ANNUAL REPORT 2011-12

Centre for Earth Science Studies

Akkulam, Thiruvananthapuram - 695 031, India

Contents

Preface

I have great pleasure in presenting this Annual Report of CESS for the year 2011-12. This reporting period continued to be another creditable year for CESS in its efforts to grow as a leading R & D centre in the country in the field of Earth Sciences. CESS continued to undertake R&D activities for the improved knowledge of earth's processes for sustainable development of our natural resources, conservation of environment and mitigation of natural hazards in accordance with its stated objectives. Notable are the implementation of 44 sponsored R & D projects and consultancy service to several public/private sector undertakings and agencies from different parts of the country, thus assuring a role for CESS in the developmental programmes of the country and in generating necessary funds to cater to the establishment and infrastructure costs. CESS continued to enhance its infrastructural facilities. The year saw setting up of a modern Geo Fluids Research Laboratory equipped with Digital Microscope and a miniature type fluorescence spectrometer. Efforts were on to set up a National Micro Laser Raman Spectrometer facility with funding from Ministry of Earth Sciences. A Brain Storming Workshop on Earth System Sciences and Natural Resources Management with the objective of working out a frame work for the future research agenda of CESS was organized, inviting distinguished Geoscientists from across the country, during July 21-22, 2011. The 12th Plan proposals were prepared and submitted incorporating research recommendations that emerged during deliberations in the Workshop.

The focus of R & D activities of CESS continued under the following broad themes: Crustal Evolution and Geodynamics, Natural Hazards, Coastal Processes and Management, Atmospheric Processes, Natural Resources and Environmental Management. Programmes under geodynamics and crustal evolution studies focused on topics like palaeomagnetism, petrology, fluid inclusion studies, seismicity and terrain analysis and land subsidence investigations. Geochemical studies on Cretaceous dykes in Kerala traced them to two distinctive mantle sources at different depths formed by different degrees of partial melting. The igneous activity was interpreted in terms of final breakup of Gondwana from the Seychelles and the Madagascar and the geodynamic evolution of the Indian Ocean region in terms of Reunion and Marion plume activity. Whole rock major and trace element geochemistry and mineral chemistry of the granulite facies rocks from the Kerala Khondalite belt have been carried out to understand the tectonothermal history and crustal growth mechanism in the southern granulite terrain in India. Isotopic investigations on charnockites of Precambrian southern granulite terrain were also carried out during this period. A project funded by the MoES, Government of India to study the palaeo fluids in the sediment fills of the Petroliferous Basins of Western Offshore including the offshore basins of Kerala was taken up in collaboration with the Oil and Natural Gas Corporation (ONGC).

CESS continued studies on palaeoenvironmental and palaeoclimatic aspects of Quaternary sediments of the southern Kerala coast. The studies unfolded many geological events that have taken place in the Holocene – the time span representing the past 10,000 years in the geologic calendar. The studies revealed the rapid terregenous flux under the rising spells of sea level in the Early Holocene.

Investigation of different hazards, and providing inputs for disaster preparedness and mitigation, was another core activity of CESS. Around 100 tremors were recorded and catalogued at our Peechi seismic observatory. A few earthquake and land subsidence incidents were investigated. A new project to understand soil piping phenomena was initiated. Our studies documented the significant control the occurrence/non-occurrence and migration of mudbank has on the shoreline changes and erosion/accretion along Munambam-Chettuwa coastal zone. Erosion along the Neendakara-Alappad coastal sector was attributed to beach sand mining and construction of coastal structures such as breakwaters, groins and seawalls. Tsunami inundation mapping based on numerical modeling was prepared for the west coast upto Mumbai.

CESS continued to monitor solar ultraviolet B radiation and minor constituents such as ozone, water vapour, carbon monoxide besides carrying out a major programme on cloud physics and precipitation. The abnormal modulation of atmospheric parameters associated with 2004 Tsunami was studied. Proximity of thunder clouds and probability of lightning strikes was continuously measured over a mountain valley using an electric field mill designed and modified in CESS. Thundercloud formation and electrical charging processes in relation to precipitation is a key area of current scientific investigations. Study of water to air fluxes of methane and nitrous oxide, their concentration and distribution in the estuarine and oceanic waters found that estuarine production and discharge are the major sources of these greenhouse gases in the coastal waters.

CESS implemented a number of projects on natural resources management covering wide ranging subjects like assessment of land system, analysis of terrain character, geomorphic evolution, nature of valley formation, quality of land for sustainable agricultural development, trend of urbanization, study on land use change as linked to climate change and settlement system, and drinking water condition. Water conservation activities were continued in Chadayamangalam Block in selected 20 water sheds under Hariyali Project. Environmental impact assessment studies were carried out at different locations of the State for different activities such as sand extraction, brick clay mining, soil quarrying, hard rock quarrying.

CESS continued to provide consultancy to Government Departments and Public/Private Sector Undertakings on earth science related topics. Detailed geophysical survey was carried out in the Special Security Zone in and around the Sri Padmanabha Swami temple using electrical resistivity sounding and profiling to explore and map subsurface features. We also undertook a detailed study for the Indian Rare Earths Ltd. to address the causative factors for depletion of heavy mineral content along the Chavara coast. CESS initiatives in preparation of cadastral level Coastal Regulation Zone (CRZ) maps have enabled local bodies to make decisions on coastal development with a perspective of Integrated Coastal Zone Management (ICZM). Such maps have been prepared for Kollam and Thiruvananthapuram Corporations and work is in progress for Kochi Corporation and Maradu municipality.

CESS Library added 11 new books and subscribed to 50 journals and online data base on 'Environment Complete' published by EBSCO. Our academic programme continued to be vibrant with as many as 28 registered students and three Ph.D awards during the year. CESS provided studentship to 8 students among the 33 students who did their M.Sc/M.Tech dissertations. Mr. S. Vishnu Mohan and Ms. V. Dhanya secured Young Scientist Award and Best Poster Award respectively under the theme of Earth System Studies and Geo-informatics in the 24th Kerala Science Congress organized by the KSCSTE. Our publication record was moderately good with 31 papers published in national/international journals.

The year witnessed the organization of several seminars/workshops/outreach programmes on different aspects of Earth Sciences. The 10th Professor C. Karunakaran Endowment Lecture was delivered by Prof. Raghuram Murtugudde of University of Maryland. The first High Level Meeting of the Hazard Vulnerability and Risk Assessment Cell under the Disaster Management Department of Govt. of Kerala was held at CESS on 12th May 2011. The inauguration of the Ocean State Forecast System for the Kerala Coast, followed by a workshop at Vizhinjam harbour on 16th July 2011, to educate coastal community about the use of sea state forecast system was significant. A National Brain Storming Workshop on Philosophy and Research Methodology in Geography was held during 7-8 December 2011. Observation of World Wetland Day, Earth Day and Science Day, and participation in Exhibitions, lectures for students were the other highlights of our outreach programmes.

The year was notable for the initiation of a proposal by Government of Kerala for take over of CESS by the Ministry of Earth Sciences, Government of India. As a result of this effort and our continued and sustained advancement in earth science related research activities we are at the door steps of achieving status as national Centre for Earth Sciences. The guidance and support received from the KSCSTE, Research Council, and Management Committee, and the unrelenting cooperation and support from the scientists and staff have been great driving force in our accomplishments. Acknowledging their support and cooperation, I present this Annual Report before you.

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) has rekindled interest because of its location, proximity and similarity in tectonic style, metamorphism and age pattern to Sri Lanka and Madagascar. However, inadequate comprehensive data set, specifically on the structural and geochrnonological aspects, have been major constraints in understanding the evolution of KKB, in turn southern India, with respects its position within East Gondwana. The Petrologic and geochemical studies so far on rocks from the KKB as well as investigations on the structural geology within the Achenkovil Shear Zone (ASZ) have presented results of studies on the development of arrested charnockites, the migmatisation of metapelites and garnet-biotite gneisses and the generation of leucogranites, geochemistry and thermobarometric evolution of the main lithologies and on the mineral chemical and whole rock isotope dating of rocks. These studies presented a complex tectono-metamorphic history spanning most of the Proerozoic era and continuing to the Pan-African. One of the aspects overlooked was on the nature of origin and interrelation between different gneissic variants, including charnockite types (arrested and massive). Major goal of this project was to address this problem by detailed quarry based field examination and trace and REE analysis of closely spaced samples.

New sets of mineral chemical data generated by us were in conformity with the published data and with reports constraining the P–T conditions of metamorphism of KKB. We applied improved

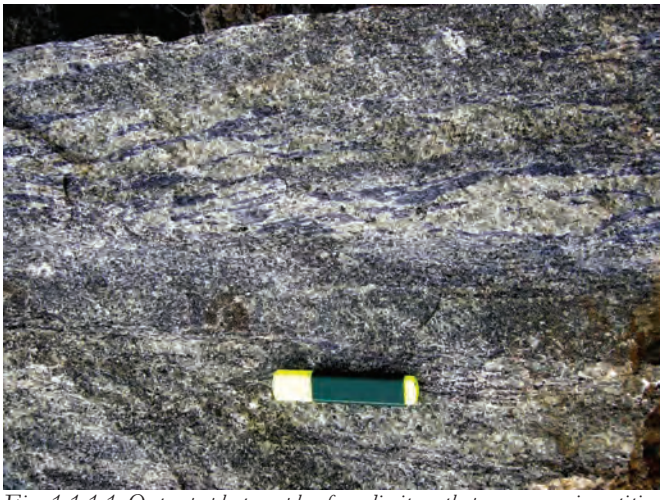

Fig. 1.1.1.1 Outcrop photograph of cordierite-orthopyroxene migmatitic gneisses of KKB, showing foliation parallel leucosomes and domains of mesosome and melanosome with distinct mineral assemblages recognized at Valamchuzhi. Note the enrichment of biotite ± cordierite assemblage along the leucosome-melanosome border showing partial rehydration of cordierites.

set of phase equilibria calculations in refinement to demonstrate the reported thermobarometric conditions to a lower P-T region of the model petrogenetic grid, and present new evidence for partial melting of continental crust at low–P levels within granulite-facies regime Achenkovil shear zone. We also investigated significance of cordierite formation (Fig. 1.1.1.1) and its possible relationship with melt formation by applying theoretical calculations in the MnO¬¬–Na2O–CaO–K2O–FeO–MgO–Al2O3–SiO2–H2O (MnNCKFMASH) system. We computed mineral–melt equilibria for the granulite-facies cordierite-orthopyroxene migmatitic-gneisses exposed along the Achankovil shear zone (AKSZ) of Kerala Khondalite Belt (KKB), southern India in MnNCKFMASH system, extending

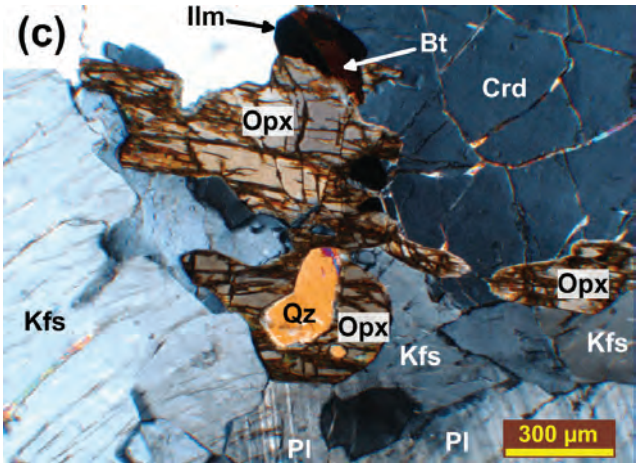

Fig.1.1.1.2 Photomicrographs showing representative mineral assemblages and textural relationships in the cordierite-orthopyroxene migmatitic gneiss of KKB. Note the co-existence of biotite and ilmenite suggesting ilmenite development from biotite incongruent melting and tongues of pyroxene projecting to cordierite.

the KFMASH model metapelite system by adding MnO, Na2O, and CaO as thermodynamic components. Our study testified the robustness of MnNCKFMASH phase equilibria for constraining decompression exhumation and low-P crustal anatexis of high-grade granite-migmatite terranes. Based on field, textural (Fig. 1.1.1.2), and P–T–X relations of cordierite-orthopyroxene migmatitic gneisses of KKB confirmed equilibration of the typical mineral assemblages at 3.2–3.3 kbars and 827–839 °C, attaining anatectic conditions at typically low–P conditions. We noted the beginning of metamorphic P–T path of KKB cordierite-orthopyroxene migmatitic gneiss as characterised by the decomposition of biotite forming anhydrous orthopyroxene bearing assemblages, within the stability fields of biotite. Several workers have shown biotite dehydration melting as common features in migmatites, which they attribute to heating in relation to crustal thickening. The clockwise P–T–t

path (Fig. 1.1.1.3) implies crustal thickening-related heating as the cause for dehydration melting. Experiments have proved that the biotite dehydration reaction can generate ~30% melts in rocks, contributing to the formation of migmatitic gneisses ranging from metatexites to diatexites as observed in the cordierite-orthopyroxene

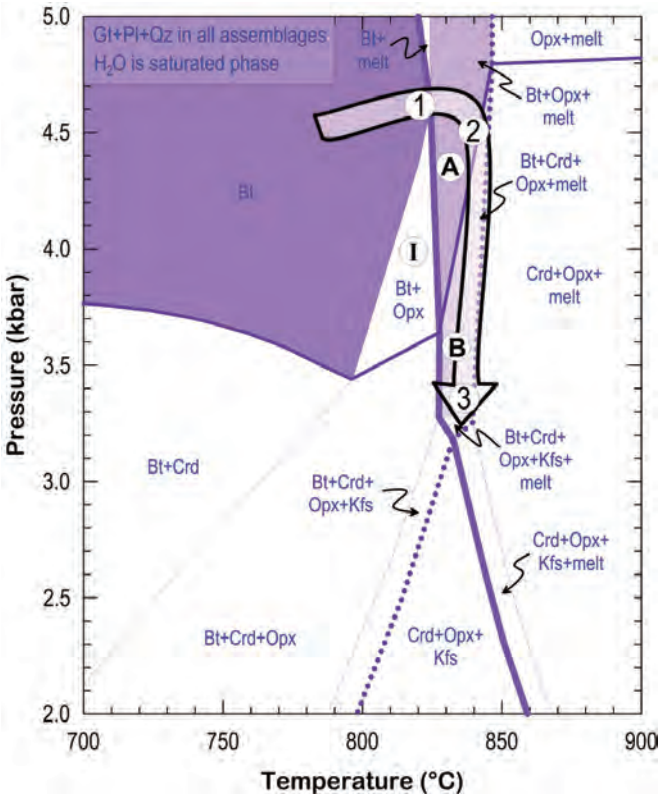

Fig. 1.1.1.3 P–T–X *pseudosection showing derived phase relations of typical mineral assemblages and solidus-suprasolidus separation in relation to cordierite and biotite stability. The metamorphic* P–T *path (arrow) typically follows clockwise array, showing isothermal decompression for crustal evolution.*

migmatitic gneisses of KKB. The sequence of reactions involving the formation cordierite-orthopyroxene-melt assemblage is consistent with an isothermal decompression (with a pressure drop of >1.5 kbars) at high temperatures (>800 °C), forming leucosomes. Biotite dehydration melting reactions, occurring above 4.5 kbars constrain prograde arm of the P–T trajectory which we interpreted as a product of crustal thickening, which was followed by rapid decompression. Our conclusions indicate low–P metamorphism and anatexis can be traced to convergent setting, where melt buoyancy considerably decreases density of the lithosphere and modifies rheology leading to rapid exhumation of the lower crust. Therefore, the crustal evolution in the Kerala Khondalite Belt is correlated with two stage processes: (i) thickening of the crust in relation to a continental-arc setting, followed by (ii) exhumation along a high-temperature stable geotherm with sufficient pressure release associated with syn- to post-convergence transpression and transtension.

In the KKB, potasic and sodic types of granitoids are interlayered in meter to kilometer scale and occur dominantly towards south and southwestern part of the KKB. Gneisses with conspicuous augen texture dominate towards the northeastern margin of KKB along the Achankovil zone. Strong foliation is noted in both sodic and potassic types defined by bands of quartzofeldspathic and mafic mineralogy (Fig. 1.1.1.4). Nature of contact between each type is not clear to permit field based classifications. High-grade metamorphism and deformation has largely modified the contact and earlier structure. In field, gneisses are medium to coarse-grained with marked inequigranularity of the minerals, foliation, and preferred orientation of the feldspar and biotite grains. We examined gneissic variants disposition, interrelation and genesis from different angles by applying field based techniques, petrographic characteristics, mineral chemical changes and trace and REE analysis. These results were synthe-

Fig. 1.1.1.4 Field relations in the high-K metagranites. Note patches of arrested charnockite overprinting gneissic fabric adjacent to pegmatite veins.

sized and integrated to interpret their space and time relations

New petrological and geochemical data with the available geochronology of the high-K granites of the KKB were successful in defining the nature and origin of these granites and their geodynamic setting. Geochemical exercise documented linear variation of major and trace elements on Harker diagrams suggesting an igneous origin of the gneisses. We recognized complementary major element patterns in the two rock groups with K2O/Na2O higher (>1) in high-K granites, while increase in Na2O content in tonalites. Our focus on metagranitoids documented high-K granites to have a narrow silica range (64–73 wt %), high K2O/Na2O ratios (1.08–3.34), with all samples showing high-K affiliation, low Nb/La (0.07-0.27) and La/Th (1.60-

5.71) ratios and showing highly fractionated REE pattern with (La/Yb)N ratios of 9–35, caused by enrichment in the LREE. A distinctive feature noted of the high-K metagranites is the strong negative Eu anomaly (Eu/Eu*=0.10–0.44). The geochemistry suggested distinctive features of arc-related magmas (Fig. 1.1.1.5) with LILE (K, Rb, and Th) and LREE enriched patterns and considerable troughs of HSFE (Nb, Zr, and Ti), features characteristic of magmatic differentiation process in their generation. The marked depletion in Nb and Sr content characterised them as typical crustal

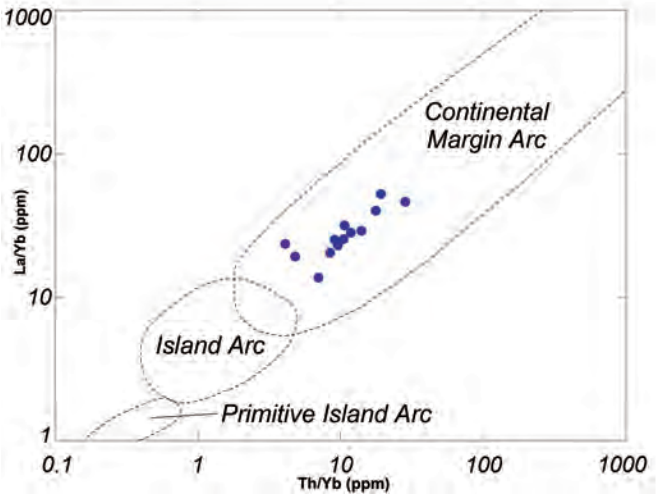

Fig. 1.1.1.5 Tectonomagmatic discrimination of high-K metagranites based on La/Yb vs. Th/Yb diagram.

derived magmas. Further, the Sr depleted and Y-undepleted nature along with the strong negative Eu anomaly suggested melting of source materials in plagioclase stability field and retention of plagioclase in the residual phase. The geochemical features of high-K granites supporting origin in relation to a convergent margin setting was significant as it suggested an important petrogenetic role of re-melting and differentiation of arc-accretionary complex crust. This observation also provided insights into possible arc-accretion processes that contributed to crustal reworking and formation of the granitic magmas. Our results and interpretation were a major departure from the earlier observation of supracrustal origin for KKB rocks. Therefore this work documented unrecognized magmatic event in the KKB, linking the arc accretionary complex setting proposed for Sri Lanka and Madagascar, implying the arc-formation process has an important event associated with the supercontinent event. Further, these results provided key geochemical fingerprints for regional comparison of the widespread arc-related magma genesis in neighbouring continental fragments including Sri Lanka and Madagascar.

G.R.Ravindra Kumar and C. Sreejith

Funding: DST, Govt. of India

1.1.2 Mafic igneous activity

Palaeoproterozoic

Main focus of study under mafic igneous activity for the understanding of the continental magmatism and lithosphere evolution during 2011-12 has been on the Palaeoproterozoic mafic dyke intrusions within the Bundelkhand and Bastar cratons. More detailed analysis of the alternate field demagnetizations data have been carried out in selected additional representative samples for thermal demagnetizations. Thermal demagnetization experiments were conducted at 50°C interval between room temperature and 500°C range and thereafter at 20°C interval up

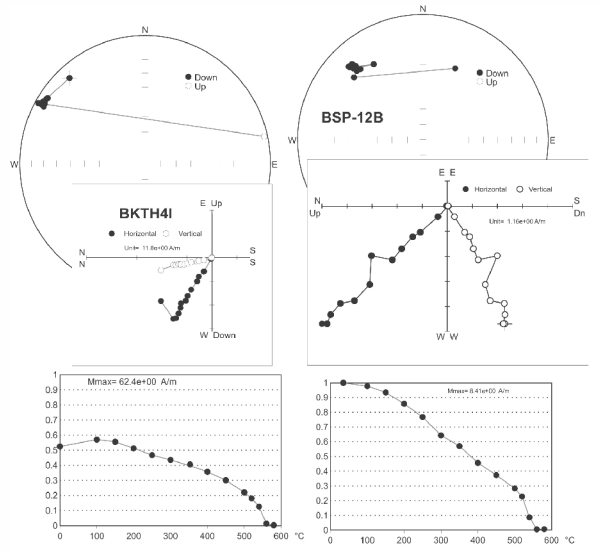

Fig.1.1.2.1 Stereographic projections, orthogonal projections and temperature-intensity plots of thermal demagnetisation responses of the Bundelkhand (left) and Bastar (right) mafic dykes

to 580°C. All the data were analysed to delineate characteristic remanent magnetizations employing principle component analysis. The line segments passing through the origin with mean angular deviations less than 10° were considered to compute characteristic magnetizations. Additional efforts were made to distinguish the steep directions further and to classify the steep remanent magnetizations into three distinct subgroups when palaeopole data are considered. Samples from each group of directions from both Bundelkhand and Bastar cratons were chosen for temperature-susceptibility and isothermal remanent magnetization experiments. These results show that titanomagnetite is the chief magnetic carrier in the mafic dykes in both the cratons with minor signatures of meghamite and pyrrhotite in some cases. Typical curie temperatures are in the range of 520-560°C. Heating and cooling curves for majority of samples exhibit reversible behaviour. Coercivity of the dyke samples in both cratons is always <30 mT. Examples of orthogonal projections of the alternate field and thermal demagnetization responses of representative samples are shown in

figure 1.1.2.1. Some of the sites which failed to obtain within-site coherence were discarded. Other sites with good within-site coherence are classified into distinct groups of remanent magnetization components and calculated between-site mean for each set of directions. Interestingly there is a good one to one correspondence between the distinct directions delineated from Bundelkhand and Bastar cratons. Efforts were made to integrate the recent zircon/baddeleyite U-Pb isotope dates and also to make correlations with the remanent magnetizations of the South Indian shield in order to assign ages to the discrete magnetizations.

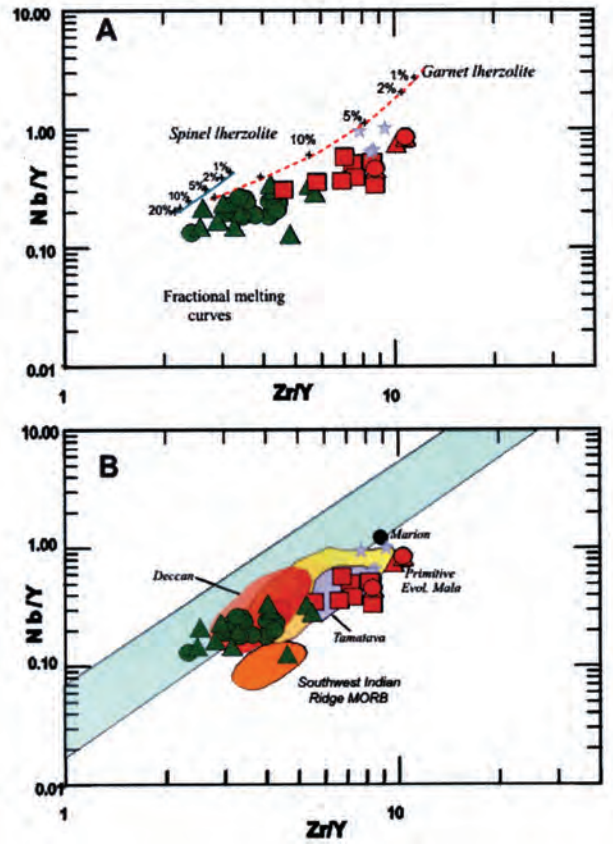

Fig. 1.1.2.2 (a) Nb/Y vs Zr/Y plot for samples of 85-90 Ma and 65-70 Ma dykes compared with Madagascan ferrotholeiites and (b) Diagram comparing the dykes and Madagascan basalts with the upper and lower bounds on data obtained for lavas from the Iceland Neovolcanic zone. Details of procedures for fractional melting curves shown for garnet and spinel lherzolite, melt parameters and partition coefficients in (a) and sources for different fields marked in (b) and additional explanation are in the original source (Radhakrishna and Mathew Joseph, Geol. Soc. Am. Bull., 2011; doi: 10.1130/B30288.1). (■ : central Kerala leucogabbro; ▲: north Kerala leucogabbro; ●: Agali-Coimbatore dolerite) and the open symbols represent 65-70 Ma dykes (●: central Kerala dolerites; ▲ : north Kerala dolerites). Stars denote high Mg-Ti basalts of Madagascar.

Late Cretaceous

With regard to the Cretaceous mafic dykes in Kerala along the western coastal stretch of India, our earlier results of palaeomagnetism and geochemistry were further analysed to characterise magma compositions and their petrogenetic history, palaeopole determinations and compare with the synthetic apparent polar wander path proposed based on data from all other continents. Further the data were analysed to assess the true polar wander contributions and the mantle plume evolution in the Indian Ocean region. The data clearly distinguishes two distinct magmas that cannot be genetically related to have occurred so near in age at 65 Ga and 85-90 Ma. Several comparisons could be drawn between the 65-70 Ma dykes and the Deccan flood basalts and the 85-90 Ma dykes and the Madagascan magmatism. Petrogenetic interpretations advocate a low degree of melting of garnet lherzolite mantle at depths corresponding to transition zone for the older dykes, whereas, the younger dykes are the products of moderate melting of spinel lherzolite mantle at shallower depths. These two magma types were linked to the Reunion and Marion mantle plume activity and to the breakup between India and Seychelles and India-Seychelles and Madagascar. The pole data for the 85-90 Ma suggest that the true polar wander contribution is minimal whereas the interpretations on the contribution from true polar wander for the 65-70 Ma dykes are equivocal. The results were interpreted in terms of migration of Marion and Reunion plumes in the Indian Ocean region. These interpretations are consistent with the interpretations and predictions for the mantle plume migrations based on Global Mantle Circulation Models in the Indian Ocean region.

Additional geochemical and palaeomagnetic work has been carried out to further constrain the interpretations that have been carried out under the Indo French Cooperation for Promotion of Advanced Research (IFCPAR) project and interpretations are under progress.

T. Radhakrishna

Funding: DST, GoI

1.1.3 Tectonothermal History of the Kerala Khondalite Belt

Trace Element Chemistry

Trace elements and REE whole rock analyses of 37 rock samples were carried out at the National Geophysical Research Institute (NGRI), Hyderabad, India, using a Perkin Elmer ICPMS - Elan DRC II instrument and three granite standards (USGS standards G-1 and G-2; Japanese standard granite JG-2). Significantly, the following major & trace element relationships were brought out and have been ploted. SiO_2 (Wt%) Vs TiO_2 (Wt%), Normative Qts Vs TiO_2 (Wt%), MgO (Wt%), FeO (Wt%), Co (Wt%), Nb (Wt%), Normative Opx – Ilm Vs TiO_2 (Wt%), Y(ppm). Fig. 1.1.3.1 and Fig. 1.1.3.2: The relationship between TiO2 and SiO2 is repre-

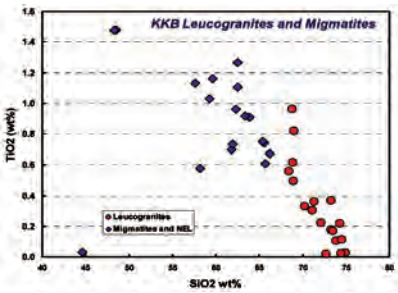

Fig. 1.1.3.1 The relationship between TiO2 and SiO2 is representative of most FM components – TiO2 decreases with increasing SiO2, and so does FeO and MgO

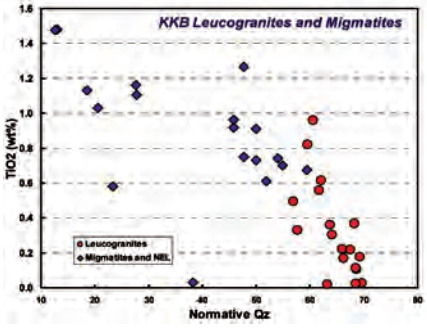

Fig. 1.1.3.2 The relationship between TiO2 and SiO2 is representative of most FM components – TiO2 decreases with increasing SiO2, and so does FeO and MgO

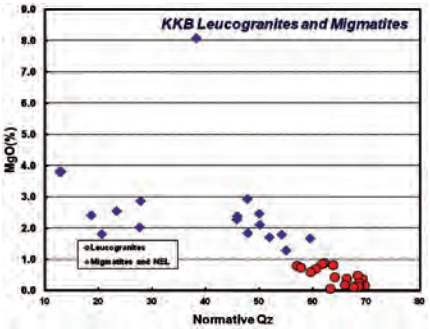

Fig. 1.1.3.3 The relationship between TiO2 and SiO2 is representative of most FM components – TiO2 decreases with increasing SiO2, and so

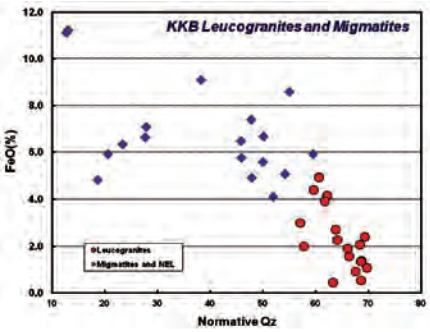

Fig. 1.1.3.4 The relationship between TiO2 and SiO2 is representative of most FM components – TiO2 decreases with increasing SiO2, and so does FeO and MgO

sentative of most FM components – TiO2 decreases with increasing SiO2, and so does FeO and MgO (Fig. 1.1.3.3 and Fig. 1.1.3.4). Leucogranites define this trend well, and migmatites follow it to lower SiO2 but with more scatter. This reflects the fact that both biotite and ilmenite contribute to the TiO2 budget in migmatites whereas in the leucogranites ilmenite is the main player. The normative Qz plot gives an improved picture of this because the SiO2 invovled with feldspars and 'pyroxene' phases is accounted for. This shows that some distinct rocks with low normative Qz have high TiO2 – reflecting high Ilmenite modal proportions.

One way to consider the role of garnet or other FM phases is to look at normative Opx- corrected for ilmenite component (as that may take up trace elements like Co, Y, Nb etc). Leucogranites display clear relations between normative Opx-Ilm and TiO2 and also Y, which suggests a role for biotite (Ti) and garnet (Y). Migmatites mostly continue the trend in terms of Ti but not in terms of Y – this clearly demonstrates that the Y-host is not the Ti-host. The Y-host is garnet.

The Nb-Co plot indicates that Co in leucogneisses is in the ilmenite. In some migmatites it has to occur in another phase as well (e.g. magnetite), or the ilmenite has to have higher Co. The correlation of Y with Nb in the leucogneisses is likely to reflect the petrographic observation that garnet and ilmenite + magnetite increase in abundance together, and that garnet often has ilmenite or magnetite inclusions. Most leucogranites, and many migmatites, appear to consist of mixtures of melt + variable Grt + Ilm (Mgt - magnetite) residua or crystals.

Fig. 1.1.3.5 shows the spectrum of REE patterns for all gneisses classified on the basis of major element chemistry as leucogranites / granites. Fractionated LREE patterns are typical, but HREE and Eu display differences that reflect non-melt compositional factors involving Grt and feldspars.

