.1.1). On the other hand, granites show enrichment in large ion lithophile elements in relation to the high field strength elements and sharp negative anomalies of Eu, Nb, Sr, Zr, and Ti with fractionated REE patterns implying significant fractionation of plagioclase into the residue and strong effects of intracrustal differentiation. Complimentary patterns of Eu and Sr anomalies in both groups, also suggest an event of intracrustal magmatic differentiation in the presence of plagioclase. Electron microprobe analysis of

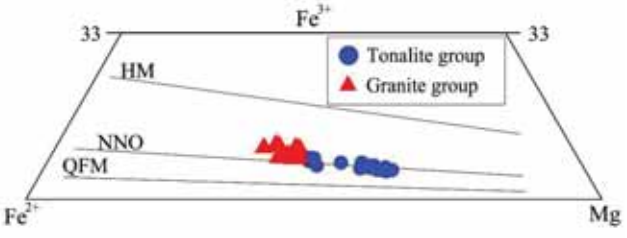


Fig. 1.1.1.3 Fe^{2+} - Fe^{3+} - Mg diagram for biotites in tonalite and granite groups of KKB

minerals in selected samples of tonalite and granite group (carried out in collaboration with Dr. EVSSK Babu of NGRI, Hyderabad) suggests that biotites preserve primary igneous composition with primary magmatic characteristics. Biotites from tonolitic group are Mg^{2+}–rich (X_{Mg}:0.47–0.63) in contrast to

those from granitic groups, which are Fe^{2+}–types with much lower X_{Mg} (0.37–0.44). Biotites from the tonolite group denote calc-alkaline host, whereas the granite group an alkaline host. Biotites in granitic group are poorer in $A1_2O_3$ than tonolites, indicating evolved nature of the magmatic protolith in granite group. Prominent decrease in ΣAl with increasing Fe/(Fe+Mg) values of biotites indicate progressive oxidising condition prevailed during magma evolution (Fig. 1.1.1.2 and Fig. 1.1.1.3). Granite group define compositions with oxygen fugacity (fO_2) slightly higher than Ni-NiO buffer, indicating moderately oxidising conditions, while the tonolites suggest fO_2 between QFM and Ni-NiO buffer, closely following that for the Ni-NiO, implying fairly reducing conditions during crystallization. This is in good agreement with the presence of ilmenite and magnetite (in variable proportions) in both rock groups.

Compositional variation of biotite allow us to speculate the nature of the host magmas of tonolite group as calc-alkaline, arc-type with features typical of Archaean TTGs and granite groups as partial melts of meta-igneous lower crust with little mantle contribution. The most plausible tectonic model that explains the generation of tonolite group is through melting of hydrous basaltic material at the base of a thick crust and that of granites by partial melting of meta-igneous source rocks. We speculate subduction zone related arc accretion setting followed by intracrustal melting for the evolution of KKB, which may therefore represent the deep-section of a collisional orogen.

G.R.Ravindra Kumar and C. Sreejith

Funding: DST, Govt. of India

1.1.2 Cretaceous mafic dyke swarms and the Precambrian mafic dykes

As part of the studies on continental magmatism and lithosphere evolution, the work on Cretaceous mafic dyke swarms and the Precambrian mafic dykes continued. During this year, the main focus has been on the Cretaceous magmatism. Alternate field demagnetization experiments, temperature-susceptibility measurements and palaeointensity determinations have been carried out on the recently collected samples of the Cretaceous dyke intrusions in Agali-Coimbatore sector, and north Kerala, the Deccan volcanic flows and a few red beds developed between the volcanic flows and the granite-granophyre complex of Ezhimala. The results show that chief magnetic carrier in these samples is titanomagnetite with curie temperatures in the range of 520-560°C with good reversibility during heating and cooling cycles (Fig. 1.1.2.1). Another interesting result is from the Ezhimala gabbro-granophyre complex. The pluton assigned Precambrian age in the literature has yielded very coherent characteristic magnetisations comparable with the late Cretaceous directions. The Ar-Ar isotopic results also corroborate the palaeomagnetic results. Samples have been irradiated for Ar-Ar incremental ages through laser aberration techniques Thus these results revealed that the 90 Ma igneous activity can be linked to Marian plume activity in India which is responsible for the breakup of India-Medagascar and the magmatism is more wide spread in India than has been known earlier. Major and trace element analysis by XRF and ICP-MS methods and. Sr, Nd and Pb isotopic work on additional samples from the recent field collection are in progress.

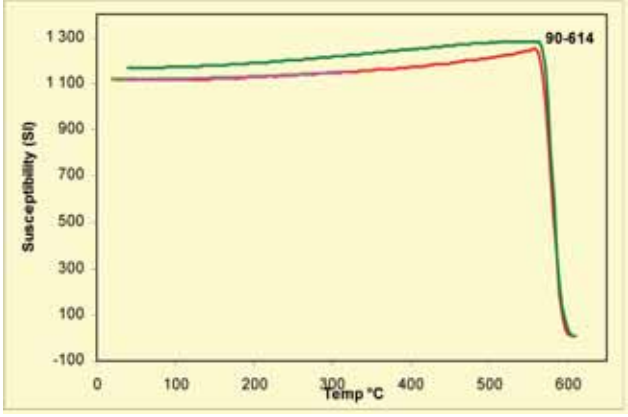


Fig. 1.1.2.1Temperature-susceptibility variation during heating and cooling cycle of a sample from granite-granophyre complex of Ezhimala

In addition, the palaeomagnetic and geochemical results obtained from the Precambrian mafic dykes of both Bundelkhand and Bastar cratons have also been analysed to understand their geodynamic implications for the evolution of Indian lithosphere.

T. Radhakrishna

Funding: The work on Cretaceous dykes is funded by the Indo French Centre for Promotion of Advanced Research (IFCPAR) and the Precambrian studies have been funded by the DST, Government of India

1.1.3 Tectonothermal History of the Kerala Khondalite Belt

The project aims at investigating the major and trace element chemistry of key minerals (garnet, monazite, zircon, cordierite etc) and their host rocks. During the reporting period detailed lithological studies were undertaken in the working quarries in KKB localities given in Fig.1.1.3.1. In addition to the above currently working quarries, samples with coronal cordierites and the cordierites that are sure to have formed as bi-products of pro-grade reactions were also collected from the quarries at Chittikara (CHT), Pangathadam (PNG), Punnelathupadi (PUN), Chittoormuri (CHO), Iramalloor (IRM) and Kadakamon (KDM).

Advanced electron microprobe (EMPA) housed in the Edinburgh Materials Micro Analytical Centre (EMMAC) at the University of Edinburgh was used for in situ U-Th-Pb chemical dating and

REE trace element analysis of monazites. Secondary ion mass spectrometry (SIMS) analysis was carried out on the IMS-4f instrument for REE and selected trace elements in zircon (Sc, P, Y, Ti, Hf, Th, U) and garnet (Ti, Zr, Sc, P). SIMS CO_2-H_2O microanalysis of cordierite, for calculation of fluid activities attending metamorphism and melting, was also carried out on the IMS-4f. SIMS in situ U-Pb isotopic dating of zircons was carried out on the 1270 instrument. All of the above analytical works were supported by intensive SEM backscattered electron and CL imaging of the phases.

Petrology/ Petrography

In addition to the 33 thin sections prepared from the CESS thin section facility, another 28 high quality polished thin sections were prepared in the lapidary facility of the University of Edinburgh for

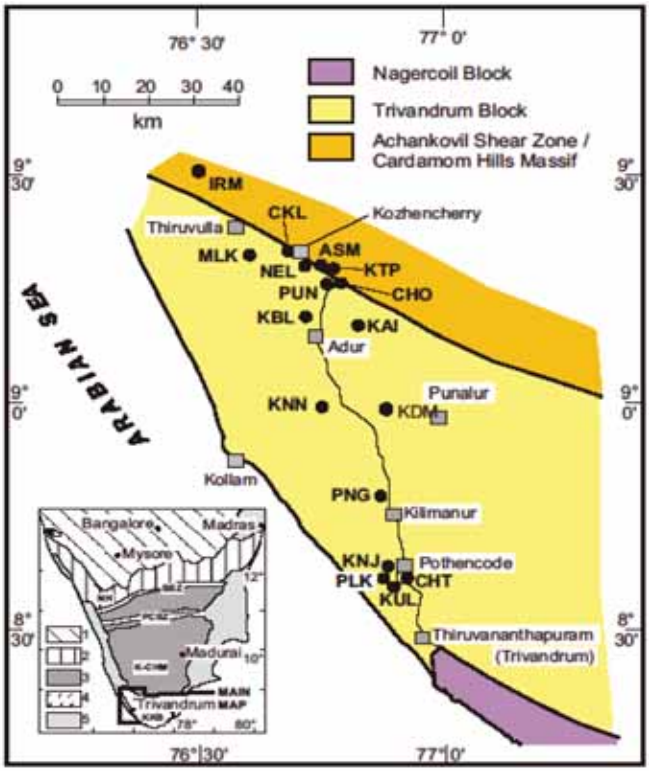
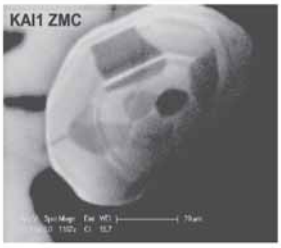
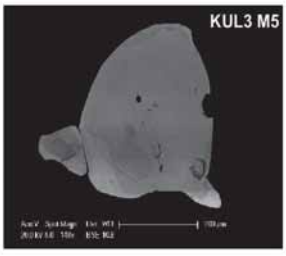


*Fig. 1.1.3.1 Map of the Kerala Khondalite Belt (*KKB*), South India, showing locations of sample sites (*circles labelled *KNJ, KUL) and main towns (squares). Inset map shows the position of the KKB in relation to other geological domains and area of southern India.* 1, *Dhawar Craton, north of the orthopyroxene-in isograd.* 2, *Archean areas south of the orthopyroxene-in isograd.* 3, *Madurai Block and Kodaikanal– Cardamom Hills massifs (*K-CHM*).* 4, *Kerala Khondalite Belt (*KKB*).* 5, *Recent cover.* NH, *Nilgiri Hills;* BSZ, *Bhavani Shear Zone;* PCSZ, *Palghat-*

accessory mineral phase characterization using Scanning Electron Microscope and Cathodo Luminescence(CL) imaging, followed by Electron microprobe and Secondary Ion Mass Spectrometry analyses. Thin sections from all the rock types collected from different





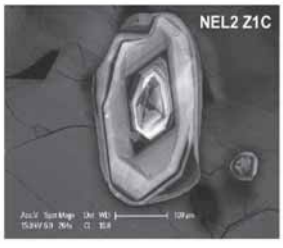


Fig. 1.1.3.2 CL image of KAI & NEL zircons

Fig. 1.1.3.3 BSE image of

quarries have been studied in detail under the polarising microscope for elucidating the petrography, both in CESS and at the University of Edinburgh. The SEM facility in EMMAC at the Grant Institute of Earth Science, Edinburgh, has been utilized to obtain the high-quality CL and BSE images (Fig1.1.3.2 and 1.1.3.3) critical for elucidation of the mineral phases that co-exist or compete with monazite for trace elements, such as zircon, apatite, garnet, and feldspars.

Major element compositions of garnet, cordierite and feldspars were determined on the Cameca-Camebax 4-spectrometer and SX-100 5-spectrometer electron microprobes at EMMAC, University of Edinburgh

Bulk rock analysis

The rock samples (37 in all) were powdered and analyzed in the XRF facility of CESS. Out of the 37 rock compositions plotted in ternary diagrams 14 show granitic compositions, 3 rocks have compositions corresponding to residual or 'restite' material with high XMg values and the remaining 20 samples lie between these extremes. The combination of features observed in the Qz-Ab-Or, SA(FM) and AFM plots demonstrate that a well-segregated leucogranitic melt has been generated from melting within the KKB pelitic migmatites.

Accessory mineral characterization

Well polished sections to characterize the accessory minerals were selected based on the petrographic considerations, including grain context, grain clustering and the quality of the phases. Following a detailed assessment of an initial set of 12 samples four were selected for microanalysis focussed on monazite, zircon and garnet. Zircons and the monazites from four locations [Kairali (KAI),

Kanjampara (KNJ), Kulappara (KUL) and Nellikkala (NEL)] were imaged on the SEM using Back Scattered Electron (BSE) detector. Following this, zircons were examined and imaged under cathodoluminisence (CL). Electron microprobe (EMP) analysis of monazites was carried out using Cameca Camebax SX-100 electron microprobe at the EMMAC. Monazite microanalysis (samples KAI, KUL and KNJ) was preceded by detailed SEM imaging. Chemical age data of KAI monazites were determined (Fig. 1.1.3.4).

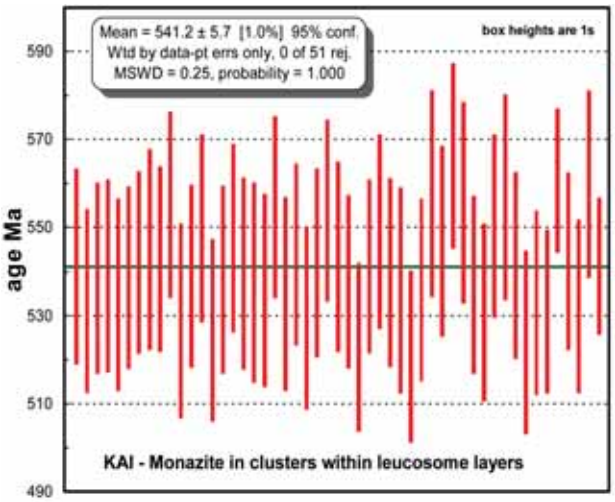


Fig. 1.1.3.4 Weighted mean age diagram (produced from Isoplot 3X: Ludwig 2007) based on 51 analyses of KAI monazites that form the tight compositional cluster referred to in the text. These data define a statistically robust age of 541 Ma, with a standard error on this mean age

Cordierite volatile contents and fluid activities in the Kerala Khondalite Belt

The volatile content of cordierite provides an important constraint on fluid activities attending metamorphism, both for peak conditions where melt may be present, and along the post-peak P-T path along which cordierite may be produced as a reaction product. Cordierites in 11 Kerala Khondalite Belt samples have been analysed in-situ in polished, gold coated thin sections on the Edinburgh EMMAC Cameca IMS-4f ion probe. H_2O and CO_2 activities were calculated for cordierites occurring in three distinct textural and assemblage assoications (Cordierite in leucosomes & veins, Cordierite with orthopyroxene and cordierite in granoblastic cordierite + garnet + sillmanite + opaque assemblages (Fig.1.1.3.5).

Fluid activities for peak assemblages formed at 6kb and 900^{0}C summed to less than unity, were consistent with melt presence but fluid absence at those conditions. Fluid activities calculated from cordierites in coronas and cordierites in reaction zones were estimated at 4.5kb and 750-800^{0}C.

Cordierite is a key phase in symplectite and corona textures formed through reactions operating in granulites on their post-peak P-T paths. Results from the Kerala Khondalite Belt demonstrate that such coronal cordierites are low in H_2O (0.2-0.4 wt%), high in CO_2 (0.8-0.9 wt%) and have elevated channel X_{CO2} (0.55). This suggests

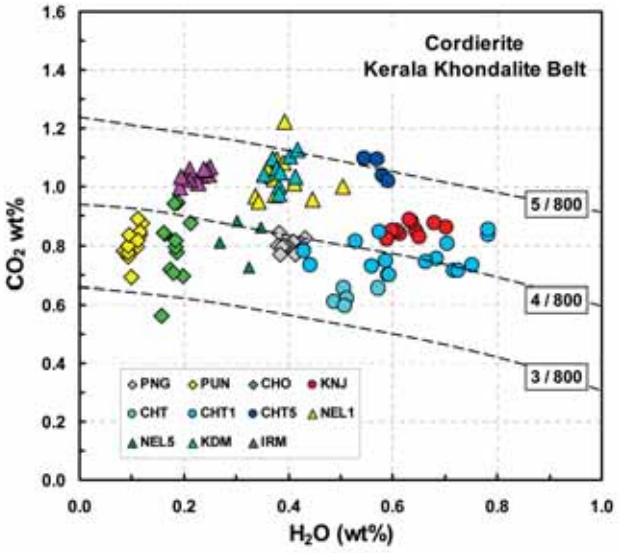


Fig. 1.1.3.5 Plot of the weight% of H2O and CO2 in cordierite for all analysed KKB cordierites. The dashed curves labelled with two numbers, e.g. 5 / 800, are saturation curves for volatile incorporation into cordierite at the defined P-T conditions, e.g. 5 kbar and 800°C.

that garnet-breakdown reactions such as Grt + Sil + Qz = Crd and Grt + Qz = Opx + Crd, which are conventionally ascribed to near isothermal decompression, will in general also involve the scavenging of low-a_{H2O} (0.05-0.2), moderate-high a_{CO2} (>0.4) fluids available subsequent to the metamorphic peak.

Dating of Zircons

Cameca IMS 1270, ion probe of EMMAC was used for REE and other selected trace elements within zircons and garnets from samples KAI, KUL, KNJ and NEL were determined using the EMMAC CAMECA IMS 1270, ion probe. The concordia plot (Fig. 1.1.3.6) shows that melt was present from at least 570 Ma to 530 Ma, and possibly from as early as 580 Ma - apparently in open system melting and melt crystallisation early (>560 Ma) and subsequently, on final melt crystallisation, in closed system reaction and equilibration with the garnet-bearing host rock. This is suggested by the change in zircon-garnet D(REE) relations in this sample, with texturally-defined relative age and U-Pb absolute age as determined for the zircon.

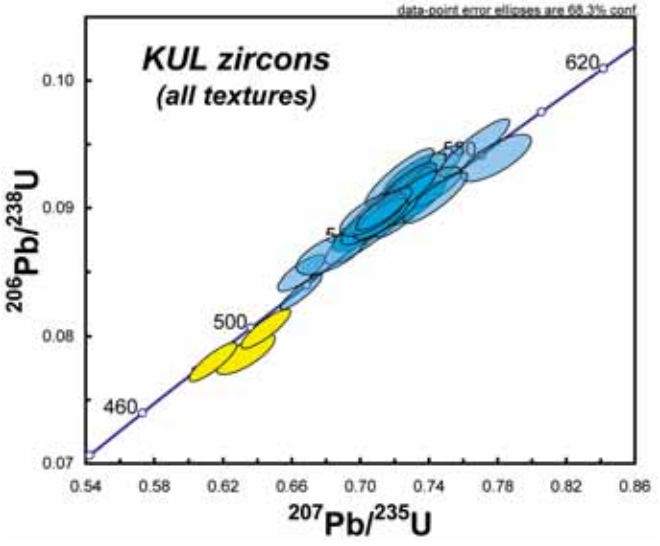


Fig. 1.1.3.6 Data from planar sector outer zones , trellis cores and replaced dark-CL lobes(Blue symbols). Range is from ca. 580 Ma to 520 Ma, with youngest ages being the replacement lobes. All these are hosted in planar-irregular zoned moderate Th monazite – which has an EMPA age of 535.3 ± 5.7 Ma (MSWD = 0.17; 33 analyses).

Nandakumar. V, Simon L Harley & Anoop S. S*
**Professor of Lower Crustal Process, University of Edinburgh.*

1.1.4 Graphitization process in Kollam District, Kerala, India

This project has been initiated to identify and classify different types of graphite, associated with different environment, based on their physico-chemical characteristics (associations) and to find out the source of Carbon of Graphitization by stable carbon isotope studies. Two field works including reconnaissance field work were conducted for sample collection (Fig.. 1.1.4.1) and the samples

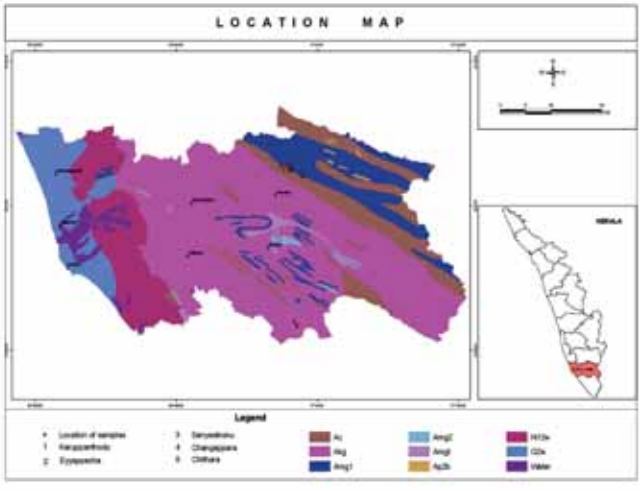


Fig. 1.1.4.1 Location of samples

were processed. The XRD and TGA analysis were conducted for two samples. The well defined peaks of XRD indicates the high degree of crystallinity as well as slow cooling rates. The TGA analysis shows that the samples are of high quality.

Ansom Sebastian

1.1.5 Quaternary geology and geomorphic evolution of the coastal lands of Kollam district, SW India

The coastal lands of Kerala with its interlacing network of wetlands are the outcome of highly fluctuating palaeoclimatic conditions to which the coast has been subjected during Late Quaternary period. The uplifted Warkalli and Quilon Formations of Early Miocene age, with channel entrenchments are the characteristic features of the coastal lands south of Karunagappalli. The low rolling terrain in the eastern side is dissected by 20 - 40m deep incised valleys. The Ashtamudi, Paravur and Nadayara estuaries and their adjoining regions of the coastal lands studied are developed on the uplifted block seen south of the Achankovil Shear Zone (ASZ). These wetlands preserve a full record of Late Quaternary climate and sea level data in its sedimentary archives.

A total of 26 sediment cores were collected from the coastal low lands for detailed sedimentological, palynological, geochronologic and geochemical studies. Besides this 51 surface sediment samples collected from the coastal plains were also studied for their textural and mineralogical charecteristics

Study of the sediment core retrieved from coastal lands of Kollam district reveals that the Early Holocene sedimentation initiated with a spell of heavy precipitation which is continued till 5.0 ky Bp. In certain borehole locations like Nedungolam, the Early Holocene is represented by a peat bed with C^{14} date of 8920 ± 110 yrs BP (Fig.1.1.3.1). The sediment signatures and radiocarbon dates obtained at various levels show that Early Holocene witnessed heavy influx of terrigenous sediments under the rising spells of sea level. This unique environmental setting was responsible for fast deposition of sediments in the river confluence zones of many coastal lagoons. The similarity in the age of wood samples with C^{14} date of 7490 ± 90 yrs BP and the embedding carbonaceous sediments of almost the same C^{14} date of 7480 ± 80 yrs BP is one of the supporting evidences of high sediment generation and rapid burial of the riparian vegetation during the Holocene Climatic Optimum. The signatures of the Pangod sediment core further reveals that the sedimentation continued till 5260 ± 120 yrs BP. This was followed by a dry spell, humid climate as indicated by the oxidized/yellow mud rich sediments. The study has shown that after the sea level rise event of Middle Holocene, the entire sediments in the upper part of the Pangod sediment core became exposed and subjected to chemical weathering and leaching of iron containing

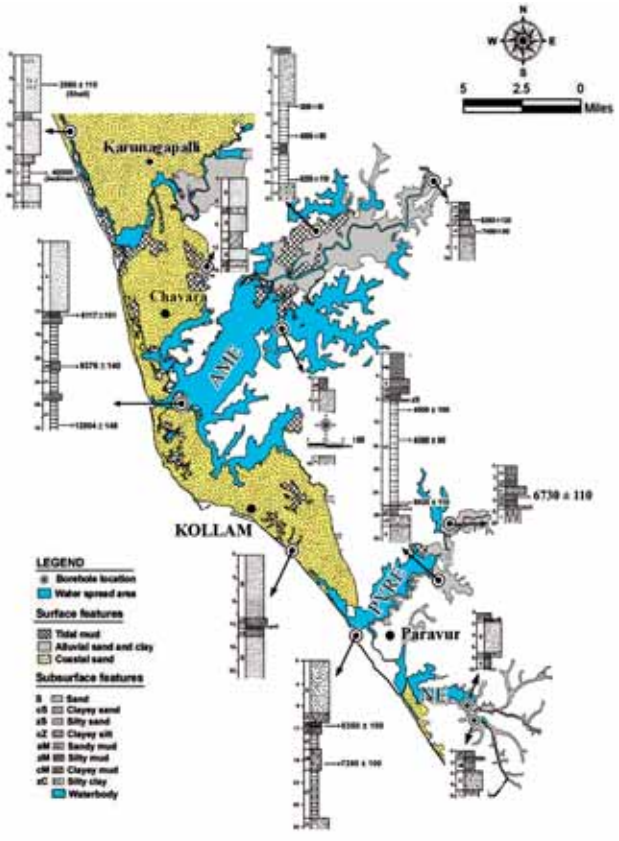


Fig. 1.1.5.1 Lithologs of the sediment cores chosen for the present study. Note the C^{14} dates at specific levels of the borehole cores.

minerals imparting an yellow coloration to the sediments. Such a yellow coloration could be traced out in the entire southern Kerala over the black clays of Middle Holocene period. In aquatic environments, this period is represented by clayey sediments with well marked light colored laminations indicating the formation of hydrogenous sediments in the dry spells. In the shallow part of the basins, the clayey sediments are often impregnated with calcareous nodules. Such occurrences of calcareous nodules are well noticed in the West Kallada and Nedungolam sediment cores. It is interesting to note that the middle clay dominated sediments in the depth range of 18.5 - 5m level contains occasional presence of calcareous nodules of various sizes and shapes. It marks the beginning of a new depositional phase influenced mainly by tidal activities and reduced rainfall. The inverted ages noticed for these sediments in Nedungolam sediment core might be attributed to deposition of older reworked sediments from the offshore over younger sediments. The dry spell was followed again by a heavy rainfall period as recorded in the palynological contents of West Kallada, Munrothuruthu and Nedungolam sediment cores. Fig. 1.1.5.2 shows selected representatives of the palynological contents of the borehole cores retrieved from the Ashtamudi and Paravur wetlands. The abundant occurrence of tree trunks and other vegetative matter with C^{14} date between 3389 ± 63 yrs BP in the Polachira wetlands and 2941 ± 102 yrs BP also reiterates the heavy spell of rainfall subsequent to the dry event of 5000 - 4000 yrs BP.

The results of the heavy mineral data generated from the fine sand fraction of the coastal lands of southern Kerala in and around the Kayamkulam, Ashtamudi, Paravur and Nadayara wetlands reveal marked spatial and temporal changes in the quantity and quality of minerals. In the Pozhikkara sediment core located in the littoral zone of the Paravur basin, the THM content exhibited an increasing trend towards the top of the borehole core. This is attributed to constant winnowing away of finer and lighter detrital grains seaward imparting a preferential enrichment of denser heavies like opaque and monazite. Contrary to Pozhikkara sediment core, the

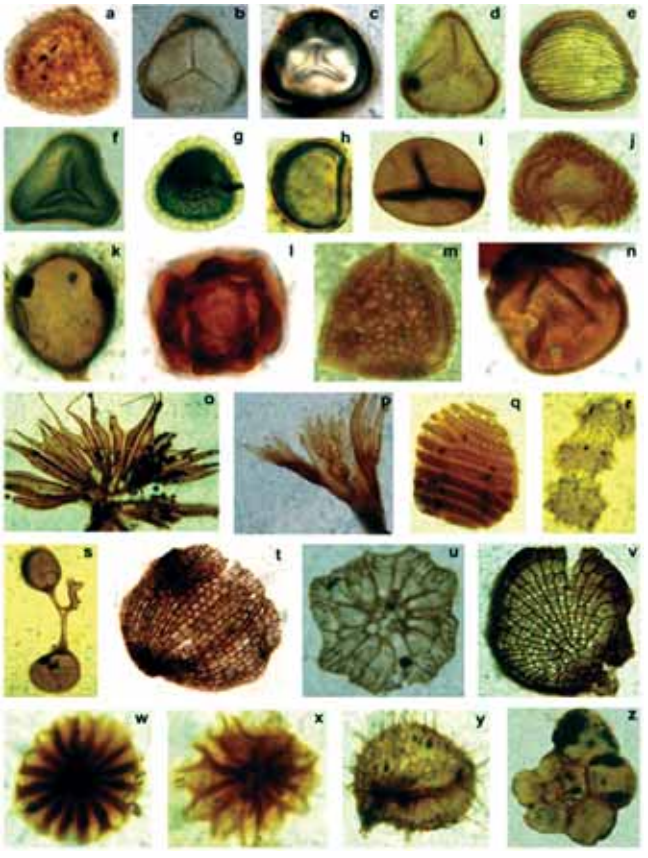


Fig. 1.1.5.2 Selected representatives of palynological assemblage of Ashtamudi and Paravur wetlands. a. Lygodium sp. b. Cyathea sp. c, d. Trilete fern spore. e, j. Ceratopteris thalictroides. f, g. Pteris sp. h. Polypodiaceae spore. i. Todisporites sp. k. Lakiapollis sp. (Reworked pollen from Warkalli). l. Ctenolophonidites sp. (Reworked pollen from Warkalli). m. Quilonipollenites sp. (Reworked pollen from Warkalli). n. Cullenia exarillata e High rainfall indicator. o, p. Cyanobacteria sp. q. Chara sp. r e Botryococcus sp. s. Glomus sp. (Fungal spore). t. Lirasporites sp. (Fungal spore). u. Callimothallus sp. (Fungalfruiting body). v. Kutchiathyrites sp.(Fungal fruiting body). w, x. Heliospermopsis sp. (Salt gland). y. Multispinula quanta. (Dinoflagellate cyst). z. Foraminiferal lining.

borehole collected from the eastern periphery of the Ashtamudi estuary at Pangod reveals marked variation in the distribution of heavy mineral species. In general, the river influenced upper estuarine regions contain garnet as the major heavy mineral and owe a khondalitic and /or biotite gneiss provenance. However, in the Pangod borehole core, the upper yellow coloured layer is devoid of much garnet content compared to the lower unaltered sand layer. The observed decline in the content of garnet in the upper layer might be attributed to post depositional oxidation of garnets and other iron containing less stable minerals like pyriboles under exposed conditions. The spatial distribution of heavy minerals in the surface sediments of the Ashtamudi estuary reveals that the content of minerals in the estuarine mouth is substantially high due to the input of heavy mineral rich sands from the adjacent beach/near shore areas by tidal currents. Such a process could be traced out in the Paravur and Nadayara estuaries as well. One of the striking observations noticed is that the monazite in the beach and coastal plains resembles to that of Tertiary sediments. Although the Kerala Khondalite Belt is the prime source for the heavy minerals in the study area, it appears that the garnet- free assemblage in the beach and coastal plains might be derived due to prolonged chemical weathering and dissolution of minerals under exposed conditions. Further, from the geomorphic view point, the coastal areas with southern Kerala host well developed cliffs. A large volume of Tertiary cliffs would have been eroded by wave activity during the rising spells of sea levels in the Quaternary period. Therefore, the heavy minerals derived from the Tertiary sediments, especially that of the Warkalli Formation, might be the probable source of heavy minerals for the beach and coastal plain sands. Detailed investigation is required to establish the mechanism of coastal retreat and volume computations of heavy minerals derived from the denudation of the cliffed coasts of southern Kerala.

Padmalal D

1.2 Atmospheric Processes

1.2.1 Measurement of cloud parameters and cloud modelling

This project was taken up with the aim to develop better understanding of the clouds, to investigate the possibility of their modification and try out cloud modification during monsoon and pre-monsoon periods. Valuable information on the cloud base height of very wide spectrum of clouds that occur in the region has been obtained. The data from the Automatic Weather Station (AWS) and Electric Field Mill were also used for the study. The cloud base height shown in Fig.1.2.1.1 depicts the presence of low level clouds from11:00h onwards. This information should be noted in conjunction with the updraft events of AWS. As indicated by the changes in RH the clouds seemed to have formed at low heights on the mountain range location.

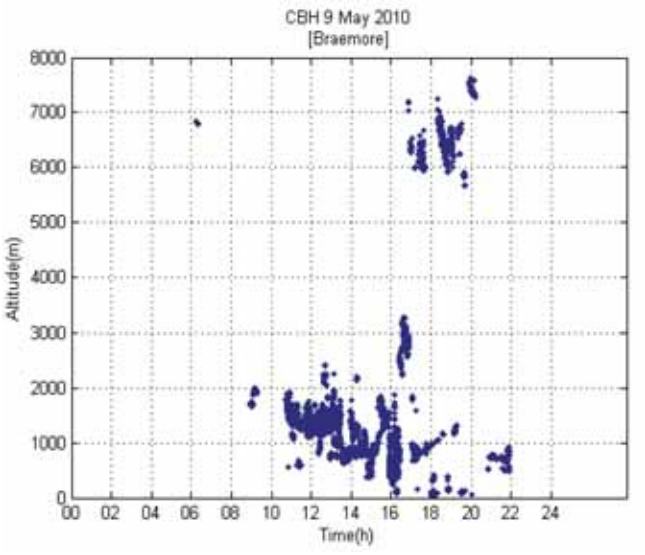


Fig. 1.2.1.1 Cloud base height recorded on 09-05-2010

It was observed that clouds formed in this region have a similar base height characteristics of the pre-monsoon clouds seen above 500m in the region. The water based condensation particle counter measurements and the Cielometer measurements from Braemore station and CESS gives an insight into cloud behavioral characteristics. We have recorded changes in particle size distribution during formation of connective cloud near mountains. Even though the lidar signals may not penetrate the cloud to a large extent the information generated will be useful in cloud modeling.

S. Muralidas

1.2.2 Continuous measurement of ambient carbon monoxide

Ambient atmospheric carbon monoxide (CO) at Thiruvananthapuram, clean coastal site, was monitored continuously using a non-dispersive IR analyzer (Monitor Europe Model 9830 B). A comparative study between the satellite measurements of carbon monoxide (CO) and our CO measurements

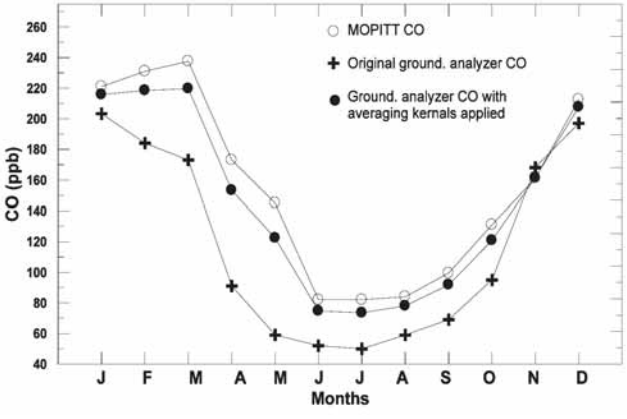


Fig. 1.2.2.1 MOPITT and ground based CO measurements

were carried out. CO at Thiruvananthapuram shows a diurnal pattern with double peak (FN peak at around 08:00 h and AN peak at around 20:00 h). Comparison between the satellite (MOPITT) and ground-based surface CO measurements is excellent with correlation coefficients better than 0.95. In order to reduce the errors due to difference in resolution, MOPITT averaging kernels was applied to smooth ground-based CO data. This has resulted in excellent comparison between the ground-based CO measurements and satellite data (Fig. 1.2.2.1).

G.Mohan Kumar

Funding: ISRO, Government of India

1.2.3 Solar Ultraviolet-B and atmospheric trace constituents in relation to climate change

Nature of variation of solar ultraviolet-B radiation and minor atmospheric constituents, viz., total ozone and water vapour at a coastal station, Thiruvananthapuram where both the SW and NE monsoons are active are important parameters that control climate change in this region. The objectives of the project are to measure the solar UV-B radiation reaching the surface at two climatically different coastal stations, one on the eastern and another on the western coast in south India and to compare the UV-B dosage from the climate angle and to quantify changes in

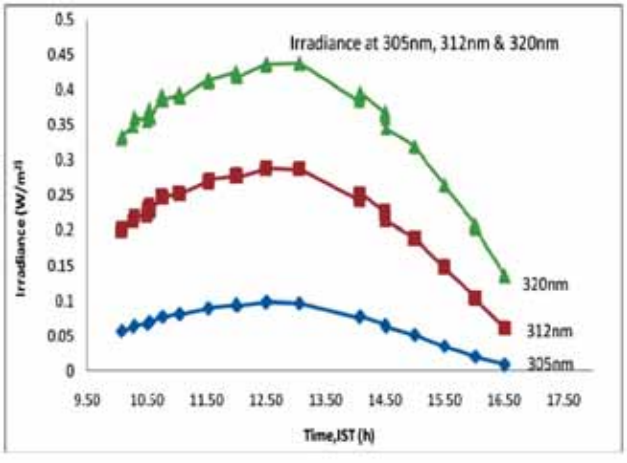


Fig. 1.2.3.1a Solar UV irradiance during fair weather day

the atmospheric water vapour column in relation to the total ozone with the corresponding changes in solar UV-B radiation.

Solar UV-B radiation at 305, 312 and 320 nm, total ozone column, condensable water vapour, single wavelength Aerosol Optical Depth at near IR (1046 nm) and erythemal UV-B radiation in 280-320 nm band are the parameters measured using Microtops II & Solar UV-Biometer. Solar UV radiation at 3 wavelengths from Microtops on a typical fair weather day is shown below (Fig.1.2.3.1 a & b) with that on a total solar eclipse day (Jan 15, 2010).

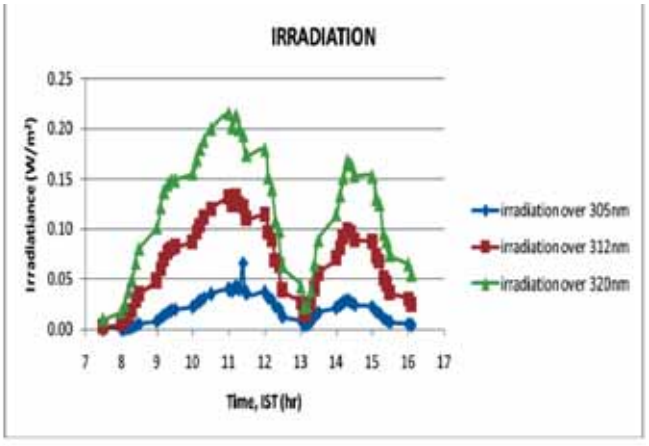


Fig. 1.2.3.1b Solar UV irradiance on solar eclipse day

The condensable water vapour did not show any appreciable excursions related to UV kinks. Alternately, we searched for water vapour data and RH profiles from satellites like Modis, TRMM and Kalpana I. Typical 3-hour rain rate images from TRMM and the daily average for June 23rd 2010 SW onset day were studied for 7 to 20 N latitude and 70 to 86 E longitude covering peninsular Indian region. The results were compared with temporal video images and the NOAA Hysplit back trajectories.

G. Mohan Kumar

1.2.4 Rainfall validation & characterization and cloud physics studies using megha-tropiques data

Monitoring of rain rate, drop size distribution and its vertical profile was carried out using Disdrometers (Fig. 1.2.4.1) and Micro Rain Radar (MRR) (Fig. 1.2.4.2). Manual rain gauges were used for daily measurement of liquid water from rain, while the radar reflectivity factor and microwave attenuation were recorded using MRR.

Experiments conducted with MRR concluded that a radar bright band signature, non-bright band signature and simultaneous transition of the slope of the Z-R relation together give a clear method for classification of tropical precipitation as stratiform or convective origin. TRMM satellite rainfall data agree well with MRG, Disdrometer and MRR data. The correlation coefficients are 0.9 and 0.6 for monthly and daily averaged data respectively. Altitudinal and temporal evolution of rain drop size distribution studies using MRR revealed that as rain drops come down, the number of smaller drops decrease and number of larger drops increase simultaneously; ie., coalescence mechanism seems to dominate. Empirical model for rain drop size distribution showed a high

Fig. 1.2.4.1 Disdrometer used for rain drop size measurements in CESS.

correlation (0.7) between the theoretical derivation and actual measurements.

Fig. 1.2.4.2 Micro rain radar installed in CESS for vertical profiling of rainfall

G. Mohan Kumar
Funding: Sapce Applications Centre, Ahmedabad

1.3 Coastal Processes

1.3.1 Shoreline Management Plan for Kerala coast

The project on Shoreline Management Plan for Kerala is undertaken in collaboration with ICMAM Project Directorate, Ministry of Earth Sciences, Chennai to develop coast specific management plans to address the coastal erosion and related morphological modifications. Under this project numerical model studies have been carried out to understand the processes leading to siltation of Muthalapozhi harbor and suggest management options to control siltation.

Muthalapozhi tidal inlet has been developed into a fishing harbour with breakwaters on either side of the inlet. The harbour mouth is getting chocked with sediment deposition and spit formation making the harbour unusable (Fig. 1.3.1.1) Based on expert advice, the breakwater design was modified changing the length and orientation. This modification was not effective in controlling siltation. The present study addresses the problem through numerical model studies and proposes a management plan.

Detailed observations on coastal process along Muthalapozhi coast have been undertaken during 2008-09. Fine grid bathymetry was generated up to a depth of 20 m from bathymetric observations. Nearshore wave and current data were collected deploying wave-tide gauges during premonsoon, monsoon and postmonsoon when the beach passes through stable, eroding and beach building phases. Beach profile data were collected every month for one year at different locations to understand the profile modifications and beach sediment movement. Shoreline has been regularly monitored through GPS mapping. Sediments were collected from the beach and nearshore and were analysed for grain size distribution. The breaker position and surf zone width were also monitored. The assessment of longshore transport is done using LITDRIFT module of LITPACK, developed by DHI, the Netherlands. The erosion during the onset of monsoon is in the form of a storm profile that happens over a short period of few days. Beach building after monsoon is a slow process. Since the nature and mode of shoreline change and sediment transport are different for monsoon and non monsoon, numerical modelling has been done using different modules. The non-monsoon shoreline variation is modelled using LITLINE module. The monsoon shoreline variation is dominated by onshore-offshore mode of sediment transport for which the LITPROF, the cross-shore profile variation model of LITPACK, is used. The shoreline along south side of the breakwater was simulated and calibrated with the observed DGPS shoreline data. After the validation of the model the production run is done with different options and the best suited management plan is suggested for controlling the chocking of the harbour.

Fig. 1.3.1.1 Muthalapozhi tidal inlet

It is seen that net sediment transport during May to August is towards south. Sediment transport during the entire beach building period extending from September to April is towards north. Shoreline evolution during the beach building period has been modeled using LITLINE. The results obtained after running of model for non monsoon months (Nov-Apr) is given (Fig. 1.3.1.2). Model result indicates significant bypassing of littoral transport since January. Field observations also show that shoreline reaches up to the tip of breakwater and further progression

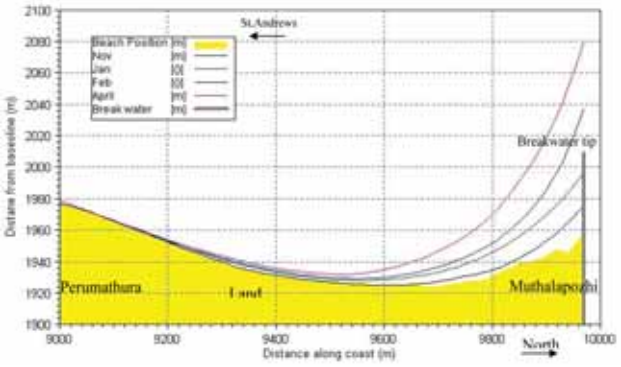


Fig. 1.3.1.2 Shoreline evolution close to breakwater during fair season (Nov-Aprl)

of shoreline results in sand bypassing into the harbour mouth resulting in its choking. The spit formed inside the harbour have been dredged 3 times by Harbour Engineering department during 2009-10 and it is estimated that the volume of sediment dredged is about 1 lakh m^3 during beach building season (Nov-Apr). The computed littoral transport during this period is about 1.2 lakh m^3.

Management of sediment transport in the harbour mouth

The dominant onshore-offshore mode of sediment transport in the form of storm profiles with southerly longhsore sediment transport component during monsoon erosion do not have significant impact on sediment accumulation in the harbour.

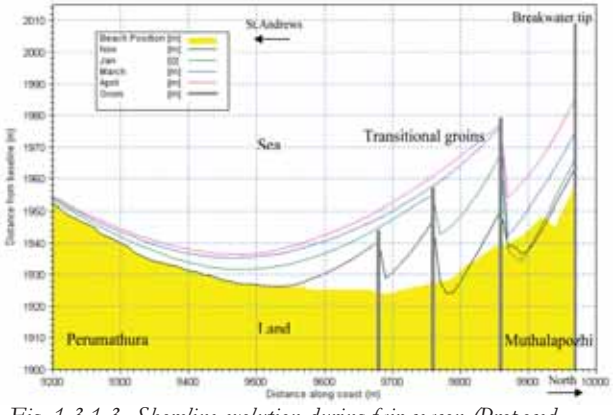


Fig. 1.3.1.3 Shoreline evolution during fair season (Proposed intervention-Case 3)

The continuous northerly transport of sediment towards the harbour mouth during beach building period needs to be managed to control siltation in the harbour. The model was run with the three different transitional groin fields at different locations where beach advancement takes place. The most suitable model result is given in Fig. 1.3.1.3. It proposes 3 transitional groins having lengths 40, 30 and 20m at 120, 220 and 300 m south of breakwater. This option has low down drift erosion and the groin length is short enough not to block the southerly longshore sediment transport during monsoon period when sediment redistribution takes place. Sediment transported towards north is redistributed within the groin field and the progradation of shoreline close to the breakwater is controlled.

K. V. Thomas

Funding: MoES through ICMAM, Chennai

1.3.2 Conservation and nourishment of selected tourism locations along Kerala coast

Evaluation of performance of artificial reefs at Kovalam

Beach being the most important component of coastal tourism, the Tourism Department, Govt of Kerala, decided to evolve programmes to sustain beaches as a coastal protection measure and recreational facility along the major coastal tourism destinations of Kerala. Kovalam being the prime coastal tourism destination, it was proposed to sustain a minimum beach throughout the year to provide round the year beach activities. A multipurpose artificial reef was constructed in the nearshore of Lighthouse beach with

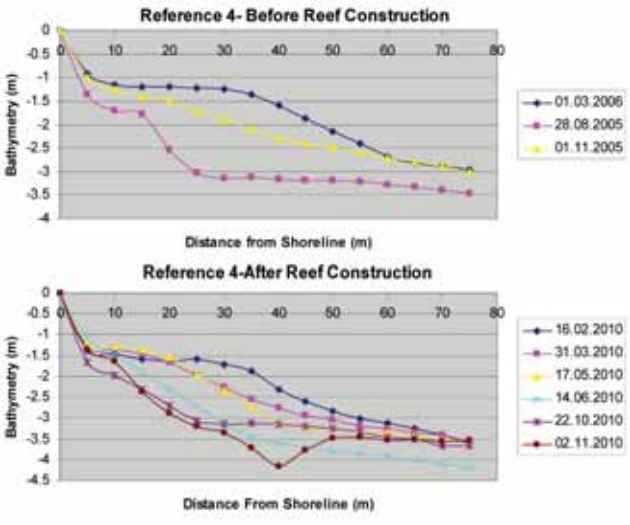


Fig. 1.3.2.1 Profiles along a selected station before and after the construction of reef

the objective of maintaining a minimum width of the beach even during the eroding monsoon season. As part of this project, the morphological modifications to the coast with the artificial submerged reef in place at the Kovalam Lighthouse beach, have been examined through monitoring of shoreline changes.

The reef is made up of large sand filled mega containers of durable geotextile material. The containers are roughly elliptical in shape with a length of the order 30m and diameter of 3-6m. The reef is located underwater in the nearshore. Shoreline response to reef has been monitored through beach profiling and GPS shoreline mapping since the construction of the reef in February 2010.

Fig. 1.3.2.2 Lighthouse pocket beach before and after the construction of promenade/walkway

The Lighthouse beach is a pocket beach confined between 2 headlands. The north headland has a tombolo connecting the beach to the headland system. The beach profile prior to and after reef construction are given in Fig.1.3.2.1. Prior to reef construction in 2005-06, the pocket beach was wide during fair season and was mostly affected by seasonal erosion/accretion associated with monsoon wave climate. The profiles after reef construction in 2010 show more or less the same beach width as seen in 2005-06, but with lower berm height. The monsoon profiles prior to and after reef construction do not show any major deviation except that the lower berm height is continued. A 5 m wide beach was present even during monsoon in June 2010.

It is seen that a major morphological modification to the Lighthouse beach was made in between the model studies for reef design (2006-07) and reef implementation (2009-10). A promenade was constructed along the monsoon berm crest during 2007-09. During the construction process material from the beach berm was moved to the landward side of the promenade, thus reducing the berm height and sand availability in the pocket beach. This is evident from the beach profiles and the pictures of the beach prior to and after promenade construction (Fig. 1.3.2.1 and Fig. 1.3.3. 2).The profiles in 2006 and February 2010 (immediately after reef placement) show that the berm height was much lower even at the time of reef construction as compared to 2006. Observations are continued to further assess the morphological modifications due to the construction of artificial reef at Kovalam.

K V Thomas

Funding: Department of Tourism, Government of Kerala

1.3.3 Spatio-temporal Shore changes during Holocene and tracing the evolutionary history of the Ashtamudi Estuary, Southern Kerala

This is an inter-institutional collaborative project between CESS and Department of Geology, Anna University, Chennai. The objectives of this project are planned with an integrated approach to document the spatio-temporal shore changes and to study the transgressive/regressive cycle's signatures from sediment fa-

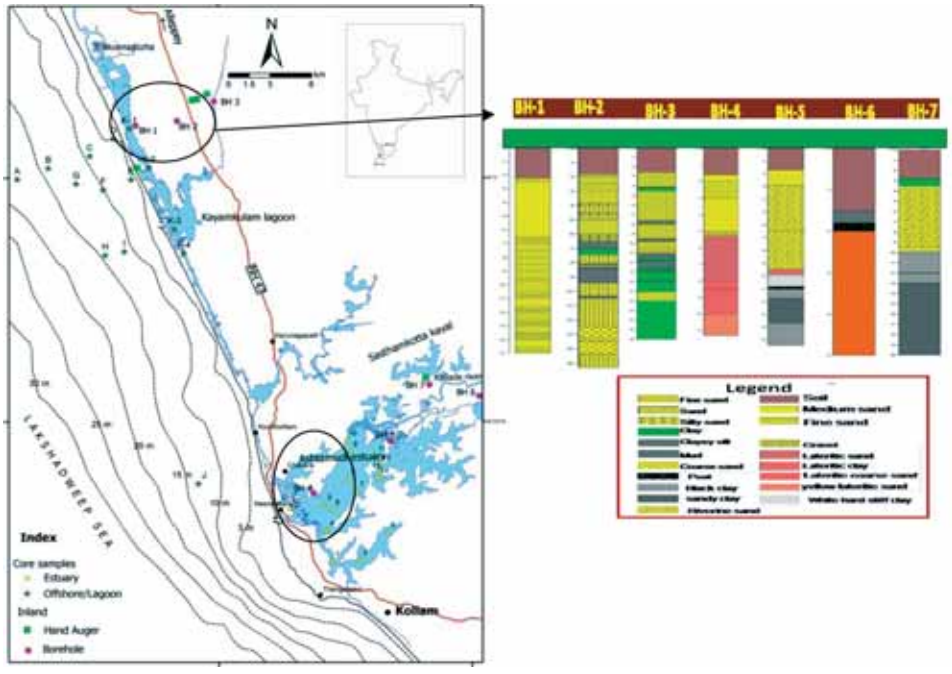


Fig. 1.3.3.1 Location map showing the sediment cores in the flood plain, estuary and offshore region along the Neendakara-Kayamkulam coast

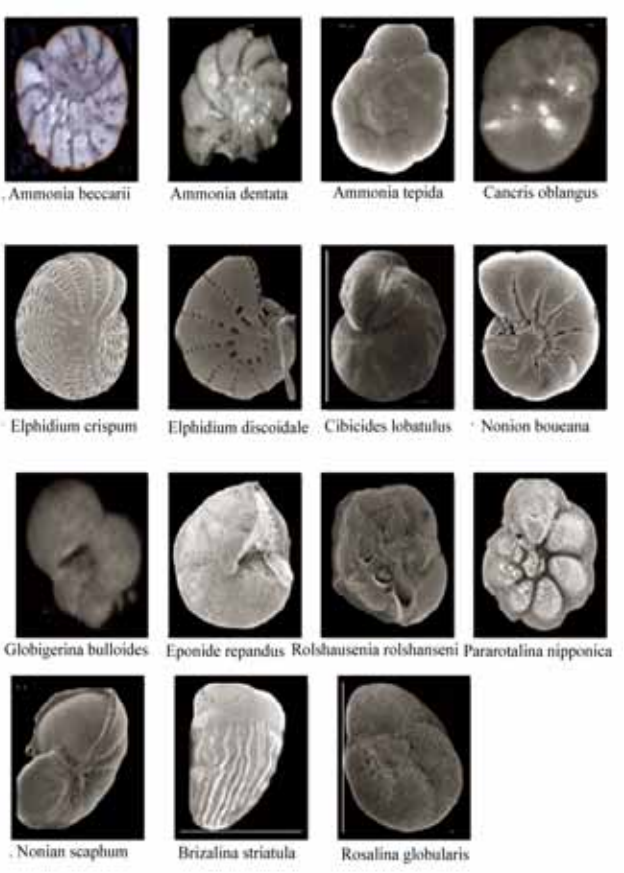


Fig. 1.3.3.2 Occurrence of different foraminifera assemblages in the Ashtamudi Estuary

cies with faunal tool. Towards this undisturbed sediment cores from the floodplain, estuary and offshore region were collected *(Fig.1.3.3.1)*. In the flood plain 8 boreholes with depth ranging from 10 to 21m were drilled along two major transects. The boreholes were selected in such a way they can satisfactorily represent the littoral-marginal marine Quaternary sections. In addition 24 gravity cores were also collected, with 15 in the Ashtamudi estuary, 3 in Kayamkulam lagoon and 5 in the offshore region.

The selected sediment cores were analyzed for subsurface lithological variation, detrital and clay mineralogy, radiocarbon dating, and distribution of foraminifer's assemblages. The preliminary analysis has indicated that there is a significant variation in the sediment lithological units and faunal assemblages in the area. The occurrence of littoral-marine in the northern sector and riverine-estuarine sequence in the southern sector could be deciphered. The presence of chlorite clay mineral in the transgressive face of the sea level along the northern part is observed. Further studies are in progress to ascertain the transgressive/ regressive phase on the sediment cores using different proxy indicators. Radiocarbon dating carried out on wood samples collected at a depth of 16m in the Kayamkulam lagoon (9° 10' 5"N: 76° 27' 24" E) has yielded an age of 8560 ±143 YBP, which indicates the early Holocene. Two more set of samples (peat) collected at the borehole (BH-5) in the southern part was sent for dating at BSIP.

Q-mode factor analysis was carried out to establish the distribution pattern of faunal assemblages in the estuarine sediments. Four biotopes were identified using the cluster analysis. The dominant foraminifera assemblages in the core sample (A15) is shown in Fig. 1.3.3.2.

T. N. Prakash

Funding: DST, Government of India

2.1 Landslides

2.1.1 Investigation of landslides and land subsidence

Every year with the onset of monsoons, slope failure in the form of landslides (Fig 2.1.1.1) and land-subsidence (Fig 2.1.1.2) are reported from the highland regions of the state. Kannur, Wayanad, Idukki, Kozhikode and Kottayam are the front runners in reporting such incidences. The monsoon 2010 was widespread in the southern districts. The SW monsoon season transgressed into the NE monsoon without any dry period in between. This means that

Fig . 2.1.1.1 Landslide at Puchapra, Idukki on 27th October 2010

the soil was in a saturated stage even at the on set of NE monsoon. Many major and minor landslide and subsidence events due to soil piping were reported from different parts of the state during this period. Many of them were from Idukki district. On

Fig. 2.1.1.2 Land subsidence due to soil piping at Udayagiri, Idukki on 14th August 2010

request of the Government, field investigations were carried out in the affected areas. Landslide/subsidence incidents areas investigated include Puchapra, Pottakkalli, East Mattukatta, Intermediate road, Arakkulam, Ponganthodu, Neyyar Dam, Karippilangad, Udayagiri, Tattekanni. The causative factors and recommendations have been submitted as technical reports to the Government Departments.

G. Sankar

2.1.2 Human-induced land modifications and its impacts: A study in Thodupuzha taluk, Idukki district, Kerala

Thodupuzha taluk witnessed large scale land modifications during the last decades. Extensive paddy fields and forest areas were transferred for settlement, cultivation and infrastructure development. Dearth of sufficient level land motivated the occupation and development of steep slope areas. In the eastern parts of the Thodupuzha taluk shallow landslides become frequent

Fig. 2.1.2.1 Landslide distribution

phenomena during the extended rainy days. About 32 landslide spots were identified around these areas during the fieldwork (Fig.2.1.2.1). Majority of these incidences are initiated during the last ten years' period. The angle of slope in all these incidents was above 16 degrees and the land use was either mixed crops or mixed crops with settlements. The investigation on the distribution of landslides highlights towards the vital role of terrain slope in initiating landslides combined with other factors mainly human interference. The frequency of these incidents is increas-

Fig.2.1.2.2 Landslide that occurred at Velliyamattom Panchayat on 27th October, 2010.

ing and the year 2010 witnessed seven landslides and two land subsidence (Fig 2.1.2.2). These incidences caused the vast devastation of cultivated areas and houses including the loss of three lives. The increasing incidence of landslide events highlights the necessity of imposing land use restrictions in high slope areas after considering the aspirations of the local people.

K Raju

2.2 Earthquake Monitoring

Centre for Earth Science Studies operates a digital Broadband Seismic Observatory (Station code: PCH) in the campus of the Kerala Forest Research Institute (KFRI) at Peechi since 1999. It was established with the funding from the Department of Science & Technology (now by Ministry of Earth Sciences) – Government of India as a part of strengthening earthquake monitoring in the southern peninsular India, for improving the detection capabilities of earthquakes as well as for azimuthal coverage in the shield region. The PCH observatory is generating high quality data that is being used for studying local (up to 200 km radius), regional earthquakes (from 200-600 km radius) and the distant or global events (beyond 600 km radius). The station is capable of recording all global earthquakes of magnitude more than 5.5, regional earthquakes of magnitude more than 2 and local tremors of even low magnitude around 1 within 15-20 km radius. Nearly 10139 earthquakes (out of which 123 are within Kerala region) have been recorded here till date and the data is sent to IMD every six months. Since July 2009, the online data transmission to NGRI is done by V-SAT digital telemetered system. The seismic events occurred in Kerala region during this year have been compiled in a table below.

Table. 2.2.1 Tremors recorded in Kerala during 2010-11

Date	Latitude	Longitude	Magnitude	Region
06/05/2010	10.32	76.30	1.9	~4.5 NW Chalakudy
25/07/2010	10.46	76.44	1.9	Near Chimmony Dam
26/09/2010	10.37	76.55	2.7	Near Athirappilly
02/10/2010	10.69	76.13	1.6	Wadakkancherry-Desamangalam
*02/11/2010	09.22	76.85	2.0	Konni
06/11/2010	09.76	76.89	2.9	Vekllakanam near Idukki
09/12/2010	10.64	76.23	2.4	Paralikkode-Athani
13/01/2011	10.34	76.29	2.3	Near Alur near Kodakara

**Not recorded at Peechi (location provided by KSEB). Location is calculated using single station method and Seisan software.*

K. R. Unnikrishnan

Funding: DST, Government of India

2.3 Tsunami

2.3.1 Tsunami and Storm Surge Inundation Modelling and Mapping for the Coasts of Kerala, Karnataka, Goa, Maharashtra and Lakshadweep

During the year under report, the preparation of vulnerability maps which was pending for the Payyanur- Thalappadi sector of northern Kerala coast has been completed. With this the work envisaged under the project has been completed for the Kerala coast.

The work was initiated for the Karnataka coast. All the field measurements envisaged under the project has been completed for the Karnataka coast. Compilation of toposheets, preparation of base maps and identification of GCPs, etc. were carried out for a total of 295 km of coast covering the entire coastal stretch of Karnataka. Field works involving measurements of positions of GCPs using the DGPs, mapping of infrastructure and assets using GPS and topographic measurements using dumpy level and DGPS were carried out for the above coast bifurcated into four different sectors. The dumpy level readings were corrected for tidal variations and reduced to the mean water level. The field data collected using DGPS were processed using Skipro and computed elevations from the ellipsoidal heights. The rectification of satellite imagery also has been completed. The rectified satellite images were digitized in GIS platform for the shoreline data which was incorporated into the grid later on.

Fig. 2.3.1.1. Tsunami inundation map of Sasihitulu-Hijamadikodi sector, Karnataka

The entire 295 km has been bifurcated into 9 sectors for initiating the model runs with each sector taking roughly around 30 km fine grid. The topographic/bathymetric grids were prepared for the whole coast. The model runs were carried out for three cases viz. the Sumatra 2004, Makran 1945 and a hypothetically worst case. A typical tsunami inundation map of a sector in the southern Karnataka coast is presented in Fig. 2.3.1.1

T. S. Shahul Hameed

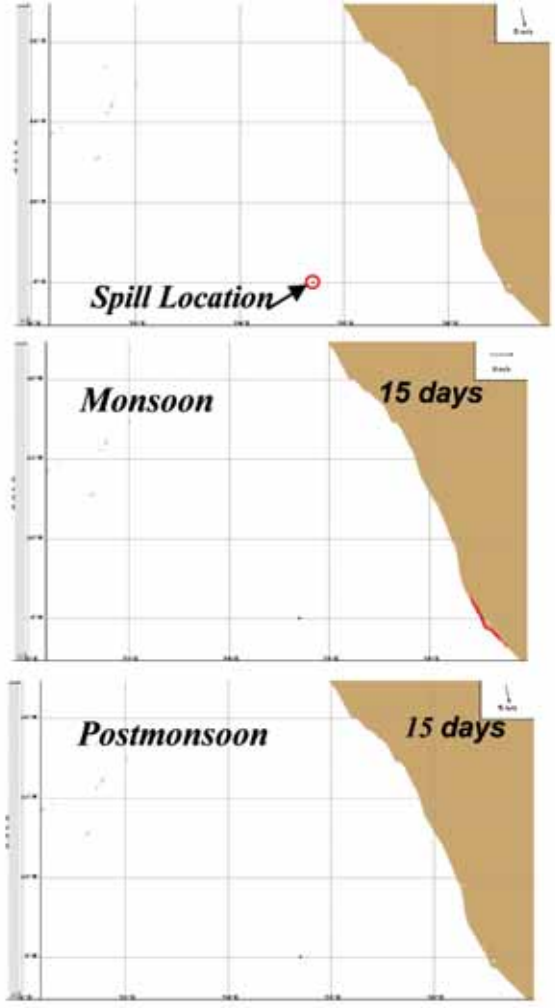
Funding: Ministry of Earth Sciences, Government of India

2.4 Other disaster related studies

2.4.1 Oil Spill Modelling for Selected Locations of Kerala and Lakshadweep

The second phase of hydrodynamic data collection for the Vizhinjam and Neendakara areas under the project was carried out in July 2010. For the collection of the inner-shelf and nearshore hydrodynamic data, instruments like Valeport (directional and non-directional) for measurement of wave parameters, ADCP for current profile measurement and RCM for point measurement of currents were deployed at four pre-defined shallow water locations in South Kerala. The locations for data collection were judiciously selected in such a way that the same set of data could be used for the numerical modeling studies of the first two coastal stations – Vizhinjam and Nendakara, proposed during the first phase of the project. A coastal stretch of approximately 100 km has been covered under this programme. Instruments were deployed at Kayamkulam, Iravipuram, Vettur and Valiathura during the period 9th -30th July. The recorded data from the various instruments were further processed and used as input for the numerical modeling work and also for calibration and validation of the models.

Numerical models for Cochin- the only major port in Kerala, was set up using MIKE21, the state-of-the-art software developed by Danish Hydraulic Institute. Since no major oil spill has been reported in this region so far, the model was set up for a hypothetical case of spill occurring at the SPM location off Cochin



2.4.1.1 Oil spill trajectories simulated for a hypothetical case of oil spill occurring offshore of Vizhinjam during monsoon and post-monsoon

during the pre-monsoon period. The hydrodynamic conditions for this case were simulated using the offshore buoy data provided by NIOT. In addition to this, modelling studies for understanding and assessing the impact in the event of an oil spill inside the Cochin estuary which is a biologically sensitive area also has been initiated.

Modelling work using one of the open source software -General NOAA Operational Modeling Environment (GNOME) was initiated. Models were set up for different scenarios covering the selected locations and preliminary runs completed with both static and variable current and wind inputs. The oil spill trajectories were simulated for a hypothetical case of oil spill occurring near Vizhinjam, the deepest natural harbour in Kerala and also the location of the newly proposed container transshipment terminal in the Arabian sea using GNOME for the 2009 monsoon and 2010 post-monsoon seasons. The results (Fig.2.4.1.1) clearly indicate that if there is a spill occurring during post-monsoon, there is no cause of alarm as the oil slick will be moving offshore. But if the spill occurs during monsoon special attention or immediate response is required as there is likelihood of the oil reaching the shore.

Sheela Nair

Funding: Ministry of Earth Sciences, Government of India

2.4.2 Geological studies in Mullaperiyar region

Geological and structural studies have been carried out in the Mullaperiyar region as part of the detailed project report for the proposed new dam. Three sections were examined down stream of the existing dam to select alignment for the new dam. The alignment presently selected is orinented 10^0 east of north and at regular interval and lies about 400 m downstream. The overburden thickness along the alignment was estimated. Sites for bore hole sampling were selected. Samples from the boreholes, mostly charnockites, were examined and were found to have good recovery with required RQD values. Detailed petrographical studies has also been carried out on the bore hole samples taken along the proposed dam axis. The seismicity of the region was another aspect covered in the report. The complex tectonic setting with deep seated faults and occurrence of several shallow focus earthquakes indicates that the region is seismically active (Fig. 2.4.2.1). Hence, in the design of the new dam, seismic aspects assumes paramount importance.

John Mathai

Funding: Department of Irrigation, Governmnet of Kerala

2.4.2.1 Closely spaced well-developed WNW-ESE oriented fractures are seen extending into the spillway section. These zones of weakness often display perceptible displacement of adjacent rock units

3.1 Water Resources

3.1.1 Rainwater Harvesting and Groundwater Recharge in Chadayamangalam Block

Hariyali is an integrated watershed development programme under implementation in the Chadayamangalam block with the technical guidance of CESS. As part of this programme rainwater harvesting and groundwater recharge was attempted in selected 20 watersheds. Activities like rainwater harvesting from roof top and recharging

Fig. 3.1.1.1 Checkdam constructed in Mangad watershed of Chadayamangalam block arresting the surface flow and maintaining elevated water table conditions in the vicinity

of domestic wells, recharging of shallow aquifer through deep pits, arresting of surface flow through contour bunds, arresting of stream flow in low order streams through check dams, enhancing of groundwater recharge through percolation ponds, sub-surface dykes to arrest base flow and to maintain elevated water table conditions etc. are under implementation (Fig.3.1.1.1 & Fig. 3.1.1.2). Domestic well recharge and recharge pits (over 500

Fig. 3.1.1.2 The trench taken in laterite exposing the white clay layer. This trench is taken to provide a sub-surface dyke that maintains elevated water table conditions by preventing seepage of groundwater

numbers) implemented in elevated areas with deep laterite sections have shown positive results with most of the wells yielding in summer. These recharge structures ensures that rainwater percolates into the deeper aquifers and holds it as groundwater for extraction in lean periods. Major structures like check dams and sub-surface dykes constructed at appropriate sites in different watersheds have arrested the base flow making water available for irrigation and domestic use of the local people during summer months.