The REE chemistry indicates that the leucogranites are seldom just simply 'melts' - they vary due to some fractionation, but more importantly they are liquid + crystal mixes, with minor / moderate residual material (e.g. Grt + Bt + Sill. maybe Qz) in some, peritectic Grt (and ilm?) in others, all of these perhaps in some, and only in a few cases is the result simply crystallised melt (forming minimum-melt compositions of Qz-Kfs-Plag-Grt-Ilm-Apat / Mnz etc).

Monazite Mineral Textures and Chemistry

Monazite microanalysis (samples KAI, KUL and KNJ) was preceded by detailed SEM imaging using secondary and back-scattered electrons. Selected examples of monazite textural relationships and internal structures that reflect chemical variations were studied in detail. The consistency of the data obtained is elucidated by Fig. 1.1.3.6.

Zircon Ti Thermometry

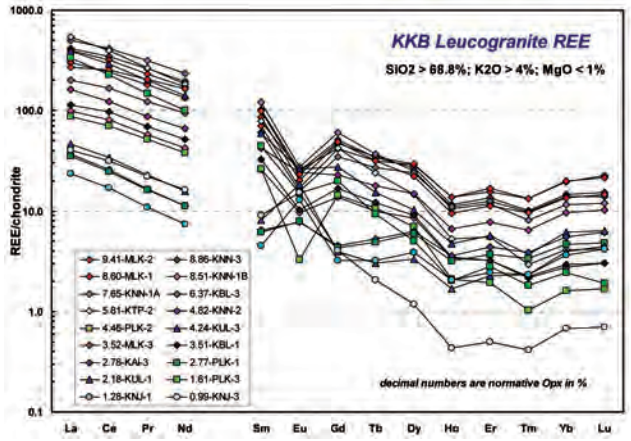

Fig. 1.1.3.5 Leucogranite REE

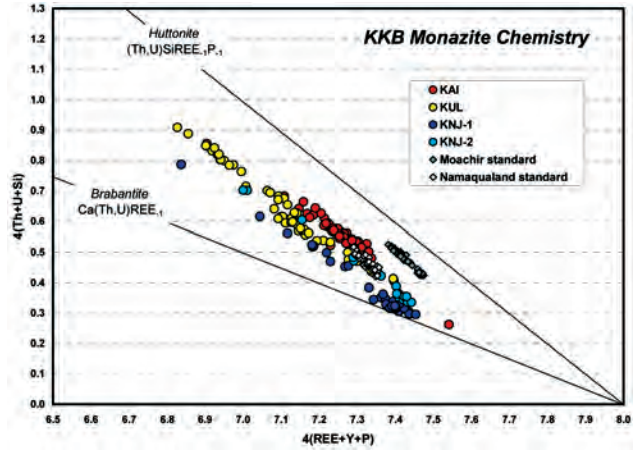

Fig. 1.1.3.6 Monazite-Brabantite-Huttonite diagram (Th+U+Si) versus (REE+Y+P) for samples from the KKB.

Table. 1.1.3.1 Ti in Zircon Temperatures for KKB Samples

Sample	Ti	Temperature °C, Ferry & Watson (2007)					
	(ppm)	aTiO2 = 1	aTiO2 = 0.8	aTiO2 = 0.6	aTiO2 = 0.4	aTiO2 = 0.3	aTiO2 = 0.15
KAI	12.8	784	807	838	884	920	
	1.1	8	9	9	10	11	
KUL flat HREE	12.5	782	805	836	882	917	
	1.6	12	13	14	15	16	
KUL high HREE	12.3	781	803	834	880	915	
	1.3	10	11	11	12	13	
KNJ	6.0	713	733	759	799	830	910
	1.2	19	19	20	22	23	27
NEL	10.6	764	786	815	860	894	
	2.8	23	24	25	27	29	

The incorporation of Ti in zircon has been calibrated as a geothermometer in recent experimental studies by Watson and co-workers. For actual temperatures to be determined it is necessary that the zircon is buffered by the presence of rutile and quartz, and that equilibrium has been attained between the three minerals. In cases where the coexisting Ti-phase is a mineral other than rutile, such as ilmenite or Ti-magnetite, the a TiO_2 will be less than unity and the temperatures calculated will only be minimal. This situation applies to all four of the samples studied from the KKB, as the coexisting 'Ti saturating" phase is either ilmenite or magnetite-ilmenite solid solution in all cases. For this reason, Ti-in-zircon temperatures are reported in Table -1 for a selection of effective a TiO_2 values, and those temperatures obtained for unit Ti activity are minimal. In all cases the temperatures have been calculated using the calibration of Ferry & Watson (2007).

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**Professor of Lower Crustal Process, University of Edinburgh.*

1.1.4 Graphitization process in Kollam District, Kerala, India

The objectives of the project are to identify and classify different types of graphite, associated with different environments, based on their physico-chemical characteristics (associations), to characterise the graphite by XRD, SEM, TGA techniques and to find out the source of Carbon of Graphitization by stable carbon isotope studies.

Extensive field work was conducted in three taluks of Kollam district and graphite-bearing and associated rock samples having different mineral assemblages were collected from Khondolite suite of rocks and its variants like Quartzofeldspathic gneiss, Garnet-Biotite gneiss and Garnetiferrous Biotite Sillimanite gneiss. Graphite is mainly associated with garnet and biotite and in some cases, there is an association of sillimanite also. The sampling locations are Nilamel, Azhanthakkuzhi, Cherukara, Chithara, Boundary Mukku, Ottumala, Karalikonam and Manjappara (Kottarakkara Taluk), Arayil (Kollam Taluk) and Eyyappacha (Pathanapuram Taluk). Five samples were analysed for XRD, SEM, TGA and Stable Carbon Isotopes. The samples were crushed to separate the graphite flakes, which were hand picked and treated with 1:1 HCL and kept on a hot plate at about 100^0 C, to remove iron oxides and carbonates, several times till the supernatent solution becomes colourless. This was followed by heating with HF to make them free of silicates. The samples thus treated were washed throughly, dried and powdered in agate mortar.

The results available for selected graphite samples were compared and compiled. The X-Ray diffractograms reveal the orderly nature of graphite as evidenced by sharp and well defined peaks, having interplanar spacing (d_{002}) values between 3.34A^0 to 3.35A^0 & 1.67A^0 to 1.68A^0 . The values are strictly in concordance with those for highly ordered standard graphite, crystallized with a hexagonal frame work having perfect hexagonal layers of carbon atoms show paral-

lel ordered stacking sequence. The SEM photomicrographs display a unique morphology of six-sided basal sections, perfect micaceous cleavage and arrangements of well formed individual layers in a regular book - type stacking sequence. The thermal decomposition pattern exhibited by TGA fluctuates from sample to sample, with regard to the starting and maximum decomposition temperature. The stable carbon isotope values fall in the range of –6.4 $^{0}/_{00}$ to -22.3 $^{0}/_{00}$. Remaining work is in progress.

Ansom Sebastian

1.1.5 Late Quaternary sediments in the coastal wetlands, Kollam district, Kerala

Kerala has a wetland wealth of 127930 *ha* comprising 34,200 *ha* of inland wetlands and 93730 *ha* of coastal wetlands (Nair, 2007). The coastal wetlands in southern Kerala, south of Achankovil Shear Zone, especially around Kollam, show antecedent characteristics and are seen incised on the Neogene sediments. The Ashtamudi lake and Paravur lake are the major wetlands in Kollam district. These wetlands enfold 20 - 35 m thick deposits of Holocene (the geologic time span representing the past 10,000 years) sediments containing many proxy evidences of landform evolution and climate changes. Holocene sedimentation in these basins was initiated at about 8920 ±110 yrs BP and is represented mainly by subfossil wood/peat or carbonaceous clays. The borehole cores generally exhibit a coarsening upward sequence comprising fluvially derived coarse to medium grained sands at the top followed downward by an organic matter rich, silt and clay dominated sediments resting uncoformably over an erosional surface. The borehole cores in the upper estuarine region of the Ashtamudi basin reveal that the cores are capped further by 2 – 4m thick yellowish brown, silt and clay rich sediments with higher $\ddot{a}^{13}C_{org}$ and $\ddot{a}^{15}N$ values indicating marine affinity of originally deposited sediments, that have been later subjected to post depositional changes. The similarity in the C^{14} ages of a wood sample (7490 ± 90 yrs BP) and the embedding sediments (7480 ± 80 yrs BP) at 5m bgl of the Pangod borehole core indicates heavy discharge of sediments from the uplands and, quick burial of vegetation during Early Holocene. Palynological analysis of the Kallada borehole core shows that Holocene sedimentation in the depositional site took place under marine / nearly marine environment and later changed to brackish water and finally to fresh water environment.

An overall evaluation of the proxy evidences in the sedimentary archives reveals that southern Kerala has experienced dramatic changes in climate and sea level during Holocene period. The changes are well recorded in the sedimentary deposits of the coastal lowlands of the state. The sedimentological, geochronological, palynological and stable isotopic studies carried out in the borehole samples collected from southern Kerala reveal that the period 10 - 5 kyrs BP had experienced extremely high rainfall than the present. It was followed subsequently by a spell of dry climate around 5 - 4 kyr BP and period of high rainfall in the beginning of Late Holocene. These changing climate events of the Holocene had significant role in carbon sequestration in the wetlands and also reddening of sediments in the exposed areas. Quantitative estimation carried out (as an example) in the Polachira wetland of the Paravur Lake reveals that this wetland system holds an amount of 30.94 million tonnes of clay dominant sediments (on dry basis) up to a level of about 10m below ground level (bgl). The estimated quantity of organic and inorganic carbon in the sediments are 1.24 million tonnes and 0.31 million tonnes, respectively. This clearly indicates that the wetlands in this part of the west coast plays a pivotal role in trapping substantial quantities of carbon and other green house gases, which are otherwise return to the atmosphere imparting marked changes in regional climate.

Padmalal D

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

The project 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 facies with faunal tool. To study this, undisturbed sedi-

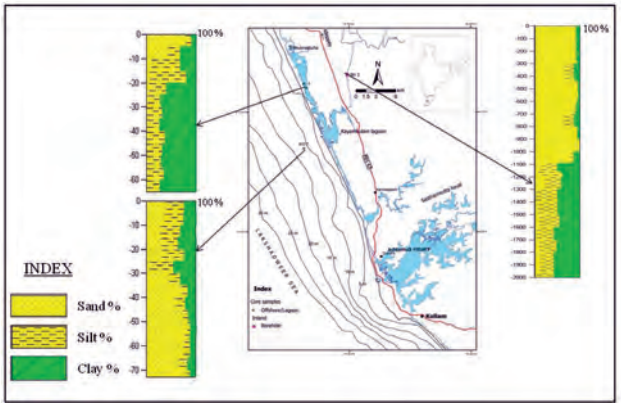


Fig. 1.1.6.1a Lithological variation of sand silt clay percentages representing inland, estury/lagoon and offshore for kayamkulam transect

ment cores from the floodplain, estuary and offshore region were collected. In the flood plain 8 boreholes with depth ranging from 10 to 21 m were collected along two major transects using rotary drilling. In addition to this totally 24 sediment cores were also collected using gravity corer from the Ashtamudi estuary, Kayamkulam lagoon and offshore region.

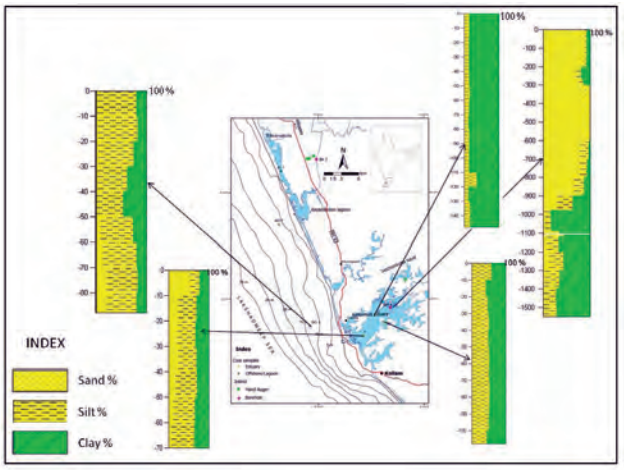
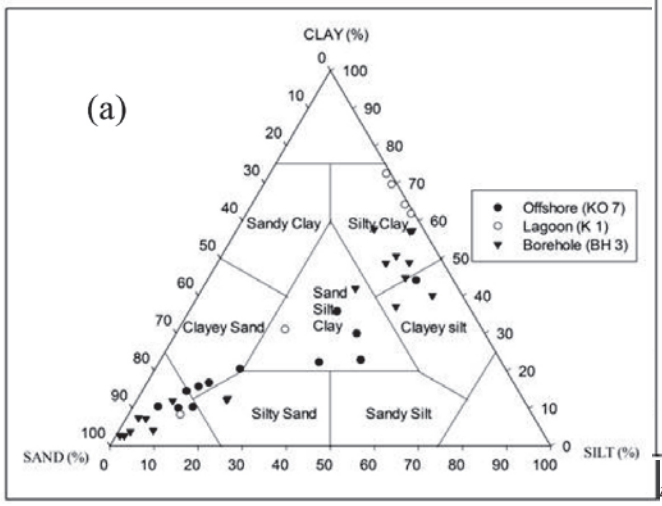


Fig.1.1.6.1b Lithological variation of sand silt clay percentages representing inland, estuary/lagoon and offshore for Neendakara



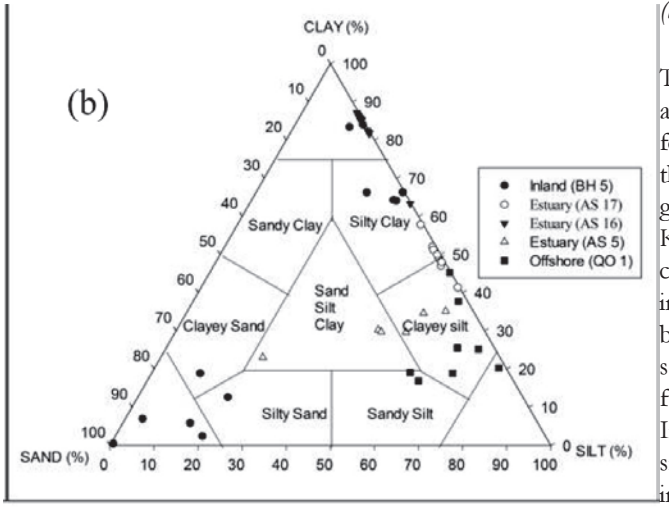
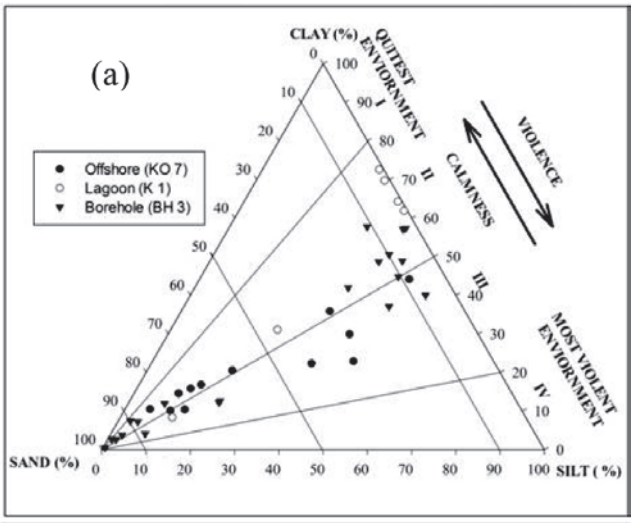
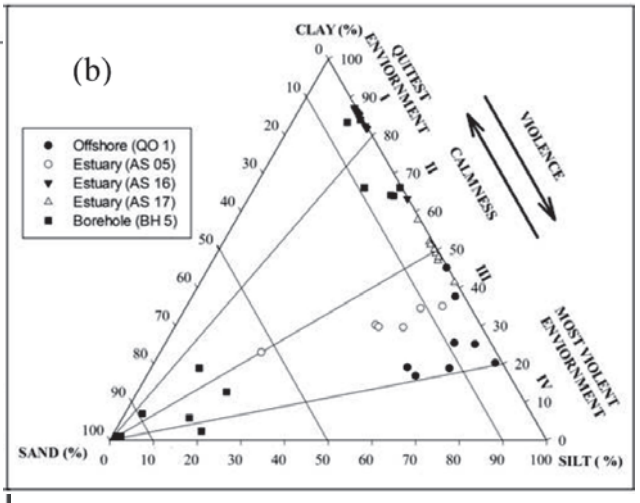


Fig. 1.1.6.2a & b Sediment classification for (a) Kayamkulam (b) Neendakara transect.





ig. 1.1.6.3a & b Dipositional environment for (a) Kayamkulam and (b) Neendakara

The sediment cores were analyzed for lithological variation, detrital and clay mineralogy, radiocarbon dating and distribution of foraminifer's assemblages. The result of textural studies indicates the variation of sediment lithological unit along the inland-lagoon/estuary and offshore region of Neendakara and Kayamkulam transect. In the Kayamkulam transect the down core lithological variation of sand-silt-clay percentages (Fig. 1.1.6.1a) indicates the dominance of sand up to a depth of 11 m followed by the equal amount of silt and clay content. In the lagoon core the sandy sediments dominates at the top but it drastically decreased further down with an enrichment of fine type of sediments (clay). In the offshore region the top 30 cm is rich in sand-silt-clay and silty clay sediments and further down the percentage of sand is increased. In the southern transect covering the Neendakara (Fig. 1.1.6.1b), the top 9 m core is carpeted by sandy sediments of terrigenous origin. Below 10 m the fine type of sediments domi-

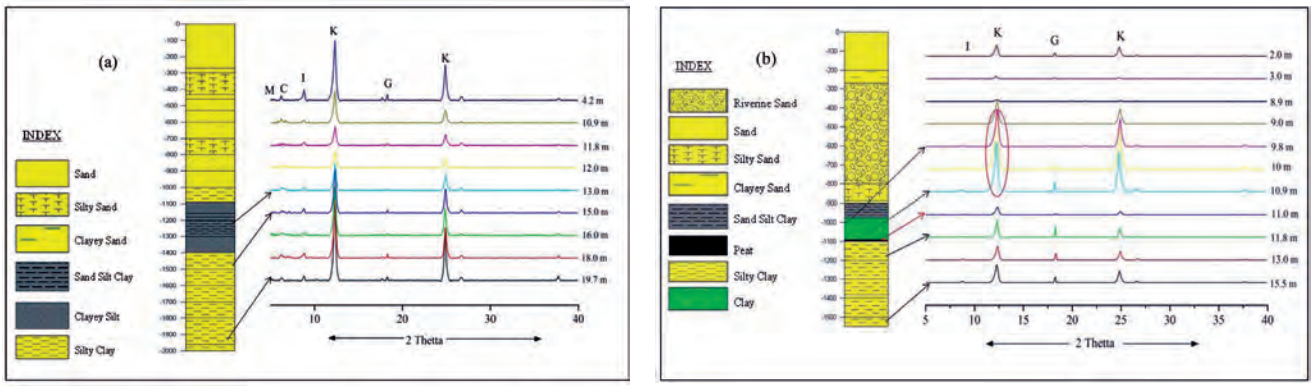


Fig. 1.1.6.4.a & b X-Ray diffraction pattern of clay minerals (K-Kaolinite, I-Illite, C-Chloride, M-Montmorillonite and G-Gibbsite

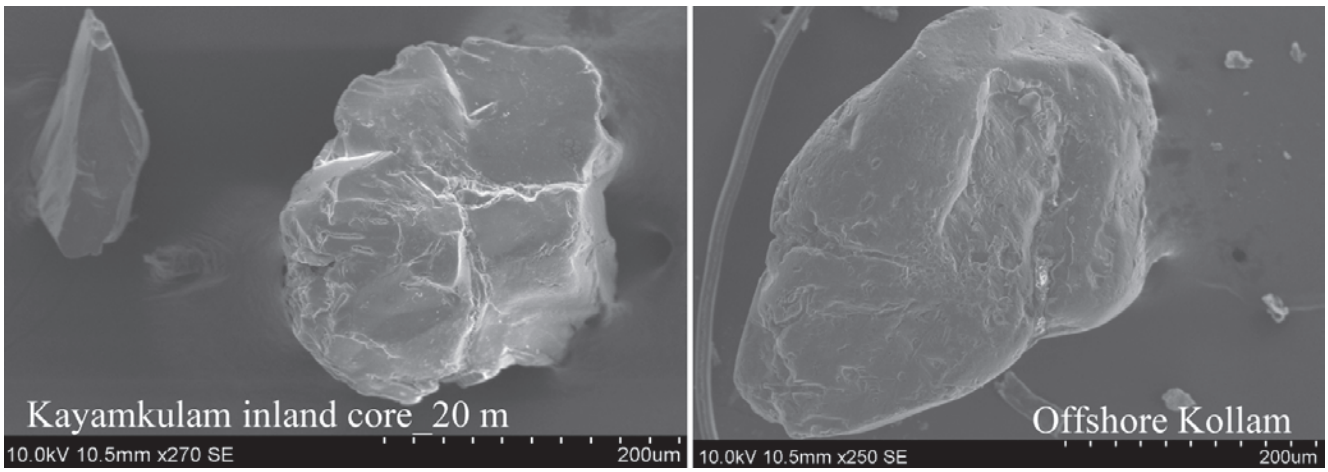


Fig. 1.1.6.5 SEM photograph of the quartz grains

nates the core. Clayey type of sediments is found to have increased in the estuarine cores whereas in the offshore region the percentages of silt increased the entire length of the core followed by clay.

Ternary diagram using sand silt clay percentages were plotted based on Shepard classification for two transects(Fig. 1.1.6.2a & b). The sediments of the inland core of Kayamkulam transect falls under the category of sand, silty clay, clayey silt and silty sand whereas the lagoon falls under the category of silty clay, sand-silt-clay and sand. Offshore core falls under the dominance of sand, clayey sand, sand-silt-clay and clayey silt. In the Neenadakara transect, the inland core falls under the category sand, silty clay, clay, clayey and silty sand, whereas the core samples from the estuary falls under the category clayey silt, silty clay and clay. The offshore core falls under the category of sandy silt and clayey silt type.

The sand-silt-clay percentages were plotted in the ternary diagram after Pejrup (1984) to understand the energy conditions of the depositional environment. The diagram shows four type of classification viz., most violent environment (IV), violent environment (III), quiet environment (II) and quietest environment (I). The sand-silt-clay percentages of the inland, lagoon and offshore sediments of the Kayamkulam trasect incorporated in the Pejrup diagram is shown in Fig. 1.1.6.3.a & b. The results indicate that the sediments of the inland core fall under the violent environment (2.6-10.8 m) to quiet environment (11-20 m). The sediments of the lagoon falls under the category of calmness (sector III). The top 45 cm of the offshore were deposited under the category of calmness whereas further down the core falls under the category of violent environment. In the Neendakara transect the core falls under the category of most violent to calmness environment. The estuarine sediments fall under the category of calmness to quietest environment whereas the offshore fall under the category of violent environment.

Clay mineralogy reveals the dominance of kaolinite, gibbsite, illite, chlorite and montmorillonite in the study area. The clay mineral intensities were plotted against the sediment lithounits for the inland core of the Neenadakara and Kayamkulam transect reveals the difference in peak intensity which further indicates the sediment cores have been deposited in different energy re-

gime. In order to further strengthen the transportational history of sediments in the region, microtextural studies of quartz grains using Scanning Electron Microscope techniques were employed.

Selected samples representing the northern and southern transect were sent for C14 dating. Radiocarbon dating has been carried out on the wood sample collected at a depth of 16m in the Kayamkulam lagoon (9° 10' 5"N: 76° 27' 24" E) yielded the age 8560 ±143 YBP, which indicates the early Holocene. Further studies are in progress to ascertain the transgressive /regressive phase on the sediment cores using different proxy indicators.

T. N. Prakash
Funding: DST. GoI

1.1.7 Quaternary evolution of the coastal plains of central Kerala

Ernakulam district of central Kerala bears the richest manifestation of Quaternary Period in the state. The district has a shoreline length of 50 km, with northern limit at Munumbam and southern boundary at Anthakaran Azhi. An average width of 8 km landward from the shoreline forms the Quaternary deposition limit in Ernakulam. More than 70% of the study area is covered by water body.

Major objectives of the project are (a) to map the study area systematically on 1:50,000 scale using satellite images, aerial

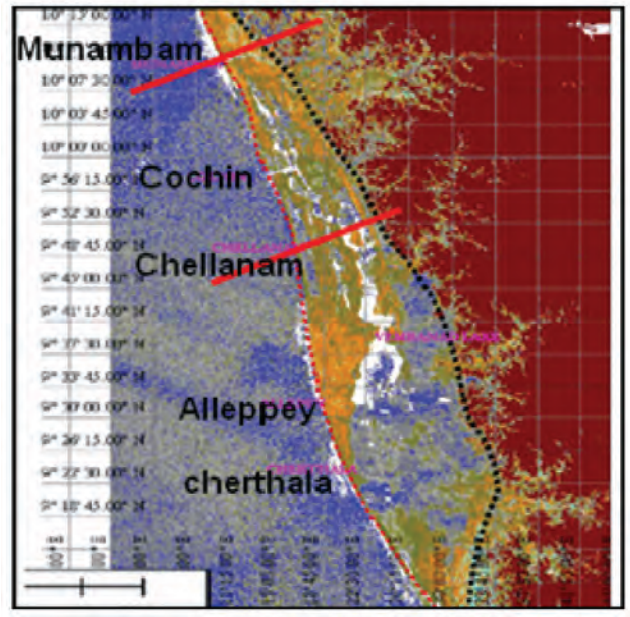


Fig. 1.1.7.1 Palaeo shoreline limit

photographs and SOI topographic sheets, (b) to identify the geomorphic features, (c) to reconstruct litho/chrono-stratigraphic sequence of Quaternary formations at selected sections and (d) to develop a coastal evolution model. Field validation and refinement of base map and geomorphic map were carried out during 2011-12. Currently, the study area is under the influence of different geomorphic processes like Marine, Fluvial, and Fluvio-Marine Processes. The landform units were demarcated based on their genesis and landuse of the study area was depicted under various themes. The Quaternary sediments of study area constitute

Fig. 1.1.7.2 Beach ridges and swales

beach sands, coastal alluvium, valley fills and buried lime shell, peat beds, and calcareous clay deposits. Fig.1.1.7.1 shows inferred disposition of palaeo-shoreline representing the alignment of sea during Quaternary. About five successive beach ridges and swales aligned parallel to the present shoreline were identified (Fig. 1.1.7.2), though at some places these ridges/swales truncate abruptly. They occur 4 to 7 km landward from the present shore line. The alignment of ridges and swales indicate retreating patterns of sea and configuration of erstwhile depositional environments.

The statistical analyses of recent beach sediments collected at an interval of 2 km revealed that majority of these samples are moderate to very well sorted and are negatively skewed showing dominance of marine environment. Textural analysis of sub surface sediments collected from 40 locations ranging from 5-75 m revealed that the majority of them fall under clayey silt/clayey sand and under silty sand/silty clay category. XRD analysis of the clay fraction below 2 microns using standard procedure revealed the presence of different clay minerals like Gibbsite, Kaolinite, Chlorite, Montmorillite, and Illite in various proportions. The clay mineral assemblages of the sediments provide a direct indication of their depositional environment. These results indicate that the coastal area was subjected to fluctuations in the climate ranging from high rainfall and good drainage condition leading to the formation of Kaolinite clays and poor drainage conditions leading to the formation of Montmorillonite clays. The presence of fresh or

saline water is also reflected by the mineralogy of different clay minerals. Further, the clay minerals assemblage has a direct relationship with the bedrock as well as soils of drainage basins. Clays were found to be rich in organic matter and might have deposited under estuarine or shallow water intertidal or fluvio-

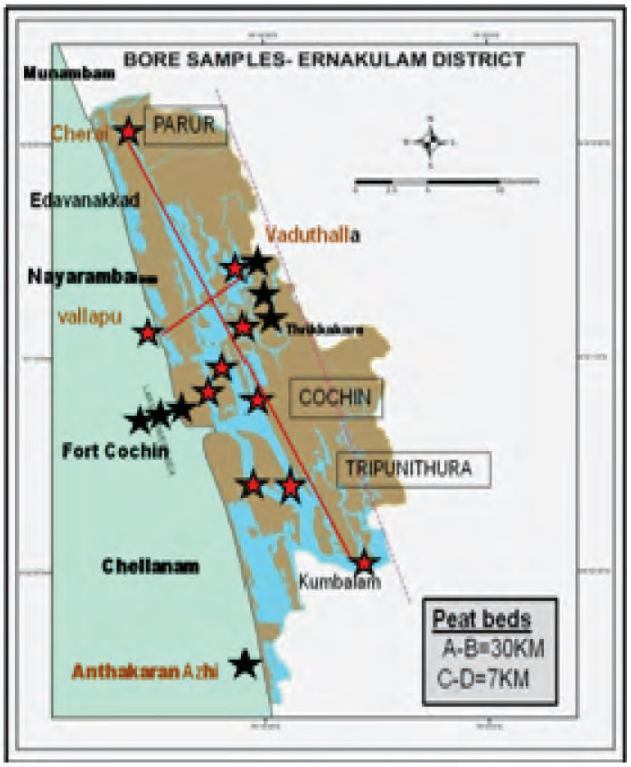


Fig. 1.1.7.3 Location of core samples

marine environment. Data from bore hole depths ranging from 5-70 m, below the surface pertaining to different locations (Fig.1.1.7.3) were examined.

Chemical analysis using standard titration method (Walkey-Black) revealed that the percentage of organic matter lies between 0.4% and 8.2%. The XRF analysis for the major, minor and trace elements for 30 samples collected from different locations were carried out. The results show abundance of certain elements in the sub-surface sediments. The maximum age of the Quaternary sediments collected from Vaduthala, a location situated 6 km landward of the present day shore line, from a depth of 50 m recorded an age of 52,300 YBP+5630 YBP (upper Pleistocene). From the same location fresh (undecomposed) peat beds at 40 m depth provided an age of 41,790 +570 YBP. Peat beds at a depth of 45 m at Vallarpadam also provided 46,900+3920 YBP indicating the lateral extent of these beds landward. On the other hand, the greyish black clays rich in fossils collected from Vallarpadam from a depth of 20 m gave an age of 4,044 +00 YBP (early Holocene). An intermediate age of 22,365 +355 YBP (upper Pleistocene) was however recorded for the clay beds collected at a depth of 25 m from the Goshree Bridge. Hence, the Quaternary sediments of Ernakulam district provide early Holocene to upper Plistocene age. The younger Holocene beds deposited at shallow depths are rich in shell deposits, while the older peat deposits occurring at depths ranging from 40 to 60 m are devoid of shell fragments.

The Quaternary evolution study of Ernakulam district has brought to light the presence of a large sedimentary basin of 10km long and 6km wide area. These sediments are rich in peat, decayed wood and organic matter and the layer thicknesses vary from place to place. C14 dating of the peat, decayed wood and clay rich in organic matter collected from depths of 50m, 45m, 40 m, 25 m 20 m below the ground level from different locations gave ages of 52,300 YBP, 46,900 YBP, 41,790 YBP, 22,365 YBP and 4,044 +00 YBP respectively. The repeated occurrence of peat and decayed wood from the same bore hole at different depths in Willingdon and Bolgatty Islands indicates that similar depositional environmental conditions recurred during Quaternary. The project work is in its final phase and a coastal evolution model for the study area is under preparation.

John Paul

1.2 Atmospheric Processes

1.2.1 Measurement of cloud parameters and cloud modelling

In connection with the studies on the distribution of rainfall and rain drop size pattern, it is desirable to have information on cloud occurrences, their altitudinal distribution, condensation particle concentration and liquid water content. This project was initiated with the objectives to set up ground stations for cloud base height measurement using LIDAR technology giving time-distribution over a site along with cloud base height and vertical visibility. Condensation particle counters were used to estimate the available concentration of condensation nuclei at the measurement location.