John Mathai

Funding: Ministry of Land Resources, Government of India

3.1.2 Interstitial water chemistry of aquatic environments and its significance in nutrient dynamics: a case study

The main objective of this project was to assess the nature of interstitial water in three lake systems having different environmental setups. This three year project which had started in September 2008 was nearing completion. Interstitial water of core sediment from all three lakes, Paravur, Vellayani, Kadinamkulam

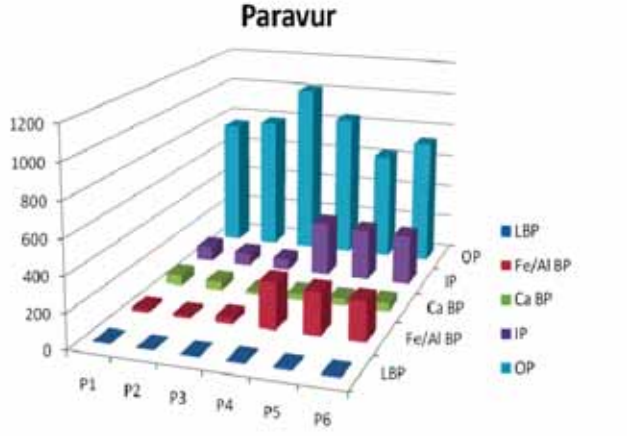


Fig. 3.1.2.1 Variation of average concentration of species of P in core sediments of Paravur lake.

revealed wide depthwise concentration variation of different parameters. All nutrient species of nitrogen and phosphorus as well as silicon and iron showed significantly higher concentration in interstitial water than corresponding bottom water. The different species of phosphorus in all core samples of the three lakes were determined, which indicated significant seasonal difference as well as variations between saline and fresh water lake systems.

K. Narendra Babu

Funding: DST, Government of India

3.1.3 Water and sediment quality monitoring and assessment of estuaries of Kerala: A case study from Kochi estuary and Periyar river

Water bodies get polluted with waste materials containing heavy metals from various sources, which accumulate in sediments. Metals accumulate through complex physical and chemical absorption mechanisms depending on the nature of the sediment matrix and the properties of the absorbed compounds and other environmental factors. Sediment analyses help to understand the intensity and the extent of heavy metal pollution. Among inorganic contaminants in water, metals like mercury, lead and cadmium are very critical due to its non-degradable nature and toxicity even at very low concentrations. Heavy metals often get accumulated through tropic level carrying deleterious biological effect. Mercury is a highly toxic, lethal metal and can be accumulated and magnified in biota and converted to methyl mercury – a toxic bomb. Though some of the metals like Cu, Fe, Mn, Ni, and Zn are essential for life process in plants and micro organisms, metals like Cd, Pb and Cr have no known physiological activity, but they have proved detrimental to organisms beyond a limit. The deadlier disease like edema of eyelids, tumor, congestion of nasal mucous membranes and pharynx, stuffiness of the head and gastrointestinal, muscular, reproductive, neurological and genetic malfunctions caused by some of these heavy metals have been documented. Therefore, monitoring of these metals is important for safety assessment of the environment and human health in particular.

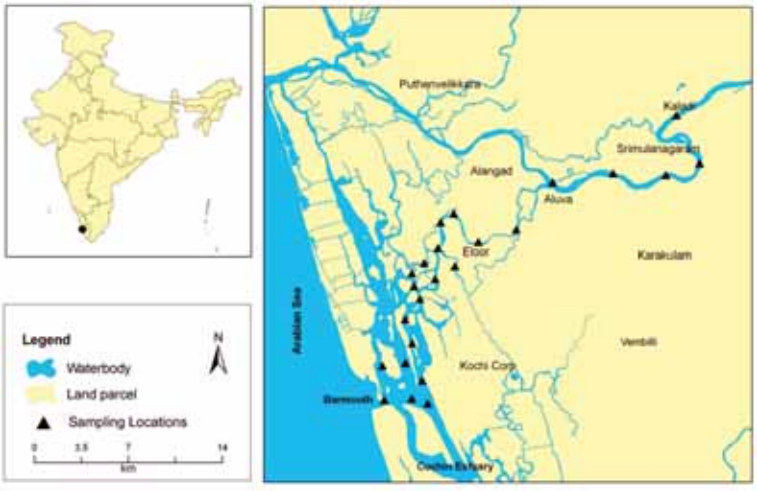


Fig. 3.1.3.1 Study area

The natural process of soil erosion gives rise to sediments in the river, estuary and the oceans. The contamination of surface water through anthropogenic activities has increased over the past several years. To fully understand the impact of this on an ecosystem long-term data from chemical, physical and biological aspects are essential. Sediments provide a record of the spatial and temporal history of pollutants. Metals that are strongly associated with the surface of particles, their transport and deposition in estuarine and coastal system are often related to the transport and deposition of fine-grained sediments. Low-level discharge of contaminants of any type may meet water quality criteria, but long term partitioning to the sediments could result in the accumulation of high loads of pollutants. Metals, especially, Hg, Cd, Pb etc, which are not removed from water by self-purification, are pollutants of high ecological significance. These metals accumulating in suspended particulate and sediments, enter in the food web and get biomagnified.

The main objective of this project is to understand the dynamic characteristics of heavy metals and its seasonal relationship with sediment texture and organic carbon in surface sediments of Cochin estuary and Periyar River. The study area is shown in Fig. 3.1.3.1. Seasonal sampling of 22 surface water samples, bottom water samples and sediments were collected from the study area during 2008-2011, and was analysed for physico-chemical parameters and few heavy metals, texture and organic carbon. Physico chemical parameters were analysed for understanding the spatial and temporal variations in the environmental quality.

The textural analyses of the sediments were carried out and the samples were categorized according to their grain size, such as sandy, silty and clayey fractions. The amounts of organic carbon present in the samples were estimated by titration method. The sediment samples were wet sieved and dried in an oven at 110^{0}C. Powered sediment digested using Hydrofluoric acid, Nitric acid and Perchloric acid and analysed for heavy metals using Atomic Absorption Spectrophotometer (Perkin Elmer, AA200). Cold Vapour Atomic Absorption Spectrometry technique was used for the analysis of mercury (Mercury Analyser MA5840). Heavy metals analysed

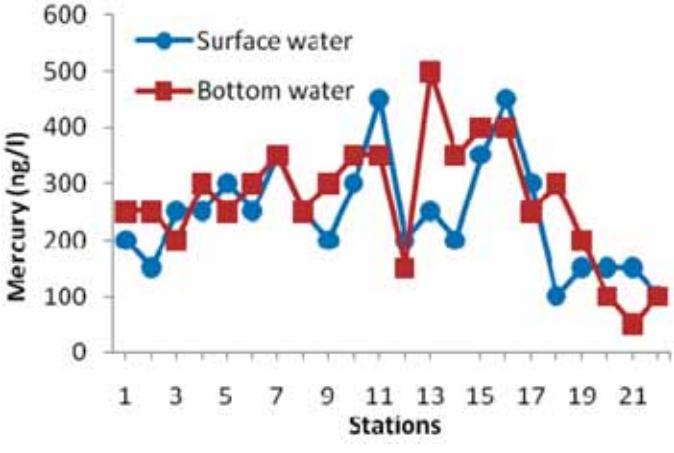


Fig. 3.1.3.2 Variations of dissolved mercury during Pre-Monsoon period

in the present study are Hg, Cd, Cr, Ni, Zn, Pb, Cu, and Fe. It was observed that the percentage of sand decreased towards the estuarine region and then increased near the barmouth, which may be due to strong flushing. Distribution nature of sand was opposite to that of organic carbon, silt and clay. Silt and clay percentage was higher downstream and decreased near barmouth. Post monsoon showed higher average value for clay (24.64%) and monsoon showed lower clay (16.90%). This may be due to high turbulence in monsoon, which might have prevented the clay particles from settling.

Most of the heavy metals are associated with organic carbon, and the organic carbon is high in the fine sediments. This association is due to high surface area to volume ratios, cation exchange capacities and affinity of metal ions to different types of clay surfaces. During monsoon mercury concentration was highest 5.06µg/g at Eloor station, in the same station where organic carbon was found to be 4.01%. The minimum concentration of mercury during monsoon was recorded in the river near Kalady (0.13µg/g) and that of organic carbon in the same station was 1.77%. During premonsoon, organic carbon value ranged from 4.66% to 0.56% and that of mercury concentration varied from 1.66µg/g to 0.33µg/g. Post monsoon season also gave highest value for mercury at Eloor station (1.58µg/g), while organic carbon at that station was 5.14%, and the minimum value for mercury was 0.11ng/g near Kalady, organic carbon in the same station was 0.82%. Mercury released into the aquatic system was in mercuric (II) state and will rapidly be adsorbed on to soluble and particulate organic material. This will be followed by its flocculation, precipitation and final accumulation in the bottom sediments. It is accelerated from the sediments in the presence of saline water and high concentrations of sulphide (USPHS 1997).

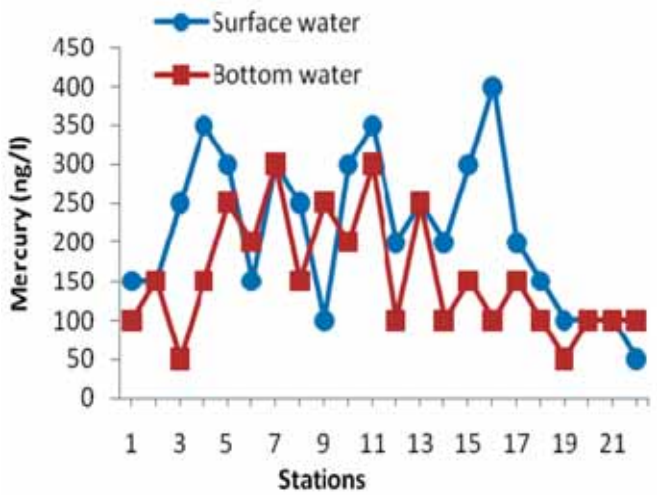


Fig. 3.1.3.3 Variations of mercury during Monsoon

Dissolved mercury in surface and bottom water were also studied. Mercury concentration was found greater in the bottom water than in surface water in all the seasons. Dissolved mercury in bottom water varied seasonally, post-monsoon (218.18µg/l), pre-monsoon (270.45µg/l) and monsoon (154.45µg/l). Dissolved mercury in surface water during pre-Monsoon fluctuated between 450µg/l and 100µg/l. Post-monsoon period recorded the lowest average concentration of mercury at 188.63µg/l.

Inorganic mercury can be methylated by microorganisms to organic mercury. Methyl mercury is soluble, mobile and quick to enter aquatic food chain. It gets bio-accumulated and biomagnified due to its high lipid solubility and long biological half-life. The concentrations in carnivorous fish at the top food chain (e.g. pike and tuna) are biomagnified 10,000 – 100,000 greater than the ambient waters (USPHS 1997). The total mercury concentration in fish samples of Vembanad Lake ranged from 1.75µg/g - 0.5µg/g and maximum concentration were found in *Ophio cephallus* (Omana and Mohan, 2008). Seasonal variations of dissolved mercury in surface and bottom water are displayed in Fig. 3.1.3.2 and Fig. 3.1.3.4

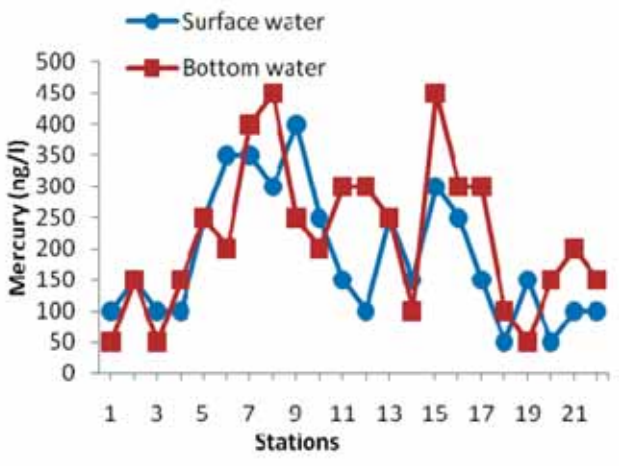


Fig. 3.1.3.4 Variations of mercury during Post-Monsoon

P. K. Omana

3.1.4 Chemical loading into reservoirs – investigation from selected watersheds of Periyar River in Western Ghats

A detailed study report was prepared after studying and analyzing the catchments of the reservoirs Kallarkutty, Mullayar, Bhoothathankettu and Mattuppetty and their upstream watersheds. The major features identified are landuse, vegetation, and human interventions.

The water quality parameters of the four reservoirs under study conforms to Class II water standards stipulated by CPCB. There

is no anoxic condition present in the surface strata of the reservoirs. Three reservoirs, except Mullaperiyar showed nutrient enrichment. This may be attributed to the agro-based activities and settlement in the catchment. The major cations and anions are all within the permissible limits. Total coliforms and fecal coliforms are observed in all the four reservoirs whereas *E.coli* was found only in the Kallarkutty and Bhoothathankettu reser-

Fig.3.1.4.1 Mullaperiyar Reservoir, dam and the catchment

voirs. Residual pesticides are absent in the water samples of Mullaperiyar reservoir,but trace 5 of organochlorine pesticides were present in the water samples from Mattupetty, Kallarkutty and Bhoothathankettu reservoir. The results of textural analysis indicate that the sediments of Mullaperiyar and Mattupetty are sandy-clay, while those of Kallarkutty and Bhoothathankettu

Fig. 3.1.4.2 Mattupetty reservoir and its catchment

are silty-sand. Clay sized particles were notably absent in Bhoothathankettu. Since the fine-grained sediments rich in organic carbon have strong affinity to heavy metals, the sediments of Mullaperiyar, Mattupetty and Kallarkutty were found to have elevated concentrations of trace metals. As per NYSDEC guidelines, the sediments in the Mattupetty and Kallarkutty res-

Fig. 3.1.4.3 Dam and the catchment of Kallarkutty

ervoirs were found to have moderate contamination levels with respect to Zinc and Copper. Lead concentrations were within the Lowest Effect Level (LEL). Chromium and Nickel content in the four reservoir sediments exceeded the Severe Effect Level (SEL)

Fig. 3.1.4.4 Tea estates in the catchment of Mattupetty reservoir

indicating severe health hazards. Residual pesticides were absent in the sediments of Mullaperiyar reservoir. But the sediments from Mattupetty, Kallarkutty and Bhoothathankettu reservoirs showed elevated levels of BHC and metabolites DDT.

Dense and open forest form the major land use units of Mullaperiyar catchment. The catchment area of Mattupetty is dominated by forest and forest plantations, followed by agricultural land. Agricultural practice and settlement are dominant activities in the catchment area of the Kallarkutty reservoir. Bhoothathankettu reservoir catchment is characterized by mixed land use pattern. These catchment characteristics are reflected in the physicochemical signatures of the respective reservoirs. The final report has been submitted to the Ministry of Environment and Forests, Government of India

C. N. Mohanan

Funding: Ministry of Environment and Forests, GoI

3.1.5 Hydro-chemical characterization and drinking water potential of coastal springs of southern Kerala

The conventional water resources of Kerala are facing maximum strain due to increased demand, overall environmental degradation and changing climatic conditions. The coastal belt of Thiruvananthapuram and Kollam districts of Kerala has plenty of springs which remained relatively untapped. Direct and indirect human influence and interference on these springs cause changes in the quality and quantity of these groundwater supplying ecosystems. The project was undertaken with the objectives to (i) locate and map the various spring water resources in the coastal and midland regions of Kollam and Thiruvananthapuram districts, (ii) assess the seasonal water potential of springs on year based flow rates measurement, (iii) evaluate the physico-chemical and bacteriological quality of spring water and its seasonal variations, (iv) identify the various environmental and anthropogenic factors that contaminates and damages the precious spring resources and (v) lay down strategies for the optimum use of the precious natural gifts of spring and its environmental management.

A total of 204 springs in the two districts were identified and mapped. All these springs were concentrated in six spring clusters; four such regions are in Thiruvananthapuram district while two are in Kollam district. The spring clusters of Thiruvananthapuram district are 1) Neyyattinkara-Vengannur (N-V), 2) Kariyavattom-Chirayankeezhu (K-C), 3) Varkala-Sivagiri (V-S) and 4) Hariharapuram-Ayroor (H-A) while the two spring clusters of Kollam district are 1) Chirakkara-Nedungolam (C-N) and 2) Kallada-Nedumpana (K-N) (Fig.1). Based on a set of properties, 62 springs were selected for a detailed evaluation of the water discharge pattern, microbiological and hydro geochemical characteristics. The major geological formations of the area are Archaean crystallines (Charnockites and Khondalites) and the

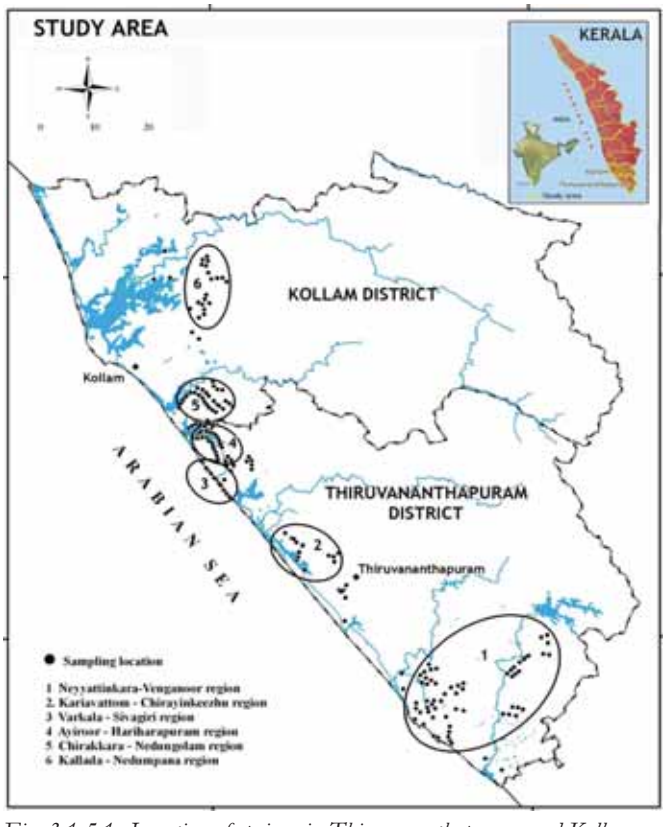


Fig. 3.1.5.1 Location of springs in Thiruvananthapuram and Kollam districts

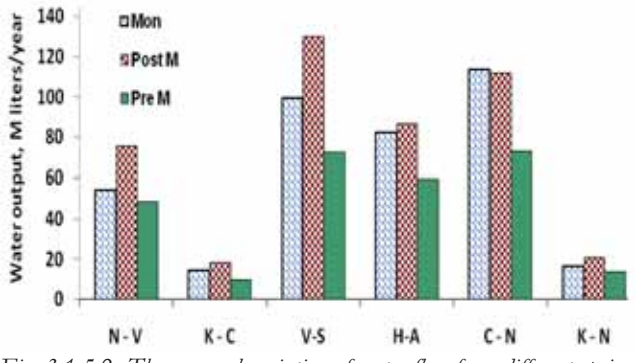


Fig. 3.1.5.2 The seasonal variation of water flow from different spring clusters

Tertiary Succession of Kerala. The coastal region consists of geomorphologic units such as beaches, coastal cliffs and coastal plains, which together constitute 6% of the study area and falls within an altitude of 20 m from the MSL.

Out of the 62 spring resources that are selected for the complete evaluation of the hydrochemistry, 43 belong to flow type and 19 comes under the pond types. Under this study only springs that belonged to flow types were assessed for its water potential. Forty three flow type springs were selected for the bimonthly evaluation of flow rates for a continuous period of one year.

The seasonal discharge range of the flow type springs were: 0.94-162 lpm in monsoon, 1.03- 239 lpm in post-monsoon and 0.59-144 lpm during pre-monsoon season. The highest flow rate in majority of the areas was observed during post-monsoon and lowest in pre-monsoon seasons (Fig. 3.1.5.2). Annually, the springs from Ayiroor-Hariharapuram spring cluster recorded the maximum water discharge and Kariavattom - Chirayinkeezhu the minimum. The chemical quality of water satisfies BIS/WHO drinking water specifications except the pH, which showed acidic characteristics in majority of the cases. In general the springs have conductivity values less than 100µS/cm and this indicated the low range of dissolved salts in the water. The major ion concentrations are in the order of Ca (0.6-16.6mg/l), Mg (0.2-10.5mg/l), Na(3.5-22.8 mg/l), K(0.1-3.8 mg/l), Fe (26.0-218µg/l), Cl (6.6-38.5mg/l), NO_3 (216-3681µg/l), etc., which control water quality well within the drinking water quality

standards. Presence of pathogenic coliforms was noticed in certain spring locations which may be due to prevailing unhealthy environmental conditions. In Chirakkara-Nedumgolam cluster region, around 85% of the spring sources were affected by *F.Coli* during monsoon while *E.Coli* was identified in 92% of the springs in Ayiroor-Hariharapuram cluster in premonsoon season. Piper diagram was used to interpret the chemical evolution of spring water which depends on pattern recognition techniques. The dominant water types evolved were Na-HCO_3/ Na-Cl, rich with subordinate of Ca and Mg. The majority of the Neyyattinkara-Venganoor spring water falls within Na-Ca-Mg-HCO_3 with low TDS type water. In Kariavattom-Chirayinkeezhu, the water type was (Na-Ca-Cl-HCO_3) with low TDS, while in Varkala-Sivagiri, Ayiroor-Hariharapuram, Chirakkara-Nedungolam and Kallada-Nedumpana clusters discharge of Na-Cl (water type) dominant groundwater with subordinate Ca/Mg/HCO_3 occurs. Groundwater discharging from these spring clusters was generally dominated by Na-HCO_3 except along the coast where the coastal transition zone becomes an important influence of Na-Cl water type. The spring resources are spread in 35 panchayats and 3 municipal regions of 12 block regions with a population of 11.7 lakh. The combined water potential of the springs is about 125 lakh lpd which is sufficient enough to meet requirement of nearly 1.8 lakh people at the rate of 70 liters of water/person/day. In other words the spring sources alone are adequate to satisfy the water requirements of 15.62% of prevailing population in the spring locations. With ever increasing population which has already quadrupled between 1950 and 2000, the requirement for land and water is also mounting up. Unscientific land use changes have resulted in the deterioration of existing water resources including springs. In the present study, 18% of the observed spring resources are on the verge of destruction. Flow discharge direction, decline in water quality particularly in regard to nutrients and micro organisms are noticed. So management of these nature's gifts is very urgently required. Timely and efficient implementations of strategies are essential for the restoration and preservation of the world-class springs that are part of Nation's unique natural heritage.

K.Narendra Babu

3.1.6 Impact of urbanization on soil and water resources of some selected cities of Kerala

Kerala is a thickly populated state that is undergoing fast urbanization. This has resulted in severe environmental degradation in all its major cities. Conversion of vast agricultural lands and rural areas to urban conglomerations causes negative impacts on the environment. Saline water intrusion into aquifers, pollution due to dumping of solid and liquid wastes to land and water bodies, air and noise pollution due to increased vehicles and industrialization, encroachment on coastal plains, dispersion of toxic elements into the environment and neglect of sites of cultural heritage and natural beauty are some of the ill effects of unplanned urbanization. The major handicap in the assessment of environmental deterioration due to urbanization is the lack of adequate data and information on air quality, surface and ground water quality, health of land mass, etc. of the affected area.

In order to deal with this situation CESS has carried out a study to assess the impact of urbanization on surface and ground water quality, soil and aquatic sediment in the three most urbanized regions of Kerala, viz. Thiruvananthapuram, Kochi and Kozhikode.

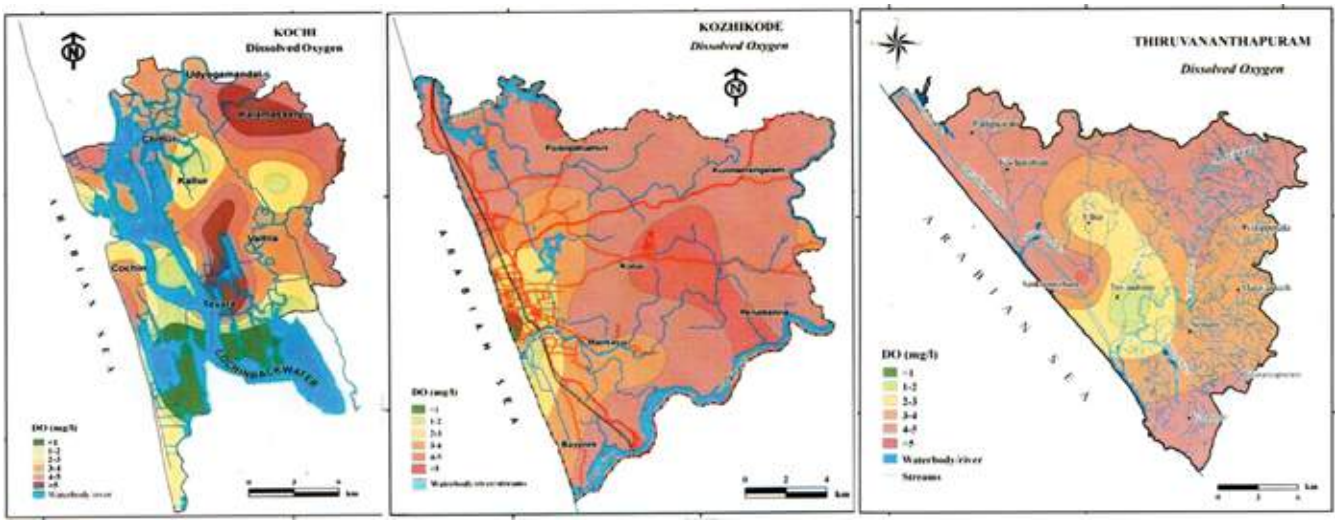


Fig. 3.1.6.1 Variations in the concentration of Dissolved Oxygen in well water in Kochi, Kozhikode and Thiruvananthapuram cities

Data on the hydro-chemical and bacteriological characteristics of water, nutrient status in soil, contamination level in lake sediments were measrued in these three cities and its immediate neighborhoods. Groundwater from wells and surface water from different sources like river, lakes, ponds, canals, temple ponds and coastal marine regions were collected and analyzed.

The study revealed that ground water quality of urban areas is considerably poor with respect to its adjoining non-urban areas and within an urban area, the degree of deterioration is directly related to density of population, soil texture, land use pattern, elevation of land, etc. The overall impact was most severe in Kochi followed by Thiruvananthapuram and Kozhikode. In Thiruvananthapuram, the groundwater quality showed greater contamination in urban areas. Both Akkulam Lake and Parvathiputhanar received wastes of complex nature from several sources. The water and sediment characteristics of Akkulam lake reflected the alarming state of this lake. Vellayani - a fresh water lake - in comparison was relatively less contaminated. The water quality of upstream and downstream stretches of the Karamana River showed high contamination with very high pollution in the lower stretches due to unprecedented urbanization.

As compared to Thiruvananthapuram, all well samples of Kochi showed high concentration of nutrients and depletion of dissolved oxygen. Regionally, both well-water and bore-well water from the highly urbanized zones of Kochi revealed greater enrichment of nutrients and depletion of dissolved oxygen. The surface water sources of Kochi city indicated high concentration of nutrients with low DO values while soil samples from agricultural regions had low nutrient levels.

The study has brought to light the need to devise strategies and management action plans for minimizing the impacts of urbanization on aquatic environment and soil/sediment systems. As an initial step, discharge of highly contaminated and potentially toxic wastes from hospitals and manufacturing units into the water bodies and the discharge of raw sewage and effluents into the river/estuarine systems should be made punishable.

K.Narendra Babu

3.2 Terrain Analysis and Landuse Studies

3.2.1 Geomorphic setting, landscape alterations and fluvial regime change in the Western Ghats provenance of southern sahyadri-south of Achankovil Ar.

The objectives of the project are demarcation and characterization of landscape alteration (major construction structures, dams townships, terracing, large scale quarrying, lowland reclamation), estimation of the extent of soil erosion and deforestation and estimation of impacts on the fluvial regime and landform-forming processes. The study area covering 2129.37 km^2 of area extends over Pathanamthitta, Kollam and Thiruvananthapuram districts and is drained by six major rivers. Interrelationship between morphogenetic processes, landuse and landform through analysis and mapping of physical determinants has been attempted. Landuse map of the area for the year 2009 is given in the Fig. 3.2.1.1.

Among various geoenvironmental factors, slope, perhaps, is the most important factor responsible for erosion. Field mapping

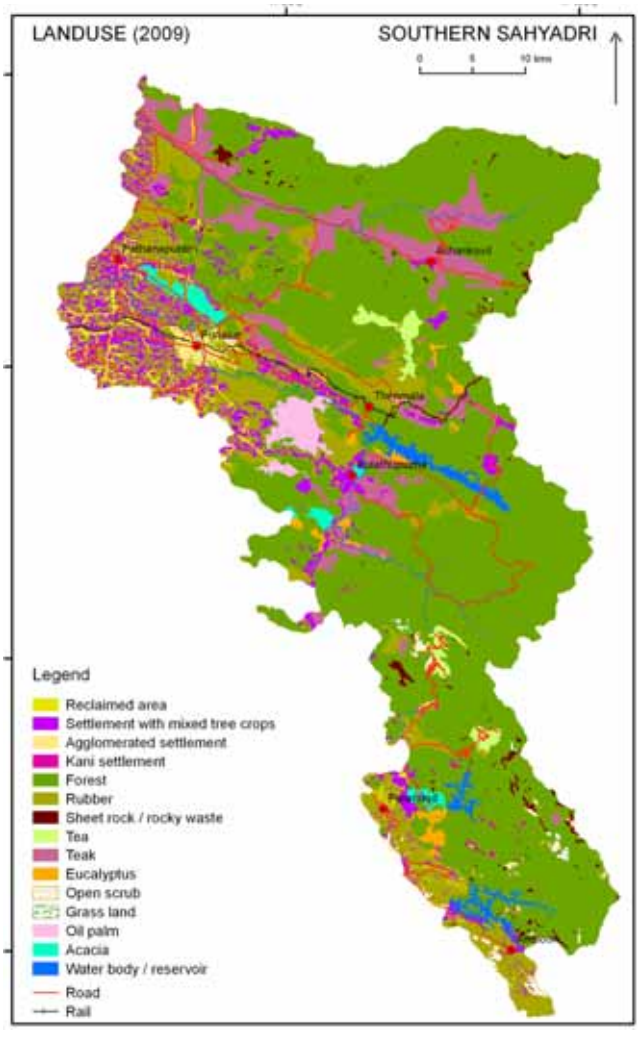


Fig. 3.2.1.1 Land use (2009) in southern Sahyadri

along with the visual interpretation of time-series imagery have not detected much forest depletion in the recent times.

Mahamaya Chattopadhyay

3.2.2 Assessment and monitoring of land quality for sustainable agriculture: A GIS based approach coupled with technology implementation

The project aims to prepare land use/land cover map of Kannur district using satellite imagery, to prepare a geochemical atlas and to discuss the issues emerged out of the analysis with experts and users. Tentative results of data analysis show that 15% of the total area in the district is agriculturally drought prone during summer months and faces acute shortage of drinking water. At the same time during monsoon about 6% of the total area is flood prone, 2% area prone to landslides and 70% prone to erosion. Heavy surface run-off is observed in the duricrust re-

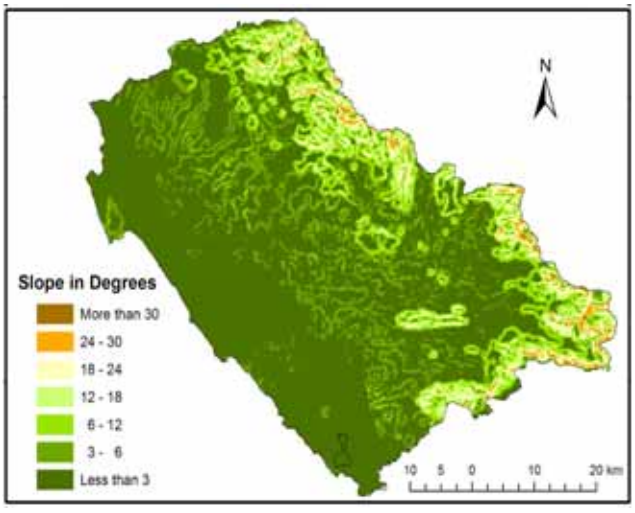


Fig. 3.2.2.1 Slope map of Kannur district

gions in the district. Fig 3.2.2.1 shows slope map of Kannur district.

B. Sukumar

3.2.3 Study of landuse/land cover changes as linked to climate change in Kerala

The objectives of the project are to assess land use/land cover change in Kerala covering forests, agricultural land and urban areas, to measure trend of change in natural vegetation cover, to measure change in paddy land and to assess change in wet lands and finally to study the linkage between landuse change and rainfall change if any. Agricultural landuse are being analysed based on secondary data and relevant thematic maps and graphs are being prepared. The area of land put under non-agricultural use increased during the last 50 years. Landuse change map of Ernakulam district has been finalized based on topo sheets and images. A study conducted in the southern parts of the Western Ghats indicates decrease in rainfall particularly during south west monsoon (Fig. 3.2.3.1).

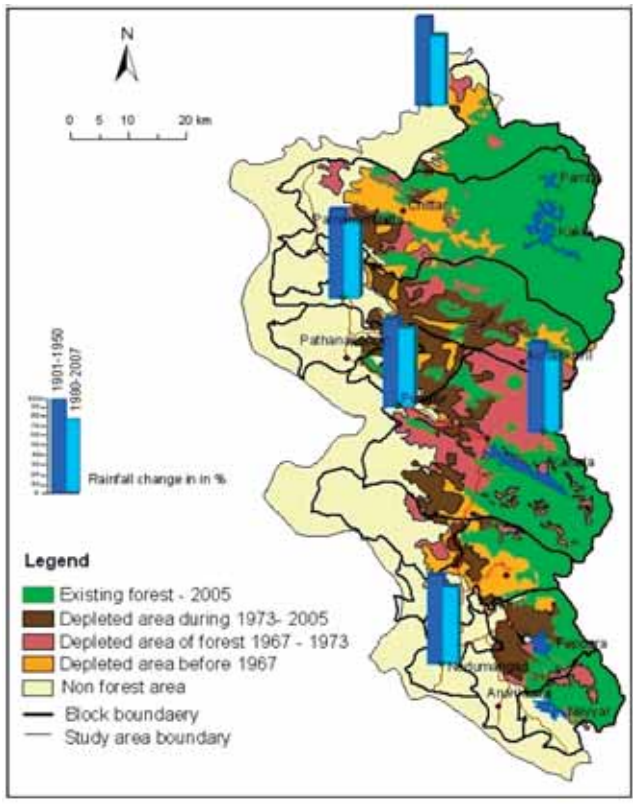


Fig. 3.2.3.1 Deforestation and change in south west monsoon rainfall (1901-1950 and 1980-2007)

Srikumar Chattopadhyay

3.3 Environmental Assessment

3.3.1 State of the Environment and Action Plan for Kochi

The state of the environment study envisages a micro-level study of the Kochi Metropolitan region covering an area of 1022 km^2 encompassing Kochi Corporation and surrounding 6 municipalities and 48 grama panchayats. This is the first time such an attempt was carried out for a Metro city like Kochi. Besides primary data, secondary information has been collected and analysed for the study. The study focussed mainly on occupational pressure; safe drinking water shortage and saline intrusion; air pollution due to low ventilation coefficient and mixing height; poor sewerage and solid waste disposal; drainage congestion and water logging; wetland reclamation; unsustained river sand, clay and lime shell mining and hard rock quarrying; traffic congestion; non compliance of CRZ, environmental and building rules, etc. were studied. Spatial and functional fragmentation hampered better integration and coordination of Kochi Corporation, the nearby Municipalities and Panchayats for planning and service delivery.

The Vembanad and related waterbodies are the worst affected by pollution from various sources. The area of water body has been considerably reduced due to reclamation for settlements/urban sprawl. Discharge of partially treated effluents from various industrial and domestic sources is common. Pollution is also due to solid waste disposal, sand mining, quarrying, etc. Large scale reduction in vegetation cover of mangroves and wild life and fishery grounds are recorded in Vembanad estuary and adjacent regions. Salinity intrusion into surface water sources up to Pathalam and beyond is reported to be serious. Water logging and salinization of coastal aquifers, and ground water contamination are common. Loss of topsoil and severe soil degradation in the midlands is reported to be one of the reasons in declining the agricultural activity and large scale conversion of prime agricultural lands to other uses including plantations. The SOE report prepared in the DPSIR format highlighted the present status of the environment encompassing both natural resources as well as the related activities that affect the resource base through prioritization matrix approach and resource activity impact matrix. The study concluded that, the

biggest asset of Kochi is the vast expanse of backwaters, rivers and networking canals. This special asset is never considered for long term planning and sustainable utilization in the spatial planning process of the metropolitan area. Though, Vembanad is declared as a Ramsar site no specific action has been taken for the effective management of these wetlands of international importance. The study report highlighted the need for efficient and wise economic use of the Vembanadl wetlands and its catchments and better long term planning for the development of the area by the planners and developers.

C. N. Mohanan

3.3.2 River Sand Auditing

The need for sand and gravel is mounting exponentially over the years to meet their ever-increasing demand in construction sector. This,often leads to over exploitation of sand and gravel from rivers and other aquatic environments causing problems to the very existence of the life support systems. Taking a serious note on the impact of river sand mining, the Government of Kerala enacted the legislation 'The Kerala Protection of River Banks and Regulation of Removal of Sand Act, 2001' to protect the river environments from large scale dredging of sand. The act also envisages provisions for periodical sand auditing in order to assess the feasibility of sand mining in the rivers of Kerala.

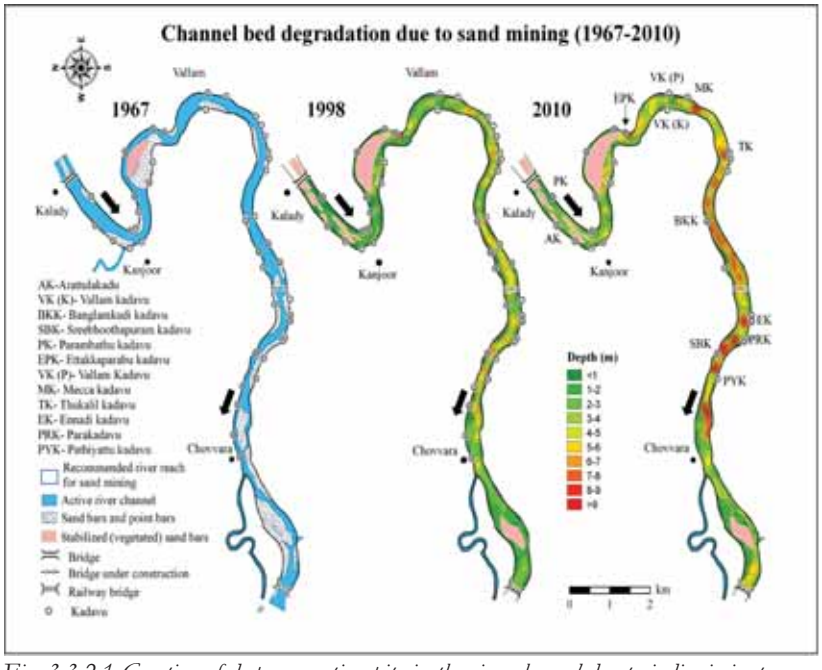


Fig. 3.3.2.1 Creation of deep excavation pits in the river channel due to indiscriminate sand mining- A case of Periyar river

River sand auditing is a procedure to evaluate the processes and environmental effects of sand mining in a river or a portion of a river after a specific period of sand mining. This exercise has to be undertaken to know how far the mining process and its execution in a river or part of a river has helped to minimize the negative effects of sand mining on one side and to maximize the positive effects on the other. In tune with the provisions of sand auditing of Kerala rivers within the ambit of the legislation, an ideal methodology has been evolved by CESS for field level application. As directed by the Hon'ble High Court and Government of Kerala, CESS has so far undertaken two sand audit studies, one in Periyar river (Ernakulam District) and the other in Manimala river (Pathanamthitta and Kottayam Districts) and submitted their major observations, findings and recommendations to the funding agencies for appropriate action.

The sand audit studies carried out by CESS revealed that the Periyar and Manimala rivers have been degraded considerably due to the uncontrolled sand mining over the past 3-4 decades. The river channel has been turned into a chain of deep pools (Fig. 3.3.2.1) due to pit excavation of sand using manual, semi-mechanical/ mechanical means. Analysis of CWC (Central Water Commission) data reveals that in Periyar river the rate of channel incision was 4.1 cm y^{-1} during 1980-85 and 3.64 cm y^{-1} during 1985-90. In the subsequent 5 year periods, the rate of incision increased by about 3 times during 1990-95 (13.2 cm y^{-1}) and 7 times during 1995-2000 (28.64 cm y^{-1}) compared to the rate of incision measured during 1985- 90 period. During the period 2000-05, the channel incision rate reduced considerably to 9.64 cm y^{-1}, with respect to the previous 5-year period (i.e.1995-2000). The average channel incision noticed during 2005 – 2010 period was quite higher (19.28 cm y^{-1}) than the previous five year period. The average channel incision noticed in the Manimala river was 9.4cm y^{-1} during the period 1990-2008. The changes in river cross- section noticed in the CWC gauging station at Kallooppara are alarming. All these points to the fact that the natural replenishment is meager in these rivers compared to the quantity of sand lifted from the river. The present level of channel incision and dearth of adequate sand in these rivers for maintaining their ecosystem structure and functions are the major threats of these life sustaining systems.

Therefore, stringent efforts are required to protect these rivers and their biophysical environments from degradation due to indiscriminate sand mining. Sand mining should be limited only to a few stretches in these rivers having sufficient quantities of mineable sand. Based on sand auditing, a local body-wise sand resource allocation scheme and a set of recommendations as suggested in the Project Completion Report would enhance the overall environmental quality of the Periyar and the Manimala rivers.

D. Padmalal

Funding: Department of Revenue, Government of Kerala

3.3.3 Environmental management plan for Alappuzha-Sherthalai canal and Kanjikuzhy grama panchayat

This action project aims to prepare a management plan for the A-S canal and Kanjikuzhy grama panchayat by involving local people. Revisit of some of the environmental issues identified during a survey conducted in 2003 also form part of this project. This project is expected to develop a guideline for environmental management at the micro level. Data collection and analysis have been completed. The final report is under preparation. In Kanjikuzhy panchayat some of the environmental problems have intensified as compared to that of 2003. The A-S canal, which was cleaned under Hariyali programme is again weed infested.

Srikumar Chattopadhyay

3.3.4 Cleaning the canal system in Alappuzha town by letting sea water into the canal: Environmental Impact Assessment

This project was taken up on request from the District Collector, Alappuzha as part of the Alappuzha town development programme. Impact of sea water inflow in the canal system has been assessed. Propagation of salt water in the canals and adjoining water bodies has also been worked out. The report has been submitted to the District Collector.

Srikumar Chattopadhyay
Department of Irrigation, Government of Keala

3.3.5 Reservoir Studies

Desiltation of reservoirs was initiated at the instance of Government of Kerala. CESS is providing technical inputs whenever necessary. In this year studies have been conducted for Lower Periyar and Kallarkutty reservoir. Water quality of Aruvikara reservoir has also been tested to assess impact of desiltation.

Srikumar Chattopadhyay
Department of Irrigation, Government of Kerala

3.3.6 Exploring inter relationship between environmental degradation and poverty: selected micro-level case studies across Kerala

This project aims to understand interrelationship between incidence of poverty and environmental degradation through case studies in selected panchayats of north Kerala. The study covers both macro and micro level analyses. Wayanad and Kannur districts have been selected for the study. Four panchayats in each of these two districts were identified for detailed study and sample survey. The environmental conditions have been evaluated through mapping of biophysical resources particularly land and water. We also attempted to analyse driving forces leading to environmental degradation. The other activities covered socio-economic survey to understand the extent of poverty, mapping and distribution of poverty affected areas / settlements and study of spatial interrelation between environmental degradation and poverty. Analysis of biophysical characteristics, mapping of the relevant parameters and socio-economic survey have been completed. Panchayat wise resource base and environmental issues have been computed (Table 3.3.6.1 and 3.3.6.2). The households covered under sample survey have been grouped into two classes in terms of incidence of poverty. The very poor group does not posses any assets and mainly depends on daily wage earning. Their family size is large and solely depends on public distribution system for food. Most of the habitations are near the river banks, which are flood prone or along steep slopes which are highly vulnerable and susceptible to landslides. Deforestation has shrunk the resource base of the tribal

Table 3.3.6.1 Resource base and environmental issues in selected panchayats of Kannur district

Name of Panchayats	Environmental Resource Base	Environmental Issues
Dharmadam	1. Fisheries 2. Seasonal agriculture & tree crops 3. Well developed infrastructural facilities	1. Salt water intrusion 2. Coastal erosion 3. Flooding 4. Extinction of many species of fishes due to improper fishing methods
Pattuvam	1. Agriculture, tree crops 2. Limited inland fishing 3. Low connectivity	1. 4 sq.kms (21%) of laterite duricrust 2. Salt water intrusion 3. Seasonal floods in some parts 4. Low productivity, crop diseases 5. Drinking water problems
Eramam-Kuttur	1. Limited seasonal agriculture 2. Tree crops 3. Pepper plantations 4. Low infrastructure	1. 16 sq.kms (22%) laterite duricrust 2. Drinking water scarcity 3. Soil erosion 4. Crop failure due to pest attacks
Padiyur	1. Seasonal agriculture 2. Tree crops 3. Pepper plantations 4. Low connectivity	1. 18 sq.kms (32%) laterite duricrust 2. Environmental issues due to laterite mining 3. Shortage of drinking water 4. Soil erosion

Table 3.3.6.2 Resource base and environmental issues in selected panchayats of Wayanad district

Name of Panchayats	Environmental Resource Base	Environmental Issues
Noolpuzha	1. Agriculture, tree crops 2. Forest	1. Seasonal flooding 2. Shortage of drinking water 3. Soil erosion
Thondernadu	1. Agriculture, tree crops 2. Pepper plantation 3. Quarrying	1. Landslides 2. Drinking water problems 3. Soil erosion 4. Crop failure due to pest attacks
Thirunelli	1. Limited seasonal agriculture 2. Tree crops 3. Forest 4. Pepper plantations 5. Low infrastructure	1. Seasonal flooding 2. Drinking water scarcity 3. Soil erosion
Meppadi	1. Seasonal agriculture & tree crops 2. Tea plantation 3. Pepper & coffee plantation 4. Forest	1. Landslides 2. Seasonal flooding 3. Shortage of drinking water 4. Soil erosion 5. Crop failure

population in Wayanad district. In the case of fishing population in Kannur, there is a noticeable shift in occupation and therefore the incidence of poverty is comparatively less. Final report preparation was initiated.

Srikumar Chattopadhyay

3.3.7 Tropical freshwater Myristica swamps of Kerala and its ecological and evolutionary significance

The Myristica swamps are part of tropical low level evergreen forests seen in the border areas of Kollam and Thiruvananthapuram districts in Kulathupuzha and Anchal forest ranges. Ecological studies have been carried out in selected swamps in Karinkuringi pacha in the Madathara area by collecting sediment, water and biodiversity details. The sediment core samples taken were subjected to geochemical and palynological investigations. The idea is to reconstruct the past history of these swamps. Ten major, minor and trace elements were analysed using XRF. Gross mineralogy was identified by X-ray diffraction on powdered samples. Organic carbon was estimated from different depths (Fig.3.3.7.1).

Two core samples were analyzed for palynology with the help of French Institute, Pudussery. Besides, pollen slides of present day flora were also prepared for further analysis and interpretation. The sediment core shows sedimentation sequence such as sandy layer (0-27 cm), alternate with dark blackish carbonaceous soil (27-50 cm), and light green silty-sand soil (50-64 cm) and bottom layer with orange yellowish laterite deposition (65-70 cm). From top to bottom all sediment cores revealed four distinct zones. There is a 4 to 5 cm thick sand zone at 25 cm depth from the top possibly due to the high sediment supply of frequent seasonal fluctuations in water table. Moderately acidic soil with high organic carbon content presents in the middle clay-rich zones at 30-50 cm depth (0.857%). The OC content of 0.314% in the surface soil progressively decreased to 0.174% in the deepest layer studied. There are remarkable variations in other properties such as pH (6.33-5.74) and conductivity (88-48 µS/cm).

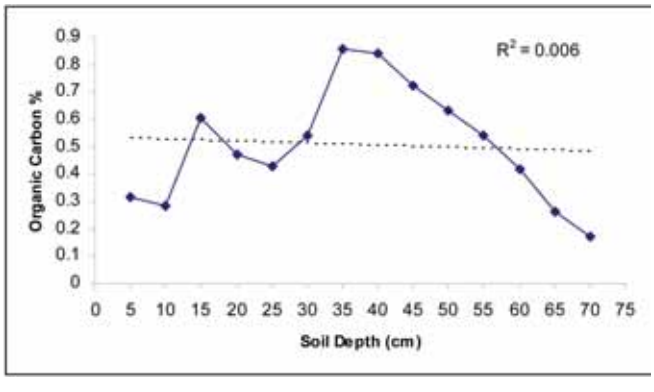


Fig. 3.3.7.1 Organic carbon content in swamp sediments

The major oxides present are generally in the order of SiO_2> Al_2O_3> Fe_2O_3> K_2O> TiO_2> CaO> Na_2O> MgO> P_2O> MnO. The trace elements such as V (151-165 ppm), Cr (57-164 ppm), Zr (85-334ppm), Ba (161-164ppm) indicate high concentration compared to other trace elements. The composition of compatible elements like Ni (46-16 ppm) and Co (27-6 ppm) shows low abundance compared to Cr (57-164 ppm). The X-ray data show the primary minerals (non- clay minerals) present in the samples to be mainly quartz and biotite. In addition to the primary minerals, small amounts of gibbsite are also identified. The mineralogical studies of Karinkurinji town have provided information on the depositional environment and climatic conditions of that area. The percentage of quartz is relatively high in sandy soil (about 40 cm) and low in silty-sand soil (55 to 70 cm).

C. N. Mohanan

3.3.8 Environmental degradation of Muvattupuzha river basin, causes, consequences and strategies for river restoration.

The present study deals with the various issues related to mining and quarrying of non-living resources, unscientific disposal of municipal solid waste (MSW), river channel degradation etc., of one of the important river basins of Central Kerala – the Muvattupuzha river basin (Fig. 3.3.8.1). The river basin is located on the southern side of Kochi city, one of the fast developing urban-cum-industrial centres in South India. The study revealed that the resource extraction and waste generation activities not only cause deterioration of the quality of the river system but also significantly affect its riparian lands and the entire basin area.

In the Muvattupuzha river basin the environmental degradation is mainly attributed to human activities like deforestation, devastation of vegetations, various types of mining and quarrying activities etc. Mining and quarrying activities are taking place in all the three physiographic regions of the basin. Major mining/quarrying activities noticed in this river basin are flood plain and instream sand mining, hard rock quarrying, soil quarrying and laterite block cutting (Fig. 3.3.8.2 & Table 3.3.8.1). Graphite mining is noticed only in the Kalloorkad area of Ernakulam district. The resource extraction of these non-renewable resources is severe in the basin and is also close to the urban-cum-industrial Kochi city. The indiscriminate mining is dominated in the highly populated midland and lowland regions of the river basin, where the socio-environmental setting is significantly disturbed. It is a fact that the resource extraction and utilization of the State has changed drastically over the past 4-5 decades and is not in tune with the principles of sustainable development.

The spatial distribution of the activities reveals their clandestine preserve in the midland part of Ernakulam district. As the Kochi

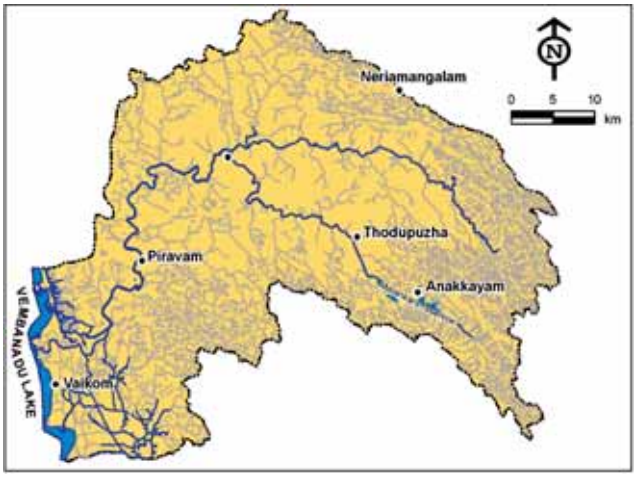


Fig. 3.3.8.1 Location of the study area –Muvattupuzha river basin

city and the satellite towns require infrastructural facilities for several mega developmental projects, the areas adjoining the urban centre (s) are exploited for different types of construction materials like hard rocks, crushed sand, instream and floodplain sands, laterite blocks, brick earths etc creatimg hazardous environmental problems. The impacts of mining, in most cases, leave permanent mark on the land which modifies significantly the actual geomorphology of the area. The area may be transferred into a basin and sometimes water logged. Unsupported mines often promote soil erosion, changes in soil texture, soil compaction etc. Due to various mining activities, the surface area of land for sustainable uses has reduced significantly.

The analysis of water in Muvattupuzha river shows that, in general, the water quality is good except for a few locations. The physico-chemical analysis shows that most of the water quality parameters are within the permissible limits prescribed by WHO (1997) and BIS (1991). In certain locations of lower stretch (Ittupuzha), the DO value is not within the permissible limit. This may be attributed to waste discharge, indiscriminate sand mining etc., which are prevalent in the basin. A few physico-chemical parameters (Ca, Mg, Cl, Na, hardness etc) show comparatively high values especially in the lower stretches of the river. This may be attributed to the saline water intrusion in the lower reaches. Most of the chemical quality parameters of water from the rock quarries are within the permissible limits.

While assessing the riparian land status in the Muvattupuzha river, it is noticed that midland and lowland river stretches are almost equally degraded. A comparison of riparian land status of the three river stretches - Muvattupuzha main river stretch in the midland, Ittupuzha and Murinjapuzha distributaries in lowlands, shows that the lowland riparian zone is the most degraded reach of the Muvattupuzha river.

The river basin is subjected to severe environmental degradation due to waste generation from urban centres. The waste

Table 3.3.8.1 Details of quarries/ mines in the Muvattupuzha river basin

Sl. No	Type of quarry / mine	Number of quarry / mine (Active/abandoned)
1	Hard rock	374
2	Soil	182
3	Laterite	111
4	River sand	101
5	Floodplain sand	117
6	Graphite	001

generation is also raising exponentially in accordance with the resource extraction activities. It is computed that the total solid waste generation in the area amounts to 201 tonnes/ day, of which the 4

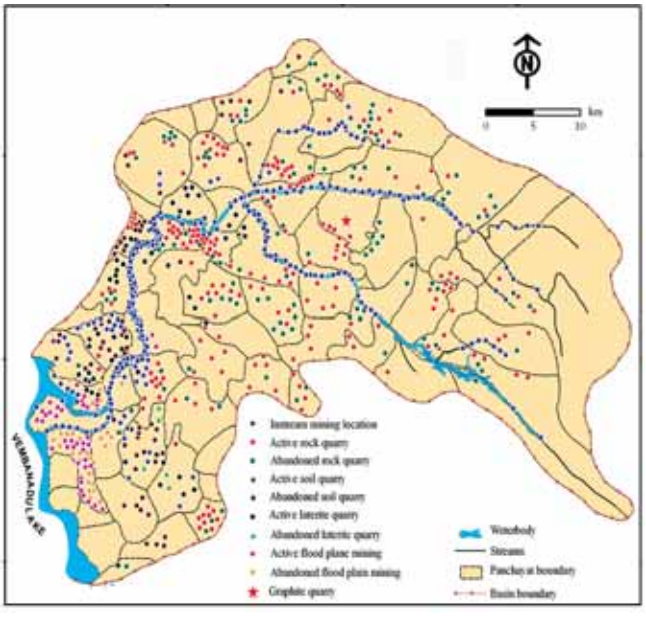


Fig. 3.3.8.2 Map showing the spatial distribution of mining / quarrying locations in the Muvattupuzha river basin

municipalities such as Vaikom, Muvattupuzha, Kothamangalam and Thodupuzha municipalities together contribute about 26 tonnes/ day. Lack of prudent solid waste disposal system is another problem that degrades the land and water systems close to the urban local bodies. An analysis of the extent of degradation of riparian lands reveals that Muvattupuzha river channel is significantly affected by various human interventions. The riparian land of Muvattupuzha main channel, Murinjapuzha and Ittupuzha distributaries have degraded substantially (79%, 89% and 69% respectively) compared to the rest of the region. The study covers almost all the components of the land and water systems of the Muvattupuzha river basin. Based on the study a set of restoration

and management plans are suggested for improving the overall environmental quality of the river basin.

K. Maya

3.3.9 Study of urbanization between Kochi and Thrissur

This project is taken up with the objectives of studying urbanization trend between Kochi and Thrissur, to analyse land use / land

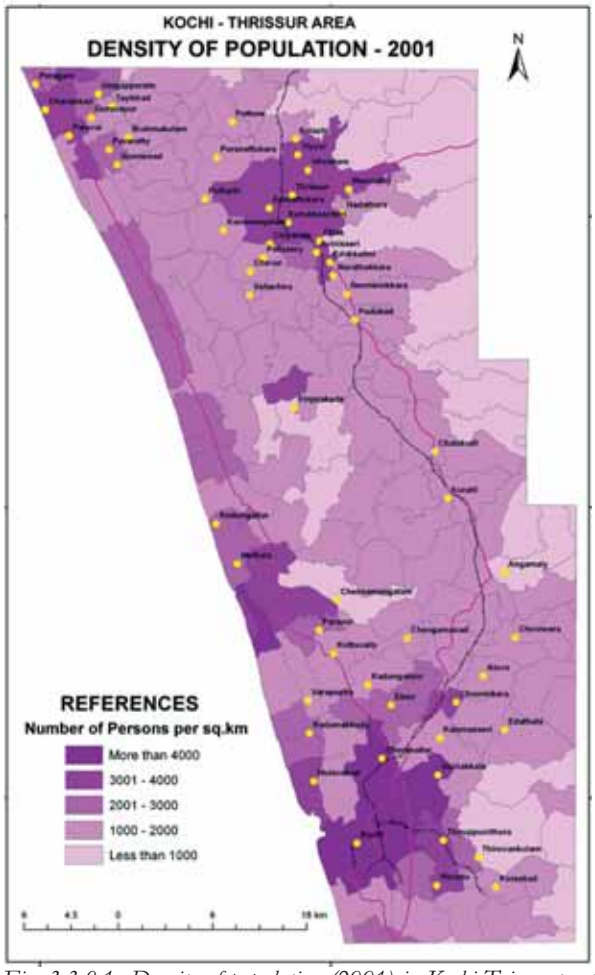


Fig. 3.3.9.1 Density of population (2001) in Kochi-Trissur tract

cover changes and to give suggestions for improving the living conditions and environment. Urbanisation is taking place rapidly between Kochi and Thrissur Corporations. As a result there is spatial expansion of built up area around the urban centers and along the National Highway 47 and 17. Most of the water logged areas and paddy fields are being reclaimed for residential, industrial and for other purposes. The population density map (Fig 3.3.9.1) indicates spatial trend of anthropogenic influences in the study area.

Ahalya Sukumar

3.3.10 Environmental impact assessment of a major settlement distribution patterns and the infrastructural development with emphasis on drinking water facilities in Thiruvananthapuram district, Kerala

The objective of the project is to assess the environmental factors such as relief, geomorphology, climate, weather and their impact on major settlements with special reference to drinking water resource availability. Collection, compilation and processing of data were continued in this year also. Maps were prepared

Fig. .3.3.10.1 Distribution of panchayats with severe drinking water problems during summer

using GIS and the data base was updated. Preparation of final project report was initiated. The study area consists of 1633 panchayat ponds, 171 private ponds, 6 quarry pools, 34 irrigation tanks, 69 holy ponds and few streams. The maximum usable water resource from all the listed sources is estimated to be 793 m^3. All the 78 Panchayats in Thiruvananthapuram district experience water shortages and the problem is very severe for 25 panchayats during summer months (Fig 3.3.10.1).

Shravan Kumar

3.3.11 Mapping of coastal cliffs and their vulnerability between Kanyakumari and Mangalore, South West Coast of India

Sea cliff erosion and slumping is a common phenomenon seen on permeable and rocky cliffed shorelines of the world and Indian coasts are no exception, which needs protection. These cliffed shorelines and their adjoining beaches,if any, are one such area, that attracts a large number of settlements/livelihood ac-

tivities for coastal communities, developmental activities and domestic/foreign tourists.

Indian coastline is privileged by a suitable natural setup in many stretches. Little studies on the identification, delineation, eroding/slumping behaviour and classification of these permeable/rocky cliffs and their vulnerability to monsoonal wave attack and sea level rise, has been done. Attention on this aspect has been focused on south west coast of India. This project attempts to fill the gaps and supplement more scientific inputs for solving the above problems. The main objectives are to (i) identify and delineate different cliffed shorelines in the study area, (ii) generate a database on the physical parameters of these cliffed shorelines, (iii) document the characteristics behavior of these cliffs spread with a suitable classification and (iv) develop a 'Cliffed Shoreline Atlas'. The study has identified, delineated and classified the different permeable/rocky cliffed shorelines between Kanyakumari and Mangalore. Cliffed Shoreline has been classified into very stable (vs), moderately stable (ms), stable (s), unstable (us) & very unstable (vus). The structural failures of Vettur -Varkala - Edava cliff section (7 km long and 2 to 30 m in height) permeable cliffed shoreline (Coastal Landmark No:CP 5639 to CP 5670) commonly called "Varkala Cliff" were documented. Completed 52 maps covering the entire study area and prepared a vulnerability Atlas.

A.S.K.Nair

3.3.12 Coastal Ocean Monitoring and Prediction System (COMAPS)

The prime objective of this long term project funded by MoES, Government of India is to assess the sources, levels, pathways and effects of various pollutants along the coastal areas of Kerala, Karnataka and Lakshadweep islands. During the current year study at Cochin, due to the influence of fluvial systems, the coastal waters showed an increase in silicate concentration. Industrial effluents and urban contaminants increased the levels of cadmium in the sediments especially at Vallarapadam transect. The concentration of nutrients (Fig. 3.3.12.1) in both Cochin bar mouth and nearshore region was generally high during pre-monsoon as well as at low tides highlighting the key role of tide in bringing land run off. In Mangalore the concentration of nutrients was high during pre-monsoon signifying increased land discharges. During low tide the concentration of nutrients in the coastal region also increased. At Kavaratti increase of nutrients of

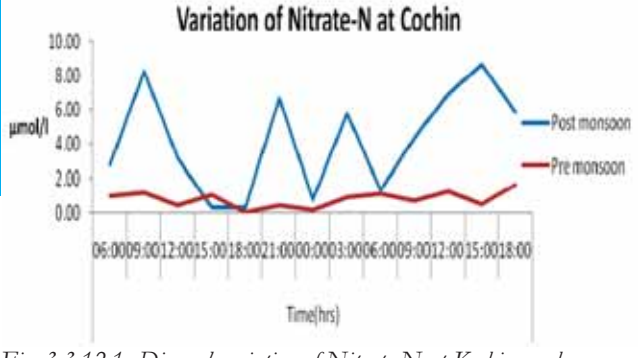


Fig. 3.3.12.1 Diurnal variation of Nitrate N at Kochi nearshore region during pre- and post-monsoon seasons

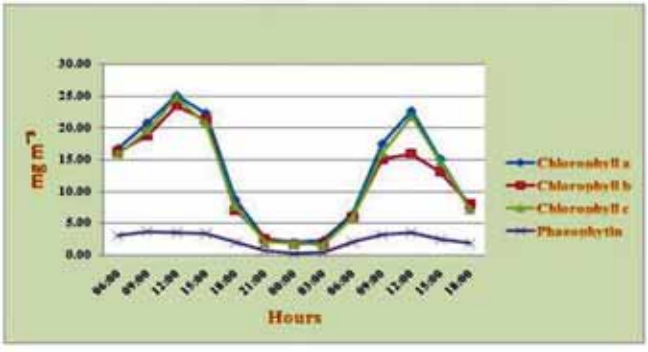


Fig. 3.3.12.2 Diurnal variation of the phytoplankton pigment concentration at Cochin nearshore waters

N and P species in the lagoon is a growing evidence of inflow of nutrients from anthropogenic sources, which is causing a detectable change in the lagoon ecosystem.

Variation in chlorophyll concentration observed at Kochi, Mangalore and Kavaratti was used to study the plankton community structure and biological productivity. Chlorophyll *a* concentration is above 5 mg/m^3. The hourly study carried out at nearshore waters of Cochin indicate that an eutrophication state is prevailing during day hours (Fig. 3.3.12.2). In general, chlorophyll concentration decreases from shore to offshore. The benthic polychaetes sp

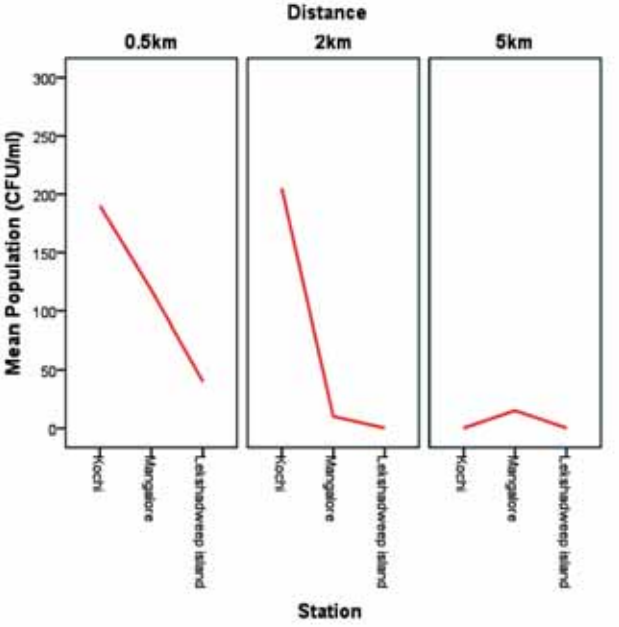


Fig. 3.3.12.3 A comparison of concentration of Escherichia coli at different offshore stations at different locations

Chaetopterus sp and *Phyllodoce castanea* indicative of pollution stress was found very much affected by the engineering modifications especially the periodic dredging carried out in the estuarine and coastal waters. Hourly sampling at Mangalore showed wide variation in the concentration of total chlorophyll during the day hours especially at 09 00, 12 00 and 15 00 hrs. The results indicate that the chlorophyll values in nearshore waters at this transect are in the eutrophic range. During the 36 hour study a bloom of *Trichodesmium erythraeum* was observed at the Kavaratti lagoon. This enhanced the total chlorophyll concentration of lagoon.