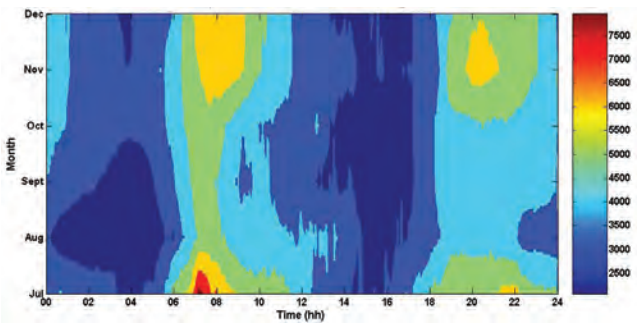


Fig. 1.2.1.1 Diurnal pattern of condensation particle density

A Ceilometer employing LIDAR technique (Vaisala make) was used for monitoring cloud base heights at CESS. The second

Ceilometer was installed at Braemore in April 2010 and regular data is being collected. The CESS Ceilometer was maintained as a reference station. A water based cloud condensation nuclei counter was operational from 2010. An electric Field Mill was also operated from 2009 at Braemore.

All the instruments were operational and output data was con-

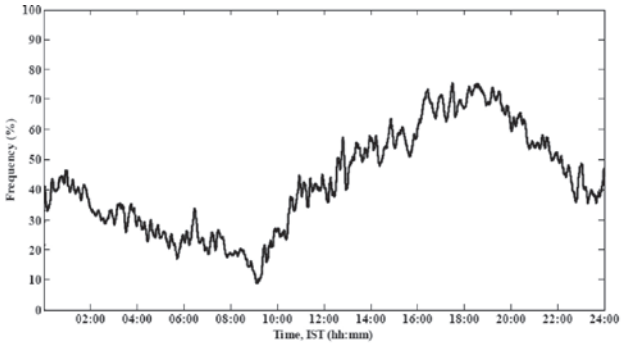


Fig. 1.2.1.2 Diurnal variation of frequency of cloud occurrence

tinuously monitored. As the Western Ghat Mountain region is

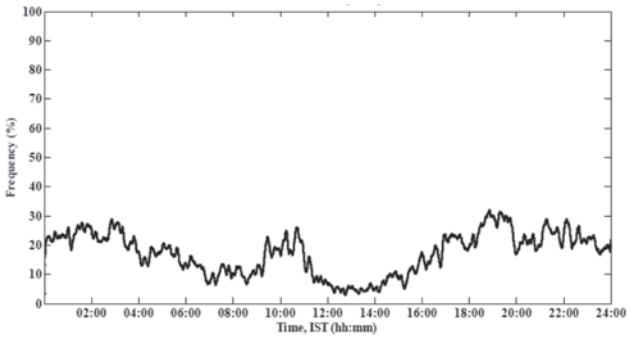


Fig. 1.2.1.3 Diurnal variation of frequency of cloud occurrence

conducive for formation of thunderclouds, data from Ceilometer, AWS and Electric Field Mill were collected from Braemore near Ponmudi Hills. Compared to the Ceilometer measurements at CESS (a coastal site) the pre-monsoon frequency of cloud occurrence at Braemore was higher. During thunderstorm months in Braemore, cloud occurrence begin by 10h, reach a maximum (~70-90%) in the AN, ascertaining convective cloud formation over hill slopes.

Particle count data was collected using Water based Condensation Particle Counter (WBCPC). Consistency is seen in the diurnal pattern during the FN, with a minimum at ~0400h that starts increasing until 0530 h. During day time the diurnal pattern does not show a consistent pattern (Fig.1.2.1.1). 2-D plots were made with data of WBCPC, from July to December 2011. Average particle density of 4052 particles/cm3 was measured. Diurnal pattern depicts bimodal distribution and a positive correlation of 0.76 with atmospheric pressure. Condensation particle concentration also has a relationship with atmospheric boundary layer, which has to be studied in detail

Electric field mills installed at CESS and Braemore were functional and these instruments continuously monitor modifications in the electric field of charged clouds. This data along with micro rain radar data is helpful in classification of clouds.

Cloud base heights for a wide spectrum of clouds and their occurrence at 2 sites were obtained (Fig.1.2.1.2 and Fig.1.2.1.3). As compared to the frequency of occurrence at CESS the frequency at the mountain site Braemore was higher favouring cloud formation. Water based condensation particle counter data at Braemeore adds to information on cloud behaviour and their characteristics. The CPC data was correlated with meteorology and it was found that particle density relates more with pressure. Changes in particle size distribution during formation of convective clouds near mountains are reported. These measurements would be useful in understanding the SW monsoon clouds and in modelling of cloud characteristics and their behaviour in the region.

G. Mohan Kumar

1.2.2 Continuous measurement of ambient carbon monoxide

Carbon Monoxide analyzer was operational throughout the year 2011-12 and the data from the instrument was collected and added to the archive. This analyzer functional from 2002 was a part of (a) the national campaign during 2004 winter on the Indo-Gangetic plains in the foot hills of the Himalayas, (b) the summer national campaign in 2006 over the Bay of Bengal and Arabian Sea and (c) measurements over the midlands (Palode), highlands (Ponmudi) and valley site (Braemore). The annual average CO baseline for Thiruvananthapuram could be drawn from this project. The present data from this project forms an input to the Climate Change program of CESS.

G. Mohan Kumar

Funding: ISRO, GoI

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

The objectives of the project are to : measure the solar UV-B radiation reaching the surface at Thiruvananthapuram, a coastal site and at a high altitude site and to compare UV-B dosages from the climate angle and to use this data to estimate and compare ozone with the Microtops II measurement, (Fig. 1.2.3.1) attempt to assess the role of the SW & NE monsoons affecting the solar UV-B through transport of atmospheric species, measure simultaneously

total ozone and water vapour using dedicated instruments at these environments and quantify changes in the atmospheric water vapour column in relation to the total ozone with the corresponding changes in solar UV-B radiation. Significance is in climate change, especially when tropical tropospheric water column varies.

Diurnal and monthly plots were prepared for ozone, water vapour and solar UV-B radiation at 305, 312 & 320 nm. A few excursions in UV flux associated with ozone depressions and water vapour fluctuations were picked out and satellite data on those episodes were searched. The satellite data from Terra/Aqua and from Modis instrument were utilized for this purpose.

Solar UV Bio-meter and Recorder *Microtops II*

Fig. 1.2.3.1 Instruments used for solar UV measurements

Convincing evidence on corresponding fluctuations in the 4-5 episodes of ozone /water vapour depression concurrent with UV enhancements could not be reached. Continuous observations are essential to arrive at the possible linkage among solar UV-ozone-water vapour.

G. Mohan Kumar

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

Rain rate, drop size, fall velocity distribution and its vertical profile was measured during 2011 - 12 using an impact type Disdrometer, Optical laser disdrometer and Micro Rain Radar. All the instruments were operational throughout the year and data from these were monitored continuously. Prototype of a raindrop charge sensor was designed and developed in the Electronics instrumentation laboratory of ASD. The unit was fabricated and installed at CESS. One of the optical disdrometers procured was installed at Braemore to study the size and velocity distribution of raindrops in orographic events.

Experiments conducted with impact type disdrometer and optical laser disdrometer concluded that during strating of a stratiform precipitation event total number of drops are high and about 85% are smaller drops (D < 1 mm). During initiation of a convective event total number of drops are less and about 90% are larger drops (D > 4 mm). Further, precipitation events from convective and stratiform clouds are identified from MRR and atmospheric electric field mill data. Percentage of convective and stratiform duration in all seasons was computed. A decrease in charge on rain drops was observed from start to end of a rain event.

G. Mohan Kumar

Funding: Space Applications Centre, Ahmedabad

1.3 Coastal Processes

1.3.1 Shoreline Management Plan for Kerala coast

The present study is to develop Shoreline Management Plans (SMP) recommending appropriate sustainable coastal protection measures for Muthalapozhi, Vadanappally and Kozhikode and to monitor the performance of the pilot groins constructed at Panathura, Thiruvananthapuram. It is proposed to have a comprehensive analysis of the problem of erosion through Shoreline Management Plans and prescribe better and more effective coastal protection measures.

The coastal stretches between Munambam and Chettuwa tidal inlets in Thrissur and Beypore tidal inlet and Elathur headland in Kozhikode are being studied for developing the SMP. One of the important factors that influence shoreline modifications along both the above coasts is mudbanks.

Detailed observations on the coastal process along Kozhikode coast (Beypore-Puthiyapa) have been undertaken during 2011-12. Fine grid bathymetry was generated up to a depth of 15m. Nearshore wave and current data were collected deploying wave-

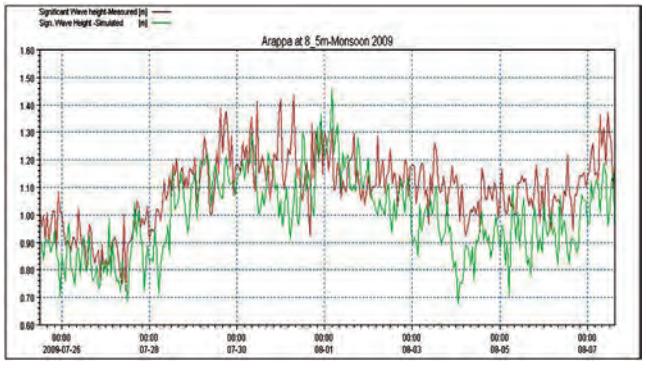


Fig. 1.3.1.1 Comparison of model computed wave heights with measured heiights at Arappa in the Munambam-Chettuva coast during monsoon

tide gauges and current meters during pre-monsoon, monsoon and post-monsoon. Shoreline has been regularly monitored through GPS mapping. Sediments were collected from the beach and nearshore and were analysed for grain size distribution. Beach profile data were collected during different months.

It is observed that the shoreline changes and erosion/accretion process are significantly controlled by the occurrence, nonoccurrence and migration of mudbanks that form along these coastal sectors. Mudbanks are features that appear during monsoon season in different sectors along the Kerala coast. Here waves get dampened which otherwise would have been very rough due to monsoon waves. Mudbanks have migrated and formed at different locations of Munambam-Chettuwa coast, thereby inducing significant shoreline changes along these sectors. Mudbanks have been reported to have formed at Nattika, Edamuttom and Kaipamangalam during the past 40-45 years. During the monsoons of 2009-11 the mudbanks have formed at Arattukadavu-Bhajanamadom about 10 km north of the Munamabam inlet.

Numerical model studies are being carried out using various modules of MIKE 21 model to understand the coastal processes and computing sediment transport and shoreline variation within the study sectors. Model has been calibrated and validated for Munambam-Chettuwa coast with the wave, current and shoreline variation data collected during pre-monsoon, monsoon and post-monsoon (Fig. 1.3.1.1).

The construction of breakwaters at Munambam has caused deposition of beach sediment on the north side of the north breakwater for about 3 km. The ongoing construction of breakwaters at Chettuwa has caused the development of beach north of the Chettuwa inlet. Unlike the Munambam and Chettuwa sectors, the construction of breakwaters at Beypore and Puthiyapa has caused significant beach development on the south side of the breakwaters. It is a reflection on the differences in the sediment transport at Muanmaba-Chettuwa and Beypore-Puthiyapa coastal sectors.

K. V. Thomas

Funding: MoES through ICMAM P.D., Chennai

1.3.2 Study on Depletion of Heavy Mineral Content in the Beach Washings of IREL, Chavara

The project was launched with the objectives to (i) study the changes, if any, in the hydrodynamic and sedimentologic characteristics in the innershelf of Chavara coast, (ii) carry out numerical model studies to understand and analyse the current coastal processes of the region and estimate the beach sediment budget and (iii) identify the factors responsible for the reported reduction in the heavy mineral content in the beach washings, and arrive at remedial measures, if any, possible. The Final Report of this project was submitted during the year.

In order to understand the physical processes and the factors responsible for the reduction in the heavy mineral content of beach along the Chavara coast, field experiments were conducted (Fig. 1.3.2.1 and Fig. 1.3.2.2) involving hydrodynamic measurements and sediment sampling in the offshore, nearshore and beach adjoining the beach washing collection sites of IREL, Chavara. Numerical models were set up to examine the system and to unravel the processes at work and finally to compute the sediment budget.

No discernible changes in the wind, wave and current characteristics other than those of inter-annual changes are noticed over a decade. In order to understand the sedimentary dynamics of the study area, beach and innershelf morphological changes have been studied. Beach profile measurements indicated that barring the two stations adjacent to the southern breakwater at Kayamkulam inlet, all other stations show accretion tendencies during the post-monsoon season and erosion tendencies during the pre-monsoon and monsoon seasons. The continued and enhanced rate of accretion at stations adjacent to the breakwater even during the pre-monsoon is evidently due to the impact of breakwater, which acts like a groin trapping the sediments transported by the predominant northerly currents.

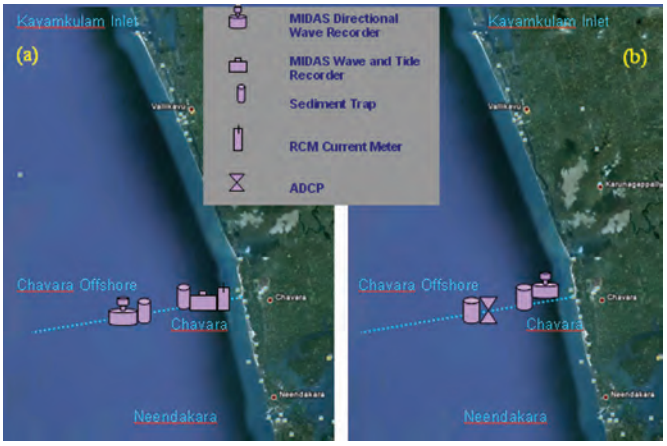


Fig. 1.3.2.1 Scheme of deployment of equipments off Chavara coast during (a) July 2010 and (b) November, 2010 & April-May 2011

The circulation pattern, sediment transport and related processes in the innershelf have been studied using the Sand Transport Module (ST) available under the comprehensive MIKE21 Flow Modelling system (FM). In addition to the computations using MIKE21, the LITDRIFT and LITPROFILE modules of the LITPACK modelling system were also used for the estimation of sediment budget. Separate models have been set up for different seasons by giving the appropriate sedimentological and hydrodynamic data as input. The calibration and validation of the sediment transport during the three seasons were carried out by comparing the simulated results with the magnitude of sediments collected using sediment traps. The spatial and temporal variations in the sediment transport during the three seasons have been studied in detail by carrying out thorough analyses of the longshore and cross-shore transport rates, total sediment load, changes in bed level, etc. at important locations along the coast. Based on the above studies

the estimate of sediment transport in the on/off shore directions, alsongshore directions and thus the beach sediment budget was carried out. Shoreline retreat had been substantial along the Neendakara-Kovilthottam sector during 1968-2006 which was reduced during 2006-10, due to shore protection measures. The entire Azhikal-Ponmana sector was affected by severe erosion during 1968-89 while the rate of erosion reduced in most of the

Fig.1.3.2.2 Deployment of equipments in progress: (a) Directional Wave Gauge, (b) Non-Directional Wave Gauge, (c) Acoustic Doppler Current Profiler (d) Recording Current Meter (e) Sediment trap assembly (f) A deployment site with the watch & ward team on duty

sectors except the mining sites during 1989-2006. During 2006-10 shoreline erosion was significant only at the mining sites because of the presence of seawalls elsewhere. The bathymetry of the area extending up to 20 m depth was measured and supplemented with cross-shore profiles at selected locations. The bathymetric changes that occurred during the past one decade were carefully studied utilising the past data. A relative deepening of the entire innershelf, particularly shallower portions of depths less than 15 m, has been noticed barring the offshore region of Kayamkulam.

During the past one decade the total heavy mineral content has reduced drastically in the beach and the innershelf sediments. Unlike on the beach, the reduction in the innershelf started much early, as early as 1987. The average heavy mineral concentration in the surficial sediments of the innershelf of Neendakara-Kayamkulam sector has drastically reduced from 17% in 1987 to 8% in 2011.

T. S. Shahul Hameed

Funding: Indian Rare Earths Limited

2.1 Landslides

2.1.1 Investigation of landslides and land subsidence

Land subsidence at Tattekanni, Idukki district

A land subsidence has occurred on 19-11-2010 near Tattekanni in Thodupuzha taluk, Idukki district. CESS carried out an investigation of the affected locality to find out the causative factors of the subsidence. Since the Neriyamangalam – Cheruthoni road at Thattekanni was affected by this process, the District Collector of Idukki requested CESS to conduct a joint investigation with the Soil Conservation Department and the Public Works Department, Government of Kerala. During March joint investigation was carried out to understand the nature of soil pipes developed beneath the road. The department has agreed to prepare a plan to salvage the affected site.

Land subsidence at Peringasserry

A land subsidence (Fig. 2.1.1.1) occurred at Peringassery in Thodupuzha Taluk, Idukki district on 10 August 2011 at about 5 pm on the Paramada-Udumbanoor road. The incident occurred on the land belonging to Sri Padmanaban, Muthupalakkal house, Peringassery. The exposed cavity of the subsidence has a diameter of 2.5 m and a depth of 2 meters approximately. At the time of inspection it was covered partially by the collapsed roof earth material. The cavity is interconnected by underground pipe like features

Fig. 2.1.1.1 View of the collapsed surface

(Fig. 2.1.1.2). The soil type is mainly lateritic on the top and clayey in the bottom. The landuse is mainly mixed crops with rubber. The area has substantial thickness of soil. A spring is seen emerging at about 200m north of the collapsed section, which could be an outlet of the pipe. An important aspect is that this pipe is ferrying water beneath the main Paramada-Udumbannur road. The initial

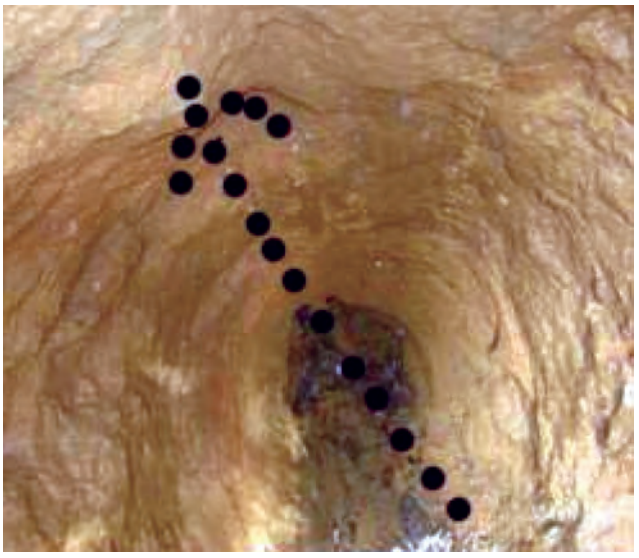


Fig. 2.1.1.2 Top view of the subsided portion. Flow direction is shown with the dotted arrow

estimates indicate that the pipes are at a depth of about 2.2m from the road level. The nature and size of pipes beneath the road section is not very clear.

The subsidence occurred here was due to a natural process called piping. Soil *Piping* is the subsurface erosion of soil by percolating waters to produce pipe-like conduits below the ground. Previously, CESS has reported incidences of piping from Thirumeni village in Taliparamba taluk in Kannur district, Palkkayam village, Mannaghat taluk of Palakkad district and Venniyanimala in the Thodupuazha taluk, Udayagiri locality in the Udumbanchola taluk of Idukki district and also Tattekanni in the Thodupuzha taluk of the Idukki district.

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 few decades. Extensive paddy fields and forest areas were converted to settlement, cultivation and infrastructure developments. 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 phenomena during the extended rainy days. About 32 landslide spots were identified around these areas during the fieldwork. Majority of these incidences were initiated during the last ten year 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 distri-

bution 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 (Fig. 2.1.2.1) is increasing and the year 2010 witnessed seven landslides and two land subsidences. These incidences caused vast devastation of cultivated areas and houses including loss of three lives. The increasing incidence of landslide events highlights the necessity of imposing land use restrictions in high

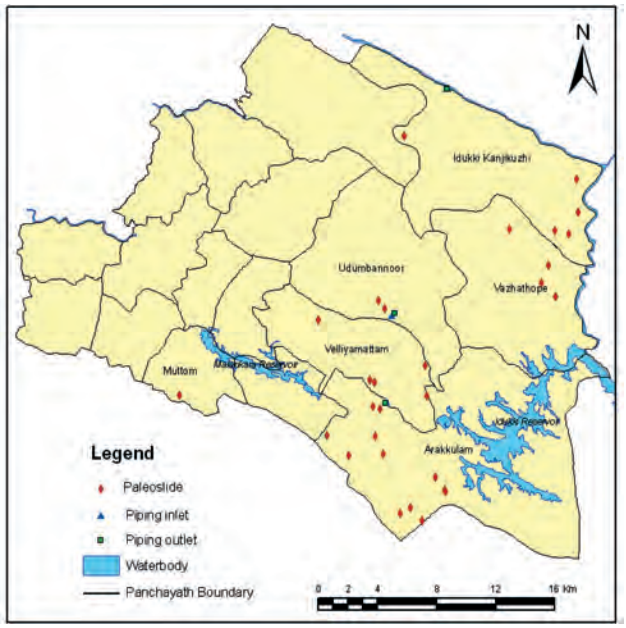


Fig. 2.1.2.1 Landslide distribution

slope areas with the cooperation of local people. The project has been completed and the final report was submitted in January 2012.

K Raju

2.2 Earthquake Monitoring

2.2.1 Seismicity in Idukki region

On 26th July 2011 an earthquake measuring 3.8 M was felt in an area of about 1500 sq. km in Kottayam and Idukki districts. The epicenter of this event was located near Kottamala. Seven after shocks were felt after the July earthquake of which three tremors were measured more than 2M. Based on field investigation it was concluded that the July earthquake was associated with WNW-ESE trending Cheruthoni-Chinthalar lineament. Subsequently tremors were felt on 16.09.2011 in Thopramkudi region located about 15 km NE of Kannampadi. In this area the surface expression was mostly acoustic emissions in the form of loud noise from depth. Subsequently several tremors were felt around Kannampadi. On 18th November two events of 2.8 M and 3.4 M occurred.

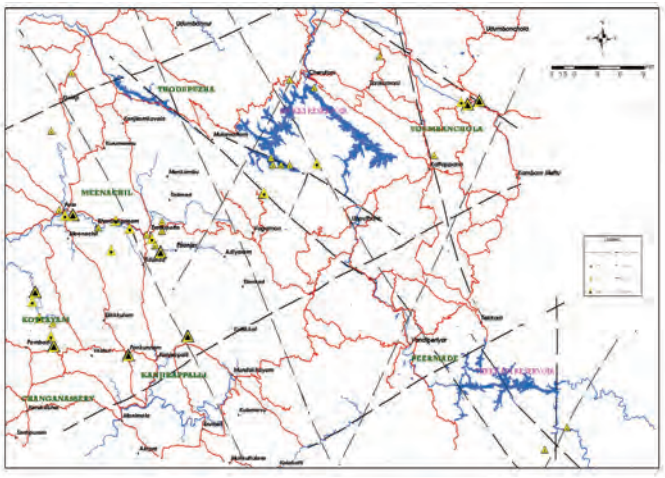


Fig. 2.2.1.1 Idukki Kottayam region showing the location of earthquakes (yellow triangles) and lineaments/deep seated fractures (dashed lines).

Table 2.2.1.1 Details of tremors felt in the Idukki region.

Sl. no	Date	Time (IST) hrs	Location		Magnitude	
			Latitude N	Longitude E	KSEB Data	CESS Observatory
1	26.07.2011	1309	09° 43.8' N	76° 55.0' E	3.8	3.9
2	26.07.2011	1315	09° 44.67' N	76° 55.2' E	2.2	2.2
3	26.07.2011	1415	09° 45.88' N	76° 57.1' E	2.9	3.1
4	26.07.2011	1513	09° 46.71' N	76° 57.0' E	1.0	
5	26.07.2011	1621	09° 46.79' N	76° 57.4' E	1.1	
6	26.07.2011	1626	09° 45.78' N	76° 56.1' E	2.6	2.8
7	26.07.2011	1711	09° 45.25' N	76° 56.5' E	1.0	
8	28.07.2011	0002	09° 45.77' N	76° 55.3' E	1.3	
9	04.08.2011	1926	09° 46.51' N	76° 57.4' E	0.6	
10	20.08.2011	0206	09° 46.43' N	76° 56.8' E	1.5	
11	23.08.2011	1927	09° 45.99' N	76° 57.1' E	2.1	2.0
12	16.09.2011	1539	09° 45.83' N	76° 56.6' E	1.0	
13	16.09.2011	2031	09° 56.96 N	77° 02.1' E	2.2	2.1
14	17.09.2011	0356	09° 47.53' N	76° 57.6' E	2.2	2.4
15	18.09.2011	0629	09° 47.06' N	76° 58.8' E	1.9	2.0
16	03.10.2011	0223	09° 45.31' N	76° 55.3' E	2.0	2.0
17	03.10.2011	2114	09° 45.31' N	76° 55.3' E	0.7	
18	07.10.2011	0316	09° 45.27' N	76° 56.6' E	2.0	2.2
19	03.11.2011	1023	09° 42.05' N	76° 54.0' E	2.4	2.4
20	18.11.2011	0527	09° 46.01' N	76° 55.7.' E	2.8	2.8
21	18.11.2011	0545	09° 46.48' N	76° 58.9.' E	3.4	3.4
22	26.11.2011	0315	09° 43.57' N	76° 55.3.' E	3.4	3.3
23	26.11.2011	0320	Near Valakod	Not available	1.0	
24	26.11.2011	0530	Near Valakod	Not available	1.7	
25	26.11.2011	0549	Near Valakod	Not available	1.4	
26	10.12.2011	1541	09° 43.2' N	76° 39.6' E	2.0	2.1
27	04.01.2012	1439	09° 45.6' N	76° 55.8' E	1.8	
28	09.01.2012	1633	09° 46.2' N	76° 55.8' E	2.0	2.0
29	05.03.2012	0017	09° 46.8' N	76° 56.8' E	2.1	2.2
30	10.03.2012	0348	09° 46.0' N	76° 55.0' E	2.3	2.3

On 26th November another event of 3.4 M was felt in the area followed by after shocks. A list of earthquakes felt in this area since July 2011 is given in table below. Thirty events are recorded from this region in less than a year.

Felt reports collected from Mullaperiyar region indicate that this area was not affected by the present sequence of earthquakes of July 26th and November 18th. The dam is located more than 30 km

from the epicenter. Strong ground motions were felt up to 15 km from the epicenter. However, the deep seated fracture plane where the present movements are located is oriented in WNW-ESE direction. When it is traced to the east it passes close to Mullaperiyar (Fig. 2.2.1.1).

John Mathai

2.2.2 Monitoring Indian Shield Seismicity with 10 BBS to understand Seismotectonics of the region using VSat connectivity

The broadband observatory at Peechi, operated by CESS in the campus of the Kerala Forest Research Institute (KFRI) was established in 1999, as a part of strengthening earthquake monitoring in the peninsular India and improving the detection and location capabilities of earthquakes in the shield region. The station has been recording local, regional and teleseismic events since then. The main objective of the project is to maintain and operate the station to record high quality data. The data recorded here is used for the studies of local/ regional earthquakes. The observatory plays host to a large number of visitors, including students and thus serve a good educational facility to the public. It also serves to provide information on earthquakes to government agencies as well as media and general public.

Continuous archiving of data, phase picks, wave form files and catalogue of events recorded in the observatory are being routinely carried out and the details sent to the IMD on a half-yearly basis. Data up to December 31, 2011 were sent to National Seismic Database Centre during January, 2012. The continuous data are being transmitted online to NGRI, Hyderabad through VSat connectivity. The seismic data from the broadband station are useful to evaluate the seismogenic potential of the Peninsular India and the western Ghat region in Kerala in particular.

The Observatory is maintained well and recorded continuous data. Out of the total 1531 events recorded during March 2011– Feb 2012, there were 1453 global events, 29 events from other parts of India (mainly from - Karnataka, Maharastra, Sikkim-Nepal border, Kashmir, India-Myanmar border) and 24 from Andaman-Nicobar region. Among the regional events, 9 events are from the neighboring area of Tamil Nadu (mainly from Vallakovil, Dharapuram; Thirupur District), one each from Madikkery, Kudagu district, Karnataka state and Nalgonda district of Andhra Pradesh. Other than earthquakes the observatory recorded a few local explosions also. An explosion in Athani cracker manufacturing unit which claimed six lives on 28th December was well recorded at Peechi.

Table 2.2.2.1 List of local earthquakes in Kerala recorded at the Pecchi Broad Band Observatory during 2011-12

Sl. No.	Date	Latitude	Longitude	Magnitude	Time (UTC)	Region
1	25/05/2011	9.08	76.8	3	10:19:37	West of Pathanapuram
2	26/06/2011	11.2	76.19	2.2	9:52:40	Near Pulpetta,13km East of Kondotty, Kozhikode district
3	26/06/2011	11.16	76.08	2.2	22:23:02	Near Pulpetta,13km East of Kondotty, Kozhikode district
4	10/7/2011	11.05	75.93	2	22:28:23	Thirurangadi
5	26/07/2011	9.727	76.917	3.9	7:39:16	Near Idukki Dam
6	26/07/2011	9.763	76.952	3.1	8:45:57	Near Idukki Dam
7	26/07/2011	9.763	76.935	2.8	10:56:44	Near Idukki Dam
8	18/08/2011	10.578	76.198	2	12:09:50	5-6 km north west of Thrissur
9	22/08/2011	10.573	76.195	2.7	9:10:32	5-6 km north west of Thrissur
10	23/08/2011	9.69	77.02	2	13:57:40	Upputhara, near Idukki
11	3/9/2011	10.556	76.076	1.9	6:05:14	Near Kakkassery, Thrissur
12	16/09/2011	9.764	76.943	1.4	10:44:12	Near Idukki Dam(Kannampadi)
13	16/09/2011	9.946	77.033	2.1	15:01:43	Parathode-Thopramkudi, near Idukki dam
14	17/09/2011	9.634	76.677	2.4	22:26:25	Near Idukki Dam(Kannampadi)
15	18/09/2011	9.78	76.98	2.1	0:59:09	Near Idukki Dam(Kannampadi)
16	2/10/2011	9.75	76.9	2	21:23:13	Venmani, near Idukki
17	7/10/2011	9.784	76.936	2.2	21:46:39	Upputhara, Idukki
18	2/11/2011	9.705	76.808	2.3	4:53:14	Valakode, Upputhara, Idukki
19	17/11/2011	9.753	76.849	2.8	23:57:58	~3.7 km south of Moolamattom, Idukki
20	18/11/2011	9.739	76.892	3.4	0:15:39	~7 km south east of Moolamattom, Idukki
21	25/11/2011	9.786	76.912	3.3	21:44:59	Near Idukki Dam(Kannampadi)
22	9/12/2011	9.708	76.666	2.2	10:11:19	Near Idukki Dam(Kannampadi)
23	4/3/2012	9.69	76.76	2.2	47:45.0	Venjurmedu, Idukki
24	9/3/2012	9.69	76.776	2.3	18:08.9	Venjurmedu, Idukki

During the reporting period, 24 events were recorded within Kerala state (Table 2.2.2.1). Eighteen events in the magnitude range of 1.4 to 3.9 originated in Idukki district, which is ~100 km south east of Peechi. There are felt reports of some events in the form of developing cracks and fissures in a few houses.

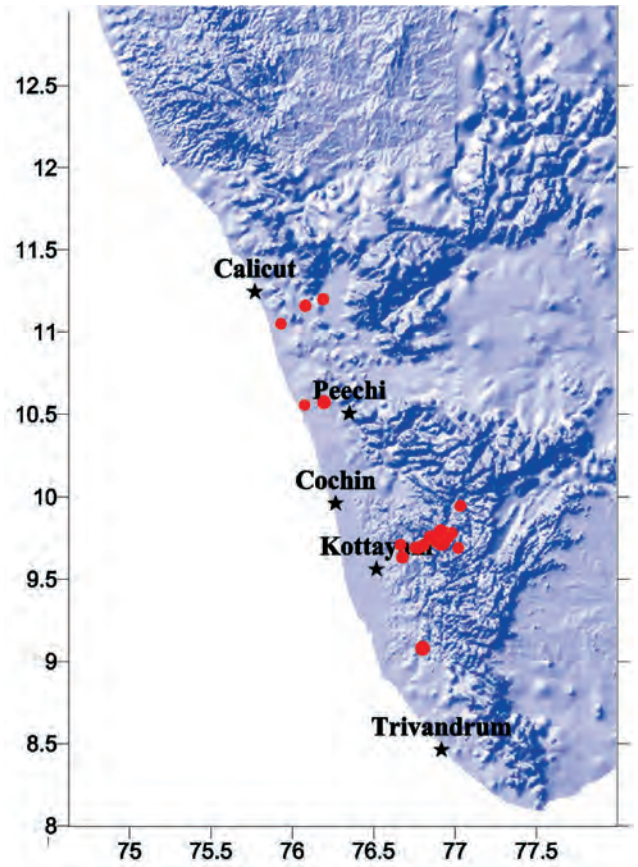


Fig. 2.2.2.1 Seismic events in Kerala during 2011-2012 recorded at Peechi observatory maintained by CESS

Other local events such as an event from Kodakara (Thrissur district; ML = 2.3), three Pulpeta-Thirurangady events (Malappuram district; ML = 2.0-2.2) and two events from Viyyur (Thrissur district; ML = 2.0 and 2.7) were also felt by many people but no damages were reported. The local events recorded in Kerala state are shown in Fig. 2.2.2.1. Fieldwork has been carried out immediately after the July 26th event and November 18th events to collect felt reports from the Idukki region. Based on the felt reports intensity maps showing isoseismals were prepared. The felt reports in the epicentral region correspond to an intensity of IV in the MM scale. The WNW- ESE trend of the isoseismals coincides with the Chinthalar- Cheruthoniar lineament.

Sreekumari Kesavan

Funding: DST, GoI

2.3 Tsunami

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

This project forms the part of a national project on *"Tsunami and Storm Surge Inundation Modelling"* co-ordinated by ICMAM Project Directorate, Chennai. The task taken up by Centre for Earth Science Studies (CESS) is to model numerically the tsunami inundation for the coastal stretches of Kerala, Karnataka, Goa and Lakshadweep of the west coast of India. The project is on the verge of completion and final report is under preparation. The globally accepted TUNAMI N2 model has been used for the model computations with reference to two historical tsunami sources and a hypothetical potentially worst case that may affect the west coast of India, in case it happens. The historical sources of tsunami are Sumatra and Makran. A hypothetical case of an earthquake of intensity similar to that of 26th December Sumatra earthquake occuring in Makran was studied since the worst case simulations form the basis for evacuation in the event of a tsunami affecting the west coast of India.

During the year, the study pertained to the coasts of Karnataka and Goa. For Karnataka, lesser run-up and slight variations among different locations of the coastal stretch are observed for the Sumatra tsunami. The run-up was in the range 2-3 m for certain southern locations like Munchuru, Padu, Tottam and Gangoli, while the

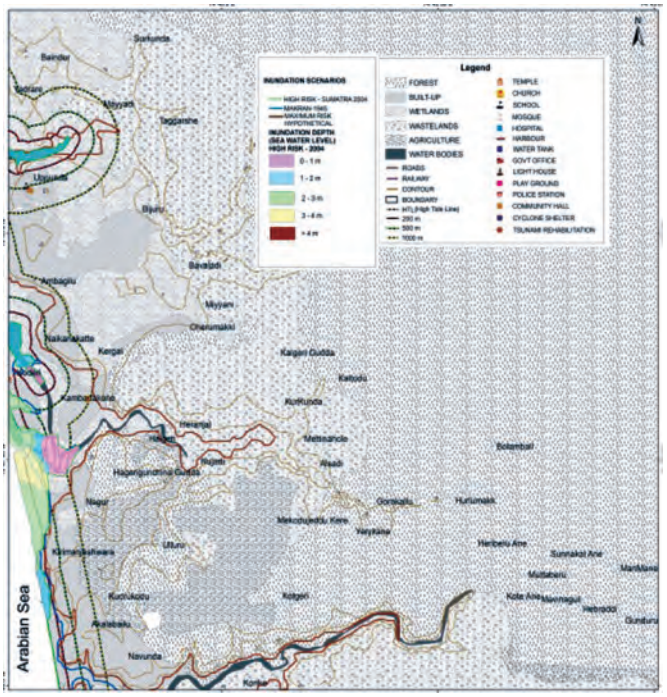


Fig. 2.3.1.1 Tsunami inundation map for a sector of Karnataka coast

northern locations like Durakeri, Honavar, Kelaginakeri showed run up of 1-2 m only. A maximum inundation of 1400 m was predicted at Nagur north by the model. The simulation for Makran source predicted a uniform run-up of 2-3 m for the entire coastal stretch except in places like Durakeri, Kelaginakeri, Hadikeri and Belekeri where the run-up was in the range of 1-2 m. A maximum inundation of 1380 m was predicted by the model at Honavar. The simulation results project hypothetical case as the most vulnerable source to the coast of Karnataka. The inundation was extensive for the entire coast with a maximum of 3470 m at Hirematha.

For the coast of Goa also the hypothetical case really dominates in terms of increased run-up and inundation. At places like Mashen, Nagorcem, Vasvado the run-ups exceeded 4 m. The other locations along the coast showed a run-up pattern in the range of 3-4 m with a maximum inundation of 2320 m at Baga. But for the Sumatra simulation the run-ups were in the range of 1-2 m all along the coast except at some locations like Mashen Nagorcem and Sasmolem where it was in the range of 2-3 m. The Makran simulation predicted a 2-3 m run-up for the entire coastal stretch of southern Goa upto Bogmalo and thereafter the values decreased to the range 1-2 for the northern coasts of Goa. A maximum inundation of 1550 m was predicted by the model at Siolim.

T. S. Shahul Hameed

Funding: Ministry of Earth Sciences, Government of India

2.3.2 Establishment of Wave Gauge Stations along the Coastal Waters of Kerala

Centre for Earth Science Studies, Thiruvananthapuram in collaboration with Indian National Centre for Ocean Information Services (INCOIS) under the Ministry of Earth Sciences (MoES), Government of India is establishing a few coastal observation stations along the Kerala coast. This programme is fully funded by INCOIS, Hyderabad. Two stations for measurement of waves were proposed to be set up during the 11th Plan period, one each at Thiruvananthapuram and Kozhikode, which are typical representation of the differing wave energy regime of this coast.

On May 4th of 2011 the first wave gauge station was established and commissioned in the coastal waters off Valiathura in Thiruvananthapuram with the deployment of a Wave Rider Buoy at 30 m water depth (Fig. 2.3.2.1). The coastal station gives real time data on coastal weather conditions which includes wave parameters, sea surface temperature and salinity. This information is vital to the local community especially the fishermen as they can plan their activities/operations and also timely warning can be given for their safety during extreme weather conditions like tsunami, cyclones, storm surges etc. Another important application of this data which could be of great help to the fishermen community is

Fig. 2.3.2.1 Deployment of wave rider buoy off Valiyathura at 30 m depth

that the data can be used for identifying potential fishing zones. The data from the buoy are extensively used for the calibration of observations made by the satellite sensors. Long-term real time buoy data from coastal buoys/observation stations are also being used for various applications like, fisheries, coastal zone management, oil exploration, offshore/coastal engineering works etc. Another significant application of buoy data is in the field of calibration and validation of sea-state forecasting model. In addition to this the real time data will be disseminated to the various scientific communities/research organizations/institutes to carry out their research work which is mostly multi-disciplinary.

L. Sheela Nair

Funding: INCOIS, MoES, GoI

2.3.3 Oil Spill Modelling for Selected Locations of Kerala and Lakshadweep

Oil spill modelling project for Kerala and Lakshadweep coasts was taken up by CESS in July 2009. Three locations namely - Vizhinjam, Neendakara, and Cochin along the Kerala coast and Kavaratti in Lakshadweep group of islands were selected for the study.

As part of the hydrodynamic data collection for the Kavaratti island current meters, wave and tide gauges were deployed at two locations during the period 19th October – 2nd December, 2011. The first location was at 5m water depth in open sea on the northeastern side of the island (very near to the Desalination plant) and the second one was at 2m water depth inside the lagoon on the western side.

Wave parameters were recorded for the open sea condition at 5 m water depth. The minimum significant wave height (H_s) during the deployment period was 0.17 m and the maximum 2.62 m. The mean H_s was 0.44 m with a standard deviation of 0.26 whereas the zero crossing period (T_z) varied between 3.21 and 10.63 s with a mean and standard deviation of 5.65s and 1.68 s respectively. The recorded peak wave period (T_p) during the deployment period showed a maximum value of 14.22 s showing dominance of swells. The minimum T_p recorded was 2.51 s with a mean value of 8.22 s and a standard deviation of 3.36s. The mean wave direction (MWD) varied between 40.33° and 131.64°

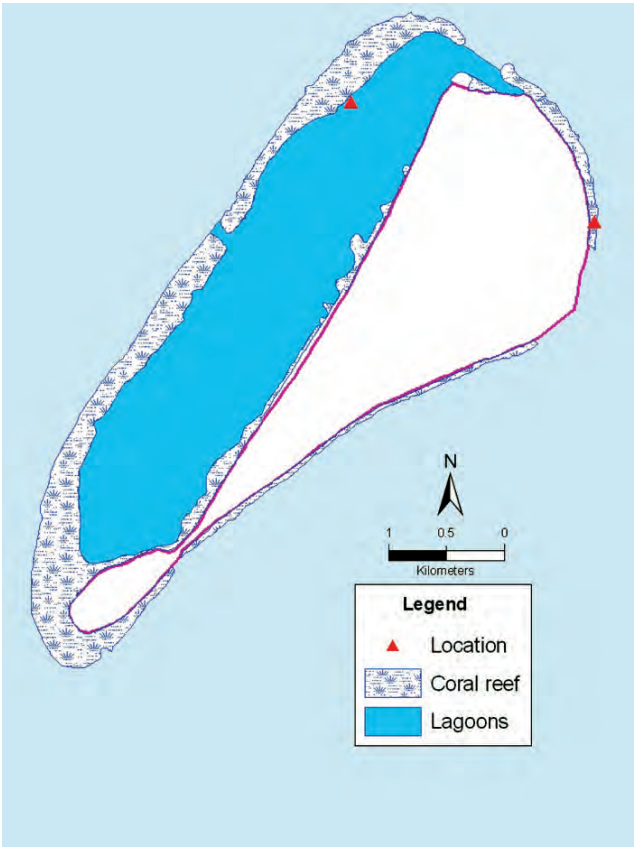


Fig. 2.3.3.1 Kavaratti island showing location of deployment of current meters, wave and tide gauges

The recorded significant wave height H_s inside the lagoon showed minimum and maximum values of 0.4 m and 1 m, respectively. The mean H_s for the deployment period was only 0.07m with a standard deviation of 0.07. The zero crossing period (T_z) inside the lagoon varied between 2.06 s and 118 s with a mean value of 23.93 s and a standard deviation of 26.34. The peak wave period (T_p) during the same period was between 1.80 s and 128.00 s with a mean and standard deviation of 39.93 and 44.37 respectively and the corresponding mean wave direction was between 36.05 and 318.97°.

Analysis of the recorded current data showed wide variation in the current speed and direction obviously influenced by tide. The current data recorded by the current meter deployed at 5m water depth in open sea showed a maximum value of 3m/s. The mean current speed during the period was 0.11 m/s with a standard deviation of 0.10 m/s. The currents were comparatively high when compared to that inside the lagoon (varied between 0.17 and 1.58m/s). Critical analysis of the progressive vector plots revealed that the net transport was towards southeast whereas the drift was towards northeast during the deployment period.

Oil spill modelling work for Kavaratti has been initiated. This is being done in two stages. First the Hydrodynamic Models (HD) for the three seasons are set up using MIKE 21 modelling system for getting the current data which is required as input for running the Oil Spill models. The model calibration and validation of the HD models are currently in progress. Once this is over the Oil Spill modelling for various scenarios in Kavaratti will be carried out using GNOME – an open source program.

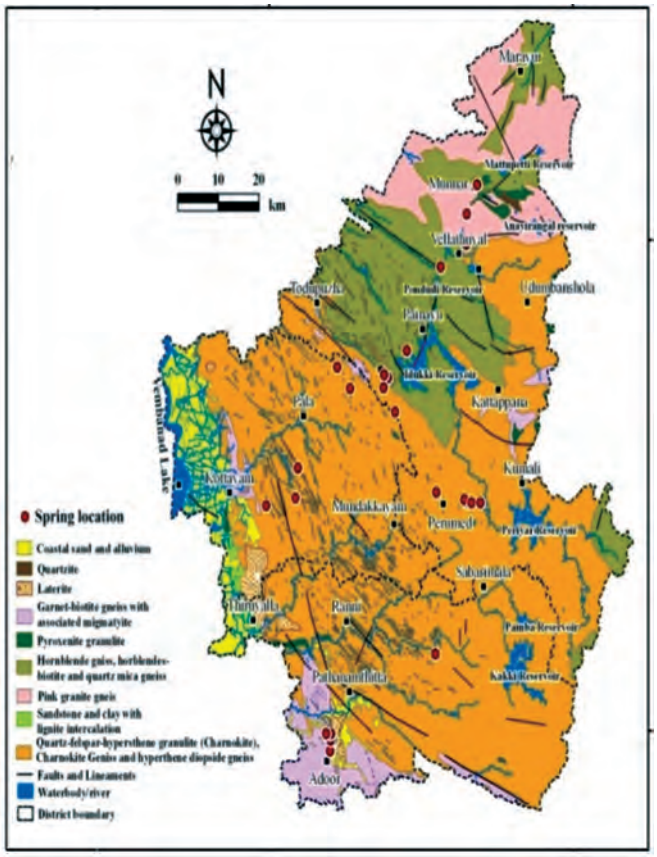
L. Sheela Nair

Funding: MoES, GoI

3.1 Water Resources

3.1.1 Appraisal of drinking water potential of springs in Pathanamthitta, Kottayam and Idukki districts of Kerala

The project aims to locate and map unexploited springs and to make an appraisal of their drinking water potential in the Pathanamthitta, Kottayam and Idukki districts of Kerala covering an area of nearly 10000 km^2. The quality of spring water was determined in terms of physical, chemical and bacteriological properties



Eig. 3.1.1.1 Study area showing geology and spring locations

using standard methods. The geological aspects of the springs were examined to maintain and manage water potential. A total of 120 springs were identified and located (Fig. 3.1.1.1) and water samples were collected from 80 springs for hydro-geochemical evaluation. The chemical quality of spring water from all sources satisfies BIS/WHO drinking water standard except in the case of pH, which showed acidic (5.23-6.67) nature. EC ranges from 22.14 to 33.04 µs/cm with an average of 27.5 µs/cm, indicating low range of dissolved salts, which could be attributed to the swift movement through the fractures /aquifer layers. TDS, generally the sum of dissolved ionic concentration, varies between 15.81 to 236 mg/L with an average of 41.06 mg/L.

Major ion and nutrient concentration were determined and the values were found to be lower than the maximum permissible levels. Bacterial contamination (*coliform*) which was randomly observed can be attributed to the prevailing unhygienic condition. Among cations, Ca and Na are the primary ions while the Cl and HCO_3 are the dominant anions. Piper diagram was used to interpret the chemical evolution of spring water which depends on pattern recognition techniques and the dominant water types evolved are Ca-Cl-HCO3, Na-Ca-Cl-HCO_3, Ca-Na-Cl-HCO3, Na-Cl-HCO3

K Anoop Krishnan

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

The study aimed to assess the level of heavy metal (Hg, Pb, Zn, Cd, Cr, Cu, Ni, Fe) contamination in the surface sediments of Cochin estuary and Periyar river which receive pollutants from both small scale and large scale industries, boatyards, dockyards, fishing harbour, the Cochin shipyard etc. The major source of mercury pollution in the Periyar River is from the Travancore Cochin Chemicals Ltd (TCL). Most of the older industrial units in the region still deploy obsolete technologies and discharges highly concentrated toxic effluents after little or no treatment.

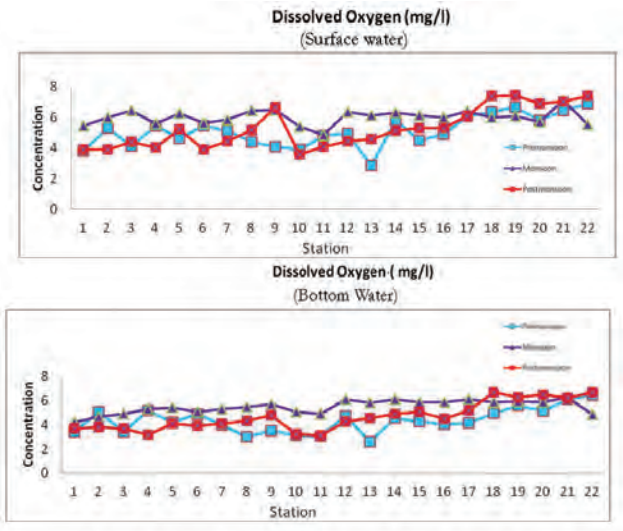


Fig. 3.1.2.1 Dissolved Oxygen (DO) rates recorded during different seasons from the surface and bottom samples

The estuary also receives untreated effluents from domestic and agricultural sectors, fish processing units etc. The presence of Hg, Cd, Zn and Pb in the sediment of Cochin estuary is matter of great concern due to their high concentration and potential toxicity to marine biota.

Sediment and water samples taken from 22 locations of the Periyar River and Cochin estuary (Monsoon, Post Monsoon, Pre Monsoon) were analysed for the heavy metal concentration. Metal concentration in sediments varies seasonally and significantly with in broad range – Pb (8ppm to 150 ppm), Zn (17 ppm to 2600 ppm), Cu (7ppm to 549 ppm), Cr (84 ppm to 583 ppm), Ni (7 ppm to 218 ppm) and Fe (1.1 % to 22.93%). The estuarine part with fine sediment particles had relatively high metal concentration where as lower reaches of Periyar river with coarse texture of sediment showed low levels of metals except Zinc. Organic Carbon and fine sediments were high in the estuarine part indicating high absorption of Organic compound on clay minerals.

Presence of heavy metals showed significant seasonal variation with low values during the monsoon and post-monsoon periods and the highest values were recorded during the pre-monsoon periods in almost all samples. The pre-monsoon increase in heavy metal content could be related to the biogeochemical changes occurring in water increases the sediment Organic Carbon.

The seasonal value of Dissolved Oxygen recorded at the surface and bottom samples are depicted in Figure 3.1.2.1. DO values of both surface and bottom water exhibited significant seasonal variations. Low DO and high Organic Matter were observed in premonsoon season. High DO values recorded in post monsoon period. The lowest value of DO was 2.73 mg/l due to the rapid decomposition of Organic matter. Heavy metal enrichments are mainly due to the anthropogenic inputs enhanced by settling of metals due to organic flocculation and inorganic precipitation. Increase of water temperature and considerable growth of algae also changes the level of DO in the water body. There by disturbing the water ecological balance, this results in mortality of selected plants and animal species and encouraging over growth of others.

P. K. Omana

3.1.3 Environmental impact assessment of major settlement distribution patterns and infrastructure 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 etc. and their impact on major settlements with special reference to drinking water resource availability. Primary and secondary data on water resources like number of wells, ponds, lakes, ground water fluctuations, rainfall, recharge potential, piped water distribution and supply status in the urban and rural sectors were collected. Data have been compiled, processed, digitized and relevant thematic maps in GIS format were prepared for Thiruvananthapuram district. Secondary data from Kerala Water Authority, Ground Water Department, Panchayat Offices, Irrigation Department and Fisheries were

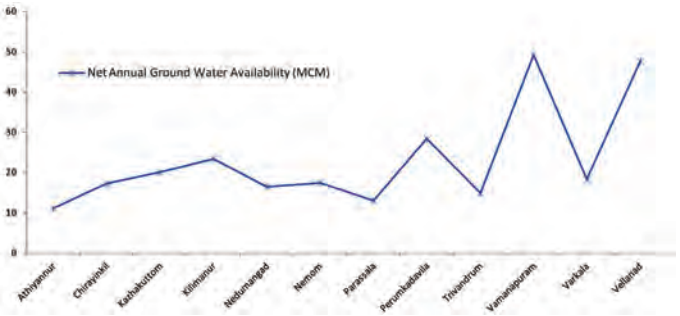


Fig. 3.1.3.1 Net annual ground water availability in the study area

analysed to see the status of demand and supply for the study area and environmental constraints. 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. In the study area, recharge from rainfall during monsoon season is 128.18 MCM and in non monsoon is 150.11MCM and natural drainage during non monsoon season is 30.48 MCM. It is observed that ground water potentials are very good in Vamanapuram block (49.24MCM) followed by Vellanad block (47.81 MCM), Nemom (28.48 MCM) and Kilimanoor (23.5 MCM),while the poor ground water potentials were reported from blocks viz Perumkadavila (11.13MCM) Athiyanoor (11.13MCM), Parasala (13.12MCM), Nedumangad (16.55MCM), Thiruvananthapuram block (14.90MCM), Chiryankhil (17.28MCM) and Varkala (18.41MCM). The net annual ground water availability is shown in Fig. 3.1.3.1

V. Shravan Kumar

3.2 Terrain Analysis and Landuse Studies

3.2.1 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 changes 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.

The study area spreads over seven districts. Work is being attempted district by district. During this period land use map of Alappuzha district has been prepared for the years 1967 and 2008 at 1:50,000 scale based on Toposheets and Satellite imageries (LISS III and LISS IV). These maps were then overlaid in GIS environment to generate the land use change map between 1967 and 2008. The land use matrix has been computed. Preparation of land use maps and the land use change matrix for Kottayam district are progressing.

Data on the land utilization pattern of Kerala and the selected seven districts have been collected from Bureau of Economics and Statistics, Centre for Development Studies, and State Planning Board. The data set is being prepared since 1956-57. Data on area and production of 18 crops in selected districts of Kerala have been collected. Triennial averages of the land utilization pattern, and area, production and productivity of important crops for Kerala were also calculated and the temporal changes were also worked out.

It emerges from the analysis of land use data pertaining to Alappuzha district that there is significant decrease in the area under paddy cultivation which has came down from 581 km^2 in 1967 to 314 km^2 in 2008 and there is considerable growth in the category of SMT (settlement with mixed tree crops) during the last four decades. The land use change matrix shows that 157 km^2 of areas under paddy cultivation has been diverted to settlements with mixed tree crops and another 110 km^2 is now kept as fallow land. It is also clear from the land use change matrix that the area under agglomerated settlement has also increased from 4 km^2 in 1967 to 20 km^2 in 2008. Change to agglomerated settlements can be considered as irreversible change.

The land utilization pattern of Kerala and the selected districts were also analyzed based on statistical data obtained from the Department of Economics and Statistics, Government of Kerala. The area of land put to non agricultural use increased considerably during the last fifty years. At the same time total cropped area and the area sown more than once show slight improvement. The area under barren and uncultivable land, permanent pastures and grazing land, miscellaneous tree crops and cultivable waste land showed decreasing trend. The area under current fallow has increased.

Srikumar Chattopadhyay

3.2.2 Valley formation and geomorphic processes under tropical wet and dry climate: Examples from Kerala

In order to elaborate upon the various forms of valleys and their genetic relationship with the streams' gradational forces in combination with geologic structure, climatic conditions, weathering rates and landscape evolution processes, Valapattanam, Bharathapuzha, Periyar, Kabani (east-flowing), Achankovil, Kallada, Ittikara and Neyyar river basins were studied. The major objectives are (i) to classify the valleys of selected river basins in different geomorphic and climatic settings based on their morphology, sediment characteristics and morpho-tectonic features, (ii) to elucidate geomorphic setting of various valley types within the same river basin, (iii) to characterize /differentiate valley types under different rivers as linked to geomorphic and climatic variations, (iv)) to link valley formation with terrain evolution processes in different physiographic units in Kerala and its relation

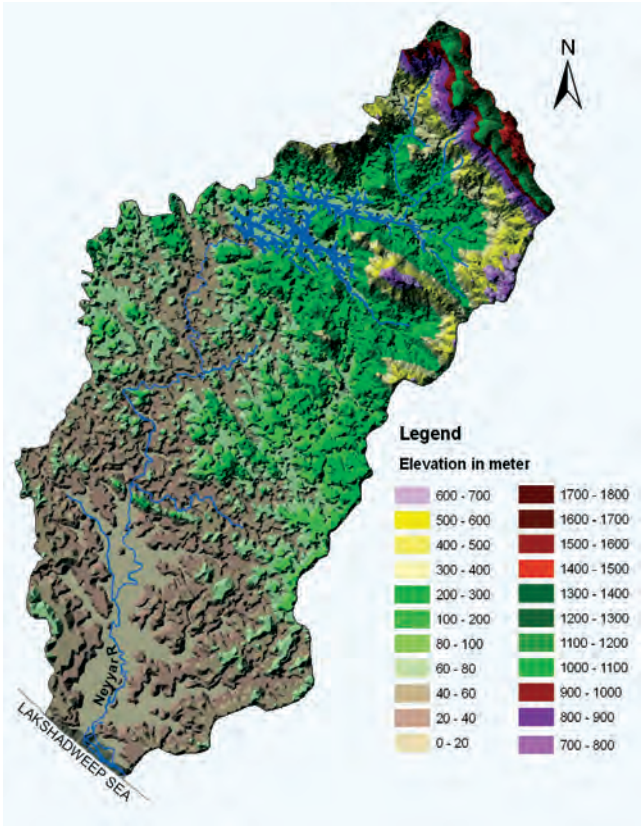


Fig. 3.2.2.1 Digital Elevation Model (DEM) of Neyyar basin

to the river morphosis widely observed in the low-level regions of Kerala, and (v) to assimilate all data through GIS application.

Base maps of the river basins and selected thematic maps were prepared. Valley profiles were surveyed in selected sites of Ittikara, Achankovil and Neyyar rivers. Stream flow and velocity were mea-

sured to compute the discharge of the tributary streams of Achankovil and Neyyar river using current meter. Digital elevation model of Neyyar basin is given in Fig. 3.2.2.1. The work is in progress.

Mahamaya Chattopadhyay

3.2.3 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 of Kannur district using satellite imagery, to prepare a geochemical atlas and to discuss the issues emerging out of the analysis with experts and users. Maps of relief, drainage, slope, aspect, landforms, geology, soil type, soil moisture, NDVI, land use/ land cover, landslide prone areas, flood prone areas, agriculturally drought prone areas, watersheds, panchayats and density of population were prepared in 1:50,000 scale and digitized in ArcGIS format.

Data analysis showed that 14.9 % of the total area in the district is agriculturally drought prone during summer and the district faces acute drinking water shortage. It also showed that about 6 % of the total area is flood prone during monsoon and 2.1 % of the area is landslide prone. Heavy surface runoff and erosion proneness necessitate soil and water conservation measures. Agriculture in Kannur is controlled by terrain, water availability and soil. Soil chemistry also plays an important role in agricultural production. About 33% of the area in the district needs high priority for land and water conservation. Geochemical atlas is also prepared for the entire district.

B. Sukumar

3.2.4 Land system analysis of Kabani river basin in Wayanad district, Kerala

The objectives of the study are: (i) to analyse the geomorphic process and land system in Kabani river basin, (ii) to compute morphometric and hypsometric data for understanding landform characteristics and its evolution, (iii) to work out relationship between landform unit and drainage discharge and (iv) to identify geomorphic indicators which help understand geomorphic system and predict landform changes.

Computation of river sinuosity and its linkage with lithology and structure for Cherupuzha - Chundal puzha segment of Kabani river basin has been carried out. Sinuosity index ranges from 1.19 – 1.99. Cross sections have been worked out across selected locations. Using morphometric data, watersheds have been prioritized and map on priority watershed has been prepared.

Kabani river basin is a seventh order stream covering an area of 1648 km ^{2}. Eleven fifth order basins were selected for detailed analysis. Morphometric and hypsometric analyses have been attempted to understand basin characteristics. Rose diagrams were drawn for all 11 fifth order basins to identify the main direction of flow. These data were further used to assess structural control on drainage development. Morphometric indices were used to prioritize 11 sub basins of Kabani river and a map depicting priority sub-basins has been prepared. Pedo - geomorphic analysis indicates close relationship between landform units and soil. Bhavali watershed is selected as a sample basin for land system analysis and watershed management.

Srikumar Chattopadhyay

3.2.5 River bank mapping: Methodology development and coordination

River Management Fund (RMF) constituted by the Department of Revenue, Government of Kerala has initiated river bank mapping and sand auditing programme in order to restore river health, estimate minable quantity of sand available in each river and develop a bench mark data base for subsequent monitoring. CESS was requested to develop methodology and coordinate the work. The river bank mapping forms the first phase of this activity. Mapping has been initiated in five rivers namely, Kabbini (Wayanad), Bharatapuzha (Palakkad), Chalakudi (Trissur), Karamana and Vamanapuram (Trivandrum).

The major objectives of the project are (a) to develop a guideline for river bank mapping including data format and reporting outline, (b) to train volunteers and supervise field work, (c) to digitise Karamana river bank maps, and (d) to prepare river bank information system

The methodology envisaged for river bank mapping is similar to that of Panchayat Resource Mapping in which all details are gathered for every survey plot in cadastral maps in 1:3960/ 1:5000 scales. It is proposed to gather information regarding the river under three broad heads, like physical, manmade and landuse features. Data collection is limited to a distance of 50 meter from the river bank on either side. Data format has been worked out, which is being filled up for every 100m distance along the river. A MoU has also been worked out by CESS for use of Revenue Department.

Work began with training class in Trivandrum. The training module consists of one day theoretical class followed by field training along Karamana river. All five teams attended the class. On their

return these teams started working in their respective areas. Subsequently CESS team visited all the five project sites and held discussion with the respective groups working for the river. In some cases repeat visits were undertaken. Field maps were verified and necessary guidance provided to the field teams.

Karamana river was taken up in order to develop a model for river bank information system. River bank mapping of the Karamana river has been carried out by the Civil Engineering Department of Mar Bassilius College of Engineering, Trivandrum. The maps and data formats were handed over to CESS for digitisation and further work. The field maps obtained form the field team were digitised in RAD's GIS laboratory. Toposheet, Image and GPS data were used for geo-referencing. The information collected from the field in maps and data formats were brought into a single database which will be helpful in analysis and data viewing. Three maps for each Panchayat depicting physical features, land use and man made features have been prepared.

River bank mapping covered the section of Karamana river flowing through seven Panchayats of Trivandrum district, namely Aruvikkara, Aryanadu, Uzhamalackal, Vilavoorkal, Vellanadu, Vattiyoorkavu and Vilappil. In certain cases Karamana river coincides the Panchayat boundary.

The second stage was to develop river bank information system. The maps were integrated into a user interactive system using Dreamweaver CS3 software that provides a visual inteface.

River bank mapping has been completed for all the five rivers taken up in the first phase, however digitisation and developing of information system for Kabini, Bharatapuzha, Chalakudy and Vamanapuram rivers are yet to be completed

Srikumar Chattopadhyay & John Mathai
Funding: Department of Revenue, GoK

3.2.6 River bank mapping of Ittikkara river

River bank mapping of Ittikara river has been taken up to develop a catchment management plan and generate baseline data for sand auditing. The major objectives of the study are (1) to characterize and map river banks as per the guidelines issued by the Revenue Department, (2) to evaluate catchment characteristics, (3) to digitize river bank maps and prepare River Bank Information System and total management plan for the river basin.

The work began by the month of January, 2012. It is proposed to map around 48km long stretch of the Ittikkara river flowing from Ittiva panchayat to Paravoor panchayat. In all there are 10 panchayats falling along the course of the river proposed to be mapped. Cadastral maps of all these 10 Panchayats have been collected. The river course has been traced.

Field work was initiated and all details covering physical features, land use and man made features are being mapped in cadastral scale (1: 3960). A structured data is being used for gathering all information. A 50 meter buffer on both the sides of the river bank was marked and data were collected for this strip.

So far mapping and data collection have been completed for a stretch of 23km from Ittiva down stream. Cross profiles were measured for 13 locations within this stretch. Profile measurements were planned on an average at an interval of 500m. The cross sections were plotted. Further work on sand assessments is being taken up.