Kochi and Mangalore reported comparatively high bacterial load with Kochi showing the highest (Fig. 3.3.12.3). Bacterial population showed a decrease towards offshore. Surface water has the numerical superiority of all indicator bacteria than bottom water. In Mangalore, indicator bacterial population showed their numerical superiority during low tide, which may be due to the low salinity profile reported during the period. Bacterial population in Lakshadweep Island was fairly low throughout the study, except in the helipad transect. The drastic reduction in bacterial population towards the offshore indicate low exchange of water between the nearshore and offshore region.

Narendra Babu

Funding: Ministry of Earth Sciences, Government of India

3.4 Coastal Zone Management

3.4.1 Cadastral scale Coastal Regulation Zone maps for Coastal Zone Management of urban areas in Kerala

The Kerala coast is thickly populated and harbours sensitive ecosystems such as mangrove forests, breeding grounds of several endangered marine and estuarine species such as turtles, low lying areas susceptible to sea level rise, tidal flats and beaches. It also has many areas of outstanding natural beauty. Coastal erosion and encroachment due to pressures of increasing population and development needs are causing severe damages to the sustainability of coastal ecosystems. These damages could be controlled, to a certain extent, by regulating high impact activities in the coastal zone. It was with this objective the Coastal Regulation Zone (CRZ) Notification (MoEF, 2011 & 1991) was introduced in the country under the Environment Protection Act. The Notification declares a defined coastal stretch as CRZ and regulates construction and other activities within this defined CRZ. This is one of the major initiatives towards bringing all the development programmes in the coastal zone under the umbrella of Integrated Coastal Zone Management (ICZM). The Coastal Zone Management Plan (CZMP) of the State was prepared based on CRZ (1991) to implement its provisions for the management of coastal zone. It consisted of maps of the coastal areas with the High Tide Line (HTL), Low Tide Line (LTL) and CRZ demarcated on it. Demarcation of the HTL, LTL and CRZ has been carried out on base maps in 1:12,500 scale based on field investigations, aerial photo and satellite imagery interpretations. The inadequacies of 1:12,500 scale CRZ maps became very evident when attempts were made to implement the CRZ using such maps. These maps provide an overall view of the Coastal Regulation Zone and are being used by the State and the Kerala State Coastal Zone Management Authority for taking major policy decisions on CRZ. Lack of cadastral information in the CZMP maps makes it difficult to implement and monitor the compliance of CRZ provisions in the field. A CRZ/CZMP map on a base map with cadastral or survey plot information with the High Tide Line (HTL), Low Tide Line (LTL) and CRZ demarcated on it, could help easy interpretation and implementation of CRZ by local level officers. Considering this the Ministry of Environment and Forests (MoEF) gave the direction that local level CRZ maps in cadastral scale be prepared for development projects in the coastal zone (MoEF, 2011 & 1999).

Fig. 3.4.2.1 Sensitive ecosystems protected through CRZ: Mangroves

The project on Cadastral scale CRZ maps for urban areas in Kerala was taken up with the support of the Kerala State Council for Science, Technology and Environment (KSCSTE). Its main objective is to develop CZMP based on cadastral based CRZ maps for the coastal zone of Kerala to facilitate easy and transparent implementation of CRZ regulations. The cadastral level CRZ maps of Kozhikode, Varkala, Kollam and Thiruvananthapuram urban areas have been prepared in the 1st phase. The Kollam and Thiruvananthapuram maps are under modification to make theses compatible with CRZ (2011) through which the water body and the bed are made part of CRZ. In the 2nd phase the cadastral scale CRZ maps of Kochi Corporation, Maradu & Kanhangad Municipalities are being prepared. A GIS based CRZ information system is also under development. High resolution satellite imageries are being used to prepare CRZ maps along with detailed field mapping.

Demarcation of the HTL is the most important aspect for field implementation of the CRZ since the regulation zones are defined with the HTL as the baseline. The HTL is defined for the

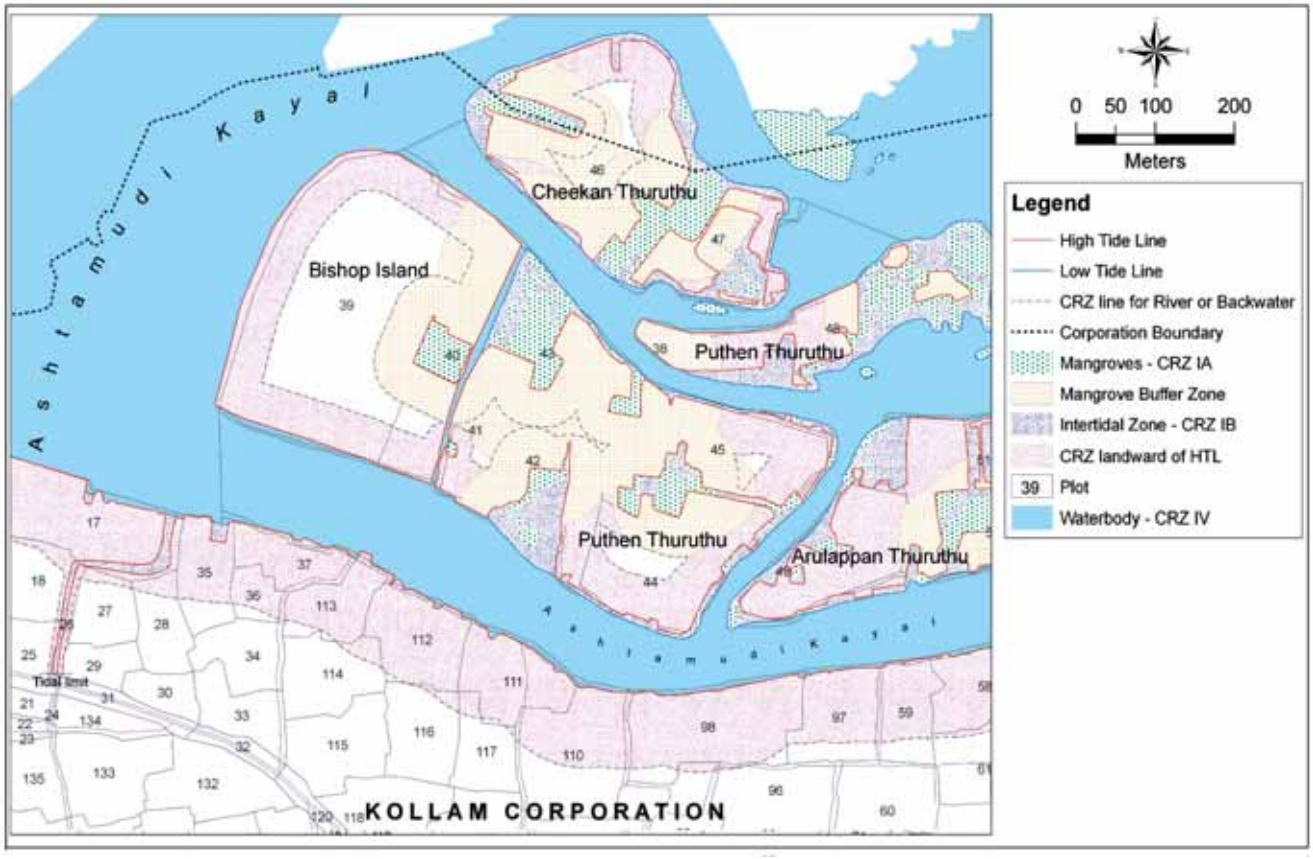


Fig. 3.4.2.2 CRZ of few islands in Ashtamudi estuary in Kollam Corporation: Mangroves (CRZ IA) till now unreported.

purpose of the notification as 'the line on the land, up to which the highest waterline reaches during the spring tide'. Tidal effects limit the distance up to which CRZ is effective upstream of rivers, creeks and backwaters which are influenced by tidal action. This is determined based on salinity concentration of 5 parts per thousand (ppt). The regulation zone on the banks of rivers, creeks and backwaters is restricted to be not less than 100 m or width of the creek, river or backwater whichever is less.

The CRZ and HTL, LTL demarcation is being carried out through field methods coupled with the use of satellite imageries. Village/cadastral maps from Survey Dept, Development Plan maps from Development Authorities, Survey of India toposheets, Naval Hydroigraphic charts and satellite imageries will form the data sources other than field mapping. The hazard line being prepared by the MoEF through Survey of India will be incorporated into the CRZ maps when these are made available to the State. The respective development authorities and local bodies are consulted at different stages of the development of CZMP. The CZMP will provide the information on HTL, LTL, sensitive ecosystems such as mangroves, sand dunes, beach, etc and its CRZ categories. The GIS based CRZ information system under development will help decision making process on CRZ transparent and simple.

K. V. Thomas

Funding: MoEF, Government of India

3.5 Biophotonics

3.5.1 Inactivation of pathogenic bacteria in periodontal diseases – Fluorescence diagnosis and photodynamic therapy

This project aims to study the effectiveness of antimicrobial photodynamic therapy (aPDT) in the treatment of aggressive periodontitis. As part of this project Profs. Latchezar Avramov and Stefan Angelov of the Bulgarian Academy of Sciences, Sofia, Bulgaria visited the Biophotonics Laboratory of CESS and carried out joint studies on the fluorescence characteristics of dental plaques collected from patients with periodontal infections. The collaborating institutes involved in this project from India are the Azzezia Dental College, Kollam and the RGCB, Trivandrum.

DR spectra were recorded on a spectrometer with white light illu-

mination in 70 healthy sites, and 63 gingivitis and 58 periodontitis infected sites by fibre optic point measurements (Fig. 3.5.1.1). Clinical parameters such as probing pocket depth, attachment level and gingival index (GI) were also recorded in the patient population. Diagnostic accuracies for discrimination of gingivitis and periodontitis from healthy gingiva were determined by comparison of DR spectral signatures with GI. Divergence of average DR spectral intensity ratio between control and test groups was studied using

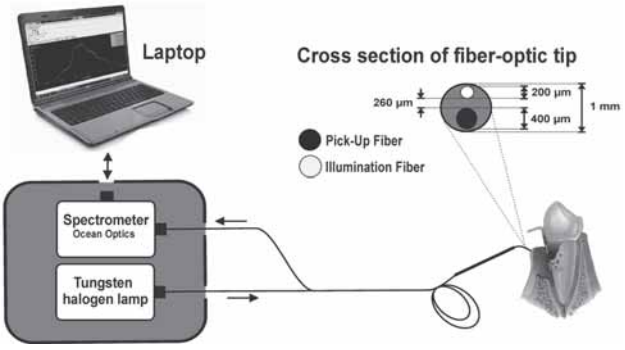


Fig. 3.5.1.1 Schematic of the experimental set-up for in vivo DRS measurement of periodontal diseases

ANOVA.

The mean DR spectrum on normalization at 620 nm showed marked differences between healthy, gingivitis and periodontitis. DR spectral intensities at 545 and 575 nm showed a decreasing trend with the progression of disease. Among the various DR intensity ratios studied the R620/R575 ratio provided a sensitivity of 90% and specificity of 94% for discrimination of healthy tissues from gingivitis and a sensitivity of 91% and specificity of 100% for discrimination of gingivitis from periodontitis.

N. Subhash

Funding: Indo Bulgarian collaborative project funded by DST, Government of India

3.5.2 Sunlight-induced multi-spectral fluorescence imaging system for vegetation assessment

Vegetation fluorescence reflects the physiological status of plants and this principle has been applied in classification of plants, identification of vegetation characteristics, physiological and nutrient stress detection, weed infestation identification and related developments. As sunlight-induced fluorescence is very weak compared to reflected sunlight, special instrumentation and signal processing techniques are required. This is accomplished by using an electron multiplied CCD (EMCCD) camera. In addition to the chlorophyll bands centered on 685 and 730 nm, fluorescence spectrum of vegetation consists of the blue-green bands centered on 440 and 520 nm arising from the pigments in the cell vacuoles of the epidermal layer.

It is well established that the intensity ratios of these emission bands, in particular the chlorophyll bands, are good indicators of photosynthetic function. However, recording of fluorescence images of plants at these emission peaks is a daunting task owing to the presence of strong reflectance and scattered background radiation. This is overcome by the Fraunhofer line discrimination (FLD) technique where sunlight reflected from plants is recorded at four ultra-narrow Fraunhofer lines located close to the plant fluorescence spectrum, in the green region at 532 nm, yellow at 607 nm, red at 687 nm and the far red at 735 nm and

Fig.3.5.2.1 The multi-spectral imaging system developed in Biophotonics Laboratory for vegetation studies

off these lines, and corrected for plant reflectance using a reflectance standard.

As part of this project a multi-spectral imaging system (Fig. 3.5.2.1) consisting of an EMCCD Camera (Andor Technology, UK, Model: LUCA R-DL-604, 1024x1024 pixels resolution) and liquid crystal tunable filter (LCTF of 7 nm FWHM; CRI Varispec Model: VIS-07-20-STD) operating in the 400 to 720nm range was developed for fluorescence imaging of vegetation. Using this instrument plant fluorescence as well reflectance images were recorded at various emission wavelengths. In Fig. 3.5.2.2 the F685/F720 ratio image of a partially dry leaf is displayed in false colours with a ratio value of 0.66 for blue, 0.829 for green and 0.918 for red. The ratio values increased from green part of the leaf to yellow region and to brown part of the leaf.

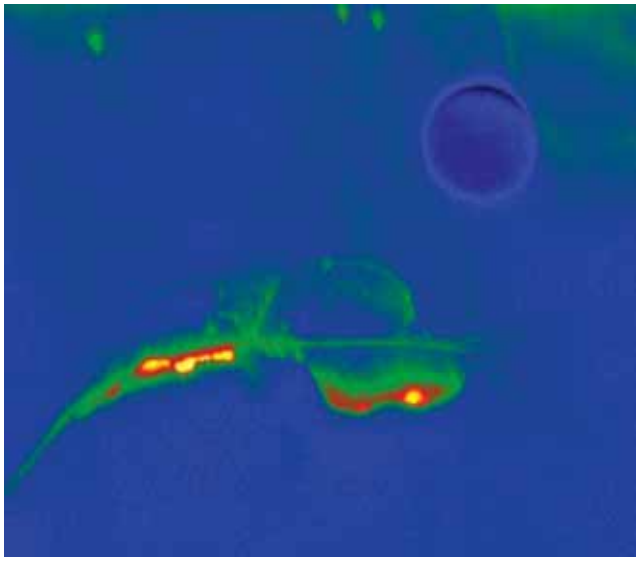


Fig. 3.5.2.2 Variation in chlorophyll fluorescence image ratio of a partially senescent -dry leaf on a dark background.

Reflectance images of distant vegetation were recorded at 720 and 687 nm with the imaging camera system for studying the impact of stress on NDVI (Normalized Difference Vegetation Index). NDVI which gives the value of productivity of a plant was calculated from the visible and NIR light reflected by vegetation. i.e., NDVI= (NIR-VIS)/ (NIR+VIS). For a green denser

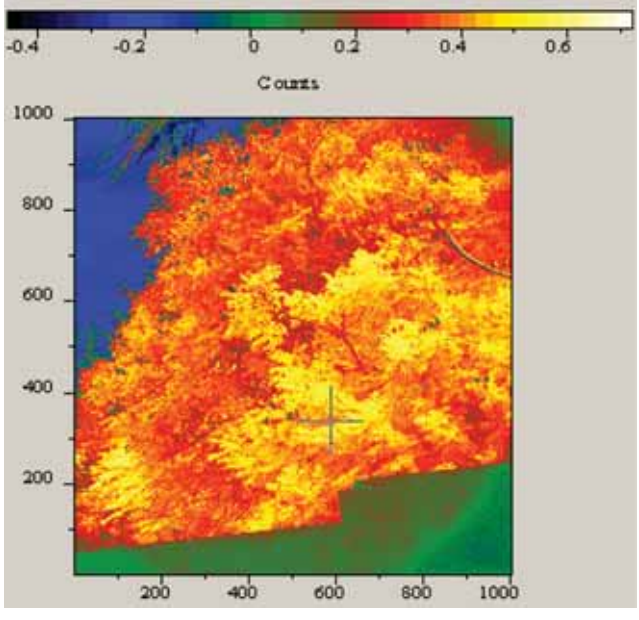


Fig. 3.5.2.3 False colored NDVI image of a tree 100 meter away from camera

region the value would be around 0.5 to 0.7 (typical range is between -1 and +1). The false coloured NDVI image of a tree is shown in Fig. 3.5.2.3; the area with vegetation is shown as red to yellow with the NDVI varying from 0.2 to 0.6. Healthy vegetation absorbs most of the visible light that falls on it and reflects a large portion of the NIR light. Unhealthy or sparse vegetation reflects more visible light and less NIR light, yielding a lower NDVI. The fluorescence ratio F687/F720 showed an increasing trend with senescence from 1.22 to 1.35, while the NDVI from the corresponding image area shows a decreasing trend from 0.27 to 0.13.

The results of the preliminary studies demonstrated the potential of multi-spectral fluorescence and NDVI imaging to differentiate between healthy, senescent and diseased leaves. Since the bandwidth of Fraunhofer lines is of the order 1nm procurement of narrow band interference filters matching with the Fraunhofer lines (on and off lines) was initiated to record sunlight-induced fluorescence images in outdoor plants.

N. Subhash

3.5.3 Monitoring the impact of environmental changes in corals of Lakshadweep archipelago by fluorescence imaging

A laser-induced multi-spectral fluorescence imaging system (LIMFIS) has been developed for studying coral health (Fig. 3.5.3.1). The system consists of a diode pumped solid- state laser (DPSS) emitting at the sea water transmission window of 457 nm, with a CW power of 200 mW (Shanghai Dream Lasers Technology Co. Ltd., China, Model: SDL-457-200T) that also operate in the pulse mode up to 20 kHz rep. ratefor excitation of fluorescence from corals. An intensified CCD camera (Andor UK, Model: DH 734; 1024X1024 pixel) captures the laser-induced fluorescence images of corals. In order to capture the fluorescence images at various emission peaks of corals, a liquid crystal tunable filter (LCTF) that can be tuned to any wavelength between 400 to 720 nm (Cam-

Fig. 1.3.3.1 LIF imaging of corals using LIMFIS at CMFRI, Vizhinjam

bridge Research & Instrumentation Inc, USA; Varispec LCTF Model VIS-20-20) was inserted in front of the ICCD camera, which is triggered by the laser pulse and gated to avoid interference from ambient light.

The corals studied were brain corals belonging to the Favidae family and were grown in a large tank with adequate lighting and aeration. A mirror was used to deflect the expanded laser beam on to the coral while another mirror collects the emanating fluorescence to the camera (Fig. 3.5.3.1). The camera captures monochrome fluorescence images at different chosen wavelengths with a Nikon 35-70 zoom lens fitted on the ICCD camera. Changes in fluorescence images during coral bleaching were studied with the LIMFIS in collaboration with the CMFRI, Vizhinjam. The F680/F720 ratio values were calculated from the ratio images for the healthy region, region adjacent to bleached area and the fully bleached region. The ratio values were found to decrease with the extend of bleaching (Fig.3.5.3.2).

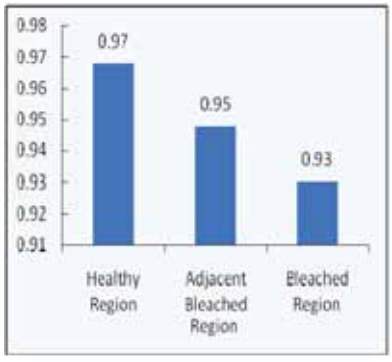


Fig. 3.5.3.2 Histogram showing the reduction in F680/720 ratio as bleaching progresses

N Subhash

Funding: DST, Government of India

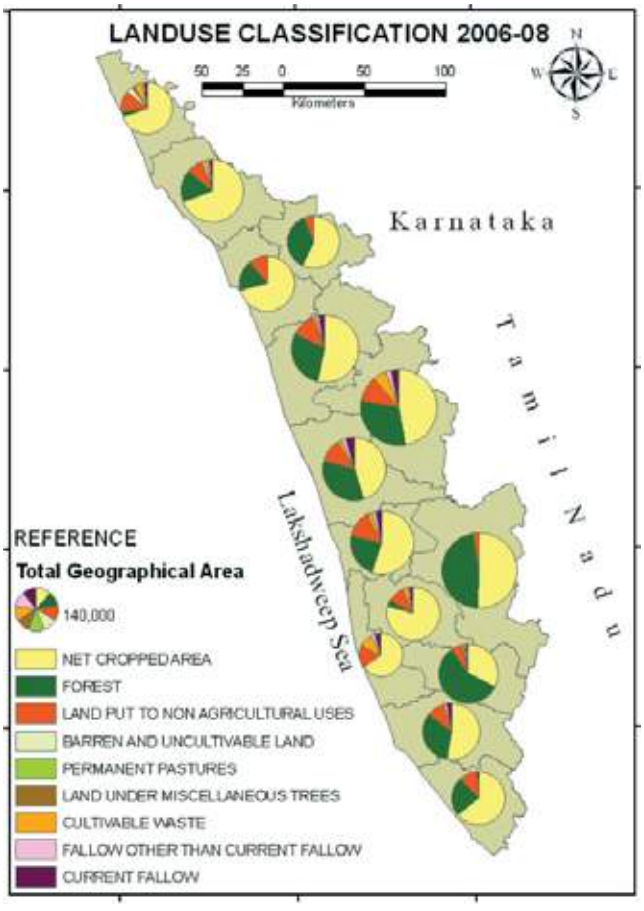


Fig. 3.6.2.1 Thematic map prepared for the Agricultural Atlas of Kerala

3.6 GIS and Remote Sensing Applications in Natural Resources Management

3.6.1 Agricultural Atlas of Kerala

The Agricultural Atlas will provide detailed information on regional cropping pattern, agricultural production, landuse and ecological conditions of Kerala. Agricultural data were collected for the period of 1986 to 2008 from various sources. The decennial average of area and production of agricultural crops were calculated for the years 1986-95 and 1996-2005. Similarly, for the years of 2005-2008 average area and production of agricultural crops were calculated. Based on this, multi-colour thematic maps were prepared showing the spatial distribution and production of crops. Cropping pattern map of Kerala for the periods 1986-95, 1996-2005 and 2006-2008 was prepared. Further cropping intensity map of Kerala was prepared for the periods 1986-95, 1996-2005 & 2006-2008. Eight fold landuse classification of Kerala for the years 1986-95, 1996-2005 and 2006-2008 were prepared. Appropriate cartographic techniques were used in the preparation of maps. Altogether 208 multi colour thematic maps were prepared using remote sensing and GIS. Fig 3.6.2.1 is one example of multi colour thematic map prepared for this Atlas.

E Saravanan

3.6.2 Digital Resource Atlas of Kerala

The project aims to bring out digital resource atlas of Kerala producing thematic maps in 1:1,000,000 scale with updated information and preparing new thematic maps in 1:250,000 scale. The themes cover land, water, climate, agriculture, demography, socio-economy, infrastructure and similar other aspects. These maps will be useful for planning and other purposes. One sample map is given in Fig 3.6.1.1. So far 151 thematic maps were prepared in ArcGIS format.

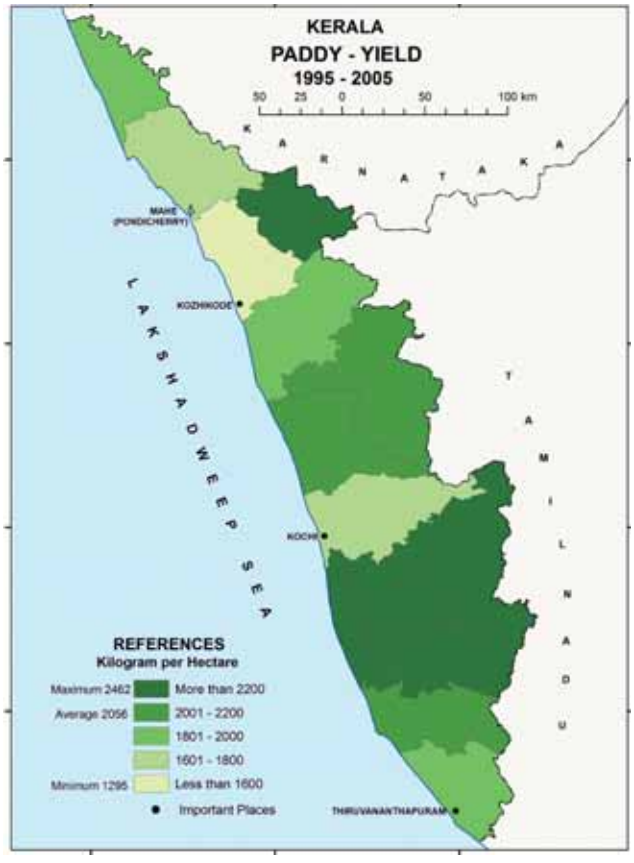


Fig. 3.6.1.1 A typical thematic map

B. Sukumar

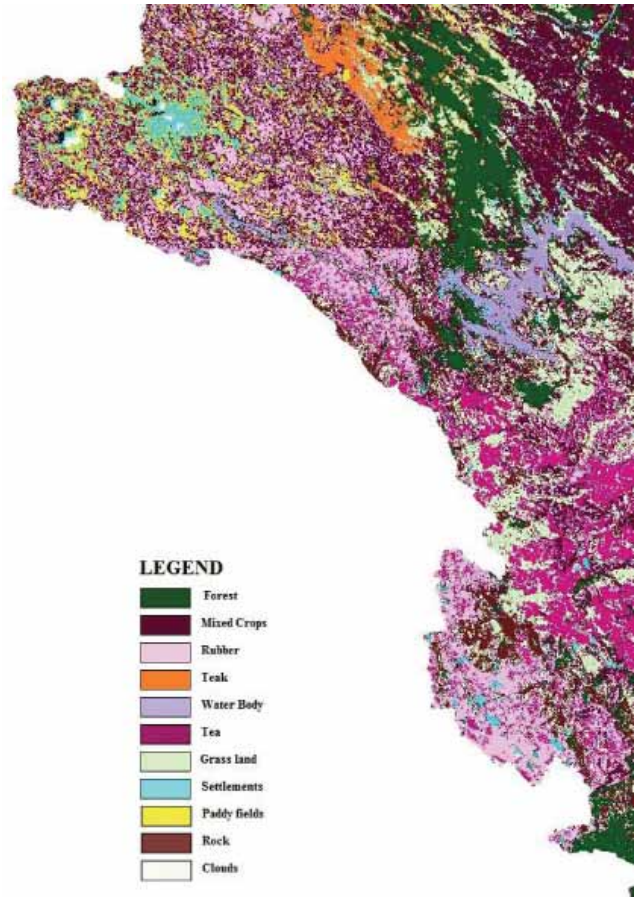


Fig. 3.6.3.1 A classified thematic map

3.6.3 Application of neural network in pattern classification of remotely sensed images

IRSP6 AWiFS satellite data of March 2007 were collected from NRSA for Idukki district. Nine day preliminary ground truth survey was conducted in the study area during March 2009. The major land-cover classes were identified. In training data set preparation, the multispectral parameters were extracted for 11 classes from the training sites identified in the image. Different ANN architectures with multiple hidden layers were created, and classification was carried out with different neural network architectures. The result shows an improvement in classification accuracy with the addition of hidden layers.

The number of unclassified/misclassified pixels were reduced with the addition of hidden layers, this in turn improves classification accuracy. ANN architecture 4-18-9 means that ANN network has 4 neurons in the input layer, 18 neurons in the hidden layer and 9 neurons in the output layer. This network has only one hidden layer. In the network 4-18-14-9, there are two hidden layers with 18 neurons in the first and 14 neurons in the second hidden layer. Similarly network 4-18-12-10-9, has three hidden layers with 18 neurons in first, 14 neurons in second and 10 neurons in the third hidden layer.

The resolution of the imagery of Idukki district is 1326 x 1846 pixels which is difficult for the MATLAB to handle. Therefore the imagery is segmented into four parts and the classified thematic map of completed area is shown in Fig. 3.6.3.1.

K. J. Mathew

3.6.4 Cadastral Level Decision Support System for Management of Natural Resources in Thiruvananthapuram District

The objectives of the project are (a) integration of land and water resource information in a cadastral base through integration of geo-informatics with particular focus on local level development, (b) developing a spatial information base for various levels of ur-

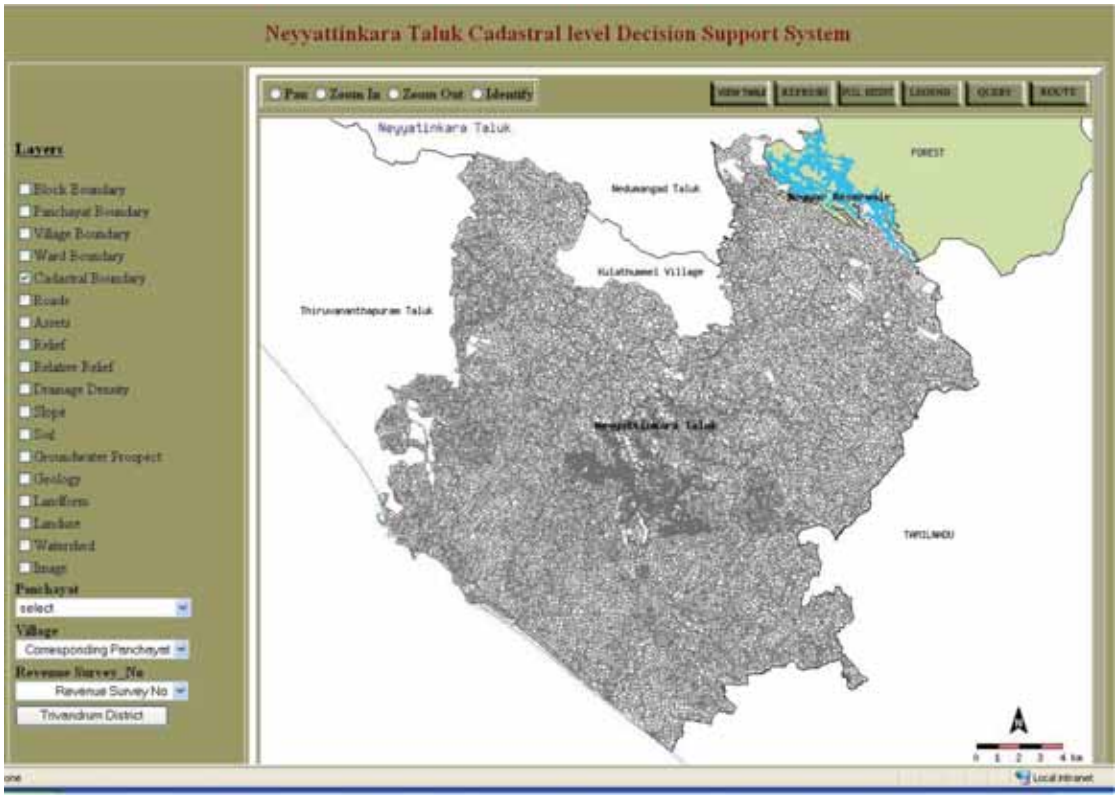


Fig. 3.6.4.1 A screen shot of the Desicion Support System showing survey plot-wise information

ban/rural planning, (c) developing a standard format for data exchange and (d) developing a Decision Support System to establish a Resource Information Centre with the participation of panchayat functionaries / people's representatives. However, due to the large volume of work components involved and inordinate delay in completing the DGPS survey, it was decided to modify the objective and complete the project by developing a DSS for the LSGD blocks and municipality of one taluk at cadastral level. Thus after integrating the digital database, the DSS for the Neyyattinkara taluk was attempted.

Survey plot-wise distributions of different themes have been generated for the thematic layers of Neyyattinkara taluk (Fig.3.6.4.1). The major themes integrated are administrative wards of the local bodies, village boundaries, transport network, drainage network, drainage density, landform, landuse, lithology, watersheds, slope, soil, relief, relative relief and ground water prospects. A cadastral level Decision Support System has been developed in-house using Map Server Open Source UMN. The program has been developed using PHP with mapscript and backend data stored in Post GIS enabled PostgreSQL. The DSS has user-friendly menus for display of thematic layers based on user queries. Multiple thematic layers can be integrated and queried with operands and fields of user's choice. The parcel wise information of different themes can be retrieved and displayed. The attribute data can be exported to .xls format. It has the facility to find the shortest path in a road network between junctions. It has certain facilities of GIS proprietary software. Users can take printouts of their area of interest in desired scales. This is a cost effective application and doesn't require license for deployment. This can be hosted in the intranet or internet..

Jayaprasad B K

3.6.5 Natural resources and environmental data base updation and utilization for local level planning in Kerala-Database infrastructure support

Under the State Planning Board's scheme on 'Application of Space Technology for the Development of Kerala' CESS has developed 'District Resource Information System' (DRIS) for all the fourteen districts of Kerala utilizing the Natural Resource and Environmental Database (NREDB) generated in 2008 with the financial assistance of the ISRO. The Kerala State Planning Board has requested CESS to re-organize the NREDB based on the 24 Agro Ecological Units identified by the National Bureau of Soil Survey and Land Use Board (NBSSLUB). Accordingly the NREDB is being re-organized with respect to the AEUs (Agro Ecological Units) identified by the NBSSLUB. Agro Ecological Unit-wise atlases are being prepared with multi color thematic maps in A3 paper size format. A customized application is also being developed as part of the project using ESRI Map Objects and Visual Basic 6.

Fig. 3.6.5.1 Agro-ecological units of Kerala

Jayaprasad B K
Funding: Kerala State Planning Board

3.6.6 Soil based Plant Nutrient Management Plan for the agro-ecosystems of Kerala

The primary objective of this project is to generate local body level base maps for all the fourteen districts of Kerala using standard geographic reference datum and projection (WGS 84 datum and UTM Zone 43 projection) and to generate hardcopy maps to locate 2,36,379 soil sample sites in the Kerala state to prepare Soil Fertility and Nutrient Management Plan for the Agro Ecological Zones of Kerala. In connection with the project, the resource persons and volunteers were trained by CESS at six institutions viz. CTCRI, Thiruvananthapuram, RARS Kumarakom, KVK, Ambalavayal, College of Agriculture, Padannakkad, RARS, Pattambi and ICRI, Idukki. The analyzed soil parameters will be spatially located and spatial analysis will be carried out using GIS software. Comprehensive spatial analysis of micro, macro and secondary nutrients in all panchayats, municipalities and corporations will be made to prepare 'Plant Nutrient Management Plans' for panchayats, districts and the whole state using Geographic Information System software.