It is observed that river banks are subject to erosion and various kinds of human intervention. The vested land along the river course is almost nonexistant indicating encroachment. There are rock body exposed within the river bed. These rock bodies cutting across the river course acts as check dams. Sand deposits are noticed in the upstream part of this feature. Sands are being mined from these sites. There are certain stretches where sand mining has been so intensive that bed rock is exposed. Government has barred any further mining is such sites and adjoining areas. River cross profile study and identification of other features are important to maintain river ecosystem. There is overall degradation of river ecosystem. This study will help to identify such stretches and a proper action plan can be worked out based on this information.

Srikumar Chattopadhyay
Funding: Department of Revenue, GoK

3.3 Environmental Assessment

3.3.1 Effect of Urbanization on the buildup of urban heat island in Kochi

The major objectives of this project are to study the development and intensity of Urban Heat Island (UHI) in the Kochi region, to examine the relation between urban growth, land cover types, and the development of the urban heat island phenomenon at the Ernakulam city and the neighboring rural areas and to investigate the UHI as a regional climate change input and the feasibility of integrating it into regional climate change models.

Classification of the study area was carried out in accordance with the thermal climate zone classification and Local Climate Zone (LCZ) maps were prepared. Recording stations were installed to continuously record air temperature, humidity, soil moisture, wind, rainfall, solar radiation, etc., at various locations in the study area covering different LCZ zones. The data was

recorded at 15 minutes intervals, compiled and analysed. In addition mobile traverse surveys were carried out during different seasons and air temperature, humidity and ground level trace gas concentration in the study area were recorded. The UHI, humidity and ground level methane concentration maps were prepared.

It is observed that the highest pre-dawn UHI intensity during winter season was 4.6 °C and that during summer was 3.4 °C. Corresponding values of evening UHI were 2.8 °C and 2.2 °C respectively. It was noticed that the recorded UHI pattern is in good agreement with the LCZ zone maps prepared on the basis of the urban land use classification. Significant thermally active LCZ present in the region are compact low-rise and compact mid-rise. The observed maximum and minimum values of ground level mixing ratio of methane within the Kochi urban region were 3.89 ppm and 2.09 ppm respectively during winter season and were 3.21 ppm and 1.71 ppm respectively during the summer. The humidity variation across the study area had a range of 25.32 to 23.35 g/m^3 during the evening and 24.70 to 22.60 during pre-dawn hours.

E. J. Zachariah

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

Nexus between poverty and environmental degradation is an important research topic particularly in the realm of interface science. Environmental degradations would primarily affect the common property resources and thereby the livelihood conditions of the poor people. Degradation of environmental resource base can make certain categories of people destitute even while the economy as a whole grows. It is possible to capture this relation only at the micro level. The project - 'Exploring interrelationship between environmental degradation and poverty: Selected micro level case studies across Kerala' tries to analyse the spatial association between environmental degradation and poverty distribution.

The objectives of the projects are (a) to evaluate extent of degradation of environmental resource base through mapping and data analysis both in the macro and micro level, (b) to analyse driving forces leading to environmental degradation, (c) to conduct socio- economic survey to understand the extent of poverty, (d) to map distribution of poverty affected areas/ settlements, and (e) to study spatial interrelation between environmental degradation and poverty.

After analyzing secondary data and considering district profile eight panchayats were selected from Kannur and Wayanad districts. These panchayats represent different types of resource base, like fisheries in the coastal Panchayat, wet land agriculture in the mid lands, plantation and forestry in the plateau areas. Agricultural labourers constitute more than 35% of the total population. Incidence of poverty in these panchayats is relatively high compared to the district average. The underlying reasons range from poor access to resources, uneconomic holdings of majority of farmers, limited employment opportunities, excessive dependence on agriculture, industrial backwardness, absence of urbanization, fall in production and productivity of crops and excessive borrowing to meet non-agricultural needs which has led to indebtedness of farmers. The lack of productivity in the agricultural sector has led to a general slowdown in the economy. Population engaged in business activities and transportation sector is meager. Less than 10% of the total population is engaged in the service sector. It is observed that the poverty stricken people overwhelmingly depend on local natural resources and live in places which are ecologically more vulnerable. About 80% of the jobs that the poor undertake are dependent on natural resources (agriculture, forestry and fisheries). In Wayanad district especially in the study area this linkage is more visible. In Meppadi and Thondernadu environmental problems like landslide, flood etc are comparatively high. The level of poverty is also high in these panchayats. The tribal people settled in the river banks and foot hills are the major victims of these problems. In Kannur district, especially in Eramom Kuttoor and Padiyoor panchayats, most of the area is covered by laterite duricrust. High temperature, water scarcity and lack of adequate capital hampered income earning opportunities of the people. In Pattuvam panchayat many people earn their livelihood being engaged in inland fishing sector. In recent years the amount of fish catch decreased very sharply due to water pollution. Disguised unemployment is a common phenomenon.

This project is in the final stage. Data analyses have been completed. Some field investigation was undertaken to cross check some of the results. Final report preparation has been initiated.

Srikumar Chattopadhyay

3.3.3 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 cover changes and to give suggestions for better 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 High ways Numbers 47 and 17. Most of the water logged areas and paddy fields are being reclaimed for residential, industrial and for other purposes and even shape of the islands in Vypin and

Vallarpadam have changed. Built-up area has increased and it is expanding towards north, northeast, east and south. Most of the paddy fields, rubber plantations, and wet lands have been reclaimed for settlement and other urban purposes. Lengths of roads and railway lines have increased. Urbanisation affected most of the paddy areas. This will continue in future also due to lack of space available for urban expansion. Most of the drainages blocked or intercepted by roads. This may pose flood problem in new areas in the upper reach of the drainage basins. Solid waste disposal is going to be a problem unless proper steps are taken to meet the increased waste disposal. The project has been completed and the final report is under preparation.

Ahalya Sukumar

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

Myristica swamps are fresh water ecosystems unique to the Western Ghats. These ecosystems are known as *Myristica* swamps due to the dominance of members of primitive Angiosperm family Myristicaceae (nutmeg family). This ecosystem has been highlighted as one of the most critically endangered habitats in Western Ghats due to the unique biodiversity and ecosystem values. The swampy microhabitats provide favorable conditions for survival and procreation of many tropical rare and endemic animals enlisted in the red- list category of IUCN. Myristica swamps are "virtually live museums" of ancient life of great interest to biologists and geologists alike and have high watershed value and terrain evolutionary significance. These swamps have high water table and occur near rivers, streams and lakes, which cause inundation throughout the year except during summer. The major river systems supporting Myristica swamps are located at the upper reaches of Kallada and Ithikkara rivers, both west flowing and originating from the hills of Kulathupuzha, Shendurny and Anchal regions. Water flowing across these swamps tends to contain dissolved nutrients and particulate matter. The different forest types which flank the swamps are evergreen, followed by semi-evergreen, moist deciduous, low level grasslands, reed and bamboo patches. The present study highlights the importanance of geomorphic evolutionary history of these swamps, the suspected paleo-link of the two river basins Ithikkara and Kallada, their geological and biological history for better conservation and management plans.

The several hand corers collected 83 cm long sediment cones in the Karinkurinji up and Karinkurinji down segments. Karinkurinji down 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 (65-83 cm). Therefore, from top to bottom the sediment core revealed four distinct zones. A 4 to 5 cm thick sand zone was noticed at depth of 25 cm from

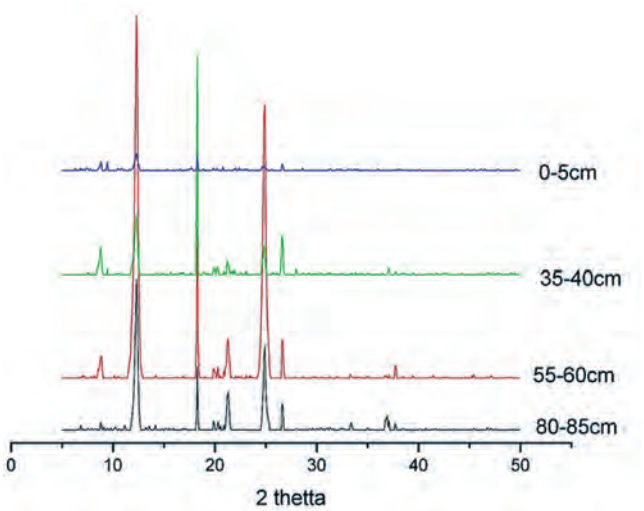


Fig 3.3.4.1 X-Ray diffractogram of the clay fraction

the top possibly due to the high sediment supply and frequent seasonal fluctuations in water table. But Karinkurinji up with three distinct zones, such as brownish and dark blackish carbonaceous soil (0-28 cm), alternate with light green silty-sand soil (50-69 cm) and bottom layer with orange yellowish laterite deposition (69-80 cm). There is no spatial differentiation between Karinkurinji up and Karinkurinji down swampy regions. In Karinkurinji down, surface sand layer shows light brownish colour due to less organic matter and more alluvial deposition. The bottom silt clays contain abundant roots but the percentage of organic matter decreases. Moderately acidic soil with high organic carbon content was present in the middle clay-rich zones at 30-50 cm depth (3.39%). The OC content of 0.314% in the surface soil progressively decreased to 0.156% in the deepest layer studied. There are remarkable variations in other properties such as pH (6.33-5.74), conductivity (88-48 µS/cm) and organic matter content.

XRF analysis revealed the presence of major oxides, generally of the order of SiO_2> Al_2O_3> Fe_2O_3> K_2O> TiO_2> CaO> Na_2O> MgO> P_2O> MnO and the trace elements, such as V (151-165 ppm), Cr (57-164 ppm), Zr (85-334ppm) and Ba (161-164ppm) indicating high concentration as compared to other trace elements. The composition of compatible elements like Ni (46-16 ppm) and Co (27-6 ppm) shows low abundance as compared to Cr (57-164 ppm).

The XRD data of randomly oriented soil 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. Clay mineral assemblages of Karinkurinji soils of Myristica swamps comprise Gibbsite, Kaolinite, and small amounts of ilite (Fig. 3.3.4.1). The presence of Gibbsite in top soil (about 40 cm) and high Kaolinite with sand content in the bottom layer (55 to 70 cm) can be explained by the fact that Kaolinite could be produced by

continental weathering. Gibbsite in these sediment samples is due to its occurrence in aluminous clays and is a common product of weathering reaction with low hydrolysis that is typical for cool to temperate and dry climates. Clay mineralogy studies were used to determine the paleoclimatic and depositional environmental conditions of Karinkurinji down and up swamps.

The grain size analysis of two core samples indicates that Karinkurinji swamps varied in texture from loamy sand to sandy loam and in depth with sandy mud. The average content of sand was with in the range 95.24% (top) to 24.56% (bottom) and the ranges of silt and clay fractions are 3.46% to 13.22% and 2.53% to37.36%, respectively.

A total of 8 sediment sub- samples were analysed for palynological investigation with the help of the French Institute, Pudussery. Several dominant pollen types were identified from the core samples. Some are identified up to species levels and some up to the level of family. The major ones identified are:-

Poaceae, *Bombax ceiba* (Bombacaceae), Combretaceae, *Aporosa cardiosperma* (Euphorbiaceae), *Schleichera oleosa* (Sapindaceae), *Knema attenuata* (Myristicaceae). *Semecarpus auriculata* (Anacardiaceae), Combretaceae, *Borassus flabellifer*, *Baccaurea courtallensis* (Euphorbiaceae), *Schleichera oleosa* (Sapindaceae), Melastomataceae, *Gomphandra tetrandra* (Icacinaceae) and Algal gel.

In shallow core samples the analytical result pollen reflects only the present day vegetation, dominated by Poaceae, Combretaceae and *Semecarpus* pollen grains, which record a uniform presence in all the layers investigated. The same is the case with Myristicaceae, which plays a dominant part of the present day vegetation in the swamps. The mineralogical studies and trace elements of Myristica swamps have provided information on the depositional environment.

C. N. Mohanan

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

The concern for the environment has grown up in the last few decades due to the growing awareness on the impact caused by various anthropogenic activities like extraction and utilization of living and non-living resources, waste disposal and pollution. In Kerala, the scenario of resource utilization has changed drastically over the past 4-5 decades due to the rise in foreign remittances and subsequent economic developments. Although Kerala is a state with low per *capita* land and resource availability, the exploitation of natural resources is not in tune with the principles of sustainable development. As a consequence, many of the highly populated areas in the midlands and lowlands are affected severely by the adverse effects of resource extraction and waste generation. Indiscriminate quarrying of soil and hard rocks,

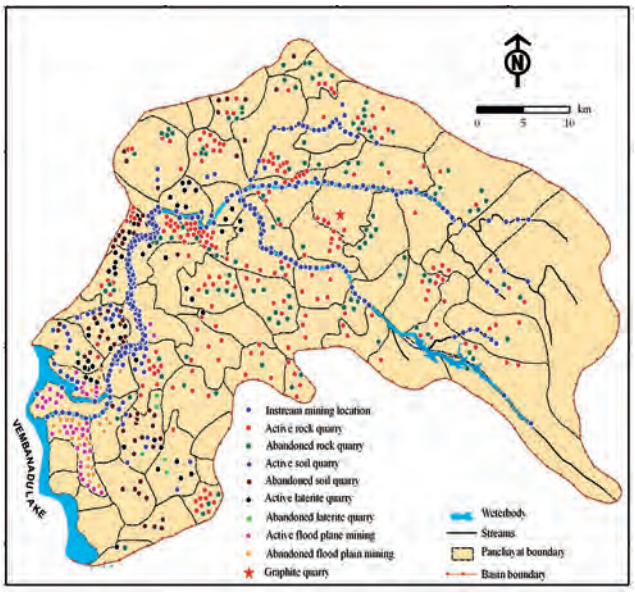


Fig. 3.3.5.1 Map showing the spatial distribution of mining locations in the Muvattupuzha river basin.

cutting of laterite blocks, extraction of sand from instream and floodplain areas, filling of wetlands for various non-agricultural uses, deforestation etc., in many of the occasions, created serious environmental problems in the Muvattupuzha river basin. Lack of adequate data base on these issues is a major set back in chalking out strategies for the conservation / management of this important river basin.

The present study deals with various issues/environmental problems related to mining and quarrying in the Muvattupuzha river basin, located on the southern side of Kochi city; one of the fast developing urban-cum-industrial centres in South India. We hope the report will be useful to all stake holders who are interested in the socio-economic development and prosperity of the state in general and the Muvattupuzha river basin in particular.

In the Muvattupuzha river basin, the environmental degradation is mainly attributed to various human activities like mining and quarrying, deforestation, pollution etc. 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.3.3.5.1). Graphite mining is limited to a small area of Kalloorkad in the grama panchayat of Ernakulam district. The indiscriminate mining predominates in the highly populated midland and lowland regions of the river basin. A spatial analysis of the activities reveals their clandestine presence in the midland part of Ernakulam district. As the Kochi city and its satellite towns require infrastructural facilities for several mega developmental projects, therequirements of building materials would also increase correspondingly. The rampant mining and

related processes widespread in the area create many hazardous on-site and off-site impacts/environmental problems. Creation of scars on the earth's surface, fallow land etc. could adversely affect the biophysical components in the river basin. The impacts of mining, in most cases, leave permanent mark on the land which modifies significantly the natural lanforms of the area. Unsupported mines often promote soil erosion, changes in soil texture, soil compaction etc. Due to various mining activities, the area of land for the sustainable use would reduce substantially. Except floodplain mining (lowlands), all the other activities are severe in Ernakulam district.

K. Maya

3.3.6 Nitrous oxide and methane in coastal ocean and estuaries

Nitrous Oxide and Methane are strong greenhouse gases capable of significant global warming. These gases are known to be abundant in the coast regions under anthropogenic influence. The production of both gases is linked to bacterial activity under anoxic or near anoxic conditions. It was in this background that this research program was taken up. The major objectives of this project was to measure the concentration and distribution of dissolved methane and nitrous oxide in the Kadinamkulam, Paravoor, Ashtamudi, Kayamkulam, Vembanad, and Kodungalloor estuaries and the adjoining coastal ocean and to estimate the amount of methane and nitrous oxide discharged into the ocean in dissolved form, from these estuaries.

Water to air fluxes and dissolved gas in water were determined in esturies and coastal ocean. TOC in the sediments were measured at all locations. Sulphate, Phosphate, Nitrite, DO, Salinity, and pH, of the water were also measured. Dissolved methane and nitrous oxide at different depths were measured

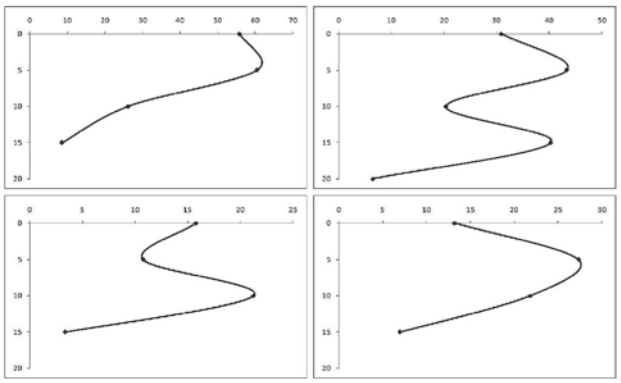


Fig. 3.3.6.1 Vertical distribution of dissolved CH_4 at a few locations in the ocean off Kayamkulam and Thottappally

and vertical distributions as well as contour plots were prepared (Fig. 3.3.6.1and Fig. 3.3.6.2). Estuarine water contains very high levels of dissolved methane and nitrous oxide. The vertical distribution of these gases in the estuary shows higher values in the bottom layers compared to surface layers, indicating production in estuarine sediments. It is observed that the concentration of dissolved methane and nitrous oxide in the coastal region is significantly higher than that measured in the open ocean.Unlike in the estuary, the general pattern in the vertical distribution of dissolved methane in the coastal ocean shows a high in the surface layers compared to the bottom layer, indicating

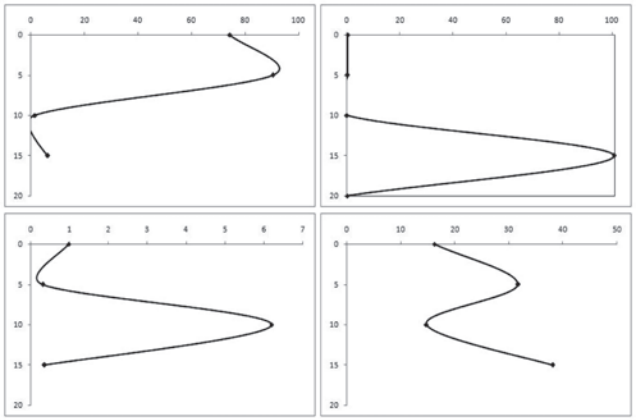


Fig. 3.3.6.2 Vertical distribution of dissolved N_2O at a few locations in the ocean off Kayamkulam and Thottappally

estuarine discharge as a major source of dissolved methane in the coastal ocean.

E.J. Zachariah
Funding: MoES, GoI

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

This action research project aims to prepare a management plan for the Alleppey-Shertallai (A-S) canal and Kanjikuzhy Gram panchayat by involving local people. Revisit of some of the environmental issues identified during a survey conducted in 2003 also forms part of this project.

The A-S canal is not continuous with flowing water. There are 22 segments. Water flows only among nine segments through vents, for rest of the 13 segments water is stagnant and over flows during monsoon months. Water is generally polluted with dense growth of weeds in many segments. Only four segments, namely, Varagady, Ponnittassery-2, Ponnittassery-1 and Kattayil are relatively clean and therefore some people living nearby use water from these four segments for domestic purposes. Canal water from most of the segments is used for irrigation purposes.

Analysis of quality of canal water for three time points, November 2008, March 2009 and February 2010, indicate that water in all segments of A-S canal is polluted. In some segments DO values are so low that even fishes can not survive. Organic pollution is very high. Some segments show high nitrite concentration, indicative of industrial pollution. Calcium hardness is prevalent in all canal segments. Segment to segment variations in water quality are related to local influence. Degraded vegetative matter within the canal has also contributed. The canal depth has reduced considerably. Many segments, which were renovated

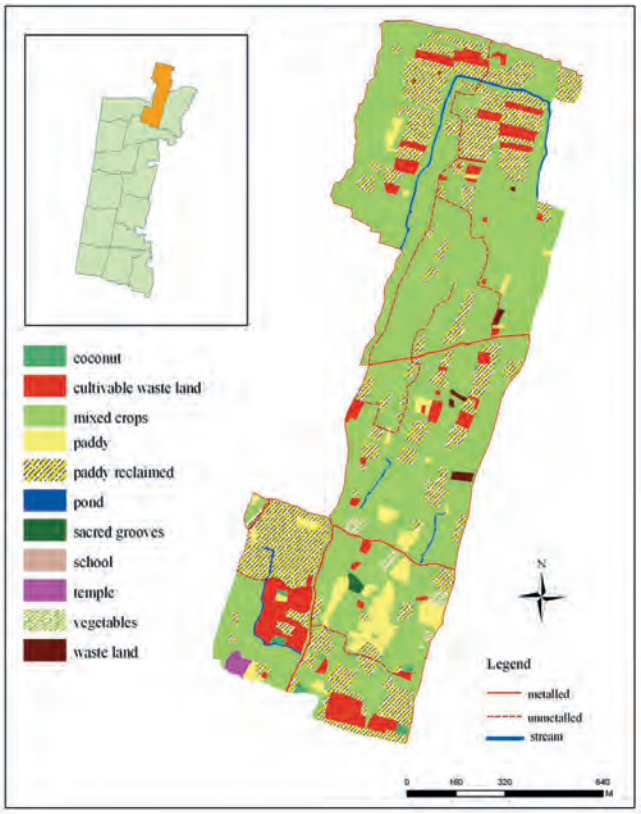


Fig. 3.3.7.1 Land use map of Ward-II, Kanjikuzhy Grama Panchayat

under Hariyali scheme, have again been weed infested. One time cleaning operation is not sufficient. There is a need for sustained effort to enhance economic potential of this canal.

The suggested management plan envisages user group formation, canal renovation, introducing picsiculture, restoration of flow and similar other environmental management practices. There is a need to form A-S canal Management Committee drawing representatives from all five Grama Panchayats. Regular monitoring is also suggested to assess impact of intervention projects and to devise mid course corrections.

In case of Kanjikuzhy Panchayat, which is well known for vegetable cultivation, the work began with documentation of cadastral level landuse and other amenities for all wards. A sample landuse map is given in Fig. 3.3.7.1. Major environmental problems in each Ward have been listed by considering all these information and interacting with local people. Similar exercise was undertaken in the year 2003 also. The major problems are: water logging and flooding during monsoon months, scarcity of drinking water, water pollution, sand mining, increased use of fertilisers and pesticides, salinity in wells and streams, improper waste disposal, declining agricultural productivity, and non cultivation of paddy lands. Severity of problems has also been worked out based on spatial spread. Water logging and flooding emerged as the most serious problem as it is affecting 10 Wards followed by discharge of industrial effluents (reported from 8 Wards) and siltation of streams (6 Wards). Environmental appraisal maps have been prepared for entire panchayat.

Environmental management action plan proposes watershed based approach to control water logging, prevention of salinity intrusion, pond renovation, rehabilitation of sand mining ditches, prevention of ground water pollution, rejuvenation of sacred groves, promotion of nature tourism, use of fallow land, management of agricultural waste, replacement of coconut plants and enhancement of land productivity. Some of the issues warrant Panchayat level initiatives and there are certain issues which can be handled at the Ward level. Management of water logging and flood problem requires inter-panchayat plans. Formations of user committees are significant. There is a need to monitor development initiatives regularly and take appropriate corrective measures as and when necessary.

This report will be useful for management of A-S canal and preparation of development report of Kanjikuzhy Grama Panchayat. Lessons learnt from renovation work of A-S canal will be useful for undertaking such initiatives in future. EMP of Kanjikuzhy Gram Panchayat can be used as an example for other coastal Panchayats to prepare such reports.

Srikumar Chattopadhyay
Funding: KSCSTE, GoK

3.3.8 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. (Fig. 3.3.8.1)

Recent studies revealed that in the Cochin offshore region, the concentration of trace metals were very high (Cd: 2.17µg/g; Pb: 26.90µg/g & Hg: 0.62µg/g). The estuary receives heavy influx of terrestrial sewage, industrial effluents and other anthropogenic

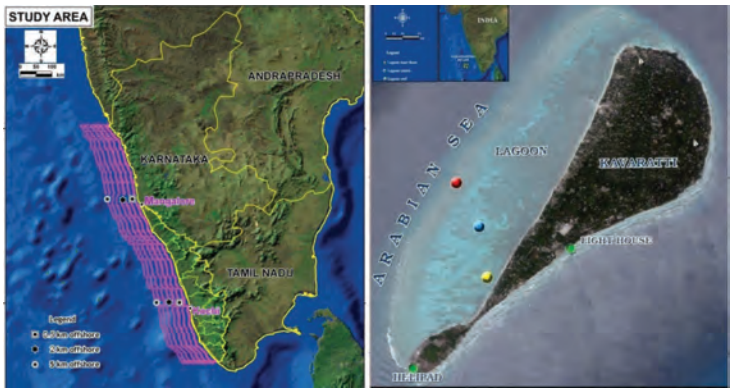


Fig.. 3.3.8.1 Study area

pollutants. Blooming of an indicator in phytoplankton species, Leptocylindrus *sp.*, showed its presence with a cell count ranging from 20,000 to1, 50,000 cells/L., signifying the aggravate phase of pollution. Besides, the higher figure of *E.coli* and faecal *Streptococci* indicates sombre microbial pollution in Cochin coastal waters. Many illegal sewers and the canals from the urban centers carrying the market wastes, septic tank effluents and animal carcasses finally enter the dynamic coastal waters results in the gross contamination with alarmingly increasing growth of pathogenic bacteria.

At Mangalore, the highest density of infectious organisms like *E.coli* (50-870 CFU/ml) and faecal *Streptococci* (60-1640 CFU/ml) were noticed. The adjoining river mouths/near shore region showed high TSS, excess nutrients and low dissolved oxygen due to massive influx of freshwater from riverine sources(Gurupur and Nethravathi). In Kavaratti, the primary productivity, Chlorophyll *a* and phytoplankton biomass were recorded very low. The phytoplankton, represented by the genera Phaeocystis *sp.* (*adversely affect fishery*) and Skeletonema *sp.* showed its representation with a maximum cell count of 3180 and 800 cells/L., respectively. It shows the enrichment of nutrients taking place in lagoon due to the unscientific disposal of sewages and other waste materials. The nearshore waters of Kavaratti are drastically affected by microbial pollution which could be the influence of domestic waste disposal.

K. V. Thomas
Funding: MoES, GoI

3.4 Coastal Zone Management

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

One of the major initiatives in the country towards bringing all the development programmes in the coastal zone under the umbrella of Integrated Coastal Zone Management (ICZM) is the Coastal Regulation Zone (CRZ) Notification (MoEF, 2011 & 1991). The Notification declares a defined coastal stretch as CRZ and regulates construction and other activities within this defined CRZ. The project on Cadastral sale CRZ maps for urban areas in Kerala was taken up with the support of the Kerala State Council for Science, Technology and Environment (KSCSTE).

The main objective of the project is to develop Coastal Zone Management (CZM) Plans with cadastral based CRZ maps for the coastal zone of Kerala to facilitate easy and transparent implementation of CRZ regulations. The High Tide Line (HTL), Low Tide Line (LTL) and CRZ demarcated on cadastral based CRZ maps help to identify the sensitive coastal ecosystems to be conserved and areas for development.

The cadastral level CRZ/CZM maps of Kozhikode, Varkala, Kollam and Thiruvananthapuram urban areas have been prepared in the 1st phase. In the 2nd phase the cadastral scale CRZ/CZM maps of Kochi Corporation, Maradu & Kanhangad Municipalities are under preparation. A GIS based CRZ information system is also under development. High resolution satellite imageries are being used to prepare CRZ/CZM maps along with detailed field mapping.

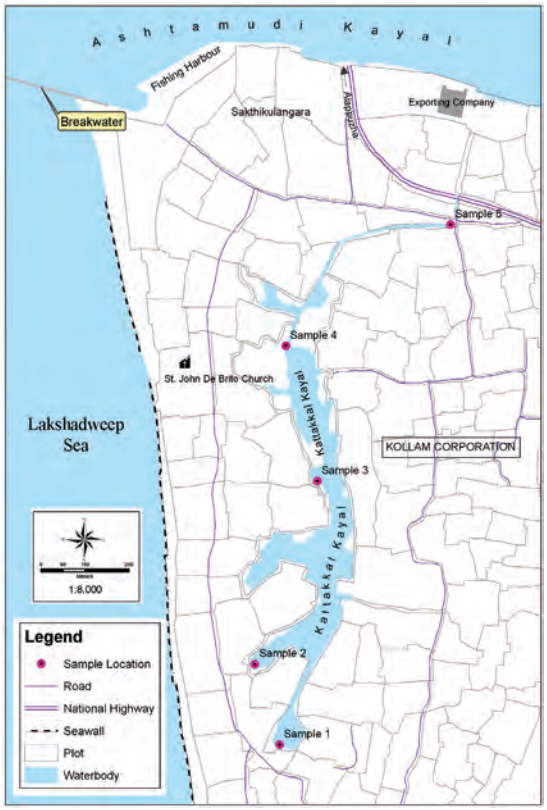


Fig. 3.4.1.1 Location map showing sample points in Kattakkal Kayal, Sakthikulangara area of Kollam Corporation

Table 3.4.1.1 Surface salinity at different locations of Kattakkal Kayal

Sl. No	Location	Depth of Sample	Salinity (psu/ppt)
1	8° 55' 8.71" N 76° 32' 36.12" E	Surface	5.51
2	8° 55' 14.67" N 76° 32' 34.32" E	Surface	5.43
3	8° 55' 28.29" N 76° 32' 39.03" E	Surface	6.8
4	8° 55' 38.30" N 76° 32' 36.66" E	Surface	18.3
5	8° 55' 47.25" N 76° 32' 49.08" E	Surface	21.7

The Kollam and Thiruvananthapuram CRZ/CZM maps are under modification to make these compatible with CRZ (2011) where in the water body and bed are also made part of CRZ. It has been observed that more areas than those existed in the CZMP 1996 (prepared with respect to CRZ 1991) have CRZ in Kollam and Thiruvananthapuram Corporations. Salinity measurements revealed that areas such as Kattakkal *kayal* in Kollam Corporation (Sakthikulangara) and areas further upstream of Thiruvallam in Karamana and Killi rivers in Thiruvananthapuram have salinity > 5ppt (Table 3.4.1.1 and Fig. 3.4.1.1).

The CRZ mapping of Maradu and Kochi is in progress. It has brought out many new areas under CRZ 1 category consisting of mangroves and mudflats within Kochi Corporation and Maradu Municipality.

K. V. Thomas

Funding: MoEF, Government of India

3.4.2 Integrated Island Management Plans (IIMPs) for Lakshadweep islands

Considering the uniqueness of the island system and their isolation from the mainland, the Ministry of Environment and Forest (MoEF), Government of India brought the development and other activities in the islands within the ambit of Island Protection Zone (IPZ), 2011 Notification with a view of providing livelihood security to the local communities. It also intends to promote conservation and preservation schemes to promote development through sustainable integrated management plan based on scientific principles taking into account the vulnerability of the coast to natural hazards. The major objective of this project is the preparation of Integrated Island Management Plans (IIMPs) for all the inhabited islands including some of the uninhabited islands of Lakshadweep (Table-1) in accordance with the guidelines provided in the IPZ, 2011.

The entire island including the aquatic area will be considered for the proposed Integrated Island Management Plan. The IIMP will be prepared in 1:25,000 scale map for macro level planning and 1:10,000 or cadastral scale for micro level planning. The approach involves the utilization of digital data base on cadastral scale of 1:4000 generated as part of the ICZM plan preparation for Lakshadweep islands during 2006. These data sets will be fine tuned with precision field measurements in the islands. After incorporating all the details in the cadastral map the draft IIMPs will be prepared which will be widely publicized and invite suggestions from the public and other stakeholders including it publishing in newspapers and website of the Lakshadweep Administration. The hard copy of the plan will also be made available to the public for comments. In addition to the IIMP plan preparation, the High Tide Line (HTL) will also be demarcated in each island in accordance with the provisions and guidelines in the CRZ 2011 notification.

T.N.Prakash

Funding: DST, UT Lakshadweep

3.5 Biophotonics

3.5.1 Diffuse Reflectance Imaging for Gingival Mapping and Antimicrobial Photodynamic Therapy

A clinical study was carried out at the Govt Dental College, Trivandrum, in 15 healthy volunteers and 25 patients to demonstrate the applicability of Diffuse Reflectance (DR) spectroscopy for non-invasive quantification and discrimination of various stages of inflammatory conditions associated with periodontal diseases. The DR spectra of diseased lesions recorded using a point monitoring system consisting of a tungsten halogen lamp and a fiber-optic spectrometer showed oxygenated hemoglobin absorption dips at 545 and 575 nm. Mean DR spectra on normalization showed marked differences between healthy and different stages of gingival inflammation. Among the various DR intensity ratios investigated, involving oxy Hb absorption peaks, the R620/R575 ratio was found to be a good parameter of gingival inflammation. In order to screen the entire diseased area and its surroundings instantaneously, DR images were recorded with an EMCCD camera at 620 and 575 nm (Fig. 3.5.1.1). We have observed that using the DR image intensity ratio R620/R575 mild inflammatory tissues could be discriminated from healthy with a sensitivity of 92% and specificity of 93%, and from moderate with a sensitivity of 83% and specificity of 96%. The sensitivity and specificity obtained between moderate and severe inflammation are 82% and 76% respectively. The technique was found helpful in identifying the underlying inflammation in the case of periodontitis with no

inflammation in gingiva. Early detection of disease and future disease progression can be monitored using this technique.

It was found that oxy Hb concentration increases during gingival inflammation, which alters the tissue absorbance at 575 nm. In clinical diagnostic procedures, gingival inflammation is considered as the initial stage of periodontal breakdown. This is often detected clinically by BOP (bleeding on probing) as it is an objective measure of gingival inflammation and is a reliable and verifiable measure. BOP is very well correlated with histological changes of gingivitis, and is readily interpretable in terms of clinical significance and can be highly correlated with gingival indices (GI). Clinically, active periods show bleeding either spontaneously or with probing. The study results show that sites with BOP correspond

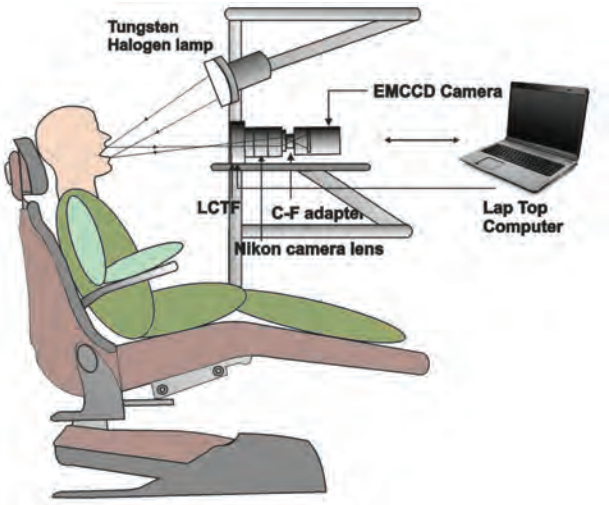


Fig. 3.5.1.1 The DR imaging setup for clinical studies of gingival mapping

well with the false colored image ratio R620/R575 pixel value.

The exact point of inflammation in moderately inflamed and severely inflamed gingiva can be seen in the false colored images are not at all observable using conventional diagnostic procedures (Fig.3.5.1.2). The identification of disease location enhances the opportunity for site specific treatments like photodynamic therapy. Periodontal destruction is site specific and does not occur in all parts of the gum and teeth at the same time, but rather on a few teeth at any given time. DR imaging identifies areas with early inflammatory changes in the underlying tissues even when the sites appear clinically healthy. This helps in identifying sites that are prone to disease. It is very common to find sites of periodontal destruction next to sites with little or no destruction. Therefore, the severity of periodontitis increases with the development of new disease sites and increased breakdown of existing sites, or both. Currently used diagnostic procedures cannot distinguish between disease-active and disease-inactive sites at any given point of time and cannot reliably identify susceptible individuals based on disease active and inactive sites. Also, chronic periodontitis is now considered a site-specific disease, but what has continued to puzzle periodontal researchers is the unpredictability of the disease at a patient and site-level. In this context, diffuse reflectance

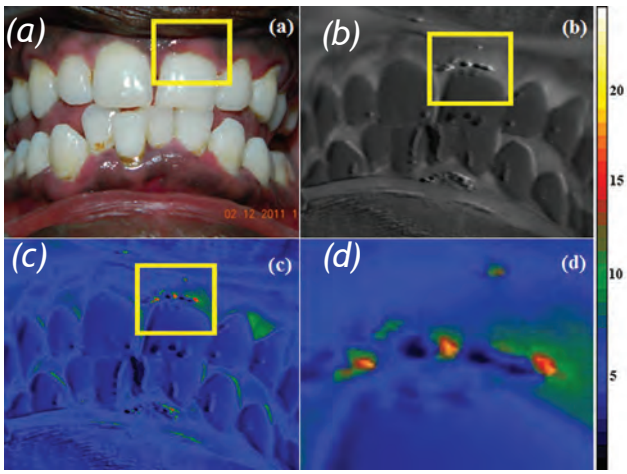


Fig. 3.5.1.2 False coloured DR image intensity ratio (R620/R575) showing regions of inflammation.

imaging using DR image ratio R620/R575 proves to be an effective tool to pin point locations of inflammation and to precisely demarcate areas with increased vascularity or gingival inflammation.

During March 2012, the project Co-investigator from Azezzia Dental College, Dr. K. Nandakumar and Mr. Prasanth Chandrasekhar visited the Bulgarian Academy of Sciences in Sofia and carried out joint PDT studies with the collaborating group using porphyrin and chlorin based photosensitizers on oral pathogens.

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

A multi-spectral imaging system to measure sunlight-induced fluorescence and reflectance images of vegetation at selected wavelengths was developed. The system consists of an EMCCD camera with Nikon lens and LCT filter with 7 nm FHWM and an optional filter wheel with discrete narrow band interference filters for wavelength selection. During fluorescence studies the Fraunhofer Line Discrimination (FLD) technique was used to extract the very low fluorescence signals in the presence of high levels of diffusely reflected sunlight. The chlorophyll fluorescence spectral images were recorded at the near-red (PSII emission) and far-red (PS I emission) bands and their false coloured image ratio was used to obtain stress sensitive signatures of outdoor plants. In addition, solar reflectance images of vegetation at 420, 531, 571, 600, 670, 694 and 720 nm were measured and Photochemical reflectance index (PRI) and NDVI were determined. Senescence induced changes in colocasia and sweet potato plants due to herbicide attack, drought and nutrient stresses were studied by growing these plants in the campus and comparing the results with a control group. Photosynthesis parameters of vegetation such as photosynthesis rate, transpiration, stomatal conductance and internal CO^2 were measured using CI-340 photosynthesis system for correlation.

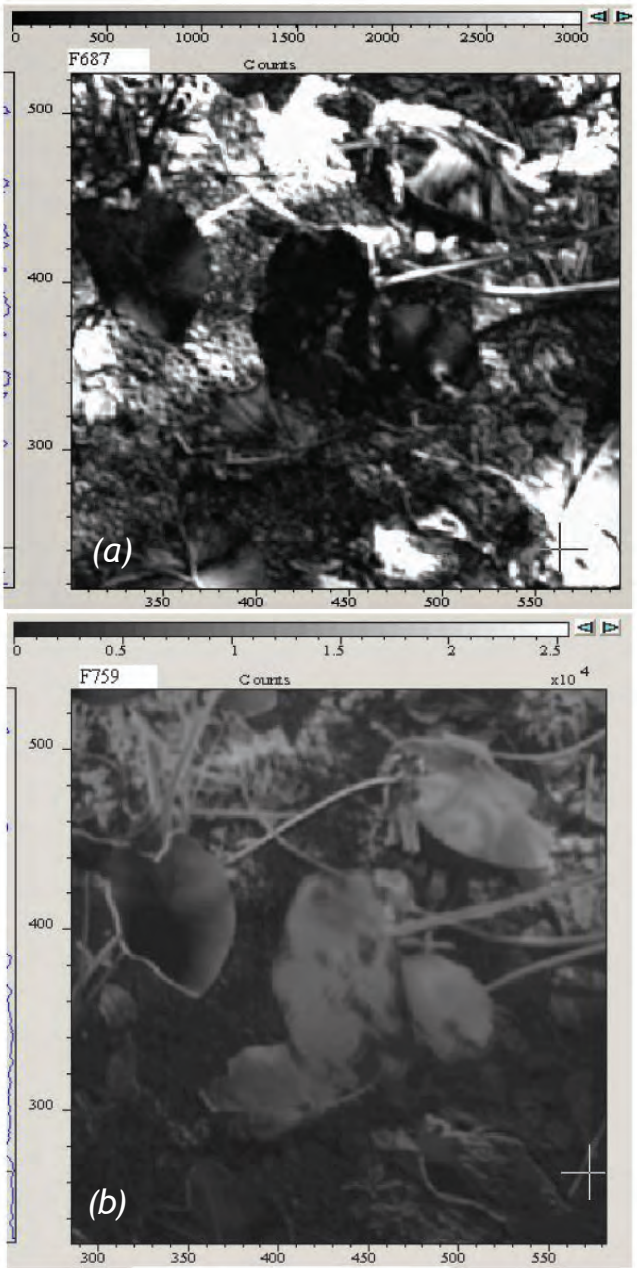


Fig. 3.5.2.1 (a&b): Sunlight-induced fluorescence image of the vegetation at 687nm and 759nm

The ability of different reflectance image intensity ratios and Photochemical Reflectance Index (PRI) in stress detection was assessed and compared with sunlight-induced fluorescence image ratio. Higher PRI values seen in the case of the healthy leaves indicate less stressful conditions, whereas the progressively lower values seen during yellowing of leaves indicate substantial stress. Among the different reflectance images ratios used, R694/R420 and R694/ R720 showed clear distinction of senescence from healthy green leaves. The net photosynthesis rate (Pn) and stomatal conductance showed constant values for the control plants, whereas for the stressed plants they were low. The decrease in

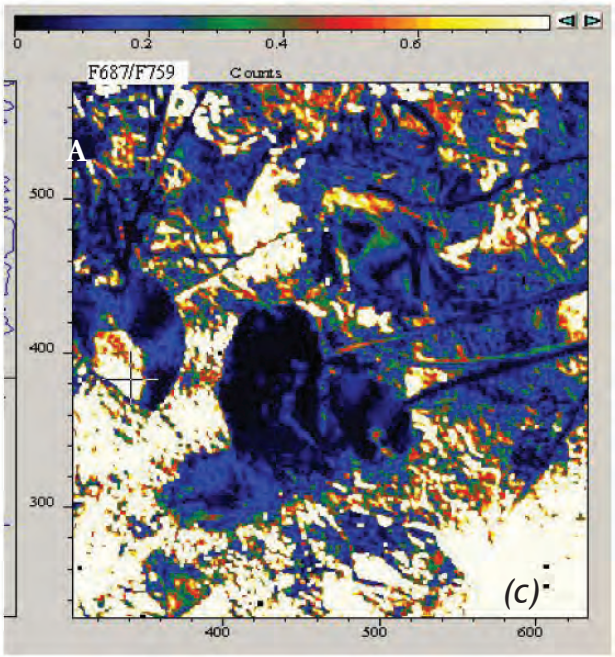


Fig. 3.5.2.1(c): False coloured fluorescence image ratio F687/759 derived using FLD principle

photosynthetic efficiency is due to the closure of the stomata under stress, which limits the supply of CO_2 to the photosynthetic system.

Fluorescence images were recorded at the selected Fraunhofer emission lines of O_2 at 687nm and 759 nm, and fluorescence spectral image intensity ratio F687/F759 was calculated using Andor Solis software and false coloured for easy visualization of the difference

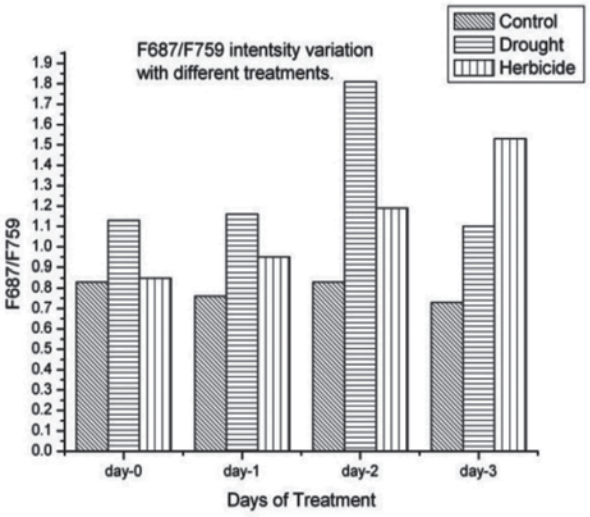


Fig. 3.5.2.2 Fluorescence image ratio F687/F759 of Colocasia plants due to Drought, Herbicide and control plants over the treatment period

between the affected and healthy regions of plant leaves (Fig. 3.5.2.1 a&b). Clear distinction is seen between healthy and chlorosis affected leaves (Fig. 3.5.2.1 c). The part of the leaf with less chlorophyll reflects more light and is represented in yellow and red colour in false-colour with high values, compared to the green coloured healthy portion of the leaf.

The reflectance ratio images R694/R420 and R694/R720 showed an increasing percentage variance for herbicide treatment. The PRI values showed high negative values for dried leaves and 0.01 to 0.05 for green healthy leaves. Among the different fluorescence and reflectance parameters measured, F687/F759 and NDVI showed a high percentage of correlation with the net photosynthesis. With the application of stress, the photosynthetic mechanism of the plant was affected,which gets reflected as a decline in net photosynthetic rate and decrease in stomatal conductance.

The results clearly indicate a positive correlation between F687/F759 and the physiological status of the vegetation (Fig. 3.5.2.2). The Fraunhofer line depth principle enabled the measurement of solar-excited fluorescence in plants and was found to be inversely proportional to net photosynthetic rate. The F687/F759 value measured using sunlight-induced imaging technique was found to be similar to the value obtained from spectral measurements taken using laser-induced point monitoring. This study clearly establishes the potential of solar-induced fluorescence imaging as a remote sensing tool for mapping of the physiological status of vegetation.

The final report of the project work is under preparation and will be submitted shortly. Further studies are planned jointly with the CTCRI to study the impact of biotic and abiotic stresses on various tuber crop plants grown under field conditions.

N. Subhash

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

Field trip was conducted to the Agatti and Bangaram islands of Lakshadweep for *in situ* multi-spectral fluorescence imaging and point monitoring of corals. LIF characteristics from different coral species were recorded and samples were collected at different depths/light intensities to study the depth wise distribution of different clades of Zooxanthellae which has a direct effect on coral health. Bar coding was done to identifify the different clades of Zooxanthellae using an universal primer and a Zooxanthellae specific primer. The DNA extraction method and PCR conditions were standardised.

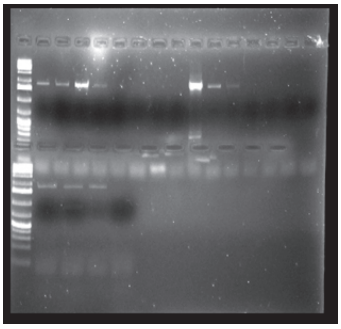


Fig. 3.5.3.1 Amplified ssrRNA genes used in clad identification on agarose gel

DNA isolation: DNA isolation was carried out using TRI reagent. Coral tissue scrapped off from the skeleton were homogenized with TRI reagent (1 mg per 100 mg of tissue). To ensure complete dissociation of nucleo protein complexes, samples were allowed to stand for 5 minutes at room temperature. 0.2 ml of chloroform (per 1 ml of TRI) was added, shaken well for 30 seconds and allowed to stand for 15 minutes at room temperature. The resulting mixture was centrifuged at 12,000 rpm for 15 minutes at 4°C. This separates the mixture into three phases: a red organic phase (protein), an interphase (DNA) and a colourless upper aqueous phase (RNA). The aqueous phase overlying the interphase was carefully discarded and in order to precipitate the DNA, 0.5 ml of 100% ethanol was added, mixed by inversion and allowed to stand at room temperature for 5 minutes. The mixture was then centrifuged at 2000 rpm for 10 minutes at 2° C. The supernatant was removed and the DNA pellet was centrifuged thrice in 0.1 M trisodium citrate and once in 10% ethanol solution. After cen-

trifugation at 2000 rpm for 5 minutes at 4°C the DNA pellet was resuspended in 75% ethanol and stored for further studies.

Gene amplification: After DNA extraction, the small subunit ribosomal RNA genes were amplified from total nucleic acid using both universal eukaryotic primer,

[ss5 (5'–GGTTGATCCTGCCAGTAGTCATATGCTTG-3') and ss3 (5'–GATCCTTCCGCAGGTTCACCTACGGAAACC-3')]and Zooxanthellae specific primer [ss5Z (an equimolar mixture of the oligonucleotides 5'-GCAGTTATAATTTATTTGATGGTCACTGCTAC-3' and 5'-GCAGTTATAGTTTATTTGATGGTTGCTGCTAC-3') and ss3Z (5'-AGCACTGCGTCAGTCCGAATAATTCACCGG-3')].

Amplifications were performed using a thermal cycler with the following thermal profile: 30 cycles for 5 minutes at 94°C, 1 minute at 94°C, 2 minutes at 50°C, 3 minutes at 72°C and 10 minutes at 72°C. The PCR products were analyzed by electrophoresis and stained with ethidium bromide. PCR products on agarose gel amplified using universal primer are shown in Fig.3.5.3.1. Initially amplicons were obtained only for universal primer. However, when the once amplified PCR products were used instead of total DNA the ssrRNA gene was amplified. Sequencing the products would help us identify the different clades of Zooxanthellae that the corals harbour.

Four large glass tanks with temparature controllers and UV light illuminators were set up at the Central Marine Fisheries Research Institute (CMFRI), Vizhinjam to the study heat induced stress on corals. The tanks were well aerated and the temperature in all the four tanks was maintained at the optimum temperature of 26°C using an immersible heater and a thermostat. The coral samples will stand at the optimum temperature for five days minimum for acclimatization. Apart from imaging, tissue samples will be taken to study the changes in Zooxanthellae subspecies and to identify the fluorescent proteins in corals.

N Subhash

Funding: DST, Government of India

3.6 GIS and Remote Sensing Applications in Natural Resources Management

3.6.1 Agricultural Atlas of Kerala

The objectives of the project are (a) to provide detailed database and spatio-temporal characteristics of the productivity of major food grains collected from various sources and to substantiate with Remote Sensing and GIS Technology, (b) to digitize the crop land use and related natural resources available from various scales, (c) to study the present conditions, its problems and prospect of agricultural activities, (d) to document the data in GIS format for updation and (e) to prepare multi-colour thematic maps in the form of resource document (Agricultural Atlas) for planning.

In the first phase, spatial data on crop land use were collected from sources like viz., Department of Economics and Statistics, Department of Agriculture, Department of Livestock, Poultry and Fisheries, Department of Soil Survey and Revenue, IMD, RARS Stations, and Agricultural University. The data collected were used for the preparation of series of multi colour thematic maps using Arc GIS 9.3.

Derivative maps will be generated from spatial and non spatial data using GIS software. After procuring the Satellite Data from NRSC, Hyderabad for entire Kerala, the crop land use analysis will be carried out using Arc GIS and ERDAS Image Processing Software in the laboratory. Subsequently field work will be carried out in selected areas for ground truth verification of crop land use. In the second half of the third phase final data base will be created using GIS and Remote Sensing and finally multi colour thematic maps will be prepared and an atlas will be brought out

E Saravanan

3.6.2 Digital Resource Atlas of Kerala

The main objective of this project is to revise the Resource Atlas of Kerala published in 1984 in digital format in CD as well as in hard copy. Maps of physical aspects and climate will be digitized and used for the revised atlas. For other thematic maps, district and taluks will be used as unit of study for the preparation of maps. Data from secondary sources like Census of India, Agricultural Dept., Bureau of Economics and Statistics and other departments will be collected and converted into appropriate thematic maps. The maps will be prepared in GIS environment to enable us to update periodically without much delay. Atlas maps will be published both in CD and as well as hard copy with Survey of India approval.

During the period under report data were collected, processed, and 200 maps were digitised. These include Kerala- administrative divisons, relief, drainage, soil, demographic aspects (Cesnus, 2001), area under banana, turmeric, cardamaom, cocoa, food crops, non foodcrops, drumstick, ginger, pepper, sugarcane, lemongrass, rubber, coffee, paddy, fodder grass, papaya, sweet potato, pine apple, tamrind, mango, jack, tapioca, plaintain, cahew, tea, sesamum, and coconut from 1985-1995, 1995-2005 and percentage to the total cropped area from 1985-1995 and 1995-2005. Demographic aspects includes total, male and female population, percentage to the total population, density of population, sex ratio, total workers, main workers, cultivators, agricultural labourers, literates, SC popu-

lation, ST population and households. Most of the maps are completed and the final report is under preparation.

B. Sukumar

3.6.3 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 urban/rural planning, (c) developing a standard format for data exchange and (d) developing a Decision Support System (DSS) 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 Differential GPS (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 prepared. However the thematic maps pertaining to bio-physical resources of Thiruvananthapuram district has been transformed with reference to the post-processed Ground Control Points (GCPs) generated during the DGPS survey in the non-forested areas of the Thiruvananthapuram district. Local body-wise distribution of the inventory/ derivative thematic database has been computed based on UTM Zone-43 projection. Parcel-wise distribution of the themes has been generated for all the thematic layers of Neyyattinkara taluk. A cadastral level Decision Support System has been built using the Map server for hosting to the web. The user can explore, manipulate and extract reliable spatial database according to their requirement.

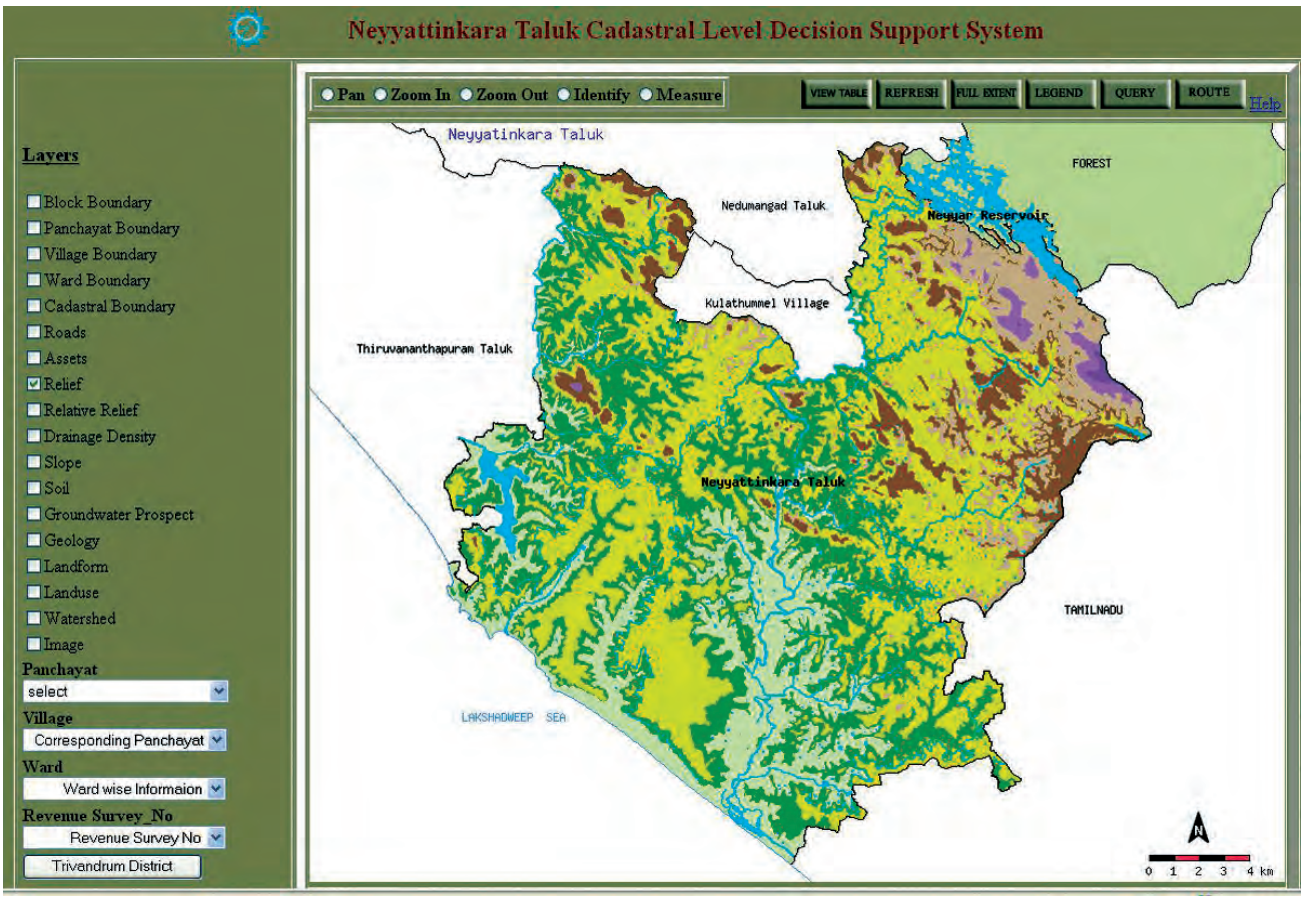


Fig. 3.6.3.1 A screen shot of the releif map included in the Decision Support System for Neyyattinkara Taluk, Trivandrum

The project deliverables were in two phases viz., DGPS mapping for establishing of Principal Reference Points (PRPs) and Ground Control Points (GCPs) and Cadastral Level Decision Support System software development. The PRP mapping services covered seven districts, where 28 PRPs have been established by making 72 hours continuous observation in seven districts viz Thiruvananthapuram, Kollam, Alappuzha, Kottayam, Ernakulam,

Thrissur, and Malappuram. In order to geo-reference cartosat-1 imagery of the Thiruvananthapuram District, 316 Ground control Points have also been surveyed. The Project is completed and the Software is ready for hosting in intranet/internet. The three reports published on completion of the project are (a) Report on GCPs for Thiruvananthapuram District, (b) Report on PRPs for Thiruvananthapuram, Kollam, Alappuzha, Kottayam, Ernakulam, Thrissur, and Malappuram districts and (c) Cadastral level Decision Support System for Thiruvananthapuram district, Kerala.

Jayaprasad B K

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

The main objective of the project was to prepare Agro Ecological Unit-wise atlases for Kerala State based on the classification made by the National Bureau of Soil Survey and Landuse Planning (NBSS & LUP). Twenty Three Agro-ecological units (AEU's) have been delineated for the State based on climatic variations, land form and soil by the NBSS & LUP. They are the Southern Coastal Plain, Northern Coastal Plain, Onattukara Sandy Plain, Kuttanadu, Pokkali Lands, Kole Lands, Kaipad Lands, Southern Laterites, South Central Laterites, North Central Laterites, North Laterites, Southern and Central Foot Hills, Northern Foot Hills, Southern High Hills, Northern High Hills, Kumily Hills, Marayoor Hills, Attappady Hills, Attappady Dry Hills, Wayanad Central Plateau, Wayanad Eastern Plateau, Palakkad Central Plains and the Palakkad Eastern Plains. In the case of the municipal corporations in Kerala; one more unit called the 'Habitation Unit' was also added. On the basis of the master polygons delivered by National Bureau of Soil Survey and Land use Planning (ICAR) Bangalore, twenty three agro-ecological units and habitation unit atlases were prepared using Natural Resource and Environmental Data Base (NREDB) generated utilizing IRS P6 imagery and other related database.

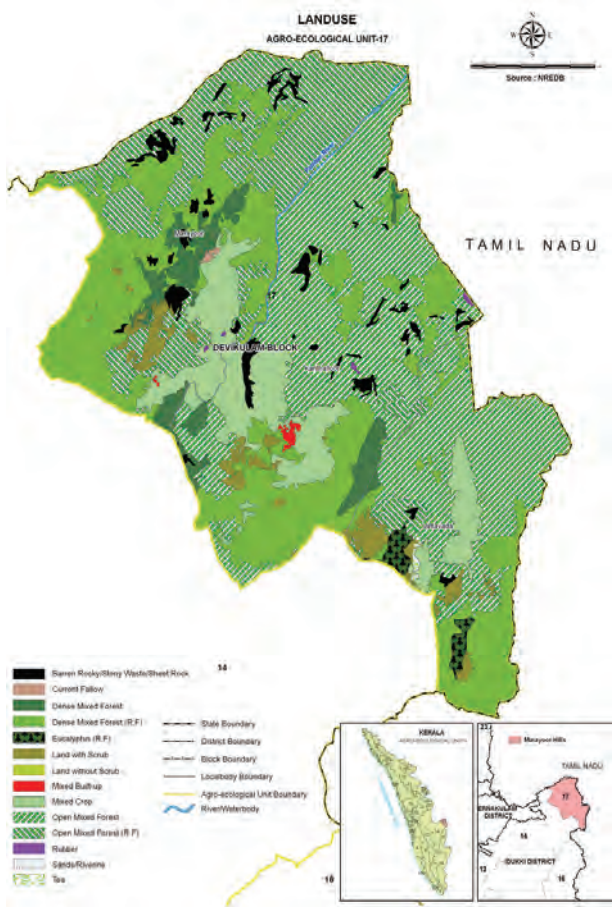


Fig.3.6.4.1 Landuse map of Marayoor hills in the Agro-Climatic Zone 17

The atlas consisted of 4650 color maps and a 1176 page report. The atlases were released on 5th March 2012 at the workshop on 'Agro-ecological planning for agricultural development in Kerala, a paradigm shift' organized by the Kerala State Planning Board.

Jayaprasad B K
Funding: Kerala State Planning Board

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

The Government of Kerala has launched a 'Plant Nutrient Management Plan' covering agro-ecosystems in the State. The project envisages analyzing 2.30 lakh soil samples from 999 panchayats and preparation of nutrient management plans for all the panchayats. In addition, the production potential of major crops in 23 agro-ecological zones of the State will be analyzed by a team of agronomists. Farmers would then be issued nutrient advisory cards.

The project is being implemented by the Department of Agriculture with the support of Indian Council of Agricultural Research (ICAR) institutes, Kerala Agriculture University (KAU), Kerala Forest Research Institute (KFRI), Centre for Earth Sciences Studies (CESS) and Indian Institute of Information Technology and Management-Kerala (IIITM-K), under the leadership of National Bureau of Soil Survey and Land Use Planning, Bangalore. The project is being coordinated by the Kerala State Planning Board. The national bureau has already completed the delineation of the 14 districts into 23 agro-ecological zones based on climate and soil. Corporations are grouped under the Habitation unit. Macro and micro

nutrients in each zone will be analyzed and nutrient management plan prepared for each zone and local body. CESS has undertaken spatial data processing using GIS and prepared base maps for locating sample sites. The volunteers have demarcated the soil sample sites in the base maps of local bodies. Based on the results of soil analysis, many analytical and synthetic maps will be prepared using the spatial analysis tools available in the GIS. A comprehensive nutrient management plan would then be made available for the farmers. The soil analysis reports are awaited for the preparation of derivative maps for the local bodies.

Jayaprasad B K
Funding: Kerala State Planning Board

3.6.6 Road network updation using high resolution remote sensing data and GPS - A pilot project for Kerala Spatial Data Infrastructure (KSDI),

Road networks are very vital for development of any region. Lack of good connectivity isolates regions from educational institutions, health institutions, social support network and sources of income. In the absence of good connectivity, the surplus produces cannot be transported to the market and this lowers the income of the local community. Good and well maintained road networks are essential for micro level planning activities.

For sectoral development at local level, the database has to be updated by utilizing the high resolution remote sensing data such as Quick Bird with resolution of 0.6 meter, so that the roads at local body level can be incorporated in the cadastral scale. CESS has taken up a pilot study of road database updation using high resolution remote sensing data and GPS survey for framing up the methodology. In order to demonstrate the capability of satellite data product, one panchayat in the Parassala Block has been taken up.

Updation and integration of the transportation network was attempted with CARTOSAT-1 and Quick Bird Satellite data supplemented with attributes such as road segment labels, junctions and local area names. A detailed field work has also been carried out for road survey using the GPS, so as to work out the methodologies for updating the transportation network, its limitations, time and cost.