Jayaprasad B K
Funding: Kerala State Planning Board

3.6.7 Development of Tribal Information System for particularly vulnerable tribal groups of Kerala

In the present study Tribal Information System was developed as a stand-alone user friendly software with all the basic functionalities customized to generate information pertaining to five particularly vulnerable tribal groups of Kerala. Spatial information of each tribal settlement is considered as point shape file. The socio-economic aspects and household information about each settlement was taken as attributes linked to the point shape file. The spatial information on tribal settlements stored in the form of point shape files are linked to the information pertaining to each house hold as well as each member of the settlement. The settlements contain a minimum of one house hold to more than fifty households. The tribal settlement information is further linked to the natural resource database such as landuse/land cover and water bodies as well as to the administrative divisions and road/rail network. Thus the data consists of themes on administrative divisions, viz., district, block and panchayat boundaries, place names, rivers and streams, transportation network, land use, landform, relief, soil, spatial information on tribal settlement and socio-economic aspects of all members in each tribe.

Information pertaining to five tribal groups can be retrieved either in the form of one particular tribal group (Fig.3.6.7.1) or based on the district. Results based on various logical query statements regarding tribal groups can be displayed in the map as pie charts. The same results can also be viewed in table format also. Settlements can be buffered on various themes. For example, land use classes falling within a radius of 1500m for a particular settlement can be retrieved and filtered from the rest of the data. The data so filtered can be displayed in the form of a map and can also be displayed in table format using identifier. Shortest path from one place to other can be displayed using click-points on map based on transportation network. Aerial distances can be measured between two points using spatial measurement tool.

The main advantage of such a standalone information system is the amount of customization that can be done based on the user requirement. The software is user friendly with better integration possibilities and gives more data security. The main disadvantage of this type of software is its limited support for latest versions of

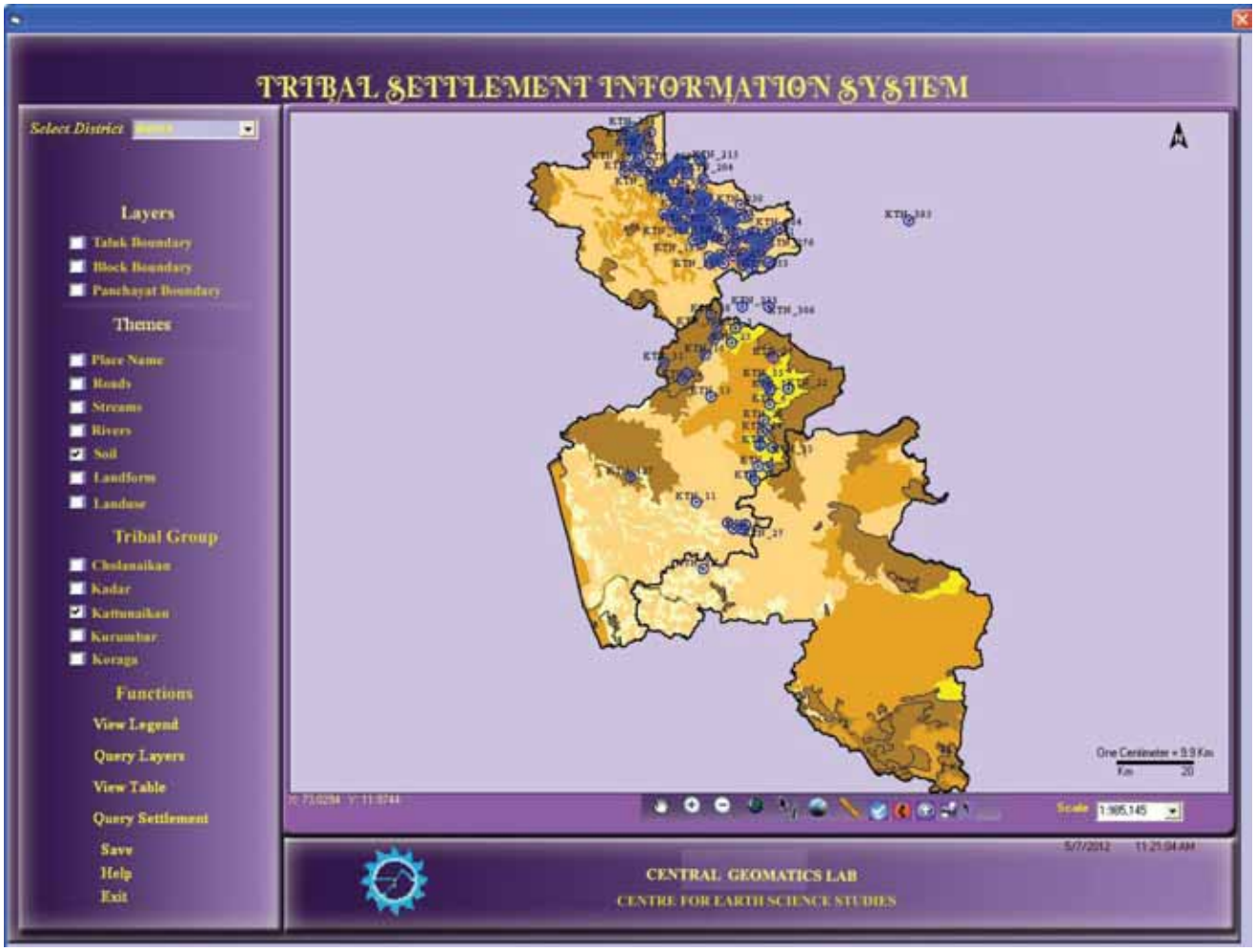


Fig.3.6.7.1 A Screen shot of the Tribal Information System

data format types and platforms. Other disadvantages are limited options for map output, lack of coarse grained objects and controls.

Archana M Nair
Funding: KIRTADS, GoK

3.7 Energy Studies

3.7.1 The Social impacts of energy technologies: Two case studies at different environs of Thiruvananthapuram district

The objectives of the project are to understand: (a) what necessitates the adoption of energy technologies, (b) how far the choices of energy technologies have met with their needs and (c) the gender related impacts of the adopted energy technologies. Survey of household energy consumption has been completed. Analysis of collected data was made.

K. Vijayakumar

3.8 Climate Change Studies

3.8.1 Monitoring Climate Change impacts in Sahyadri

Climate change is a multi-faceted issue, incorporating direct and indirect effects on human activity. Direct effects include land use conversion and intensification, and emissions of pollutants (eg. NOx, O_3, heavy metals, acids). Indirect effects include atmospheric change associated with increase in trace gas emissions and stratospheric ozone degradation and subsequent impact on climate and UV-B radiation. Mountains are home and hotspots to a substantial portion of the planet's diversity of species and ecosystems. Globally, mountain regions provide water to about

50% of the world's population both in the mountains themselves and also to the downstream lowlands. Some of the direct effects of global change can only or best be studied in high mountains since these systems are among the few where direct human impacts are not so pronounced. Therefore, Western Ghats (WG) mountain regions present unique challenges and opportunities for Global Change research.

Being one of the Global hotspots of biological diversity, this programme is focusses on the Southern Western Ghats. The project is conceived to concentrate on major themes that provide a minimal set of research and monitoring requirement to study global change impacts in a cross section of area south of Palghat gap and north of the Achenkoil shear zone. The transect study initially selected the Eravikulam National Park (ENP), the highest plateau in WG with montane cloud forests as the reference point which are relatively undisturbed for data collection. This core area of sholas, adjoining moist forests of Idamala Puyankutty valleys in the western slopes, the dry deciduous Muthirapuzha- Chinnar valleys in the eastern slopes, and relatively disturbed Anjanad valley and Kannandevan hills are planned for continuous monitoring and field study to ascertain probable impact of climate change and to find out model mitigation and adaptation strategies.

The steep slopes found in WG regions give rise to some of the sharpest environmental gradients found on land surfaces. The characteristics of these gradients include: rapid and systematic changes in climatic parameters, especially temperature and precipitation, over very short distances. Sharp climatic changes independent of photo-period (length of daylight) and often of soil type (thus, they complement high latitude gradients where photoperiod and soil type often change). Mountains also harbor systematic often-monotonous variations in slope angle, aspect and exposure. This would greatly enhance direct runoff and erosion, thus strongly influencing the overall hydrology. Systematic variation of other environmental parameters includes soil depth, structure, CO_2, UV-B radiation with elevations. The listed characteristics make mountain regions providing basic understanding of hydrological and ecological responses to global change, particularly susceptible to the impacts of a rapidly changing climate, likely to be the areas where signals of climate change impacts can be expected and studied on a long term basis.

Natural processes and socio-economic responses along altitudinal gradients in WG mountain areas are yet to be studied in detail. Along altitudinal gradients, ecosystems often show differential, highly non-linear responses to changes in environmental parameters. Hence the extrapolation of information gathered from site-oriented studies often is not appropriate. On the other hand, vegetation that stabilizes soils has a profound influence on hydrology and, specifically, on downslope safety. Thus, comprehensive, gradient-oriented basic research is a fundamental requirement to advance a predictive understanding of hydrology and ecology in mountain regions.The project envisages long term permanent plots, climate change studies through setting up Green house gas observatory at Munnar, and regional correlation/modelling studies.

C N Mohanan

3.8.2 Effect of urbanization on the buildup of urban heat island in Kochi

The project aims to measure the air temperature, humidity and surface temperature of building exteriors and road surfaces, soil moisture and soil temperature, wind velocity, rainfall etc. at a number of locations in Ernakulam city and adjoining rural areas and to collect data regarding vegetation cover, floor area, coverage area, W/H ratio of the street, resident population, electricity consumption etc. Survey on urban landuse and mapping of urban climate zones was carried out.

Urban regions of the world which cover only about 2 percent of earth's surface host nearly 50 percent of global population. This trend is still increasing and may reach 60 percent by 2030, according to some estimates. Though the level of urbanisation in Kerala cities is not as intense as in the west, we have also started observing the signs of urban climate modifications. Urban Heat Island (UHI),

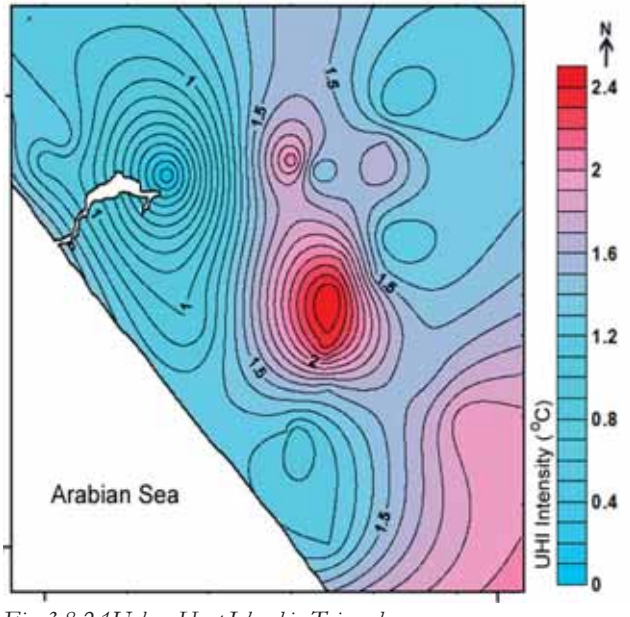


Fig. 3.8.2.1 Urban Heat Island in Trivandrum

the night time elevated temperatures observed within the urban center compared to its rural surroundings, is the most pronounced

among such modifications. This temperature elevation can be as high as 8-10 °C, in large and densely populated urban areas. Thiruvananthapuram and Kochi currently exhibit a UHI in the order of 2-4 °C. Mobile traverse surveys to record air temperature in Kochi and Thiruvananthapuram cities, as well as measurement of ground level mixing ratio of methane in these urban region were carried out. Fig. 3.8.2.1 shows the Urban Heat Island distribution of Trivandrum.

E. J. Zachariah

3.8.3 Monitoring of soil moisture under bare and cropped conditions

This project aims at validating single layer moisture model for tapioca/pineapple in Thodupuzha area (midlands of Western Ghats) with inputs on weather data, soil moisture at different depths. Observation of manual weather data on rainfall, temperature, humidity, wind direction/speed and soil temperature were completed in the Malankara area of Thodupuzha and arranged in the required format. Based on soil temperature at different depths, soil moisture was estimated using the facilities at the Pineapple centre, Vazhakulam. Soil models for the study were obtained from ICRISAT/CRIDA for validation.

P.V.S.S.K. Vinayak

Funding: Kerala State Planning Board, Government of Kerala

3.8.4 Nitrous oxide and methane in coastal ocean and estuaries

Nitrous oxide and methane are strong greenhouse gases with a large potential for global warming through radiative forcing of the Earth's climate system. Both these gases have their major natural sources in the coastal environment.

Sampling and analysis of water and sediments from estuaries and coastal regions off Kerala coast were continued. Water to air fluxes of Methane as well as presence of Methane and Nitrous Oxide in dissolved form in the water were estimated. Horizontal as well as vertical distribution of these gases in estuaries and coastal waters along with other related water and sediment parameters were obtained. Offshore sampling was done at a grid interval of approximately 00:03:00 while vertical profile was obtained at a sampling interval of 5m off Neendakara, Kayamkulam, and Thottappally coasts. Dissolved methane in the surface layers off Thottappally is given in Fig. 3.8.4.1

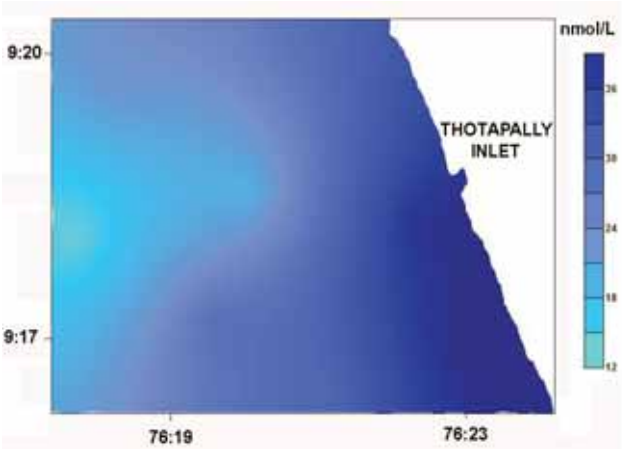


Fig. 3.8.4.1 Dissolved methane (nMol/L) in the surface layers of the coastal ocean off Thottappally.

The estuarine discharges to coastal ocean have been identified as a significant source of oceanic methane and nitrous oxide in the coastal regions. The data were analysed and compiled and interim report was submitted. Methane was measured using FID and nitrous oxide using ECD on a gas chromatograph. Estuarine discharges are modeled using standard methodologies like LOICZ model.

E. J. Zachariah

Funding: Ministry of Earth Sciences, Government of India

4.1 Coastal Regulation Zone Status Reports

In recognition of our expertise in the field of Coastal Zone Management, CESS has been authorized by the Govt. of India as one among the 7 institutes in the country to demarcate the High Tide Line and Low Tide Line for the purpose of Coastal Regulation Zone (CRZ). CRZ Reports were being prepared through identifying the coastal ecosystem and delineating HTL and LTL. It also included identification of different categories of Coastal Regulation Zones based on land use, landform and status of development. The CRZ maps were prepared in cadastral scale for easy interpretation by implementing agencies. DGPS control points are relied upon for rectification and data input.

The extent of influence of tidal action in the water bodies was determined based on salinity. The HTL and LTL were determined from geomorphologic signatures such as berms crests, tidal flats and cliffs. The sensitive coastal ecosystems such as mangroves, sand dunes, tidal flats, fish breeding grounds, etc. were identified and their spatial extent demarcated. The CRZ report and maps help the decision making authorities to identify the areas for conservation and protection and for development in the coastal zone.

CRZ mapping has been undertaken for different departments and public undertakings in the State. The Kerala Minerals and Metals Ltd, Indian Rare Earth Limited, National Highway Authority of India, NTPC are some of the organizations for which CRZ mapping has been undertaken. In addition to this a major CRZ mapping programme is being carried out for the Govt. of Maharashtra. A list of projects implemented during the year is given in Table 4.1.1

Technical support was provided to KSCSTE and Kerala Coastal Zone Management Authority on numerous issues connected with Coastal Regulation Zone, such as court cases, expert opinion on violations and CRZ clearances.

Table 4.1.1 List of CRZ Reports during the year 2010-11

Sl.No.	Institution	Location	Project
1.	Greater Cochin Development Authority	Kochi, Kerala	Ring road
2.	National Highway Authority of India	Kannur-Kuttippuram, Kerala	Upgradation & Widening of NH roads
3.	Synthite Industries Ltd.	Ernakulam, Kerala	Hotel Complex
4.	Indian Rare Earths Ltd.	Kollam, Kerala	Mining Block in Arattupuzha, & Cheryazheekkal in Alappad
5.	Om Prakash & CO, Mumbai	Versova village, Mumbai, Maharashtra	Development Project
6.	National Highway Authority of India	Cherthala-Trivandrum, Kerala	Upgradation & Widening of NH roads
7.	National Highway Authority of India	Kasargod-Kannur, Kerala	Upgradation & Widening of NH roads
8.	Niyama Ayurvedic Beach Resorts (P) Ltd., Thrissur	Chavakkad, Thrissur, Kerala	Ayurvedic Resort
9.	JSW Energy (Ratnagiri) Limited, Maharashtra	Chaferi, Ratnagiri, Maharashtra	Power Project
10.	Berggurian Hotels Pvt. Ltd, Mumbai	Thevara, Ernakulam, Kerala	Hotel
11.	Marari Beach Resorts Pvt Ltd, Kochi	Mrarikkulam North, Alappuzha, Kerala	Beach Resort
12.	Goodwill Investment Company Pvt. Ltd.	Bandra, Mumbai, Maharashtra	Development Project
13	Goshree Islands Development Authority	Moolampilly Chathanad, Kerala	Moolampilly-Chathanad Road
14.	Tourist Resorts (Kerala) Ltd., Government of Kerala	Veli, Trivandrum, Kerala	Veli Tourist Village

Sl.No.	Institution	Location	Project
15.	Indian Garnet Sand Co. (P) Ltd. Chennai	Ratnagiri, Maharashtra	Mining site
16.	Essar Steel Ltd.	Hazira, Surat, Gujarath	Steel Industry
17.	Muthoot Hotels and Infrastructure Ventures (P) Ltd, Thiruvananthapuram	Adimalathura, Chowara, Thiruvananthapuram	Beach Resort
18.	Holiday Mantra Hotels & Resorts Ltd, Trivandrum	Manrothuruth, Kollam, Kerala	Tourist Resort
19.	Kerala Minerals and Metals Ltd. Chavara	Neendakara, Chavar, Alappad, Azheekkal, Kollam, Kerala	Mining site
20.	DHI (India) on behalf of GAIL.	Vypeen-Kayamkulam, Kerala	Pipeline
21.	Larsen & Toubro Ltd.	Suvali Village, Surat, Gujarath	Expansion of industry
22.	Ellora Project Consultants Pvt Ltd. (Orchid Infra Developers Pvt Ltd)	Juhu & Bandra, Mumbai, Maharashtra	Development Project
23.	Immaculate Conception Church, Pullichira	Pullichira, Mayyanad, Kollam	Church School
24.	Mantra Beach Resorts Pvt Ltd, Kasargod	Kanhangad, Kasaragod, Kerala	Beach Resort
25.	TRIF Projects Pvt. Ltd., Kochi,	Ernakulam, Kerala	Group Housing Project
26.	Kuruvi & Kuruvi hotels Pvt. Ltd. Cochin	Pollethai, Mararikkulam, Alappuzha, Kerala	Tourist Resort
27.	M Y Chouhan	Versova Village, Maharashtra	Development Project
28.	Edava Panchayath	Edava Panchayath, Thiruvananthapuram	Coastal zone of Panchayath
29.	Harbour Engineering Dept. GoK	Thiruvananthapuram	Ports
30.	EQMS India Pvt. Ltd., Delhi	Versova Village, Maharashtra	Communication Cable Entry Point
31.	Moosa,Uppala, Kasargod	Uppala, Kasargod, Kerala	Ayurvedic Resort
32.	National Thermal Power Corporation, Kayamkulam	Cheppad, Kayamkulam, Kerala	Expansion of Project
33.	Aegis Logistics Ltd.	Mahul Village, Trombay, Maharashtra	Bulk Liquid Storage Terminal
34.	DM Health Care Pvt. Ltd., DM Medicity Hospitals India Pvt. Ltd. & M/s. Ambady nfrastructure Pvt. Ltd.	Cheranallur, Ernakulam, Kerala	Hospital cum Hotel Project
35.	Broomfield Builders Pvt. Ltd.	Kadakkampally Village Trivandrum, Kerala	Housing Project
36.	The Vicar, Madre De Deus Church, Vettucaud	Vettucaud, Thiruvananthapuram	Modification of Church

Sl.No	Institution	Location	Project
37.	First Estate Properties Pvt.Ltd.	Thanthonni Thuruth, Ernakulam, Kerala	Housing Project
38.	Meritra Homes Pvt. Ltd	Panangad, Kochi, Kerala	Residential Projects
39.	Oberoi Realty Pvt.Ltd	Juhu Village, Mumbai, Maharashtra	Residential Project
40.	Maritime & Marine Services Pvt. Ltd.	Versova & Andheri Villages, Mumbai Maharashtra	Development Project
41.	Chakolas Habitat Pvt.Ltd.	Edakochi, Kerala	Housing Project

K. V. Thomas, N. P. Kurian, D. Raju, S. Mohanan & M. Ramesh Kumar

Funding: Various Agencies

4.2 Environmental effects of the Pappinisseri Kandal Theme Park

This study was undertaken for the Kerala Coastal Zone Management Authority (KCZMA) . The muti-disciplinary team consisted of experts from CESS as well as from outside. They visited the site, studied the impacts and estimated the damages to the mangrove ecosystem in Pappinisseri, Kannur. The report has been submitted to KCZMA.

4.3 Environmental impact of the proposed Super thermal plant at Chimeni, Kasaragod

This was a multidisciplinary study undertaken for the KSCSTE. The experts from KFRI and CWRDM were involved in the study. The report has been submitted to KSCSTE.

List of Projects

5.1 External Grant-in-aid Projects

Sl. No.	Project Title	Funding Agency	Principal Investigator	Division	Co-Investigators	Project Period	Total Outlay (Rs. in lakh)	Fund received during the year (Rs. in lakh)
1.	Paleointensity and reunion/marion plume activity in India (Indo-French)	Indo-French Centre for the Promotion of Advanced Research	Dr. T. Radhakrishna	Geosciences	Sri. Balasubramonian	2006-09	22.45	0.84
2.	Landslide stabilization schemes of Agricultural Department (AGRI 3)	Soil Conservation Unit, Dept. of Agriculture	Sri. G. Sankar	Geosciences	--	2009-10	0.19	0.34
3.	Oil Spill Modelling for selected locations of Kerala and Lakshadweep (MOES 4)	Ministry of Earth Sciences, GoI	Dr. N. P. Kurian	Marine Sciences	Mrs. Sheela L. Nair, Dr. T. S .S. Hameed, Dr. K. V. Thomas	2009-11	75.00	0.00
4.	River Sand auditing-Periyar (RSA 1)	Revenue Dept., GoK	Dr. D. Padmalal	Environmental Sciences	Dr. K. Maya	2009-10	24.66	0.06
5.	Monitoring the impact of environmental changes in coral of Lakshadweep archipelago by fluorescence imaging (DST 76)	Dept. of Science & Technology, GoI	Dr. N. Subhash	Atmospheric Sciences	Dr. T. N. Prakash, Dr. M. S. Syed Ismail Koya (DST, UTL)	2008-11	34.44	4.00
6.	Inactivation of pathogenic bacteria in periodontal disease: Fluorescence diagnostics and photo-dynamics therapy (DST 77)	Dept. of Science & Technology, GoI.	Dr. N. Subhash	Atmospheric Sciences	Dr. Ajayakumar & Dr. E. Sreekumar (RGCB) Dr. N. Nandakumar (ADC), Dr. L. Arramov (BAS, Bulgeria)	2008-11	5.27	1.75
7.	Interstitial water chemistry of aquatic environments and its significance in nutrient dynamics : a case study (DST 75)	Dept. of Science & Technology, GoI	Dr. K. Narendra Babu	Chemical Sciences	Dr. D. Padmalal	2008-11	15.22	4.00
8.	Spatio-temporal shore changes during Holocene and tracing the evolutionary history of the Ashtamudi estuary, Southern Kerala (DST 78)	Dept. of Science & Technology, GoI	Dr. T. N. Prakash	Marine Sciences	Dr. M. Samsuddin Prof. Nagendra, Anna University	2009-12	30.38	7.13
9.	Coastal ocean monitoring and prediction system along the coast of Kerala, Karnataka and Lakshadweep islands. (COMAPS 3)	Ministry of Earth Sciences, GoI	Dr. K. Narendra Babu	Chemical Sciences	--	2008-13	222.50	21.70
10.	Environmental Management Plan for Alappuzha-Sherthalai Canal and Kanjikuzhy Grama Panchayat-A participatory action research programme (KSCS 11)	Kerala State Council for Science, Technology and Environment	Dr. Srikumar Chattopadhyay	Resources Analysis		2008-10	7.50	0.00
11.	Application of Space Technology for the development of Kerala (PLG 13)	Kerala State Planning Board	Sri.V.N.Neelakandan	Central Geomatics Lab	Mr.B.K.Jayaprasad	2008-11	12.62	0.00

Sl. No.	Project Title	Funding Agency	Principal Investigator	Division	Co-Investigators	Project Period	Total Outlay (Rs. in lakh)	Fund received during the year (Rs. in lakh)
12	Shoreline Management Plan for Kerala (MOES 3)	Ministry of Earth Sciences	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian, Dr.T. S. Shahul Hameed, Mrs. Sheela Nair L., Dr. Reji Sreenivas	2008-12	176.63	0.00
13	Rainfall validation & characterization and cloud physics studies using megha tropiques data (SAC 13)	Space Applications Centre	Dr.G.Mohan Kumar	Atmospheric Sciences		2007-10	31.82	4.60
14	Optical characterization of coral reef diversity for understanding the impact of changing environmental conditions (SAC 14)	Space Applications Centre	Dr. M. Samsuddin	Central Geomatics Lab	Dr. T. N. Prakash	2009-13	15.00	3.80
15	Physical, chemical & biological monitoring study at dredging site in Vembanad lake (TCL 2)	Travancore Chemicals Ltd.	Dr. P. K. Omana	Chemical Sciences	--	2008-10	1.15	0.57
16	Shore Protection Measures for Lakshadweep Islands (UTL 5)	Dept. of Science & Technology, UT, Lakshadweep, GoI	Dr. T. N. Prakash	Marine Sciences	Mrs. Sheela L Nair	2008-10	25.48	0.00
17	River sand auditing Manimala (RD 7)	Revenue Dept., GoK	Dr. D. Padmalal	Environmental Sciences	Dr.K.Maya, Dr.K.Narendra Babu	2008-09	34.53	0.00
18	Environmental Impact of Reservoir desiltation (WRD 1)	Water Resources Dept, GoK	Dr. Srikumar Chattopadhyay	Resources Analysis	--	2009-10	5.75	2.87
19	Nitrous Oxide and methane in coastal ocean and estuaries (MOES 2)	Ministry of Earth Sciences, GoI	Dr. E. J. Zachariah	Atmospheric Sciences	--	2007-10	18.48	4.30
20	Monitoring of soil moisture under bare cropped conditions of tapioca and pineapple in the mid land highlands of Western Ghat areas of Kerala (PLG 11)	Western Ghat Cell, Kerala State Planning Board	Dr. P. V .S. S. K. Vinayak	Atmospheric Sciences	--	2009-10	10.25	0.00
21	Chemical loading reservoirs: Investigation from selected Watersheds of Periyar Basin in Western Ghats, Kerala (DOE 20)	Dept. of Environment, GoI	Dr. M. N. Muralidharan Nair Dr. C. N. Mohanan (since 30.06.2009)	Chemical Sciences	Dr. D. S. Suresh Babu & Dr. R. Ajaya Kumar Varma	2005-09	10.30	2.50
22	Conservation and nourishment of beaches of selected tourism locations of Kerala (TD 2)	Dept. of Tourism, GoK	Dr. K. V. Thomas	Marine Sciences	--	2006-07	20.04	0.00

Sl. No.	Project Title	Funding Agency	Principal Investigator	Division	Co-Investigators	Project Period	Total Outlay (Rs. in lakh)	Fund received during the year (Rs. in lakh)
23	Rejuvenating lateritic areas in Neyyar of Western Ghat region in Thiruvananthapuram using natural rock powder as Geo-nutrient for sustainable agriculture: a technological intervention (PLG 12)	Planning &Economic Affairs (WGC) Department, GoK	Dr. Narayanaswamy	Geosciences	--	2007-10	13.13	0.00
24	Monitoring Indian Shield Seismicity with 10 BBS to understand seismotectonics of the region using V-sat connectivity (MoES 5)	Ministry of Earth Sciences, GoI	Sri. K. R. Unnikrishnan	Geosciences	Mrs. Sreekumari Kesavan	2010-13	13.93	0.00
25	Establishment and maintenance of wave gauge stations in the coastal waters of the SW coast in India (MoES6)	Ministry of Earth Sciences, GoI	Mrs. L. Sheela Nair	Marine Sciences	Dr. T .S. Shahul Hameed, Dr. N. P. Kurian, Dr. K. V. Thomas	2010-12	27.18	15.59
26	Continuous measurement of atmospheric carbon monoxide at Thiruvananthapuram, a Tropical site (ISRO 2)	Indian Space Research Organisation, GoI	Dr. G. Mohankumar	Atmospheric Sciences		2002-06	11.73	0.00
27	Tsunami and storm surge inundation modelling and mapping (MoES 1)	Ministry of Earth Sciences, GoI	Dr. N. P. Kurian Dr. T. S. Shahul Hameed (Since 1-1-2011)	Marine Sciences	Dr. T. N. Prakash, Dr. K. V. Thomas, Sri. B. K. Jayaprasad, T. S.Shahul Hameed	2006-08	27.80	0.00
28	Cadastral scale CRZ maps for Urban areas in Kerala; Phase 1-Kozhikode, Kollam & Trivandrum corporations and Varkala Municipality (KSCS 6)	Kerala State Council for Science Technology & Environment	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian, Sri. D. Raju, Sri. S. Mohanan, Sri. M. Rameshkumar	2006-07	6.99	0.00
29	Study on Depletion of Heavy Mineral content in the Beach washings of IREL, Chavara (IRE 3)	Indian Rare Earths Ltd., Chavara	Dr. N. P. Kurian Dr. T. S .Shahul Hameed (Since 1-1.2011)	Marine Sciences	Mrs. L. Sheela Nair Dr. T. N. Prakash Dr. K. V. Thomas Dr. Reji Srinivas	2010-11	49.00	14.70
30	Generation of Geographic information system of five particularly vulnerable tribal groups (PTG's) (KIRTADS)	KIRTADS	Dr. Archana M. Nair	Central Geomatics Lab	Mr. B. K.Jayaprasad	2010-11	1.86	1.86
31	Sediments budgeting studies for the mining site of Kerala Minerals and Metals Ltd.Chavara (KMML 1)	Kerala Minerals and Metals Limited, Chavara	Dr. K. V. Thomas	Marine Sciences	Dr. T. N. Prakash Mrs. Sheela Nair Dr. T. S. S. Hameed Dr. Reji Srinivas	2010-12	39.50	19.75
32	Soil based plant nutrient management plan for agro ecological zones (SPB 2)	State Planning Board	Sri. B .K. Jayaprsad	Central Geomatics Lab	--	2010-12	13.6	12.69

5.2 Consultancy Projects

Sl. No.	Project Title	Funding Agency	Principal Investigator	Division	Co-Investigators	Project Period	Total Outlay (Rs.in lakh)	Fund Received during the year (Rs.in lakh)
1.	CRZ Status Report	Reliance Infrastructure	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	2.20	2.20
2.	-do-	ESSEL World, Mumbai	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	1.06	1.06
3.	-do-	PSEZ Ltd. Mundra	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	9.96	9.96
4.	-do-	JSW Energy Ratnagiri	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	3.36	3.36
5.	-do-	GCDA, Kochi	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	1.78	1.78
6.	-do-	National Highway Authority of India	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	7.32	7.32
7.	-do-	ADELIE Builders and Developers, Kochi	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	1.5	1.5
8.	-do-	DLF Ltd, Kochi	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	1.49	1.49
9.	-do-	Indian Oil Corporation Ltd, Kochi	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	5.06	5.06
10.	-do-	Centurions, Kochi	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	1.49	1.49
11.	-do-	Niyama ABR-Thrissur, Chavakkad	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11		0.00
12.	-do-	Carnoustie Resorts, Kochi	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	1.65	1.65
13.	-do-	Rizvi Builders, Mumbai	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11		0.00
14.	-do-	Raja Islands, Thrissur	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11		0.00
15.	-do-	Pritam Nair & Associates, Mumbai	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	7.42	7.42
16.	-do-	IREL, Vellanathuruthu, Kollam	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	1.90	1.90
17.	-do-	Burggruen Hotels, Kochi	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	1.47	1.47
18.	-do-	National Highway Authority of India	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	7.44	0.00
19.	-do-	JSW Energy-Chaferi, Ratnagiri	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	6.60	6.60
20.	-do-	Techno park, Kundara, Kollam	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11		0.00

Sl. No.	Project Title	Funding Agency	Principal Investigator	Division	Co-Investigators	Project Period	Total Outlay (Rs.in lakh)	Fund Received during the year (Rs.in lakh)
21	-do-	Apple A Day Properties Ltd, Kochi	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	2.32	2.32
22	-do-	Matsyafed, Thiruvananthapuram	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	0.68	0.68
23	-do-	Synthite Industries Ltd., Kochi	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11		0.00
24	-do-	HarbourEngineering Dept.	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	0.68	0.68
25	-do-	Indian Garnet Sand Co.Pvt Ltd, Ratnagiri.	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	15.72	15.72
26	-do-	Goshree Islands Development Authority(GIDA),Kochi	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11		0.00
27	-do-	Muthoot Hotels & Infrastructure P.Ltd, Adimalithura, Chowara , Thiruvananthapuram	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	0.97	0.97
28	-do-	Goodwill Investment Co., Mumbai	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	0.97	0.97
29	-do-	Marari Beach Resorts P.Ltd., Cherthala	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11		
30	-do-	KMML Chavara, Kollam	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	7.35	7.35
31	-do-	DHI Water & Environment, Vypeen-Kayamkulam.	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	3.45	3.45
32	-do-	Larzen & Toubro Limited, Gujarat	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	6.75	6.75
33	-do-	Ellora/Orchid Infra developers P.Ltd., Mumbai	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	3.67	3.67
34	-do-	Immaculate conception Church, Kollam	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	0.62	0.62
35	-do-	Manthra Beach Resort P.Ltd., Kasaragod	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	1.50	1.50
36	-do-	Tourist Resorts Kerala Ltd, Veli	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	0.61	0.61
37	-do-	Holiday Manthra, Thiruvananthapuram	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	1.20	1.20
38	-do-	TRIFF Kochi Projects Pvt Ltd, Kochi	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	0.61	0.61
39	-do-	Kuruvi &Kuruvi Hotels, Cherthala	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	1.50	1.50
40	-do-	Edava Gramapanchayat	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	0.50	0.50

Sl. No.	Project Title	Funding Agency	Principal Investigator	Division	Co-Investigators	Project Period	Total Outlay (Rs.in lakh)	Fund Received during the year (Rs.in lakh)
41	CRZ Status Report	HED-Manjeswaram, Kasaragod	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	0.67	0.67
42	-do-	M. Y. Chauhan, Versova	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	3.75	3.75
43	-do-	EQMS India Pvt.Ltd	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	3.97	3.97
44	-do-	Moosa, Uppala, Kasaragod	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	1.50	1.50
45	-do-	NTPC Ltd, New Delhi	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	3.15	1.58
46	-do-	AEGIS Logistics Ltd., Mumbai	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	3.97	3.97
47	-do-	DM Health care Pvt.Ltd	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	1.95	1.95
48	-do-	Broom fields, Thiruvananthapuram	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	0.97	0.97
49	-do-	Madre de Deus Church, Thiruvananthapuram	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	0.68	0.68
50	-do-	KSIDC Ltd, Thanthonnithuruth	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	4.50	4.50
51	-do-	Meridian Homes, Kochi	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	2.10	2.10
52	-do-	Oberoi Reality Ltd. Mumbai	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	4.50	4.50
53	-do-	Maritime & Marine Services P. Ltd Goa	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	9.00	9.00
54	-do-	Chakolas Pvt.Ltd	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	2.85	2.85
55	-do-	K. T. Nicholes, Thiruvananthapuram	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2010-11	1.80	1.80

5.3 Plan Projects

Project Code	Project Title	Principal Investigator	Division	Co-investigators	Period	Total outlay (Rs. in lakh)	Expenditure during the year (Rs. in lakh)
PLAN 211	Creation of digital data bank at CESS	Mr. V. N. Neelakandan	Central Geomatics Lab	Dr. C. M. Harish, Mr. B. K. Jayaprasad	2005-10	12.10	0.01
PLAN 231	A cadastral level decision support system for management of natural resources in Thiruvananthapuram District	Mr. B. K. Jayaprasad	Central Geomatics Lab	Dr. M. Samsuddin, Mr. John Mathai	2005-10	59.64	6.47
PLAN 234	Measurement of cloud parameters and cloud modeling	Dr. S. Muralidas	Atmospheric Sciences	Dr. G. Mohan Kumar	2005-12	187.37	12.40
PLAN 250	Exploring interrelationship between environmental degradation and poverty: selected micro level case studies across Kerala	Dr. Srikumar Chattopadhyay	Resources Analysis	Mr. C. K. Sasidharan, Mrs. C. Sakunthala	2007-10	24.28	8.42
PLAN 251	Geomorphic setting, landuse alterations and fluvial regime change in the Western Ghats provenance of southern Sahyadri south of Achankovil Ar.	Dr. Mahamaya Chattopadhydy	Resources Analysis	Mr. B. Sukumar, Dr. K. Raju	2008-10	25.06	2.93
PLAN 252	Mapping of coastal cliffs and their vulnerability between Kanyakumari and Mangalore sough west coast of India	Dr. A. S. K. Nair	Marine Sciences	Mr. G. Sankar, Mr. John Paul	2007-10	25.06	3.54
PLAN 254	Quaternary geology and geomorphic evolution of the coastal lands of Kollam district, SW India	Dr. D. Padmalal	Environmental Sciences	Dr. K. Narendra Babu, Mr. B. Sukumar, Dr. K. Maya	2007-10	19.00	6.76
PLAN 255	Tropical Freshwater Myristica swams of Kerala and its ecological and evolutionary significance	Dr. C. N. Mohanan	Environmental Sciences	Dr. D.S. Suresh Babu,	2007-10	15.00	3.33
PLAN 257	Study of urban sprawl – stretch between Kochi and Thrissur Corporations	Mrs. Ahalya Sukumar	Resources Analysis	Mr. B. Sukumar, Dr. K. Raju	2008-10	11.68	0.10
PLAN 259	Application of neural network in pattern classification of remotely sensed images	Mr. K. J. Mathew	Atmospheric Sciences		2008-10	7.58	8.05
PLAN 260	Sunlight-induced multi-spectral fluorescence imaging system for vegetation assessment	Dr. N. Subhash	Atmospheric Sciences	Dr. C.N. Mohanan	2007-10	26.50	7.02

Project Code	Project Title	Principal Investigator	Division	Co-investigators	Period	Total outlay (Rs. in lakh)	Expenditure during the year (Rs. in lakh)
PLAN 261	Human-induced land modifications and its Impacts: A study in Thodupuzha taluk-Idukki district, Kerala	Dr. K. Raju	Training & Extension	Mr. G. Sankar, Dr. V. Nanda Kumar	2007-10	5.98	4.35
PLAN 263	Solar ultraviolet-B and atmospheric trace constituents in relation to climate change	Dr. G. Mohan Kumar	Atmospheric Sciences	Dr. S. Sampath	2007-13	20.25	3.89
PLAN 265	Characterization of laterites of Kerala and preparation of laterite distribution map	Dr. Narayanaswamy	Geosciences		2007-10	15.09	6.47
PLAN 266	Quaternary evolution of the coastal plains of southern Kerala	Mr. John Paul	Marine Sciences	Dr. A. S. K. Nair	2007-10	36.50	1.05
PLAN 267	Digital resource atlas of Kerala and environment atlas	Mr. B. Sukumar	Resource Analysis	Mrs. Ahalya Sukumar Dr. E. Saravanan, Mr. V. Shravan Kumar	2008-12	37.40	6.62
PLAN 268	Agricultural atlas of Kerala	Dr. E. Saravanan	Training & Extension	Mr. B. Sukumar, Mr. V. Shravan Kumar	2008-10	27.48	25.99
PLAN 270	Water, sediment quality monitoring and assessment of estuaries of Kerala: A case study from Kochi estuary and Periyar River	Dr. P. K. Omana	Chemical Sciences		2008-10	10.87	8.23
PLAN 271	The social impacts of energy technologies: two case studies at different environs of Thiruvananthapuram district	Mr. K. Vijayakumar	Atmospheric Sciences		2008-10	1.77	2.70
PLAN 272	Environmental impact assessment of major settlement distribution patterns and the infrastructural development with an emphasis on drinking water infrastructure facilities in Thiruvananthapuram	Mr. V. Shravankumar	Marine Sciences	Dr. A. S. K. Nair, Dr. S. Suresh Babu	2008-11	5.05	5.92

Project Code	Project Title	Principal Investigator	Division	Co-investigators	Period	Total outlay (Rs. in lakh)	Expenditure during the year (Rs. in lakh)
PLAN 273	Assessment and monitoring of land quality for sustainable agriculture: A GIS based approach coupled with technology implementation	Mr. B. Sukumar	Marine Sciences	Dr. A .S. K. Nair, Dr. G. Mohan Kumar, Dr. E. Saravanan, Mr. G .Sankar, Dr. P.V.S.S.K Vinayak, Sri.. V. Shravan Kumar, Mrs. Ahalya Sukumar, Mr. V. Vasudevan, Mr. K. Vijayakumar, Dr. Ansom Sebastian, Mr.. K. J. Mathew, Mr. John Paul.	2008-11	8.82	24.88
PLAN 274.	Kerala Resources Information System & Services (KRISS)	Sri. V. N. Neelakandan	Central Geomatics Lab	Dr. K. K. Ramachandran, Dr. M. Samsuddin	2009-10	102.00	1.21
PLAN 275	Study of land use/land cover change linked to climatic change in Kerala	Dr. Srikumar Chattopadhyay	Resources Analysis	Dr. P.V.S.S.K Vinayak, Mr. C. K. Sasidharan	2009-12	41.40	2.79
PLAN 276	Effect of urbanization on the buildup of urban heat island in Kochi	Dr. E. J Zachariah	Atmospheric Sciences	Dr. P.V.S.S.K Vinayak	2009-12	44.88	20.74
PLAN 277	Solar ultraviolet-B radiation and atmospheric trace constituents in relation to climate change	Dr. G. Mohan Kumar	Atmospheric Sciences		2009-13	29.63	11.47
PLAN 278	Monitoring climate change impact in Sahyadri	Dr. C. N. Mohanan	Environmental Sciences	Dr. G. Mohankumar, Dr. E. J. Zachariah, Dr. P. V. S.S. K Vinayak, Dr. P. K. Omana, Mr. B. K. Jayaprasad, Dr. K. Raju, Dr. A Krishna Kumar	2009-12	59.62	2.91
PLAN 280	Tectonothermal history of the Kerala Khondalite Belt	Dr. V. Nandakumar	Geosciences		2009-12	22.20	4.65
PLAN 281	Climatological features of Kerala- a ready reckoner	Dr. P.V.S.S.K. Vinayak	Camp Office, Kochi	Mrs. Sreekumari Kesavan	2009-11	7.51	2.66
PLAN 282	Graphitization Process in Kollam District, Kerala	Dr. Ansom Sebastian	Training & Extension		2010-13	4.49	1.30

5.4 R & D Laboratory Infrastructure Projects

Project Code	Project Title	Co-ordinator	Division	Expenditure during the year (Rs. in lakh)
PLAN 101	XRF Facility	Dr. G. R. Ravindra Kumar (SIC)	Geosciences	6.32
PLAN 102	Upgradation of Geosciences laboratories	Head, GSD	Geosciences	26.35
PLAN 103	Strengthening of Ecological laboratory	Head, ESD	Environmental Sciences	4.29
PLAN 104	Upgradation of Atmospheric Sciences laboratories	Head, ASD	Atmospheric Sciences	12.49
PLAN 105	Upgradation of Chemical laboratory	Head, CSD	Chemical Sciences	11.16
PLAN 106	Upgradation of Library facilities	Head, TED	Training & Extension	30.00
PLAN 107	Publication of monographs / memoirs / annual report/newsletter	Director		1.23
PLAN 108	Upgradation of training / extension /exhibition/LAN and other technical facilities	Head, TED	Training & Extension	5.12
PLAN 110	Seminars/workshops/meetings	Director		3.75
PLAN 111	Marine laboratory infrastructure development	Head, MSD	Marine Sciences	23.08
PLAN 112	Geomatics laboratory infrastructure development	Head, CGL	Central Geomatics Lab	16.23
PLAN 117	Upgradation & maintenance of CESS LAN	Dr. C. M. Harish	Central Geomatics Lab	0.04
PLAN 100	Research & Development general expenditure	Director		361.17

5.5 R & D building Infrastructure Projects

Project Code	Project Title	Co-ordinator	Expenditure during the year (Rs.in lakh)
PLAN 109	Construction of SAF building	Registrar	0.00
PLAN 119	Recreation facilities at CESS	Secretary, Recreation club	0.00
PLAN 120	Upgradation of centralized Air Conditioning & facilities of CESS buildings	Registrar	0.73
PLAN 123	Upgradation/repair and maintenance of toilets	Registrar	1.20
PLAN 124	Upgradation of EPABX	Registrar	0.00
PLAN 126	Garden development and landscaping	Estate Section	1.95
PLAN 128	Upgrading electrical installations and facilities	Registrar	1.38
PLAN 150	Construction of Water tank and modification to the WSS	Registrar	0.00
PLAN 151	Replacement of damaged cast iron stair case in the administrative building	Registrar	0.00
PLAN 155	Upgradation of the canteen	.Registrar	0.00
PLAN 156	Construction of compound wall in the land at Ernakulam	Registrar / SIC, Camp Office	0.00
PLAN 157	Construction of additional floor in the scientists blocks	Registrar	0.00

Honours, Awards & Academic Activities

6.1 Awards & Honours

Dr N. Subhash, Head, Atmospheric Sciences Division, was conferred as Senior Fellow of the Head and Neck Optical Diagnostic Society (HNODS) by the University College of London, UK, for his contributions in the field of cancer diagnosis using optical spctroscopy techniques.

Dr.V.Nanadakumar was awarded the INSA-Royal Society Fellowship to visit University of Edinburgh, Scotland, UK for a period of three months. Advanced micro analytical facilities including ion probe were utilized for studies pertaining to Kerala Khondalite Belt.

Dr. Shiny Sara Thomas was awarded Ph.D Degree under the Faculty of Science, Cochin University of Science and Technology, Kochi for her research on 'Spectroscopic investigation of tooth caries and demineralization' carried out under the supervision of Dr. N. Subhash, Head, Atmospheric Sciences Division.

Ms. M. Vandana, Project Fellow, Resources Analysis Division has secured second position in the Prof. N.P.Ayyer Young Geographer Award for her research paper entitled 'Landform evolution of Kabani river basin, Wayanad district Kerala' presented during the 32nd India Geography Congress held at the Punjab University, Chandigarh.

Mr. George Thomas, Project Fellow, ASD, was endowed with the second best performer award by Department of Science and Technology & Indian Institute of Tropical Meteorology on successful completion of the 'SERC School on Global Warming and Climate Change'

Mr. R. Vishnu, Research Scholar, Atmospheric Sciences Division was awarded foreign travel grant by the Committee on Space Research, France, INSA Bangalore, and CSIR New Delhi for participating and presenting two papers on Cloud Physics in the 38th Scientific Assembly of Committee on Space Research (COSPAR-2010) at Bremen, Germany.

6.2 Membership in Committees

Dr. N. P. Kurian

Member, Project Management Board, Coastal Engineering Division, National Institute of Ocean Technology

Member of the Board of Studies in Physical Oceanography under the Faculty of Marine Sciences, Cochin University of Science and Technology, Cochin.

Member of the Kerala Dam Safety Authority by Water Resources (Inter State Water Cell) Department, Government of Kerala.

Member of the Kerala Protection of River Banks of Regulation of Removal of Sand Rules 2002 – State High Level Committee for River Management Fund by Revenue (P) Department, Government of Kerala.

Member, Governing Body, LBS Centre for Science & Technology by Higher Education Department, Government of Kerala.

Member, Kerala Coastal Zone Management Authority by Ministry of Environment & Forests, Government of India.

Member, Working Group for Water Sector by Water Resources (IR) Department, Government of Kerala.

Member, Governing Body, Institute of Land and Disaster Management, Revenue Department, Government of Kerala.

Dr. T. Radhakrishna

MoES Nominee of the Management Board of OASTC at Mangalore University

Member of the Executive Council, Geological Society of India,

Member of the Editorial Board, Indian Association of Geochemists.

Dr. K. V. Thomas

Member of Lakshadweep Coastal Zone Management Authority constituted by the Ministry of Environment & Forests, Government of India.

Dr. Srikumar Chattopadhyay

Member, Advisory Committee, Inter University Centre for Social Sciences Research & Extension, Mahatma Gandhi University.

Subject Expert, Departmental Doctoral Committee, Department of Geography, Kannur University.

Member, Governing Council, Institute of Indian Geographers, Pune.

Dr. C. N. Mohanan

Member, Ecological fragile land identification and verification committee, State forest department.

Member, Wetland Technical Unit, KSCSTE

Sri. G. Sankar

Member, Integrated River Basin Master Plan for Chaliyar, constituted by the Government of Kerala.

6.3 Visit Abroad

Dr. Anoop Krishnan visited department of Civil Engineering, Tokyo Institute of Technology, Japan and delivered a talk on 'Water Quality Status in Peninsular India – Problems and Possible Remedies' as part of the workshop on 'Asian Water Environments'sponsored by the Japan Society for the Promotion of Science.

6.4 Internship / Summer Training

Name of student	Affiliation	Name of supervising scientist
Sangeetha M	College of Engineering, Trivandrum	Dr. K. V. Thomas
Tiji Antony	-do-	Dr. K. V. Thomas
Remya Mary K J	-do-	Dr. K. V. Thomas
Jancy I	-do-	Dr. K. V. Thomas
Sonika Mohan S	-do-	Dr. K. V. Thomas
Amitha G Prakash	University of Madras	Smt. Ahalya Sukumar
Arun Babu R	-do-	Sri. B. Sukumar
Shemin Mol S S	-do-	Smt. Ahalya Sukumar
Anjana M K	-do-	Smt. Ahalya Sukumar
Abhiya Abbas Mundol	NIT, Surathkal	Dr. K. K. Ramachandran
Minu S	-do-	Dr. K. K. Ramachandran
Jishnu S Babu	IIT Kharagpur	Dr. D. Padmalal
Jeeno Soa George	-do-	Dr. Srikumar Chattopadhyay
Indrajith R S	-do-	Dr. C. N. Mohanan
Tessy Rose R	University of Kerala	Dr. K. K. Ramachandran
Naicy Joseph	-do-	Dr. K. K. Ramachandran
Rintu Abraham	-do-	Dr. K. K. Ramachandran
Divya Shankar	-do-	Dr. C. N. Mohanan
Abhijith U V	Delhi University	Dr. D. Padmalal

6.5 Ph. D Students

Student	Topic	Research Guide	University
Abhilash P P	Charcterization of marine pollution along the southern coast of Kerala using the macrobenthic assemblages	Dr. P. P. Ouseph	CUSAT
Arjun S	Numerical modelling of tides and coastal flooding	Dr. N. P. Kurian	CUSAT
Arun J John	Tracking the anthropocene in the sedimentary basin of Kerala, SW coast of India	Dr. T. N. Prakash	CUSAT
Anu Baburaj	Fluorescence Imaging of Corals	Dr. N. Subhash	CUSAT
Balachandran K P	Investigation of the relationship between atmospheric electrical conductivity and meteorological parameters	Dr. S. Muralidas	MG
Balakrishnan M.	Landuse/land cover change and its implication on mountain ecosystem – A case study in parts of Southern Sahyadri	Dr. Srikumar Chattopadhyay	Kerala
Dhanya V	Environmental resource management in Achancovil river basin- a watershed based approach	Dr. Srikumar Chattopadhyay	Kerala
Dhanya C. R.	Study of Urban Heat Island over Cochin	Dr. E. J. Zachariah	CUSAT
Divya V.	Ecological Studies along Elevational Gradients in a Transect in Southern Western Ghats, with special reference to Forest Soil	Dr. C. N. Mohanan	Kerala
Hema C. Nair	Water quality and drinking water potential of the ground water resources of Kallada and Ithikkara river basin Kerala, SW India	Dr. D. Padmalal	CUSAT
Noujas V.	Numerical Modelling Studies on Coastal Hydrodynamics and Sediment Transport Regime of the Central Kerala Coast	Dr. N. P. Kurian	CUSAT
Prabitha V. G.	Early detection of tissue abnormalities by optical imaging	Dr. N. Subhash	Kerala
Prasanth C S	Fluorescence monitoring of periodontal bacteria and treatment of periodontal infections by photodynamic therapy	Dr. N. Subhash	Kerala
Prasanth M	Physico-chemical characteristics and speciation of heavy metals in the selected reservoirs of the periyar river basin: Western Ghats, Kerala	Dr. M. N. M. Nair	CUSAT
Prasad R.	Sediment Dynamics in Coastal Waters	Dr. N. P. Kurian	CUSAT
Praveen. M N	Geological aspects of the eastern part of betal belt, Central Indian tectonic zone	Dr.G.R.Ravindra Kumar	CUSAT
Praveen S S	Numerical modelling of tsunami inundation along Kerala Coast	Dr. N. P. Kurian	CUSAT
Raji S. Nair	Multi Spectral Imaging	Dr. N. Subhash	Kerala
Ranikrishna L	Tropical freshwater myristica swamps of Kerala and its ecological and evolutionery significance	Dr. C. N. Mohanan	Kerala
Rinoy G.	Eco-geomorphological characterization and environmental response assessment of Lakshadweep coral reeps, UT of India using geo informatics	Dr. D. Padmalal	CUSAT
Silpa. B. L.	Morphodynamics of the beaches of varying energy regimes of Kerala Coast	Dr. T. N. Prakash	CUSAT
Sreejith C	Evolution of the lower crust in the neo-proterozoic Kerala Kohndalite Belt (KKB) southern India: petrological and geochemical constraints and implications for Gondwana assembly	Dr. G. R. Ravindra Kumar	Kerala
Sreekanth T S	Characterization of tropical rain fall in terms of drop size distribution at surface, its variation with altitude and comparison of rain rates with satellite measurements	Dr. G. Mohan Kumar	Kerala
Sudhanandh V S	Studies on pathogenic enteric bacteria and their seasonal distribution with special reference to public health along the southern Kerala coast	Dr. P. P. Ouseph	Kerala
Tiju I Varghese	Beach and estuarine evolution of Kollam coast during holocene	Dr. T. N. Prakash	CUSAT
Udayakumar P	Distribution of heavy metals in marine environment and its bioaccumulation along central and northern coast of Kerala, India	Dr. P. P. Ouseph	CUSAT
Vandana M	Land system analysis of Kabani river basin	Dr. Srikumar Chattopadhyay	Kerala
Vishnu R	Electrical charcteristics of thunderstorms and lightning	Dr. S. Muralidas	Kerala
Vishnu Mohan S.	Quaternary Geology of the coastal lowlands of southern Kerala, SW India	Dr. D. Padmalal	CUSAT

6.6 Post Graduate Studentship Programme

CESS supports post graduate students by awarding studentships, to improve research aptitude among students in different areas of Earth Science. During the academic year 2010-11, 53 applications were received from meritorious students from different parts of Kerala and twelve of them were awarded studentship of Rs. 2000/ month during the period of their P.G dissertation work in CESS. The details of students awarded the studentship are given in the table below:

Name of Student	Affiliation	Topics of Dissertation	Supervisor
Santhy A	S N College, Kollam	Evaluation of Phosphors species in core sediment of Paravur lake and its relation with sediment characterization	Dr. K. Narendra Babu
Sophia T	SN College, Kollam	Relation of Phosphorous species with iron, organic carbon and textural quality of core sediment from selected locations of Kadinamkulam	Dr. K. Narendra Babu
Lekshmi I	All Saint's College, Trivandrum	Hydrochemistry and water quality assessment of Neyyar river, Southern Kerala	Dr. K. Maya
Nisha U R	All Saint's College, Trivandrum	Water quality assessment of irrigation projects- A case study from Neyyar river basin, Kerala	Dr. K. Maya
Remyasree R S	University College Trivandrum	Land use change as an indicator of urbanization in Trivandrum Corporation	Dr. K. K. Ramachandran
Aswathy M B	University College Trivandrum	Land use/Land cover changes in Neyyattinkara municipality	Sri. B. K. Jayaprasad
Remya K P	University College Trivandrum	A geoinformatic approach of land use/land cover changes and its relation with the terrain characterization of Kili river basin, Trivandrum district	Dr. Srikumar Chattopadhyay
Sreedhu M S	University College Trivandrum	Coastal Zone Management Plan for Vizhinjam Panchayat	Dr. K V Thomas
Anumol N	Government College for Women, Trivandrum	Laser induced Fluorescence imaging – a potential toll for detecting early signs of coral bleaching.	Dr. N Subhash
Resmi Krishnan	Government College for Women, Trivandrum	An investigation on the detection of coral bleaching using laser-induced fluorescence spectra	Dr. N Subhash
Alfred Johny	CUSAT	The role of wave steepness in determining the erosion/accretion of the beach	Dr. T. S. Shahul Hameed
Soumya G S	Govt. College, Kasaragod	A revisit to Selenology: Lithological studies using Remote Sensing Data for Chandrayaan-I	Dr. Archana M Nair

6.7 M.Sc / B.Tech / M.Tech Dissertation Programmes

Name of student	Affiliation	Topics of Dessertation	Supervisor
Saranya. S.	M. G. University, Kottayam	Photoinactivation in Enterococcus faecalis using Toludine Blue	Dr. N. Subhash
Aswathy. C.G.	M. G. University, Kottayam	Photoinactivation in Enterococcus faecalis using Methylene Blue	Dr. N. Subhash
Sreelekshmi. S.	University of Kerala	Geomapper – using Php with Postgre sql	Dr. V. N. Neelakandan
Divya Sankar. L.S.	University of Kerala	Geomapper – using Php with Postgre sql	Dr. V. N. Neelakandan
Shiji. V.J.	University of Kerala	Geomapper – using Php with Postgre sql	Dr. V. N. Neelakandan
Sruthy. S. Madhu	M. G. University, Pathanamthitta	Aquatic Chemistry	Dr. K. Narendra Babu
Sangeetha Sajeev	College of Engineering, Trivandrum	Tsunami inundation modelling	Dr. N. P. Kurian
Prabhisha. P. R.	College of Engineering, Trivandrum	Tsunami inundation modelling	Dr. N. P. Kurian
Shamla. D. S.	NIT, Calicut	Restoration of Abandoned Quarries. A case study in Eripara Quarry	Sri. G. Sankar
Sreedevi. S.	NIT, Calicut	Restoration of Abandoned Quarries. A case study in Eripara Quarry	Sri. G. Sankar
Nayana Bose	SNDP Yogam College, Konni	Raindrops size distribution and its relationship with precipitational micro physical parameters of a coastal station	Dr. G. Mohan Kumar
Soumya S. Soman	SNDP Yogam College, Konni	An automatic motor control system	Dr. S. Muralidas
Athira. J. S.	SNDP Yogam College, Konni	An automatic motor control system	Dr. S. Muralidas
Rohini. K. M.	Anna University	Palaeomagnetism	Dr. T. Radhakrishna
Habeeb Rahman T	National Institute of Technology, Surathkal	Oil spill modelling	Ms. L. Sheela Nair
Ammu Mol. P. C	IIT, Roorkee	Palaeomagnetism	Dr. T. Radhakrishna
Manju Narayanan	IIT, Roorkee	Palaeomagnetism	Dr. T. Radhakrishna
Arunima M. Lal	Pondicherry University	Palaeomagnetism	Dr. T. Radhakrishna
Prasanthi. S	University of Kerala	Urban Heat Island in Trivandrum city	Dr. E. J. Zachariah
Aswathy Chandran	University of Kerala	Urban Heat Island in Trivandrum city	Dr. E. J. Zachariah
Anuradha. R	Kariyavattom University	Effect of Rain drop size distribution on Rain intensity and other physical parameters in 2009	Dr. G. Mohan Kumar
Beegum Sarsheen. N. R	University Campus, Kariyavattom	Effect of Rain drop size distribution on Rain intensity and other physical parameters in 2009	Dr. G. Mohan Kumar
Priya. S. S.	University Campus, Kariyavattom	Effect of Rain drop size distribution on Rain intensity and other physical parameters in 2009	Dr. G. Mohan Kumar
Shamila. A	Kannur University	Environmental impact of thermal power plant at Chimeni Kasaragod	Dr. C. N. Mohanan
Ashitha. V. C.	Kannur University	Impact of laterite mining in Keezharakunnu region of Kannapuram panchayat Kannur	Dr. C. N. Mohanan

Name of student	Affiliation	Topics of Dessertation	Supervisor
Javairiya. C. V	Kannur University	Impact of China clay mining in Madayipara, Kannur	Dr. C. N. Mohanan
Siju Thankappan	CUSAT	Pollutants dispersion modelling	Ms. L. Sheela Nair
Dr. Neeta Parate	Govt. Dental College, Trivandrum	Effect of Photodynamic therapy on sensitization of Aggregatibacter Actinomycetem comitans: An in-vitro study	Dr. N. Subhash
George Basil	SRM University Tamil Nadu	Remote sensing and GIS based Runoff modeling with emphasis on the impact of landuse changes	Dr. Archana. M. Nair
Athullia R. Nair	Danalekshmi Srinivasan College	Characterization of tropical rain in terms of rain intensity and number of events in the vicinity of E1-Nino & LA – Nina events	Dr. G. Mohan Kumar
Jithin K P	Mangalore University	Exposure of marine geological and oceanographic instruments: An approach to field and laboratory techniques	Dr. T. N. Prakash
Vineetha R C	MG University	Sunlight induces multi-spectral reflectance imaging of plants	Dr. N. Subhash
Melwyn Joshua	Bharathidasan University	Environmental Impact Assessment of Vilappilsala solid waste management system	Dr. C. N. Mohanan
Reshma A	Govt. College, Kasaragod	Environmental Impact Assessment of Kannur International Airport	Dr. C. N. Mohanan
Sreevidya K	Govt. College, Kasaragod	Rainwater harvesting	Sri. John Mathai
Sanitha N K	Govt. College, Kasaragod	Salt water intrusion	Sri. John Mathai
Srikala K R	Govt. College, Kasaragod	An evaluation of Natural Hazard, occurring in Kannur distrct.	Sri. G. Sankar
Fathimath Bushra C A	Govt. College, Kasaragod	Landslide susceptibility mapping of Thodupuzha taluk, Idukki district, Kerala	Sri. G. Sankar
Rajeswari P	Govt. College, Kasaragod	A simple method for regional scale agricultural drought susceptibility assessment using satellite remote sensing data.	Sri. G. Sankar
Vidya S Unni	SN College, Kollam	Drinking water potential of the Ground water sources of Navaikulam Grama Panchayat	Dr. A. Krishnakumar
Simson Sunny C	SN College, Kollam	Assessment of surface water quality of Chettuva backwater: A multivariate statistical approach	Dr. A. Krishnakumar
Vishnu V	SN College, Kollam	Heavy and trace metal Chemistry of sediment cores from the Paravur estuary, Kollam district	Dr. D. Padmalal
Reshmi R Nath	SN College, Kollam	Evaluation of phosphorous in the core sediment of Paravur lake; its relation between Iron, organic carbon and texture	Dr. K. Narendra Babu
Anusree P S	SN College, Kollam	Evaluation of phosphorous in the core sediment of Paravur lake; its relation between Iron, organic carbon and texture	Dr. K. Narendra Babu

Library

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Collection in the Library consists of books, journals, back volumes, CDs, VCDs, CD ROM Database, Maps, Atlas, Theses, Project Reports, reference books, annual reports etc. The library facility is also used by members from other institutes and universities, both inside and outside the state.

During this year, the library procured 42 books and subscribed to 46 journals, including international journals. In addition to this, the library receives many journals *as gratis*. Library is in the process of creation of digital contents consisting of electronic journal articles, VCD films, CD ROM Data base, Conference Proceedings etc.

The major services rendered by library are reference service, literature search, library membership, reprint service, press clipping service and document delivery service to users. E-mail alerts are sent to scientists who request for new arrival of books and publications. The bound volumes of publications of CESS scientists up to 2011 are available for reference. CESS Library also provides internet browsing facility for users in addition, to current awareness service such as list of new additions, display of CESS publications, useful article display, Fellowship information, forthcoming conferences, seminars etc.

Library has taken Institutional Membership in various reputed libraries to enable its users to visit such libraries and use the resources available there. At present library is automating using the software KOHA, an integrated open source software, that supports all in house operations of the library. The software has different modules like Acquisition, Catalogue, Circulation, Serial Control, OPAC, Administration etc. Books are arranged according to the subject and DDC scheme has been followed. Very soon library will provide access to Online Public Access Catalogue(OPAC) (Fig. 7. 1)within CESS campus.

Fig. 7.1 A screen shot of the Online Public Access Catalogue (OPAC) software installed in the CESS Library

Publications

8.1 Research Papers

8.1.1 In Journals

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Thomas K V, Kurian N P, Raju D Coastal Regulation Zone Status Report for Bulk Liquid Storage Terminal in Mahul Village, Trombay, Maharashtra M/s Aegis Logistics Ltd.

Thomas K V, Kurian N P, Raju D Ramesh Kumar M Coastal Regulation Zone Status Report for Housing Project in Kadakkampally Village, Trivandrum, Kerala M/s Broomfield Builders Pvt. Ltd.

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Thomas K V, Kurian N P, Raju D Coastal Regulation Zone Status Report for Tourist Resort at Manrothuruth, Kollam, Kerala, Holiday Manthra Hotels & Resorts Ltd.,Trivandrum.

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Thomas K V Coastal Regulation Zone Status Report for Veli Tourist Village Tourist Resorts (Kerala), Ltd., GoK

Thomas K V Coastal Regulation Zone Status Report for Steel Industry at Hazira, Surat, Gujarat M/s Essar Steel Ltd.

Thomas K V Coastal Regulation Zone Status Report for Development Project at Juhu & Bandra, Mumbai, Maharastra M/s Ellora Project Consultant Pvt. Ltd.