An attempt has been made to evaluate and compare the extent of road network generated with the help of the satellite data and data generated by PWD, CESS and KSREC for road network in Parassala Panchayat of Parassala Block. A table of comparison has also been made. Apart from delineating the road network data from multi-resolution and multi -temporal satellite images and data captured from the field, customized GIS application software has also been developed in open source to demonstrate the utility of software in extracting the road database information by querying. The software 'Road Information System' is a customized GIS application developed in Map Server Open source UMN.

The Quick Bird image with a resolution of 0.60 meters, which has a fair coverage in terms of archive data over the Kerala State, is ideal for delineating road network up to the local body-level. Satellite image study was supplemented with extensive field work for validating and updating disjoint portion of the linear road network and other spatial features of interest.

The services of the local volunteers and officials from the corresponding local body were utilized for field assistance and labeling of road segments with local names.

Fig. 3.6.6.1 Road network of Parassala panchayat seen from the QuickBird satellite image

The 'Road Register' available with the concerned local body and Public Works Department was used for labeling of roads and lanes. For widening roads, road width information has to be incorporated in the database. Category-wise road numbers are essential for future updation and labeling.

B.K.Jayaprasad
Funding: IT Dept., GoK

3.6.7 Creation of a model GIS database for Malappuram Municipality under the Spatial Urban Information System (SUIS)

'Urban Information System' is the backbone for city planning. The digital maps and GIS database can be useful for preparation of various master plans for projects in the municipality limits. It can be also used to collect property tax, plan and execute disaster management plans, streamline traffic flow, planning utilities like water supply, sewage system and electricity. CESS and Information Kerala Mission have initiated a collaborative project to create a model GIS data base with plot level details for Malappuram municipality.

CESS is entrusted with DGPS survey for generating Principal Reference Points (PRPs)and Ground Control Points(GCPs), field survey verification and vetting, geo-referencing and digitization of cadastral and satellite imagery, providing faculty training for municipal personnel and surveyors, ward-wise atlas preparation and customization. DGPS survey has been completed. The World View-2 satellite imagery with a spatial resolution of 0.50 mts has been geo-referenced with reference to the post processed DGPS data. Training of municipal personnel and surveyors has been completed. Extraction of land use theme has also been completed. The remaining components of the project work are progressing.

B.K.Jayaprasad

Funding: Information Kerala Mission, GoK

3.7 Energy Studies

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

Energy is the prime mover of economic growth. It occupies the central stage in developmental issues. This implies that for the fructification of the concept of inclusive growth, energy has to be provided to the needy in the manner and form required by them. The broad objectives of the project are to bring out the salient features of socio-economic and other impacts of energy technologies which are used in day to day life in rural panchayat of Kilimanoor and in the urban area of Pattom, both in Thiruvananthapuram district. The methodology involved was to carry out household survey in the chosen areas employing a detailed and comprehensive questionnaire. The survey was conducted in randomly chosen one hundred house holds in each of the study area which comprise of regions in two different environs. The rural panchayat of Kilimanoor also happens to be more populated with agricultural workers compared to other areas in the district. This has enabled a comparison between agricultural and non-agricultural areas in their modes of energy use. The general socio economic features of the households of the regions surveyed formed the backdrop and this study has been completed and the final project report was submitted.

It can be said without doubt that of all the technological developments so far made, electrification has had the maximum capacity to affect the way people live, work, entertain and communicate. Hence, the study has dealt with awareness, adoption and impact of various applications through micro level study at household level. The study conducted in Kilimanoor panchayat, which has an agricultural background, yielded interesting insights. Some thoughts on the presently relevant twin problems of energy and food securities are also discussed in the report.

K. Vijayakumar

4.1 Coastal Regulation Zone Status Reports

The Ministry of Environment and Forests (MoEF) enacted the Coastal Regulation Zone (CRZ) notification under the Environment Protection Act of 1986 in 1991 to control and minimise environmental damage to sensitive coastal stretches from unplanned human interference. The Government of India Notification [S.O.19 (E) dated 6.1.2011] has redefined the CRZ. Accordingly the CRZ has been declared as 'the coastal stretches of the country and the water area up to its territorial water limit'. The CRZ consists of : (a) land area from the High Tide Line (HTL) to 500 m on the landward side along the sea front, (b)land area between the HTL to 100 m or width of the creek whichever is less on the landward side along the tidal influenced water bodies that are connected to the sea; the distance up to which development along such tidal influenced water bodies is to be regulated is governed by the distance up to which tidal effects are experienced which is determined based on salinity concentration of 5 parts per thousand (ppt) measured during the driest period of the year; the distance up to which tidal effects are experienced will be clearly identified and demarcated accordingly in the Coastal Zone Management Plans (CZMPs) (Tidal influenced water body means water body influenced by tidal effects from sea in the bays, estuaries, rivers, creeks, backwaters, lagoons, ponds connected to the sea or creeks and the like), (c) land area falling between the hazard line and 500 m from HTL on the landward side, in case of seafront and between the hazard line and 100 m line in case of tidal influenced water body, (The word 'hazard line' denotes the line demarcated by Ministry of Environment and Forests (MoEF) through the Survey of India (SoI) taking into account tides, waves, sea level rise and shoreline changes) (d) land area between HTL and Low Tide Line (LTL), which will be termed as the inter-tidal zone, (e) water and the bed area between the LTL to the territorial water limit (12 nm) in case of sea and the water and the bed area between LTL at the bank to the LTL on the opposite side of the bank, of tidal influenced water bodies.

The CRZ Notification categorizes Coastal Regulation Zones as CRZ I, CRZ II, CRZ III and CRZ IV based on whether the area is ecologically sensitive, developed, undeveloped or waterbody and its bed. Ecologically sensitive and important areas and the inter-tidal zone constitute CRZ I. The areas that have already been developed upto or close to the shoreline are categorized as CRZ II. Areas that are relatively undisturbed belong to CRZ III. The water area and the bed constitute CRZ IV. Development and other activities are regulated within the different CRZ categories to ensure sustainable development and conservation of beach and other sensitive coastal ecosystems.

In view of the unique coastal systems of backwater and backwater islands and space constraints along the coastal stretches of Kerala, the CRZ (on the landward side) in the islands within the backwaters in Kerala have been defined as 50 m from the High Tide Line on the landward side. The CRZ Notification of 2011 has also defined Critical Vulnerable Coastal Areas (CVCA), which includes Sunderbans, and other identified ecological sensitive areas in which 'Vembanad in Kerala' is also included. The new CRZ Notification issued in January 2011 (CRZ 2011) is in supercession of CRZ 1991 except as respects things done or omitted to be done before such supercession. The Coastal Zone Management Plan (CZMP) approved in 1996 remains valid for two more years or till a new CZMP is prepared and got approved.

The Centre for Earth Science Studies has been authorised by the Ministry of Environment and Forests, Govt of India for the demarcation of the HTL and LTL. Accordingly the CESS has taken up a number of studies on CRZ in different coastal states of the country. A list of the projects completed during 2011-12 is given in Table 4.1.1

Table 4.1.1 List of CRZ Reports during the year 2011-12

Sl. No	Institution /Agency	Location	Project
1	Harbour Engineering Department	Valiyathura	Harbour development
2	Harbour Engineering Department	Vellayi	Harbour development
3	Harbour Engineering Department	Arthunkal	Harbour development
4	Waterline Resorts Pvt.Ltd	Kozhikode	Resort development
5	Pavis Resorts Pvt.Ltd	Thrissur	Ayurvedic resort development
6	Nuclear Power Corporation of India (NPCI)	Kudankulam	Nuclear Power Plant
7	Kerala State Urban Development Project (KSUDP)	Kollam	Sewage Treatment Plant
8	Kerala State Urban Development Project (KSUDP)	Kozhikode	Sewage Treatment Plant

Sl. No	Institution / Agency	Location	Project
9	Rohan Lifescapes Pvt.Ltd	Mumbai	Development site
10	Harbour Engineering Department	Manjeswaram	Harbour development
11	First Estate Developers Pvt.Ltd	Thanthonnithuruth	Development site
12	IHMCT	Kovalam	Hostel Construction
13	Ultra-Tech Cement Ltd	Wellington Island	Development site
14	Esel Outdoor Location	Mumbai	Studio development
15	Kerala State Urban Development Project (KSUDP)	Kochi	Sewage Treatment Plant
16	Harbour Engineering Department	Tanur	Harbour development
17	Long Island Nature Hotel & Resort Private Limited	A & N islands	Beach Resort
18	Honnavar Port	Karnataka	Port Development
19	APM Terminals Pvt.Ltd	Gujarat	Port Development
20	Kent Constructions Pvt.Ltd	Kochi	Housing Project
21	LULU Convention And Exhibition Center Pvt Ltd	Bolgatty Island	Hotel Cum Convention Centre
22	MIV Logistics Pvt.Ltd	Vallarpadam	Container Freight Station Project
23	Hazira Infrastructure Private Limited	Gujarat	Critical Rail Infrastructure & Utility Corridor
24	Adani Hazira Port Private Limited	Gujarat	Port Development
25	Hotel Sea Park Pvt.Ltd	Kannur	Resort development
26	Royal Blue Hotels Pvt.Ltd	Kadinamkulam	Resort Development
27	Skyline Foundations (SFS) Pvt.Ltd	Akkulam	Residential Project

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

Funding: Various Agencies

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.	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	0.00
2.	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	2.98
3	Inactivation of pathogenic bacteria in periodontal disease: Fluorescence diagnostics and photodynamics 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	0.00
4.	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. R. Nagendra (Anna University)	2009-12	30.38	1.00
5.	Coastal Ocean Monitoring and Prediction System (COMAPS)	Dept of Ocean Development	Dr. K. Narendra Babu (Since 1.6.2009) Dr. K. V. Thomas (Since 1.10.2011)	Chemical Sciences	Dr. K. Anoop Krishnan	2008-13	217.50	86.05
6.	Preparation of Integrated Island Management Plans (IIMP) for Lakshadweep Island (UTL-6)	Dept. of Science & Technology, UT, Lakshadweep, GoI	Dr. T. N. Prakash	Marine Sciences	Dr. K. V. Thomas	2011-13	45.33	45.33
7.	Establishment of national early warning system for tsunami and storm surges in Indian ocean (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, Dr. T. S. Shahul Hameed	2006-12	27.80	17.98
8.	Nitrous Oxide and methane in coastal ocean and estuaries (MOES 2)	Ministry of Earth Sciences, GoI	Dr. E. J. Zachariah	Atmospheric Sciences	--	2007-12	20.07	0.00
9.	Shoreline Management Plan for Kerala (MOES 3)	Ministry of Earth Sciences, GoI	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian, Dr. T. S. Shahul Hameed, Smt.. L. Sheela Nair, Dr. Reji Sreenivas	2008-12	176.63	37.99
10.	Oil spill modelling for selected locations of Kerala and Lakshadweep (MOES 4)	Ministry of Earth Sciences, GoI	Dr. N. P. Kurian Smt.. L. Sheela Nair, (Since 1-1-2011)	Marine Sciences	Dr. T. S. S.Hameed, Dr. K. V. Thomas	2009-11	75.00	0.00

11.	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	Smt. Sreekumari Kesavan	2010-13	13.93	1.56
12.	Establishment and maintenance of wave gauge stations in the coastal waters of the SW coast in India (MoES 6)	Ministry of Earth Sciences, GoI	Smt. L. Sheela Nair	Marine Sciences	Dr. T. S. Shahul Hameed, Dr. N. P. Kurian, Dr. K. V. Thomas Dr. Reji Sreenivas	2010-12	27.18	0.00
13.	Paleo fluids in the petroliferous basins of Western offshore India (MoES 7)	Ministry of Earth Sciences, GoI	Dr.V.Nandakumar	Geosciences	Dr. K. Narendra Babu	2011-14	265.67	221.17
14.	Heavy mineral chemistry in different source rocks and coastal sediments of SW coast of India: understanding provenance and processes in Placer deposit formation (MoES 8)	Ministry of Earth Sciences, GoI	Dr. G. R. Ravindra Kumar	Geosciences		2012-15	18.36	6.51
15.	Monitoring of soil moisture under bare cropped conditions of tapioca and pineapple in the mid land highlands of western ghats areas of Kerala (PLG 11)	Western Ghat Cell, Kerala State Planning Board	Dr. P. V. S. S. K. Vinayak	Atmospheric Sciences	--	2009-12	10.25	0.00
16.	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	--	2007-12	13.13	0.00
17.	Application of space technology for the development of Kerala - (PLG 13)	Kerala State Planning Board , GoK	Sri. V. N. Neelakandan	Central Geomatics Lab	Sri.B. K. Jayaprasad	2008-11	12.62	0.00
18.	Rainfall validation & characterization and cloud physics studies using megha tropiques data (SAC 13)	Space Applications Centre	Dr. G. Mohan Kumar	Atmospheric Sciences		2007-12	31.82	4.72
19.	Optical characterization of coral reef diversity for understanding the impact of changing environmental conditions (SAC 14)	Space Applications Centre	Dr. K. K. Ramachandran	Central Geomatics Lab	Dr. T. N. Prakash	2009-13	15.00	0.00
20.	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, GoK	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian, Sri. D. Raju, Sri. S. Mohanan, Sri. M. Rameshkumar	2006-12	6.99	0.00

21.	Environmental Management Plan for Alappuzha-Sherthalai Canal and Kanjikuzhy Gramapanchayat-a participatory action research programme (KSCS 11)	Kerala State Council for Science Technology & Environment, GoK	Dr. Srikumar Chattopadhyay	Resources Analysis	---	2008-12	7.50	2.81
22.	Sea level Change and its Impacts (KSCS 18)	Kerala State Council for Science Technology & Environment, GoK	Dr. K. V. Thomas	Marine Sciences	Dr. T. S. Shahul Hameed	2011-16	81.54	10.00
23.	Landuse/Land cover change as linked to climate change in Kerala (KSCS 19)	Kerala State Council for Science Technology & Environment, GoK	Dr. Srikumar Chattopadhyay	Resources Analysis	Dr. Mahamaya Chattopadhyay, Dr. P. V. S. S. K. Vinayak, Sri. C. K. Sasidharan	2011-14	34.48	15.00
24.	Solar UV-B radiation and atmospheric trace constituents measurements (KSCS 20)	Kerala State Council for Science Technology & Environment, GoK	Dr. G. Mohan Kumar	Atmospheric Sciences	Dr. E. J. Zachariah	2011-14	23.19	5.00
25.	Monitoring global change impacts in Sahyadri (Western Ghats) (KSCS 21)	Kerala State Council for Science Technology & Environment, GoK	Dr. C. N. Mohanan	Environmental Sciences	Dr. A. Krishnakumar Sri. B. K. Jayaprasad	2011-14	63.46	10.00
26.	Greenhouse gases monitoring (KSCS 22)	Kerala State Council for Science Technology & Environment, GoK	Dr. E. J. Zachariah	Atmospheric Sciences	Sri. C. K. Sasidharan	2011-14	36.90	10.00
27.	Geomorphic evolution and terrain characteristics: A case study of the Achankovil river basin, Kerala (KSCS 23)	Kerala State Council for Science Technology & Environment, GoK	Dr.Mahamaya Chattopadhyay	Resources Analysis	Dr.K. Raju	2011-13	7.86	3.74
28.	Paleoclimate and sea level records in the late quaternary sediments of coastal wetlands of Pallickal and Achankovil river basins, Kerala-its implications on coastal evolution (KSCS 24)	Kerala State Council for Science Technology & Environment, GoK	Dr. D. Padmalal	Environmental Sciences	Dr.K. Maya	2011-13	10.54	5.27
29.	Inventory of wetlands of Kerala (DECC 1)	Directorate of Environment & Climate Change	Dr. C. N. Mohanan	Environmental Sciences	Dr. A. Krishnakumar Sri. B. K. Jayaprasad	2011-12	7.61	5.44
30.	Soil based plant nutrient management plan for agro ecological zones (SPB 2)	Kerala State Planning Board, GoK	Sri. B. K. Jayaprasad	Central Geomatics Lab	--	2010-12	13.6	0.91
31.	Updating natural resources and environment database covering coastal AEZ (SPB-3)	Kerala State Planning Board, GoK	Sri. B. K. Jayaprasad	Central Geomatics Lab	----	2012-13	8.00	7.25
32.	Creation of a model GIS database for Malappuram municipality under Spatial Urban Information System (IKM)	Information Kerala Mission (IKM)	Sri. B. K. Jayaprasad	Central Geomatics Lab	----	2012-13	3.62	3.63

33.	Hazard Vulnerability and Risk Assessment (HVRA) of the State as part of preparing disaster management plan for the state. (HVRA)- **Technical Support**	HVRA Cell	Sri. G. Sankar	Geosciences	---	2011-13	1.45	1.45
34.	GPS facilitation, GIS mapping & customization for soil mapping and soil nutrient management plan preparation (VFPCK)	Vegetable and Fruit Promotion Council Keralam	Sri. B. K. Jayaprasad	Central Geomatics Lab	Dr. Archana M Nair	2011-12	11.08	5.02
35.	Photo dynamic therapy laser design and development of photo dynamic therapy laser system (DBT 1)	Department of Biotechnology	Dr. N. Subhash	Atmospheric Sciences	---	2011-12	7.00	2.10
36.	Physical, chemical & biological monitoring study at dredging site in Vembanad lake (TCL 2)	Travancore Chemicals Ltd.	Dr. P. K. Omana	Chemical Sciences	--	2008-12	1.15	0.57
37.	Environmental impact of reservoir desiltation (WRD 1)	Water Resources Dept, GoK	Dr. Srikumar Chattopadhyay	Resources Analysis	--	2009-12	5.75	0.00
38.	Conservation and nourishment of beaches of selected tourism locations of Kerala (TD 2)	Dept. of Tourism	Dr. K. V. Thomas	Marine Sciences	--	2006-12	20.04	0.00
39.	Continuous measurement of atmospheric carbon monoxide at Thiruvananthapuram, a Tropical site (ISRO 2)	Indian Space Research Organisation	Dr. G. Mohankumar	Atmospheric Sciences		2002-12	11.73	0.00
40.	River bank mapping of Neyyar and at Ithikkara rivers (RBM 1)	Revenue Department, GoK	Dr. Srikumar Chattopadhyay	Resources Analysis	---	2011-12	5.40	0.72
41.	River bank mapping of Ithikkara river (RBM 2)	Revenue Department, GoK	Dr. Srikumar Chattopadhyay	Resources Analysis		2011-12	4.89	0.97
42.	Study on depletion of heavy mineral content in the beach washings of IREL, Chavara (IRE 3)	Indian Rare Earth Ltd., Chavara	Dr. N. P. Kurian, Dr. T. S. Shahul Hameed (Since 1-1.2011)	Marine Sciences	Dr. T. N. Prakash Dr. K. V. Thomas Smt. L. Sheela Nair	2010-11	49.00	14.70
43.	Generation of Geographic Information System of five particularly vulnerable tribal groups (PTG's) (KIRTADS)	KIRTADS	Dr. Archana M. Nair	Central Geomatics Lab	Sri. B. K. Jayaprasad	2010-11	1.86	0.00
44.	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 Dr. T. S. Shahul Hameed Smt. L. Sheela Nair	2010-12	39.50	0.07

5.2 Consultancy Projects

Sl. No.	Project Title	Funding Agency	Principal Investigator	Division	Project Period	Total Outlay (Rs.in lakh)	Fund Received during the year (Rs.in lakh)
1.	CRZ Status Report	Reliance Infrastructure, Navi Mumbai.	Dr. K. V. Thomas	Marine Sciences	2011-12		
2.	-do-	ESSEL World, Mumbai.	Dr. K. V. Thomas	Marine Sciences	2011-12	1.06	0.00
3.	-do-	PSEZ Ltd., Mundra.	Dr. K. V. Thomas	Marine Sciences	2011-12	9.96	0.00
4.	-do-	National Highway Authority of India.	Dr. K. V. Thomas	Marine Sciences	2011-12	7.32	0.00
5.	-do-	Indian Oil Corporation Ltd., Kochi.	Dr. K. V. Thomas	Marine Sciences	2011-12	5.06	0.00
6.	-do-	Centurions, Kochi.	Dr. K. V. Thomas	Marine Sciences	2011-12	1.49	0.00
7.	-do-	National Highway Authority of India.	Dr. K. V. Thomas	Marine Sciences	2011-12	7.44	0.00
8.	-do-	JSW Energy-Chaferi, Ratnagiri.	Dr. K. V. Thomas	Marine Sciences	2011-12	6.60	0.00
9.	-do-	Apple A Day Properties Ltd., Kochi.	Dr. K. V. Thomas	Marine Sciences	2011-12	2.32	0.00
10.	-do-	Harbour Engineering Dept. Thiruvananthapuram.	Dr. K. V. Thomas	Marine Sciences	2011-12	0.68	0.00
11.	-do-	Indian Garnet Sand Co. Pvt Ltd., Ratnagiri.	Dr. K. V. Thomas	Marine Sciences	2011-12	15.72	0.00
12.	-do-	KMML Chavara, Kollam.	Dr. K. V. Thomas	Marine Sciences	2011-12	7.35	0.00
13.	-do-	Larzen & Toubro Limited, Gujarat.	Dr. K. V. Thomas	Marine Sciences	2011-12	6.75	0.00
14.	-do-	Tourist Resorts Kerala Ltd., Veli.	Dr. K. V. Thomas	Marine Sciences	2011-12	0.61	0.00
15.	-do-	Institute of Hotel management & catering Technology Kovalam-Thiruvananthapuram.	Dr. K. V. Thomas	Marine Sciences	2011-12		0.67
16.	-do-	Edava Gramapanchayat.	Dr. K. V. Thomas	Marine Sciences	2011-12	0.50	0.00
17.	-do-	NTPC Ltd., New Delhi.	Dr. K. V. Thomas	Marine Sciences	2011-12	3.15	0.00
18.	-do-	AEGIS Logistics Ltd., Mumbai.	Dr. K. V. Thomas	Marine Sciences	2011-12	3.97	0.00

19.	-do-	Madre de Deus Church, Thiruvananthapuram.	Dr. K. V. Thomas	Marine Sciences	2011-12	0.68	0.00
20.	-do-	Meridian Homes , Kochi.	Dr. K. V. Thomas	Marine Sciences	2011-12	2.10	0.00
21.	-do-	Maritime & Marine Services Pvt. Ltd., Goa.	Dr. K. V. Thomas	Marine Sciences	2011-12	9.00	0.00
22.	-do-	Chakolas Pvt. Ltd., Edakochi.	Dr. K. V. Thomas	Marine Sciences	2011-12	2.85	0.00
23.	-do-	Vizhinjam International Seaport Ltd., Thiruvananthapuram.	Dr. K. V. Thomas	Marine Sciences	2011-12	3.45	3.45
24.	-do-	HED, Thanur.	Dr. K. V. Thomas	Marine Sciences	2011-12	3.15	3.15
25.	-do-	HED, Arthunkal.	Dr. K. V. Thomas	Marine Sciences	2011-12	0.97	0.97
26.	-do-	Larsen & Tourbo Limited, Gujarat.	Dr. K. V. Thomas	Marine Sciences	2011-12	2.40	2.40
27.	-do-	IMC limited, Mumbai.	Dr. K. V. Thomas	Marine Sciences	2011-12	0.97	0.97
28.	-do-	Water Line Hotels,Thrissur	Dr. K. V. Thomas	Marine Sciences	2011-12	2.85	2.85
29.	-do-	Pavis Resorts Pvt. Ltd.,Kollam.	Dr. K. V. Thomas	Marine Sciences	2011-12	1.80	1.80
30.	-do-	Mundra Port & SEZ Ltd,Gujarat.	Dr. K. V. Thomas	Marine Sciences	2011-12	9.00	9.00
31.	-do-	Heera Construction Co.(P) Ltd., Vazhuthacaud.	Dr. K. V. Thomas	Marine Sciences	2011-12	1.32	1.32
32.	-do-	Focus Maritime,Goa.	Dr. K. V. Thomas	Marine Sciences	2011-12	3.68	3.68
33.	-do-	ESEL out door location, Mumbai.	Dr. K. V. Thomas	Marine Sciences	2011-12	3.68	3.68
34.	-do-	Kudankulam Nuclear Power Corporation.	Dr. K. V. Thomas	Marine Sciences	2011-12	0.97	0.97
35.	-do-	MIR-Kannur.	Dr. K. V. Thomas	Marine Sciences	2011-12	0.67	0.67
36.	-do-	Reliance industrial infrastructure Ltd., Mumbai.	Dr. K. V. Thomas	Marine Sciences	2011-12	0.97	0.97
37.	-do-	KSUDP, Kollam.	Dr. K. V. Thomas	Marine Sciences	2011-12	0.25	0.25
38.	-do-	Skyline Foundations & Structures (P) Ltd., Thiruvananthapuram.	Dr. K. V. Thomas	Marine Sciences	2011-12	1.32	1.32
39.	-do-	Ultra Tech Cement Ltd., Kochi.	Dr. K. V. Thomas	Marine Sciences	2011-12	4.35	4.35
40.	-do-	ESSAR Ltd., Hazira.	Dr. K. V. Thomas	Marine Sciences	2011-12	9.60	9.60
41.	-do-	ESSAR Ltd., Kadia Bet.	Dr. K. V. Thomas	Marine Sciences	2011-12	7.65	7.65

42.	-do-	KSUDP, Kozhikode.	Dr. K. V. Thomas	Marine Sciences	2011-12	3.15	3.15
43.	-do-	KSUDP, Kochi.	Dr. K. V. Thomas	Marine Sciences	2011-12	3.15	3.15
44.	-do-	Honnavar Port. Pvt. Ltd Karnataka.	Dr. K. V. Thomas	Marine Sciences	2011-12	3.67	3.67
45.	-do-	Hazira Infrastructure Private Limited, Ahmedabad.	Dr. K. V. Thomas	Marine Sciences	2011-12	22.50	22.50
46.	-do-	Officina Builders, Thiruvananthapuram.	Dr. K. V. Thomas	Marine Sciences	2011-12	1.32	1.32
47.	-do-	Rohan Lifescapes, Mumbai.	Dr. K. V. Thomas	Marine Sciences	2011-12	4.50	4.50
48.	-do-	Kent Constructions Pvt., Kochi.	Dr. K. V. Thomas	Marine Sciences	2011-12	3.15	3.15
49.	-do-	MIV Logistics Pvt. Ltd, Ernakulam	Dr. K. V. Thomas	Marine Sciences	2011-12	3.15	3.15
50.	-do-	Lulu Convention, Kochi.	Dr. K. V. Thomas	Marine Sciences	2011-12	3.15	3.15
51.	-do-	Royal Blue Hotels Pvt. Ltd., Thiruvananthapuram.	Dr. K. V. Thomas	Marine Sciences	2011-12	1.32	1.32
52.	-do-	Adani Hazira Infrastructure Pvt. Ltd., Gujarat.	Dr. K. V. Thomas	Marine Sciences	2011-12	10.80	10.80
53.	-do-	Hazira LNG Pvt. Ltd, Surat.	Dr. K. V. Thomas	Marine Sciences	2011-12	7.50	7.50
54.	-do-	Orange Country, Bangalore.	Dr. K. V. Thomas	Marine Sciences	2011-12	3.67	3.67
55.	-do-	APM Terminals, Gujarat.	Dr. K. V. Thomas	Marine Sciences	2011-12	6.75	6.75
56.	-do-	Aegis Logistics Ltd., Mumbai.	Dr. K. V. Thomas	Marine Sciences	2011-12	5.25	5.25
57.	-do-	Maharashtra Coastal Zone Management Authority.	Dr. K. V. Thomas	Marine Sciences	2011-12	12.69	12.69
58.	-do-	Dewa Projects Pvt. Ltd., Kochi.	Dr. K. V. Thomas	Marine Sciences	2011-12	3.15	3.15
59.	-do-	Rainbow Realtors, Kannur.	Dr. K. V. Thomas	Marine Sciences	2011-12	2.85	2.85
60.	-do-	Clarity Aqua Systems Pvt. Ltd., Ernakulam.	Dr. K. V. Thomas	Marine Sciences	2011-12	3.15	3.15
61.	-do-	Rohan Developers Pvt. Ltd.,Mumbai.	Dr. K. V. Thomas	Marine Sciences	2011-12	3.00	3.00
62.	-do-	Mangal A Gogte, Belgaum.	Dr. K. V. Thomas	Marine Sciences	2011-12	3.67	3.67
63.	-do-	Hotel SFA Park-Kannur.	Dr. K. V. Thomas	Marine Sciences	2011-12	1.20	1.20

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 234	Measurement of cloud parameters and cloud modeling	Dr. G. Mohan Kumar	Atmospheric Sciences	----	2005-12	187.37	8.61
PLAN 250	Exploring interrelationship between environmental degradation and poverty: selected micro level case studies across Kerala	Dr. Srikumar Chattopadhyay	Resource Analysis	Sri. C. K. Sasidharan Smt. C. Sakunthala	2007-12	24.28	4.52
PLAN 252	Mapping of coastal cliffs and their vulnerability between Kanyakumari and Mangalore,south west coast of India	Dr. A. S. K. Nair	Marine Sciences	Sri. G. Sankar Sri. John Paul	2007-12	25.06	2.78
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 Sri. B. Sukumar Dr. K. Maya	2007-12	19.00	5.24
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	2007-12	15.00	2.52
PLAN 257	Study of urban sprawl – stretch between Kochi and Thrissur Corporations	Mrs. Ahalya Sukumar	Resources Analysis	Sri. B. Sukumar Dr. K. Raju	2008-12	11.68	1.22
PLAN 259	Application of neural network in pattern classification of remotely sensed images	Sri. K. J. Mathew	Atmospheric Sciences	Sri. G. Sankar	2008-12	7.58	1.39
PLAN 260	Sunlight-induced multi-spectral fluorescence imaging system for vegetation assessment	Dr. N. Subhash	Atmospheric Sciences	Dr. C. N. Mohanan	2007-12	26.50	4.83
PLAN 261	Human-induced land modifications and its Impacts: A study in Thodupuzha taluk-Idukki district, Kerala	Dr. K. Raju	Training & Extension	Sri. G. Sankar Dr. V. Nanda Kumar	2007-11	5.98	0.26
PLAN 263	Solar ultraviolet-B and atmospheric trace constituents in relation to climate change	Dr. G. Mohan Kumar	Atmospheric Sciences		2007-13	20.25	0.79
PLAN 264	Glimpses of Kerala through Maps	Dr. Srikumar Chattopadhyay	Resources Analysis	----	2007-11	1.38	0.79

PLAN 265	Characterization of laterites of Kerala and preparation of laterite distribution map	Dr. Narayanaswamy	Geosciences	----	2007-11	15.09	3.76
PLAN 266	Quaternary evolution of the coastal plains of southern Kerala	Sri. John Paul	Marine Sciences	Dr. A. S. K. Nair Dr. D. S. Suresh Babu	2007-12	36.50	4.16
PLAN 267	Digital resource atlas of Kerala and environment atlas	Sri. B. Sukumar	Resources Analysis	Smt. Ahalya Sukumar Dr. E. Saravanan Sri. V. Shravan Kumar	2008-12	37.40	4.84
PLAN 268	Agricultural atlas of Kerala	Dr. E. Saravanan	Training & Extension	Sri. B. Sukumar Sri. V. Shravan Kumar	2008-12	27.48	11.83
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		2008-12	10.87	4.37
PLAN 271	The social impacts of energy technologies: two case studies at different environs of Thiruvananthapuram district	Sri. K. Vijayakumar	Atmospheric Sciences	----	2008-11	1.77	0.83
PLAN 272	Environmental impact assessment of major settlement distribution patterns and the infrastructural development with an emphasis on drinking water infrastructure facilities in Thiruvananthapuram	Sri. V. Shravankumar	Resources Analysis	Dr. A. S. K. Nair Dr. S. Suresh Babu	2008-12	5.05	2.46
PLAN 273	Assessment and monitoring of land quality for sustainable agriculture: A GIS based approach coupled with technology implementation	Sri. B. Sukumar	Resources Analysis	Dr. A.S.K. Nair, Dr. G. Mohan Kumar Dr. E. Saravanan Sri. G .Sankar Dr. P. V. S. S. K. Vinayak Sri.V. Shravan Kumar Smt. Ahalya Sukumar Sri. V. Vasudevan Sri. K. Vijayakumar Dr. Ansom Sebastian Sri. K. J. Mathew Sri. John Paul	2008-12	8.82	13.17
PLAN 274.	Kerala Resources Information System & Services (KRISS)	Sri. V. N. Neelakandan	Central Geomatics Lab	Dr. K. K. Ramachandran Dr. M. Samsuddin	2009-12	102.00	1.86
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 Sri. C. K. Sasidharan	2009-12	41.40	4.42