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Thomas K V Coastal Regulation Zone Status Report for Development Project at Versova & Andheri Villages, Mumbai, Maharashtra

9.1 Twenty third Kerala Science Congress

Hon'ble Chief Minister of Kerala Sri. V S Achuthanandan delivering the inaugural address of the 23rd Kerala Science Congress at the Centre for Earth Science Studies on 29th January 2011

Kerala Science Congress was organized during 29-31 January 2011. The three day event was inaugurated by the Hon'ble Chief Minister of Kerala Sri. V. S. Achuthanandan. Several national luminaries like Dr.K..Kasturirangan, Prof. Madhav Gadgil, Prof. Prabhath Patnaik, Prof. J. Sreenivasan were among the distinguished speakers. The Congress had around 800 registered delegates and a total of around 190 paper presentations including posters. 10 young scientist Awards and eleven best Poster Awards were presented.

Prof. Prabhat Patnaik, Vice Chairman, Kerala State Planning Board, delivering the Dr. P. K. Gopalakrishnan memorial lecture (left) Dr. Patnaik receives a memento from Dr. C. T. S Nair, EVP, KSCSTE

Dr. C. T. S Nair, Executive Vice President, KSCSTE handing over a memento to the Hon'ble Chief Minister during the inaugural function. Dr. R.V. G. Menon, President of the Kerala Science Congress, Dr. K. Kasthurirangan, National Planning Commission, Dr. G. J. Samathanam, Advisor, Department of Science & Technology, Dr. K. K. Ramachandran, General Convener, 23rd Kerala Science Congress are also seen.

Prof. Madhav Gadgil, Garware College Pune, delivering the P.T. Baskara Panicker memorial lecture (left). Prof. Gadgil receiving a memento from Sri. Binoy Viswam, Hon'ble Minister for Forests, Government of Kerala.

9.2 Prof. C. Karunakaran Endowmwent Lecture Series

The Prof. C. Karunakaran Endowment Lecture, the nineth in the series was delivered by Prof. Tanu Padmanabhan, an internationally acclaimed Theoretical Physicist and Cosmologist whose research spans a wide variety of topics in Gravitation, Structure formation in the Universe and Quantum Gravity, on August 13, 2010. The topic of his lecture was 'Our Changing View of the Cosmos'.Prof. Padmanabhan spoke on the discovries about the Universe and elaborated on the current research in cosmology. Sri. S. Singanenjam, Director, GSI, Trivandrum paid tributes to Prof. C.Karunakaran. Dr. R. Krishnan, Associate Director, IIST, Dr. V. Unnikrishnan Nayar, Emeritus Professor, IISER and Dr. Chithra Karunakaran, daughter of Prof. C. Karunakaran spoke on the occasion. Dr. T. Radhakrishna, Director in Charge welcomed the gathering and Sri. G. Balasubramanian proposed the vote of thanks.

Prof. T Padmanabhan, Dean, Core Academic Programmes, Inter-University Centre for Astronomy & Astrophysics, Pune delivering the nineth Prof. C.Karunakaran Endowment Lecture on 13 August 2010

9.3 National Technology Day

National Technology Day 2010 was observed in CESS jointly organized by Department of Science & Technology, Government of India and the Kerala State Council for Science, Technology & Environment on 8 June 2010. Dr. Anil Bharadwaj F.N.A, F.A.Sc, Scientist, Space Physics Laboratory, Vikram Sarabhai Space Centre, Thiruvananthapuram delivered a talk on the 'Chandrayan-1: Indian Lunar Mission'.

Dr. R.V.G.Menon delivering the Presidential Address during National Technology Day function. Dr. N. P. Kurian, then Director in Charge, Dr. Anil Bhardwaj and V. Shravan Kumar, Scientist, CESS are also seen.

9.4 National Green Corps - Best Eco Club Award 2010

A Two day workshop was held in CESS during 5-6 August 2010 to select the best performing Eco Club for the year 2010, under the National Green Corps (NGC) programme implemented by the Kerala State Council for Science, Technology and Environment in selected schools all over Kerala. Forty two schools, three schools from each district, which entered the final round of selection, made presentations before a panel of experts. The two day workshop was inaugurated by Dr. R.V.G Menon, noted scientist and science populist. Dr. C. T. S Nair, Executive Vice President, KSCSTE, Dr. T. Radhakrishna, Director-in-charge CESS, Dr. Kamalakshan

Dr. C.T.S Nair, Executive Vice President, KSCSTE, presenting the Best Eco Club award to the students of Ramakrishna High School, Kozhikode

Dr. R.V.G. Menon inaugurates the two day workshop to select best eco clubs at State and District levels on 5th August 2010 at CESS. Dr. C.T.S Nair, Dr. T.Radhakrsihna and Dr. Kamalakshan Kokkal are also seen

Kokkal, Joint Director, KSCSTE and Dr. Harinarayanan, Scientific Officer, KSCSTE also spoke on the occasion. Sree Ramakrishna Mission High School, Kozhikode bagged the best Eco Club in the State for the year 2010 and has won a project worth Rs. 100000.00 The best clubs in each district were awarded with a project worth Rs. 50000.00.

9.5 Invited Lectures

Dr. N. P. Kurian

Delivered a lecture on Vulnerability of Kerala to Coastal Hazards in the Workshop on 'Hazards, Risks and Vulnerability Assessment' on 4th October 2010.

Dr. N. Subhash

Delivered a lecture at the Advanced Centre for Training, Research and Education in Cancer (ACTREC), DAE, Govt. of India, Khargar, Mumbai on 'Laser induced fluorescence in cancer detection' on 30th September 2010

Dr. K. K. Ramachandran

Delivered a talk entitled 'Geo-informatics for the preparation of the thematic maps' in the training programme organized by Central Ground Water Board and Kerala Water Authority on 30th September 2010.

Delivered a talk entitled 'Geo informatics for micro mapping' in a training programme on 27th September 2010 in IMG jointly organized by State Ground Water Department and Institute of Management in Government.

Delivered a talk on GPS at a workshop held for the Town planners of the Town Planning Department of GoK on 4th October, 2010.

Dr. M. Samsuddin

Delivered a talk entitled "Kerala Spatial Data Infrastructure" in a training programme on 27th September 2010 in IMG jointly organized by State Ground Water Department and Institute of Management in Government.

Sri. V. N. Neelakandan

Delivered a talk entitled 'Geo-informatics' in a training programme on 27th September 2010 in IMG jointly organized by State Ground Water Department and Institute of Management in Government.

Sri. B. Sukumar

Delivered a talk on 'Disaster management and geoinformatics,' in the National Seminar on 'Frontier Areas of Research and Teaching in Geosciences', organized by the Dept. of Geography, Bharathidasan University at Thiruchirappalli on 26th February, 2010.

Sri. G. Sankar

Delivered a talk on 'Natural Disasters of Kerala' in the Disaster, Risk and Vulnerability conference 2011 organized by the School of Environmental Sciences, MG University Kottayam on 12th March, 2011.

Delivered a talk on 'piping' in the meeting organized by Madhavan Pillai foundation, Trivandrum on 19th March, 2011.

Sri. B. K. Jayaprasad

Delivered a talk entitled "Geo informatics in urban areas in a training programme on 27th September 2010 in IMG jointly organized by State Ground Water Department and Institute of Management in Government.

Dr. K. Anoop Krishnan

Delivered a lecture on "Water Quality status in Peninsular India-problems and possible remedies' in the International Workshop on Asian water Environments (JSPS Asian Core Programme) on January 26, 2011 at Tokoyo Institute of Technology, Tokyo, Japan.

9.6 Conference / Workshop / Symposium / Seminar

Name	Conference/Symposium/Seminar	Title of the Paper
Sri. S S Praveen	9th International Conference on Hydro-Science and Engineering (ICHE-2010), a conference held at Indian Institute of Technology, Chennai during 2-5 August, 2010	Numerical modelling studies on Tsunami inundation along the Kerala coast
Sri. V R Shamji	9th International Conference on Hydro-Science and Engineering (ICHE-2010), a conference held at Indian Institute of Technology, Chennai during 2-5 August, 2010	Numerical modelling of beach erosion along Southwest coast of India during Southwest monsoon
Smt. Manju Stephen	Indian Association of Oral and Maxillofacial Pathologists (IAOMP), November 2010	Diffuse reflectance spectral imaging: a non-invasive promising tool for early diagnosis of malignant changes in the oral cavity
Sri. B Sukumar	4th session of the IAG Working Group in Geomorphological hazards (IAGEOMHAZ) and International workshop in Geomorphological hazards held at Kanyakumari during July 2010	Geomorphic hazards due to anthropogenic processes-A study between Thrissur and Ernakulam districts of Kerala Hazard zonation mapping of Valapattanam river basin in Kannur district of Kerala using GIS and remote sensing.
Sri. B Sukumar	Group meeting on Application of geomatics for disaster management at Osama University, Hyderabad during 8-12 December, 2010	Nil
Dr. D Padmalal Sri. Vishnu Mohan	International Conference on Climate Change and Environment at Kochi and Lakshadweep	EIA of sand mining from the small catchment rivers in the south west coast of India: A case study
Dr. K V Thomas	Seminar on CRZ 2010 Draft Response and Challenges organized by the International Centre Goa (ICG) and National Institute of Oceanography (NIO)	Setback lines for Coastal Regulation Zone
Dr. Reji Srinivas	Short Term Training on Isotope tracer techniques for water resources development and management, sponsored by DST, Government of India, held at CWRDM, Kozhikode (June, 2010)	Nil
Sri. B Baijulal Sri. S Vishnu Mohan Smt. S Anooja Sri. B Baburaj Smt. R Resmi	National Seminar on Mining of river sand held at CWRDM Kozhikode during 18-19 February, 2011	EIA of river sand mining using Rapid Impact Assessment Matrix (RIAM)- A case study (Resmi R, Baburaj B, Sannthosh V, Sreebha S and Padmalal D) Impact of sand mining on river bed changes and bed material characteristics-a case analysis (Anooja S, Baijulal B, Maya K, Sreebha S and Padmalal D) Environmental effects of alluvial sand mining on the biological environment of Kerala rivers (Baijulal B, Jissy Jyothi S, Padmalal D, Maya K) Sand mining in Pamba river (Vishu Mohan S, Sreebha S, Padmalal D, Maya K and Lini Krishna)
Dr. K Narendra babu Dr. K Anoop Krishnan	International Conference Sustainable Water Resource Management and Treatment Technologies at NEERI, Nagpur during 19-21 January, 2011.	Mapping and hydrochemical evaluation of coastal Spring of Southern Kerala, India, An alternate drinking water resource with high potential (Narendra Babu K, Baiju R S, Padmalal D, Renjini V S, Anoop Krishnan K) Impact of Urbanization on hydrochemical characteristics of three main cities, Thiruvananthapuram, Kochi & Kozhikode in Kerala, India (Anoop Krishnan K, Sreejith M I, Maya K, Liji T M, Narendra Babu K)
Dr. Srikumar Chattopadhyay	National Seminar on Hills and Hillocks of Kanyakumari district during 15th May, 2010.	Impact of topographic alteration on the natural resources.

9.7 Workshop on 'Interdependences between, rivers and backwaters: consequences for water quality ecology, economy and environmental governance

CESS has organised and conducted a workshop with Leibniz Centre for Tropical Marine Ecology (ZMT), Bremen during 21-22, February 2011. Topic of the workshop was 'Interdependencies between rivers and backwaters: consequences for water quality, ecology, economy and environmental governance: A case study of Kerala, India.' The workshop dwelt upon investigation of pollution effects on the ecology of aquatic organisms in the Vembanad lake ecosystem and its watershed through the contribution of multi-disciplinary approaches. Delegates from different departments of University of Kerala, Jawaharlal Nehru University, Directorate of Environment and Climate Change, Government of Kerala, etc. attended the workshop. Fruitful discussions and deliberations were held through two Technical sessions.

10.1 Earth Day 2010

Dr. T. Radhakrishna, Director -in- Charge, CESS, addressing the students who visited the campus on Earth Day 2010.

Earth Day 2010 coincided with the World People's Conference on Climate Change, held in Cochabamba, Bolivia, and with the International Year of Biodiversity. The focus of the fortieth anniversary of Earth Day was on outdoor environment. CESS observed the Day along with the rest of the world on 22 April 2010. More than 150 students from nearby schools along with parents and teachers visited CESS. The laboratories of CESS were opened to students and they were given opportunities to interact with the scientists. Dr. N. P. Kurian gave a lecture on Tsunami Early Warning System. Lectures were also delivered for children on Green House Effect and the Ozone hole.

Students interacting with scientists. Many laboratories of the Institute were open to the public and students on Earth Day 2010

10.2 Earth Watch Centre (Museum & Park)

The programme is aimed at establishing an Earth Watch Centre (EWC) in CESS which comprises of a Park and Museum in CESS. The EWC will provide opportunity for students and public to study, research, promote, preserve and conserve geo-heritage. The EWC will also function as a centre of geo-heritage collections and science communication. This centre will act as a knowledge disseminating centre for helping the fellow citizens of our country to have scientific understanding about the basic earth processes through specimens, models and audio visual media. The immediate task is to bring out a full fledged project report including the design of the buildings, lay out and various audio visual programmes. The project report thus prepared will be forwarded to several external funding agencies for financial assistance.

An approach paper for establishing an Earth watch- Geo Park, Museum and a Dynamic Earth Pavilion within the CESS campus was mooted.

10.3 National Science Day 2010

National Science Day was observed on 28th February 2011. Around 70 students from Kendriya Vidyalaya, Akkulam visited various laboratories of CESS in connection with the National Science Day 2011. A short talk was also delivered on the focal theme, 'Chemistry in Our Lives.'

10.4 Exhibition

CESS participated and opened a stall in connection with 'Santhigiri Expo 2010' held at Santhigiri Ashram, Pothencode, Trivandrum during 6 -15, September, 2010. This international exhibition was organized by the Santhigiri Ashram Thiruvananthapuram as part of 'Parnasala Dedication' event.

CESS also organized an inter-institutional exhibition in connection with the 'Twenty Third Kerala Science Congress' held at Thiruvananthapuram during 29-31, January, 2011.

10.5 Earth Science Forum

The Earth Science Forum of the Centre has organised seven lectures by eminent personalities like Dr. Ivan Angelov, Bulgarian Academy of Sciences on PDT in Dental Practice, Sri. Ajay Vasudev, Dy. General Manager, Oil and Natural Gas Commission, Ltd. on 'Oil's quest for equity oil abroad', Prof. J. N. Goswami, Director, Physical Research Laboratory, Ahmadabad on Chandrayan I and Beyond, Dr. K. P. Thrivikramji, Prof. Emiritus, Department of Geology, University of Kerala on 'Earth Surface Process Research Re-dedicating Earth Sciences in Public Service' etc. The Forum also initiated ineractive sessions on frontier areas of Earth Sciences for the Post Graduate students in geology studying in different Universities in Kerala. The programme was inaugurated on 26th March 2011. Forty six students from the University of Kerala attended the inaugural session. Senior scientists of the Centre conducted interactive sessions for students on fifteen identified topics.

10.6 Campus Green Committee

A Campus Green Committee is functioning in the Centre to implement programmes to keep the CESS campus clean and to demonstrate modern methods of solid waste management. To begin with, twenty five labelled waste bins with lids have been installed in the campus to collect biodegradable, plastic and toxic & hazardous materials. Arrangements have also been made for the proper disposal of the collected waste materials. The Committee is also implementing long term programmes to improve the overall easthetic appeal of the campus. A 'CESS Green Corps' was formed to propagate and implement the green technologies in the Campus.

10.7 Lectures for students

Dr. K. K. Ramachandran, Head, Central Geomatic Laboraory delivered a talk on 'Remote Sensing' for the students of St. Joseph's School, Trivandrum on 29th April, 2010 as part of 'Science Popularization Initiative Face to Face with Frontier of Science' organised by Swadeshi Science Movement.

Dr. Srikumar Chattopadhyay, Head Resources Analysis Division, talked on 'Natural Resources Management' in a students' camp at Wayanad organised by the M.S.Swaminathan Foundation on 12th May 2010.

Sri. B. K. Jayaprasad conducted a seminar on Geographical Information System and Remote Sensing in Civil Engineering at Amal Jyothi Engineering College, Kanjirapally, Kottayam on 03rd February, 2011.

10.8 Othes Activities

CESS Recreation Club celeberated onam 2010 with traditional gaiety and fervor on 19th August 2010. The event was named "Poovili 2010". *As in the previous years,* 'Athappookkalam *Competition,* PuliKali, *variety entertainment progammes of staff and children created an atmosphere of fun and joy in the Campus.*

CESS Recreation Club enacted a drama named "Prithvi" before the delagates of 23rd Kerala Science Congress held in CESS campus on 30th January 2011

Christmas and New Year celeberations were held at CESS campus on the last working day of 2011. Dance and other entertainment performances by children of the staff members were the highlight of the evening

Committees

11.1 Statutory Committees

11.1.1 Research Council

Dr. Shailesh R Nayak *Secretary, Ministry of Earth Sciences, Government of India* *Maha Sagar Bhavan, Lodhi Road, New Delhi*	*Chairman*
Dr. B. K. Saha *Former Senior Deputy Director General* *Geological Survey of India* *School of Oceanographic Studies* *Jadavpur University, Kolkata*	*Member*
Dr. V. Raghavaswamy *Group Director* *Land use, Urban study Remote Sensing, GIS area,* *National Remote Sensing Centre* *Balanagar, Hyderabad*	*Member*
Prof. A. D. Rao *Centre for Atmospheric Sciences* *Indian Institute of Technology* *New Delhi*	*Member*
Prof. V. N. Sivasankara Pillai *Former Director* *School of Environmental Studies* *CUSAT, Santhi,43/2205 A* *SRM Road, Kochi*	*Member*
Dr. K. Krishnamoorthy FNA, FASc, FNNASc *Project Director, ARFI & Head, AACCR* *Space Physics Laboratory* *Vikram Sarabhai Space Centre* *Thruvananthapuram*	*Member*
Prof. S. Anirudhaan *Head, Department of Geology* *University of Kerala, Kariavattom* *Thiruvananthapuram*	*Member*
Member Secretary *Kerala State Council for Science,* *Technology & Environment* *Thiruvananthapuram*	*Permanent Invitee*
Director *Centre for Earth Science Studies* *Thiruvananthapuram*	*Ex-Officio Convener*

12.1.2 Management Committee

Director Centre for Earth Science Studies Thiruvananthapuram	Chairman
The Director Centre for Water Resources Development & Management, Kunnamangalam, Kozhikode	Member
Sri. G. P. Ramachandran Additional Secretary General Administration Department Government of Kerala	Member
Dr. T. Radhakrishna Head, G S D Centre for Earth Science Studies Thiruvananthapuram	Member
The Controller of Administration Kerala State Council for Science, Technology & Environment Thiruvananthapuram	Member
Registrar Centre for Earth Science Studies Thiruvananthapuram	Member Convener

11.2 Internal Committees

11.2.1 Heads of Divisions

Director, CESS	Chairman
Dr. N. Subhash Atmospheric Sciences Division	Member
Dr. M. Samsuddin Central Geomatics Laboratory	Member
Dr. K. Narendra Babu Chemical Sciences Division	Member
Dr. C. N. Mohanan Environmental Sciences Division	Member
Dr. T. Radhakrishna Geosciences Division	Member
Dr. N. P. Kurian (till 1-12-2010) Dr. K. V. Thomas (from 1-12-2010) Marine Sciences Division	Member
Dr. Srikumar Chattopadhyay Resources Analysis Division	Member
Sri. G. Balasubramanian Training & Extension Division	Member
Sri. P. Sudeep Registrar	Member
Sri. C. K. Sasidharan SIC, Technical Cell	Convenor

11.2.2 Editorial

Director	
Dr. N. Subhash	Chairman
Dr. G. R. Ravindra Kumar	Member
Smt. L Sheela Nair	Member
Sri. S. Sidharthan	Convenor

11.2.3 Purchase

Dr. N. P. Kurian (till December 2010)	Chairman
Dr. E. J. Zachariah (from January 2011)	Chairman
Sri. V. N. Neelakantan (till December 2010)	Member
Dr. G. R. Ravindra Kumar (from January 2011)	Member
Sri. P. Sudeep	Member

11.2.4 Library Management

Director	Chairman
All Heads of Divisions	Members
Deputy Registrar, Accounts	Member
SIC, Technical Cell	Convenor

11.2.5 Library Stock Verification

Sri. G. Sankar	*Chairman*
Sri. John Paul	*Member*
Sri. P. Rajesh	*Member*
Sri. K. Eldhose	*Member*

11.2.6 Canteen

Sri. V. Vasudevan	*Chairman*
Dr. K. K. Ramachandran	*Convenor*
Dr. K. Maya	*Member*
Smt. Femi R Sreenivasan	*Member*
Sri. P. Rajesh	*Member*

11.2.7 Plan Project Evaluation & Monitoring

Dr. S. Chattopadhyay	*Chairman*
Sri. John Mathai	*Member*
Dr. K. V. Thomas	*Member*
Dr. K. Narendra Babu	*Member*
Dr. M. Samsuddin	*Member*
Sri. G. Balasubramonian	*Member*
Dr. G. Mohankumar	*Member*
Sri. C. K.Sasidharan	*Convenor*

11.2.8 Campus Development Committee

Dr. K. V. Thomas	*Chairman*
Sri. G. Sankar	*Member*
Sri. S. Sidharthan	*Member*
Sri. K. Eldhose	*Member*

11.2.9 Campus Green Committee

Dr. V. Nandakumar	*Chairman*
Dr. Tomson J Kallukalom	*Member*
Dr. Archana M Nair	*Member*
Sri. V. Subair	*Member*

Staff Details

12.1 Directors office

Dr. N. P. Kurian	Director (From 01/12/2010)
Dr. T. Radhakrishna	Director-in-Charge (1/03/10 to 30/11/10)
Sri. N. Rajasekharan Nair	P. A to Director
Sri. C. K. Sasidharan	Scientist-E1 & SIC, TC
Sri. S. Sidharthan	Scientist-E1 & SIC, WIC
Sri. V. Chandran Nair	Helper (Gr. 2)
Sri. G. Krishnan Nair	Driver (Gr.1)

12.2 Atmospheric Sciences Division

Dr. N. Subhash	Scientist-G & Head
Dr. E. J. Zachariah	Scientist-F
Dr. G. Mohan Kumar	Scientist-F
Dr. S. Muralidas	Scientist-F
Sri. V. Muralidharan	Scientist-E2
Sri. K. Vijayakumar	Scientist-E1
Sri. K. J. Mathew	Scientist-E1
Sri. Mohammed Ismail	Technical Officer (Gr. 4)
Smt. Nita Sukumaran	Technical Officer (Gr. 1)
Ms. P. Prabhavathy	Stenographer (Gr. 1)

12.3 Chemical Sciences Division

Dr. K. Narendra Babu	Scientist-F & Head
Dr. P. K. Omana	Scientist-E2
Dr. K. Anoop Krishnan	Scientist-B
Smt. T. M. Liji	Technical Officer (Gr. 1)

12.4 Central Geomatics Laboratory

Dr. M. Samsuddin	Scientist-G (on deputation)
Dr. K. K. Ramachandran	Scientist-F & Head
Sri. V. N. Neelakandan	Scientist-F
Dr. C. M. Harish	Scientist-F
Sri. B. K. Jayaprasad	Scientist-C
Dr. Archana M . Nair	Scientist-B
Sri. P. B. Vipin	Technical Officer (Gr. 1)

12.5 Environmental Sciences Division

Dr. R. Ajayakumar Varma	Scientist-G(On deputation)
Dr. C. N. Mohanan	Scientist-E2 & Head
Dr. D. Padmalal	Scientist-E1
Dr. K. Maya	Scientist-E1
Dr. A. Krishnakumar	Scientist-B

12.6 Geo Sciences Division

Dr. T. Radhakrishna	Scientist-G & Head
Sri. John Mathai	Scientist-G
Dr. C. P. Rajendran	Scientist-G (on long Leave)
Dr. Narayanaswamy	Scientist-F
Sri. G. Sankar	Scientist-F
Dr. G. R. Ravindrakumar	Scientist-F
Dr. V. Nandakumar	Scientist-E1
Dr. Tomson J Kallukalam	Scientist-B
Sri. N. Nishanth	Technical Officer (Gr. 1)
Sri. S. S. Salaj	Technical Officer (Gr. 1)
Sri. K. Eldhose	Technical Asst. (Gr. 1)

12.7 Marine Sciences Division

Dr. K. V. Thomas	Scientist-G & Head
Dr. T. N. Prakash	Scientist-F
Dr. T. S. Shahul Hameed	Scientist-F
Dr. A. S. K. Nair	Scientist-E2
Sri. V. Vasudevan	Scientist-E2
Ms. L. Sheela Nair	Scientist-E1
Sri. John Paul	Scientist-E1
Dr. D. S. Suresh Babu	Scientist-E1 (on long Leave)
Dr. Reji Srinivas	Scientist-B
Sri. S. Mohanan	Technical Officer (Gr. 4)
Sri. A. Vijayakumaran Nair	Technical Officer (Gr. 4)
Sri. M. Ajith Kumar	Technical Officer (Gr. 4)
Sri. M. Ramesh Kumar	Technical Officer (Gr. 4)
Sri. M. K. Rafeeque	Technical Officer (Gr. 1)
Sri. M. K. Sreeraj	Technical Officer (Gr. 1)
Sri. Louis Williams	Helper (Gr. 2) (VCL)

12.8 Resources Analysis Division

Dr. Srikumar Chattopadhyay	Scientist-G & Head
Sri. B. Sukumar	Scientist-F
Sri. Shravan Kumar	Scientist-E2
Ms. Ahalya Sukumar	Scientist-E2
Dr. Mahamaya Chattopadhyay	Scientist-E1
Ms. C. Sakunthala	Technical Officer (Gr. 4)
Sri. K. Surendran	Stenographer (Gr. 1)

12.9 Training & Extension Division

Sri. G. Balasubramonian	Scientist-F & Head
Dr. E. Saravanan	Scientist-E1
Dr. Ansom Sebastian	Scientist-E1
Dr. K. Raju	Scientist-C
Ms. K. K. Rimsy	Tech. Officier (Gr.1)
Sri. R. Sivarajan Pillai	Tech. Asst. (Gr. 5)
Ms. S.Najumunniza	Tech. Asst.(Gr. 5)

12.10 Library

Sri. A. Abdunnasar	Scientist-B
Smt. K. Reshma	Professional Asst. (Gr. 1)
Sri. P. M. Gopakumar	Clerical Assistant

12.11 Camp Office, Kochi

Dr. P. V. S. S. K. Vinayak	Scientist-F& S I C
Sri. K. R. Unnikrishnan	Scientist-F
Ms. Sreekumari Kesavan	Scientist-C
Sri. D. Raju	Technical Officer (Gr. 4)
Sri. K. P. Bhaskaran	Stenographer (Gr. 1)
Ms. M. K. Radha	Typist (Gr. 1)

12.12 Administration

Sri. P. Sudeep	Registrar
Sri. A. V. Anil Kumar	Internal Audit Officer
Sri. M. P. Sivakrishnan	Dy. Registrar (Accts)
Sri. K. Sreedharan	Dy. Registrar (Admn)
Sri. M. A. K. H Rasheed	Assistant Registrar (Accts)
Sri. K. Gopinathan	Assistant Registrar (Admn)
Ms. K. V. Padmaja Kumari	Section Officer (Accts)
Sri. T. D. Besherdeen	P.A to Registrar
Sri. R. Haridas	Section Officer
Ms. K. Viswabharathy	Section Officer
Sri. C. M. Yousuf	Section Officer
Sri. M. Madhu Madhavan	Section Officer
Ms. R. Jaya	Office Asst. (Gr. 2)
Sri. V. Subair	Technical Officer (Gr. 1)
Sri. S. Krishnakumar	Office Asst. (Gr. 2) (on deputation)
Ms. G. Lavanya	Office Asst. (Gr. 1)
Ms. Femi R. Sreenivasan	Office Asst. (Gr. 1)
Sri. Rajesh P	Office Asst. (Gr. 1)
Ms. Rasi P. C	Office Asst. (Gr. 1)
Mr. Siju V	Office Asst. (Gr. 1)
Sri. C. Shensha	Office Asst. (Gr. 1)
Ms. S. R. Surekha	Office Asst. (Gr. 1)
Mr. K. M. Dinesh	Office Asst. (Gr. 1)
Smitha Vijayan	Office Asst. (Gr. 1)
Ms. N. J. Saramma	Typist (Gr. 1)
Ms. K. Prasanna	Typist (Gr. 1)
Ms. K. Nirmala	Clerical Assistant
Sri. N. Jayapal	Clerical Assistant
Sri. K. R. Satheesan	Clerical Assistant
Sri. M. Parameswaran Nair	Skilled Assistant
Sri. C. Surendran	Skilled Assistant
Sri. R. Karthikeyan Nair	Helper (Gr. 1)
Sri. P. C. Sasikumar	Helper (Gr. 1)
Sri. N. Unni	Helper (Gr. 1)
Ms. S. Vimala Kumari	Helper (Gr. 1)
Sri. P. S. Anoop	Helper (Gr. 1)
Smt. P. S. Divya	Helper (Gr. 1)
Sri. B. Rajendran Nair	Helper (Gr. 2)
Sri. P. Saseendran Nair	Helper (Gr. 2)
Sri P. Rajendra Babu	Helper (Gr. 2)

12.13 New Recruitments

Dr. K. Anoop Krishnan
Scientist-B
Chemical Sciences Division

Dr. Archana M Nair
Scientist-B
Central Geomatics Laboratory

Dr. A. Krishnakumar
Scientist-B
Environmental Sciences Division

Dr. Reji Srinivas
Scientist-B
Marine Sciences Division

Dr. Tomson J Kallukalam
Scientist-B
Geosciences Division

Smt. Nita Sukumaran
Technical Officer
Atmospheric Sciences Division

Sri. M. K. Rafeeque
Technical Officer (Gr.1)
Marine Sciences Division

Smt. K. Reshma
Professional Assistant (Gr.1)
Library

Smt. K. K . Rimcy
Technical Officer (Gr.1)
Training & Extension Division

Sri. M. K . Sreeraj
Technical Officer (Gr. 1)
Marine Sciences Division

Sri. V. Subair
Technical Officer (Gr.1)
Estate Management

Sri. P. B. Vibin
Technical Officer (Gr.1)
Central Geomatics Laboratory

Sri. A.. Gopinathan
Assistant Registrar (Admn)
retired on 30 April 2010

Sri. K. P. Bhaskaran
Stenographer
Camp Office Kochi
retired on 30 April 2010

Sri. K. M. Dinesh
Office Assistant (Gr. 1)
Administration

Smt. Smitha Vijayan
Office Assistant (Gr. 1)
Administration

Sri. R. Sivarajan Pillai
Technical Assistant (Gr. 4)
retired on 31 January 2011

Sri. Abdunnasar,
Librarian resigned on 14 Sep. 2010 to take up the post of Librarian in IIST, Tvm.

Smt. S. R. Surekha
Office Assistant (Gr. 1)
Accounts

Sri. C. Shensha
Office Assistant resigned on 31.01.2011 to take up employment in IIMK, Kozhikode

Sri G. Krishnan Nair
Driver Grade I
retired on 31 August 2010

12.14 Retirements/Resignations

Sri. V. N. Neelakandan
Scieientist-F & Head, Central Geomatics Laboratory
retired on 31 December 2010

Dr. S. Muralidas, Scientist- F
Atmospheric Sciences Division
retired on 28 February 2011

Sri. R. Karthikeyan Nair
Helper Grade I
retired on 30 June 2010

Sri P. C. Sasikumar
Helper Grdae I
retired on 31 October 2010

Sri. M. P. Sivakrishnan
Deputy Registrar (Accounts)
retired on 31 August 2010

Sri. K. Sreedharan
Deputy Registrar (Admin.)
retired on 31 August 2010

Balance Sheet

CENTRE FOR EARTH SCIENCE STUDIES
(An Institution of Kerala State Council for Science, Technology and Environment)
Balance Sheet as at 31st March 2011 (without excluding inter-unit balances of CESS and External Projects)

Liabilities	SCH	31.03.2011	31.03.2010	Assets	SCH	31.03.2011	31.03.2010
		Rs. Ps.	Rs. Ps.			Rs. Ps.	Rs. Ps.
General Fund	I	63860465 .00	59932708.00	Fixed Assets	VI	63860465.00	59932708.00
Current Liabilities and Provisions	II	16825822.00	12860424.00	Current Assets	VII	2790282.85	1827705.85
				Loans & Advances	VIII	23494965.00	27434123.00
Unspent balance of Grant from GOK		9459425.85	16401404.85	**Grant-in-Aid Research & Service Component Projects**			
Unspent Balance of Grant-in-Aid Research & Service Component Projects	III	18052361.71	32080854.71	Current Assets	IX	14410395.71	30791809.71
				Loans & Advances	X	3641966.00	1289045.00
Unspent balances of Consultancy Projects	IV	21151709.00	25248792.50	**Consultancy Projects:** Current Assets			
				Loans & Advances	XI	18559184.00	14624002.50
					XII	2592525.00	10624790.00
Corpus Fund	V	49004354.50	42092268.50	**Corpus Fund**			
				Balnce with SBT	XIII	6575.50	
				Term Deposits		36097779.00	42092268.50
				Fund Transfer		12900000.00	
Total		**178354138.06**	**188616452.56**	**Total**		**178354138.06**	**188616452.56**

Significant Accounting Policies and Notes on Accounts forming part of Accounts - Schedule-XIV

Sd/-
Dy. Registrar
Sd/-
Registrar
Sd/-
Director

AUDITORS' REPORT
As per our report of even date attached

Thiruvananthapuram
Date: 22.09.2011

For Jayakumar George & Associates
Chartered Accountants
Sd/-
U. Jayakumar, B.Com., FCA
Membership No. 208958