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	3.18
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	2.15
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 Sri. B. K. Jayaprasad Dr. K. Raju Dr. A. Krishna Kumar	2009-12	59.62	1.75
PLAN 280	Tectonothermal history of the Kerala Khondalite Belt	Dr. V. Nandakumar	Geosciences	-----	2009-12	22.20	4.32
PLAN 281	Climatological features of Kerala-A Ready Reckner	Dr. P. V. S. S. K. Vinayak	Camp Office, Kochi	Smt. Sreekumari Kesavan	2009-11	7.51	2.92
PLAN 282	Graphitization Process in Kollam District,Kerala	Dr. Ansom Sebastian	Training & Extension	----	2010-13	4.49	1.79
PLAN 283	Valley formation and geomorphic processes under tropical wet and dry climate; examples from Kerala	Dr. Mahamaya Chattopadhyay	Resources Analysis	Smt. Sakunthala C	2011-14	3.13	3.12
PLAN 284	Land system analysis of Kabani river basin	Dr. Srikumar Chattopadhyay	Resources Analysis	-----	2011-13	2.44	1.23
PLAN 285	Appraisal of Drinking water potential of springs in Pathanamthitta, Kottayam and Idukki districts of Kerala	Dr. K. Anoop Krishnan	Chemical Sciences	Dr. A. Krishnakumar	2011-13	2.83	2.67
PLAN 286	Study on the environmental effects of human interventions in the Periyar river basin; Central Kerala	Dr. K. Maya	Environmental Sciences	Dr. D. Padmalal	2011-14	2.30	1.93

5.4 R & D Laboratory Infrastructure Projects

Project Code	Project Title	Co-ordinator/PI	Division	Expenditure during the year (Rs. in lakh)
PLAN 101	XRF Facility	Director Dr. G. R. Ravindra Kumar (SIC)	Geosciences	8.09
PLAN 102	Upgradation of Geosciences laboratories	Head, GSD	Geosciences	99.40
PLAN 103	Strengthening of Ecological laboratory	Head, ESD	Environmental Sciences	5.22
PLAN 104	Upgradation of Atmospheric Sciences laboratories	Head, ASD	Atmospheric Sciences	12.74
PLAN 105	Upgradation of Chemical laboratory	Head, CSD	Chemical Sciences	7.19
PLAN 106	Upgradation of Library facilities	Librarian	Training & Extension	33.47
PLAN 107	Publication of monographs / memoirs / annual report/newsletter	Director	Publication Committee	3.13
PLAN 108	Outreach /training / extension /exhibition/ other technical facilities	Head, TED	Training & Extension	4.64
PLAN 110	Seminars/workshops/meetings	Director		1.91
PLAN 111	Marine laboratory infrastructure development	Head, MSD	Marine Sciences	32.06
PLAN 112	Geomatics laboratory infrastructure development	Head, CGL	Central Geomatics Lab	5.62
PLAN 117	Upgradation & maintenance of CESS LAN	Director Dr. C. M. Harish (SIC)	Central Geomatics Lab	3.21
PLAN 118	Development of laboratory for Resources Analysis Division	Head, RAD	Resources Analysis	13.68
PLAN 100	Research & Development general expenditure	Director		137.64

5.5 R & D building Infrastructure Projects

Project Code	Project Title	Coordinator	Expenditure during the year (Rs.in lakh)
PLAN 119	Recreation facilities at CESS	Secretary, Recreation club	0.00
PLAN 120	Upgradation of centralized Air Conditioning & facilities of CESS buildings	Registrar	1.51
PLAN 123	Upgradation/repair and maintenance of toilets	Registrar	-0.16
PLAN 124	Upgradation of EPABX	Registrar	0.00
PLAN 126	Garden development and landscaping	Dr.C.N.Mohanan	1.23
PLAN 128	Upgrading electrical installations and facilities	Registrar	0.00
PLAN 150	Construction of Water tank and modification to the WSS	Registrar	-1.29
PLAN 151	Replacement of damaged cast iron stair case in the administrative building	Registrar	0.00
PLAN 153	Upgradation of security area and rooms	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
PLAN 158	Estate development	Engineer	0.00
PLAN 159	Library block	Engineer	0.00
PLAN 160	Construction of I floor (record room) above the parking shelter	Registrar	-1.98
PLAN 161	Construction of compound wall & road	Registrar	0.95
PLAN 162	Construction of guest house & students hostal		0.00
PLAN 163	Construction of storage facility for unserviceable items	Registrar	0.00
PLAN 164	Partition of administrative block for accommodating personnel of EA&M/ Purchase/ Inward/ Despatch sections	Registrar	0.00
PLAN 165	Earth Watch Geopark, Museum and Dynamic Earth Pavilion	Dr.V.Nandakumar	2.49
PLAN 166	Campus Greening	Chairman, Campus Green Committee	3.95

Honours, Awards & Academic Activities

6.1 Honours & Awards

Dr. Shamji V R has been awarded Ph.D Degree under the Faculty of Marine Sciences, Cochin University of Science and Technology, for his thesis, 'Studies on beach morphological changes using numerical models'. Dr. N. P. Kurian, Director, Centre for Earth Science Studies was his supervising guide.

Dr. Balachandran K P has been awarded Ph.D Degree under Faculty of Physics, Mahatma Gandhi University, Kottayam for his thesis, 'Investigation of the relationship between atmospheric electrical conductivity and meteorological parameters'. Dr. S. Muralidas, Scientist-F (retired), Centre for Earth Science Studies was the supervising guide for his Ph.D dissertation work.

Vishnu Mohan S secured the Young Scientist Award of the Kerala State Council for Science, Technology and Environment for his paper entitled "Evidences of changing climate in the past 10000 years from the sedimentary archives of southern Kerala" presented in the 24th Kerala Science Congress held at Rubber Research Institute of India, Kottayam during 29-31 January 2012.

Dhanya V has won the Best Poster Award of the Kerala State Council for Science, Technology and Environment for her poster presentation entitled, 'Is Achankovil an antecedent river ?' during the 24th Kerala Science Congress held at Rubber Research Institute of India, Kottayam from 29 to 31 January 2012. She has also received Prof. N. P. Aiyyar Young Geographer's award during the 33rd IGC (NAGI) seminar held at Burdwan University, West Bengal during 11-13 November 2011.

6.2 Membership in Committees

Dr. N. P. Kurian

Member, Project Management Board, Coastal Engineering Division, National Institute of Ocean Technology, Ministry of Earth Sciences, Government of India.

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

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

Member, 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

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. N Subhash

Guest Editor of a Special issue on Fluorescence in Natural Systems being brought out by the International Journal of Spectroscopy (Hindawi Publishing Corporation, USA).

Member of the Governing Council of STIC (Sophisticated Test & Instrumentation Centre), Cochin.

Dr. K. V. Thomas

Member, KCZMA subcommittees to look into various CRZ issue implementation, policies, violations and reports.

Dr. Srikumar Chattopadhyay

Editor of the ANNALS, National Association of Geographers, India

Dr. R. Ajayakumar Varma

Chairman of the Committee constituted for assessing the damages to the properties of local people due to the blasting operations in a 7 km long tunnel of Sengulam Augmentation Scheme.

Expert Member in the Assessment Committee of C-DIT.

Sri. John Mathai

Member, State Level EIA Authority (SEIAA)

Dr. E. J. Zachariah

Member, Research Advisory Committee, Sophesiticated Test and Instrumentation Centre, Kochi.

Member, Panel of Laboratory Assessors, National Accreditation Board for Testing & Calibration Laboratories, Department of Science and Technology, GoI

Dr. C. N. Mohanan

Member, State Level EIA Authority (SEIAA)

Member, Technical Committee of Karumpukonam Community Ecosystem Management Committee constituted by Dept. of Environment & Climate Change.

Dr. C. M. Harish

Member of the Board of Studies in Environmental Studies at CUSAT

6.3 Visits Abroad

Dr.Mahamaya Chattopadhyay visited Bremen, Germany on invitation from the Centre for Tropical Marine Ecology (ZMT) for a period of three weeks starting from 15 May 2011. The purpose of visit included developing and furthering discussions on the proposed collaborative project between CESS and ZMT, on 'Interdependencies between Kerala rivers and backwaters: Consequences for water quality, ecology, economy and environmental governance'. Dr. Chattopadhyay delivered two lectures on 'Watershed characteristics and water quality: A case study of the Kall Ar basin, Kerala' and on 'Terrain evaluation of the Periyar Plateau, Kerala'.

Dr. K. Anoop Krishnan visited ZMT, Bremen, Germany during 12 January 2012 to 23 January 2012 in connection with the project "Interdependencies between River systems and Vembanad lake".

Sri. Prasanth C. S, Ph.D Research Scholar, Biophotonics Laboratory, Atmospheric Sciences Division (ASD), visited Bulgarian Academy of Sciences (BAS), Sofia, Bulgaria in March, 2012 as a part of the joint Indo-Bulgarian project funded by the DST, Govt of India. The work mainly focuses on the photodynamic inactivation of gram-negative pathogenic bacteria using new generation photosensitizers and is being supervised by Dr. N. Subhash, Scientist G & Head, ASD. The Azezzia Dental College, Kollam and Rajiv Gandhi Centre for Biotechnolgy, Trivandrum, are the institutions collaborating in this study from India whereas from BAS the Institute of Electronics, Institute of Microbiology and the Institute of Organic Chemistry are involved.

6.4 Internship / Summer Training

Name of Student	Affiliation	Name of Supervising Scientist
Manasa P. S.	Govt. Engineering College, Thrissur	Dr. Archana M. Nair
Lekshmi Mohanlal	Govt. Engineering College, Thrissur	Dr. Archana M. Nair
Nihila K.	Govt. Engineering College, Thrissur	Dr. Archana M. Nair
Reshma Antony	Govt. Engineering College, Thrissur	Dr. Archana M. Nair
Anupama K S	Central University of Karnataka	Sri. B. K. Jayaprasad
Devika M S	University of Madras	Sri. B.K. Jayaprasad

6.5 Ph. D Students

Student	Topic	Research Guide	University
Abhilash P. P.	Characterization 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
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 of Vegetation	Dr. N. Subhash	Kerala
Ranikrishna L.	Tropical freshwater myristica swamps of Kerala and its ecological and evolutionary 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 characteristics 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
George Thomas	Development of Urban Heat Island in a tropical coastal city	Dr. E. J. Zachariah	Kerala

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 Sciences. During the academic year 2011-12, 58 applications were received from meritorious students from different parts of Kerala and fourteen of them were awarded studentship of Rs. 2000/- month during the period of their P.G. dissertation work in CESS. The details of students who were awarded the studentship are given in the table below:

Name of Student	Affiliation	Topics of Dissertation	Supervisor
Nisha K.V.	Kannur University	EIA of hard rock quarrying: An example form Parakkadavu grama panchayat, Ernakulam district, Kerala	Dr. K. Maya
Nisha Mathew	Kannur University	Removal of Pb(II) from aqueous solution using ragi husk: Adsorptive modeling at solid-liquid interface	Dr. K. Anoop Krishnan
Preetha R.	Government College for Women, Trivandrum	Major ion chemistry and compositional structure of selected groundwater sources of Karamana river basin, Southern Kerala.	Dr. P.K. Omana
Silpa A.S.	CUSAT	Studies on clay mineralogy of surficial sediment samples of Kollam coast, Southern Kerala	Dr. T.N. Prakash
Sruthi T.	Kannur University	Hydrochemistry of the surface and subsurface water sources in the coastal low lands of the Periyar river basin Kerala.	Dr. K. Maya
Vijina K.V.	Government College, Kasaragod	Diel and tidal variations of water quality: An assessment study in coastal waters of Cochin and Mangalore, south west coast of India	Dr. K. Anoop Krishnan
Vinya T.K.	Govt. College, Kasaragod	Morphological and sedimentlogical Studies of Vellananthuruth-Kovilthottam sector of Chavara coast	Dr. K.V. Thomas
Vivek Renchan	Govt. Arts College	Hydrochemical framework of Kili Ar, A major tributary of Karamana river, Thiruvananthapuram, Southern Kerala	Dr. P.K. Omana

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

Name of Student	Affiliation	Topics of Dissertation	Supervisor
Jaquilin Ceasar	St. Xaviers College, Thumba	Application of neutral network in classification of remotely sensed image based on transferred normalized difference vegetation index.	Sri. K. J. Mathew
Preetha T.	St. Xaviers College, Thumba	Classification of remotely sensed image using artificial neutral network based on normalized difference vegetation index.	Sri. K. J. Mathew
Sangeetha J.	All Saints College, Trivandrum	Water quality of Neyyar reservoir, Thiruvananthapuram district, Kerala	Dr. D. Padmalal
Ajmal. K.	S N College, Kollam	Evaluation of adsorptive properties of kaolinite type clay for the removal of methylene blue from aqueous solutions.	Dr. K. Anoop Krishnan
Sini Suresh S.	S N College, Varkala	Retention of 2,4-dinitrophenol on activated charcoal surface: Kinetics and isotherm studies	Dr. K. Anoop Krishnan
Sajeer S.	S N College, Varkala	Removal of Pb(II) from aqueous solution using commercial activated carbon: An overview of adsorption process	Dr. K. Anoop Krishnan
Rahul A. R.	S N College, Trivandrum	Evaluation of physico-chemical characterization of various water resources from Neyyar river surroundings in Neyyattinkara urban area, Kerala, India	Dr. K. Anoop Krishnan
Manoj J.	S N College, Kollam	Chemical characterization and carbon loading in the sub surface sediments of Polachira wetland (Kollam district), Kerala	Dr. D. Padmalal
Nimmy A. M.	S N College, Kollam	Modeling and simulation of the impact of Tsunami waves for disaster reduction along a coastal stretch of Kollam	Dr. T. S. Shahul Hameed
Sayana K. P.	Govt. College, Kasaragod	Mercury geochemistry of recent sedimentary environs of the river dominated mixing zone in a tropical coastal estuarine system, Southwestern India.	Dr. P. K. Omana
Shakkeela K. P.	Govt. College, Kasaragod	Portraying the dynamics of phosphorus in an Urban-fringe estuarine system: An example from Cochin, Southwestern coast of India.	Dr. P. K. Omana

Priya P.	Sree Sankara College, Kalady	Hydrochemical studies of Periyar River flowing through Kalamassery Municipality, Kerala	Dr. A. Krishna Kumar
Noorjahan M. A.	Sree Sankara College, Kalady	Studies on the elemental variation of different types of soils in Chengamanad Grama Panchayat, Ernakulam District	Dr. A. Krishna Kumar
Shamna S.	CUSAT	Texture and mineralogy of beach sands of Thiruvananthapuram and Kollam districts (Kerala), SW India	Dr. D. Padmalal
Summayya Abdul Hameed	S N College, Varkala	Evaluation of Hydrochemical fingerprints, Rock source deduction and conservation measures for the selected spring sources of southern Kerala.	Dr. K. Anoop Krishnan
Beenu S. L.	S N College, Varkala	Modelling Groundwater chemistry of Kavaratti Island (U.T. of Lakshadweep) using important pattern recognition techniques & multivariate statistical tools.	Dr. K. Anoop Krishnan
Lekshmi Mohanlal	Govt. Engineering College, Thrissur	Effect of urbanization on ground water.	Dr. Archana M Nair
Krishna Priya U. M.	S N College, Varkala	Equilibrium and isotherm studies on the adsorption of phosphate onto iron impregnated titanium dioxide	Dr. K.Anoop Krishnan
Revathy S. Raj	S N College, Varkala	Evaluation of adsorptive properties of waste chilly stalk powder for the removal of crystal violet from aqueous solution	Dr.K.Anoop Krishnan
Jobish E. A.	Madurai Kamaraj University	Temporal coastal land from changes in Trivandrum district: using GIS and remote sensing.	Sri. B. K. Jayaprasad
Neethu Sha A. P.	S N College, Varkala	A preliminary comparative study on the fine particulate matter concentration in the ambient air using aerosol spectrometer of the urban and rural selected locations in Trivandrum district.	Sri. V. Muralidharan
Anuraj K.	Kerala University	In vivo detection of cervical intraepithelial neoplasia using diffuse reflectance	Dr. N Subhash
Rency Rajan	Kerala University	Study on the potential of laser induced autofluorescence for early detection of cervical cancer.	Dr. N Subhash
Rajasree A.	Govt. College, Kasaragod	Land degradation due to land subsidence A case study on the high lands of Kerala	Sri. G Sankar
Shyni M.	Govt. College, Kasaragod	Coastal geomorphology of Trivandrum	Sri. John Paul

Library

CESS Library is one of the advanced libraries in Earth Sciences in terms of its collection and services. The collection includes books, journals, back volumes, CDs, VCDs, CD ROM database, maps, atlases, project reports, reference books, annual reports etc. The Institute has subscribed to 50 national and international journals and receives many more journals *as gratis*. The library has subscribed to the online database titled *'Environment Complete'* published by EBSCO which contains more than 2.4 million records from more than 2,200 domestic and international titles going back to the year 1888.

The major services rendered to users by the library are reference service, literature search, library membership, reprint service, press clipping service and document delivery service. 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 the year 2011 are available for reference. Library has good network connectivity with facility for internet browsing and offers current awareness service such as listing of new additions, display of CESS publications, useful article display, fellowship information, forthcoming conferences, seminars etc. Library has taken institutional membership in reputed libraries in the city to enable access to the users.

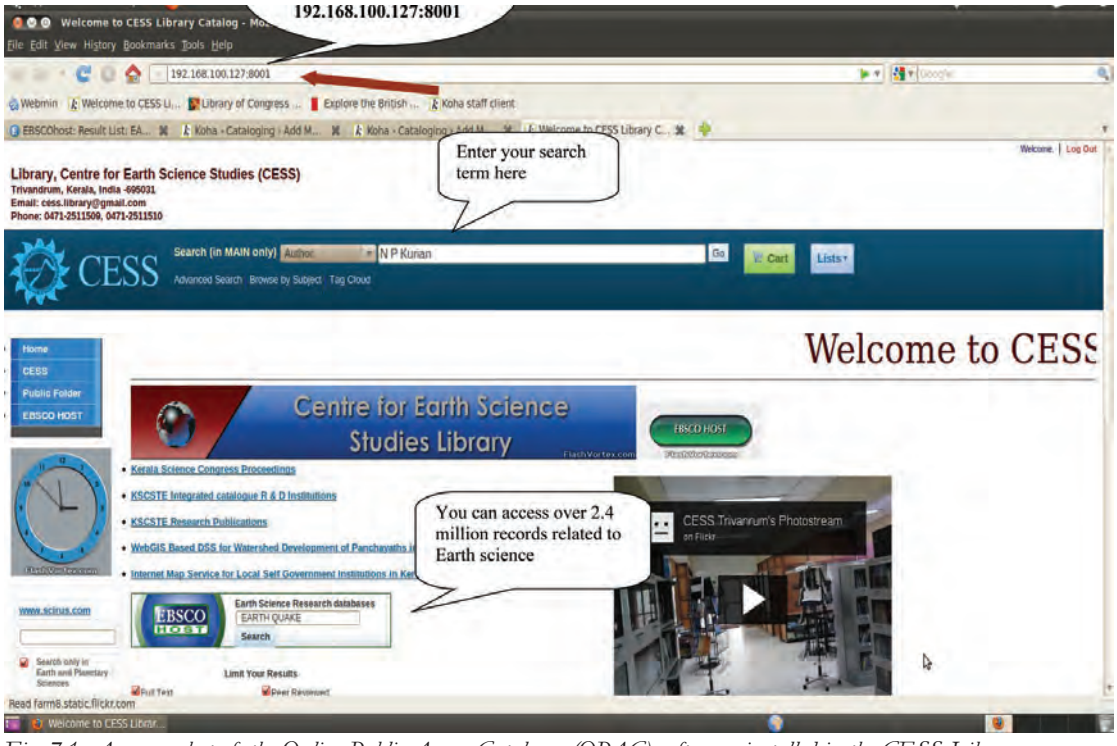


Fig. 7.1 A screen shot of the Online Public Access Catalogue (OPAC) software installed in the CESS Library

Library is using the software KOHA, an integrated open source library management software, that supports all in house operations of the library. Bibliographic records of books available in the library can be accessed through OPAC. Web OPAC module has been developed and incorporated with the KOHA so as to enable users to search the library database from their desktop inside the campus. The database of books is being updated on a day-to-day basis of recently acquired books. Library collection and details of all inhouse project reports are included in the database.

Publications

8.1 Research Papers

8.1.1 In Journals

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Thomas K.V, Raju.D Demarcation of HTL, LTL AND CRZ for a Development Site in Dadar, Mumbai, Maharashtra for Rohan Lifescapes Pvt. Ltd.

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Thomas K.V, Raju.D, Mohanan.S HTL, LTL and CRZ for the Proposed Development Site in Cochin Port Area in Willingdon Island in Ernakulam, Kerala for Ultra Tech Cement Ltd Kochi.

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Thomas K.V, Raju.D HTL, LTL and CRZ for Proposed Sewage Tretment Plant at Mudamveli in Kochi, Kerala for Kerala Sustainable Urban Development Project, Thiruvananthapuram.

Thomas K.V, Raju.D, Sreeraj.M.K High Tide Line and Coastal Regulation Zone for Proposed Fishery Harbour at Tanur, Malappuram, Kerala for Harbour Engineering Department, Govt of Kerala.

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Thomas K.V, Raju.D High Tide Line and Coastal Regulation Zone for Proposed Port Construction at Honnavar, Uttara Kannada, Karnataka for Honnavar Port Pvt. Ltd, Karnataka.

Thomas K.V, Raju.D Delineation of HTL, LTL and CRZ for Expansion of APM Terminal at Pipavav Port, Gujarat for APM Terminals Ltd.

Thomas K.V, Raju.D, Sreeraj.M.K High Tide Line and Coastal Regulation Zone for the Proposed Housing Project at Edakochi, Ernakulam, Kerala for Kent Constructions Pvt Ltd Kochi.

Thomas K.V, Raju.D, Sreeraj.M.K HTL, LTL and CRZ for the Proposed Hotel Cum Convention Centre at Bolgatty in Ernakulam, Kerala for Lulu Convention and Exhibition Centre Pvt. Ltd Kochi.

Thomas K.V, Raju.D, Sreeraj.M.K HTL, LTL and CRZ for the Proposed Container Freight Station Project at Vallarpadam, Ernakulam for MIV Logistics Pvt. Ltd Kochi.

Thomas K.V, Raju.D Delineation of HTL, LTL and CRZ for Critical Rail Infrastructure & Utility Corridor, Surat, Gujarat for Hazira Infrastructure Pvt. Limited.

Thomas K.V, Raju.D Delineation of HTL, LTL and CRZ for Hazira Port Area, Surat, Gujarat for Adani Hazira Port Pvt. Limited.

Thomas K.V, Raju.D HTL, LTL and CRZ for Hotel Sea Park at Payyambalam, Kannur, Kerala for Hotel Sea Park Pvt. Limited Kannur.

Thomas K.V, John Paul, Vasudevan.V HTL, LTL and CRZ for Resort Development in Kadinamkulam, Thiruvananthapuram for Royal Blue Hotels Pvt. Limited Thiruvananthapuram.

Thomas K.V, Raju.D HTL, LTL and CRZ for Survey Nos.1882 and 1888 in Village Kadakampally, Thiruvananthapuram for Skyline Foundations and Structures Pvt. Ltd Thiruvananthapuram.

9.1 Inauguration of the Ocean State Forecast System for Kerala

Shri. Oommen Chandy, Hon'ble Chief Minister of Kerala inaugurates the 'Ocean State Forcast and Fishery Information System for Kerala at Vizhinjam, Thiruvananthapuram. Dr. Satheesh C. Shenoi, Director, INCOIS, Shri. Shashi Tharoor, M.P, Smt. Jameela Prakasam M.L.A, Smt. K. Chandrika, Mayor, Thiruvananthapuram Corporation, Smt. Gladis Alex, Councillor Vizhinjam, Dr. N. P. Kurian, Director, CESS and Dr.K.K.Ramachandran, Member Secretary, KSCSTE are also seen.

The first phase of the Ocean State Forecast System for the Kerala coast jointly established by Indian National Centre for Ocean Information Services (INCOIS), Hyderabad and CESS at Vizinjam harbour, near Thiruvananthapuram was formally inaugurated by Shri Oommen Chandy, Hon'ble Chief Minister of Kerala on 16th of July 2011. The Electronic Display Board facility set up at Vizhinjam harbour for the dissemination of the sea state forecast information to the local fishermen community was unveiled by Dr. Shashi Tharoor, Member of Parliament from Thiruvananthapuram. Smt. Jameela Prakasam, Member Legislative Assembly, Kerala presided over the function.Dr. N. P. Kurian, Director CESS delivered the welcome speech and Dr. Satheesh C Shenoi, Director, INCOIS introduced the Ocean State Forcast and Fishery Information System. Smt. K. Chandrika, Mayor, Corporation of Thiruvananthapuram, Smt. Gladis Alex, Councilor, Vizhinjam and Dr. K. K. Ramachandran, Member Secretary, Kerala State Council for Science, Technology and Environment also spoke on the occasion. Dr. T. M. Balakrishnan, Head, Information Services Group, INCOIS proposed the vote of thanks.

The information system issues real time details on tides, wind, waves, ocean current, etc for the use of the coastal community, Coast Guard, National Hydrographic Office etc. Information on Potential Fishing Zones is also disseminated through electronic sign boards installed at designated points. The data is processed at INCOIS and bulletins and forecast warnings are issued on weather conditions, storms etc. through their website.

As part of this project another coastal observation station and electronic display board will be established in Kozhikode soon. The programme will be further expanded by establishing more coastal observation stations along the Kerala coast during the 12th Plan period.

A workshop was also organized after the inaugural function to educate the coastal community about the use of sea state forecast system.

9.2 Brain Storming Workshop on Earth System Sciences and Natural Resources Management

A Brain Storming Workshop was organized in CESS during July 21-22, 2011 with the objectives of having a critical appraisal of the various research activities that have been carried out at CESS with special reference to the current status at the national/ international scenario and the developmental needs of the state,

Dr. Shailesh Nayak, Chairman, RC, CESS & Secretary, Ministry of Earth Sciences, Government of India addressing the brain storming session

and working out a broad framework for the future agenda of research activities. The proceedings included an overview on the Centre's activities by the Director, presentations by the scientists of the Centre under a few broad themes, giving background and gist of the work carried out until now and the prospects of future research and the perceptions of the experts. The invited experts of different specializations who took part in the workshop were Dr. Shailesh Nayak, Chairman, RC, CESS & Secretary, Ministry of Earth Sciences, Government of India, Prof. S. K. Tandon, Professor, Dept. of Geology and PVC (Retd), Delhi University, Dr. S. Sinha Roy, DDG, GSI (Retd.), Prof. V. Sundar, Dept. of Ocean Engineering, IIT Madras, Dr. P. Vethamony, Scientist-G, NIO, Dr. P.V. Joseph, Visiting Professor, Dept. of Atmospheric Sciences, Cochin University of Science & Technology, Dr. B. Nagender Nath, Scientist-G, NIO, Dr. H.S. Sharma, Dept. of Geography, University of Rajasthan, Dr. P.C.S. Devara, Scientist-G, IITM, Pune, Prof. P. Ravi Gupta, Dept. of Earth Sciences, IIT, Roorkee, Prof. Baleshwar Thakur, Professor (Retd), School of Geography, Delhi University, Dr. B.K. Saha, Member, RC, CESS & DDG, GSI (Retd.), Dr. K. Krishnamoorthy, Member, RC, CESS & Director, Space Physics Laboratory, VSSC and Prof. V.N. Sivasankara Pillai, Member, RC, CESS & Former Director, School of Environmental Sciences, CUSAT

The presentations, expert opinions and the perceptions on the future research activities covered the following themes viz. solid-earth geoscience studies, atmospheric electricity and minor constituents, coastal processes and coastal zone management, sedimentological and mineralogical aspects of coastal zone, Quaternary geology of Kerala, environmental quality and pollution, environmental studies and impact assessments, natural resources management, remote sensing of the environment and geomatics for planning and development. The objectives of the workshop were fully realised and the proceedings brought out for future reference.

9.3 Prof. C. Karunakaran Endowmwent Lecture

Prof. Raghuram Murtugudde, Dept. of Atmospheric and Ocean Sciences of the Earth System Science Inter-disciplinary Centre, University of Maryland, U.S.A, delivered the 10th lecture in the Prof. C.Karunakaran Endowment lecture series on 16th July 2011 at the CESS auditorium. The topic of the lecture was 'Earth, Life and Sustainability: A long-term perspective.

Prof. Murtugudde is internationally acclaimed for his contributions in earth system modelling. At present he is working on regional earth system prediction. The lecture was attended by a large gathering of scientists and students from other institutions in and around Thiruvananthapuram. Dr. N. P. Kurian, Director, CESS welcomed the gathering. Shri. M. P. Muraleedharan, former Director, Geological Survey of India paid tributes to Prof. C. Karunakaran. Dr. K. Krishnamurthy, Director, Space Physics Laboratory, Vikram Sarabhai Space Centre introduced the speaker. Dr. Srikumar Chattopadhyay, Head, Resource Analysis Division proposed the vote of thanks.

Prof. Raghuram Murtugudde, Dept. of Atmospheric and Ocean Sciences of the Earth System Science Interdisciplinary Centre, University of Maryland, U.S.A delivering the Endowment Lecture

9.4. High level meeting of Hazard Vulnerability and Risk Assessment (HVRA) cell

A rsearch cell to study Hazard Vulnerability and Risk Assessment (HVRA) was set up by the Department of Revenue and Disaster Management, Kerala State Disaster Management Authority in collaboration with the Centre for Earth Science Studies and Institute of Land and Disaster Management. The first high level meeting of the HVRA Cell was held at Centre for Earth Science Studies on 12th May 2011. The meeting was presided over by Dr. Nivedita P Haran, Additional Chief Secretary, Department of Revenue and Disaster Management. Smt. C. A. Latha, IAS, Hon. Secretary, SDMA delivered the welcome address and Sri. G. Sankar proposed vote of thanks.The agenda of the meeting were to discuss *modus operandi* (i) to identify the available data, (ii) to initiate HVRA related data sharing between stakeholder departments, (iii) to collect and compile data from stakeholder departments and institutions, (iv) to identify Nodal Officers from each department. The Addl. Chief Secretary in her presidential address declared that the HVRA Cell has started functioning officially. She opined that this being the first of its kind in the country, the Government of India looks upon Kerala as the model for HVRA also like many other 'Kerala Models'. Dr. N.P Kurian, Director CESS and Vice Chairman (Research) of the cell gave an invited address in the opening session. Shri. G. Sankar, Principal Investigator and Dr. Sekhar L. Kuriakose, Head (Scientist) HVRA Cell, provided a brief overview of the general approach towards conducting HVRA and the activities proposed in the first phase of the HVRA programme. The meeting had 4 rounds of expert's interactive sessions. Dr. C.T.S Nair, Executive Vice President, KSCSTE chaired the afternoon interactive sessions. Directors and Scientists of CESS, CWRDM, NATPAC, KSDI, KSREC and senior

Dr. Nivedita P Haran, Additional Chief Secretary, Department of Revenue and Disaster Management presiding over the first high level meeting of the Hazard Vulnerability and Risk Assessment Cell at Centre for Earth Science Studies, Thiruvananthapuram.

officials from Police, Fire & Rescue, Health, PWD, Agriculture, Forest and Irrigation participated in the meeting. The disaster related data available at diferent departments were identified and the delegates could arrive at a consensus for data sharing. Nodal officers for HVRA data sharing were identified from all the organizations and departments who participated in the meeting.

9.5 Launching of the project on Green Technology Centres in selected Grama Panchayats of Kerala

The Government proposed to launch a project for establishing Green Technology Centres (GTC) in selected Grama Panchayats and it was included as a priority programme of KSCSTE Accordingly, the KSCSTE entrusted the task of implementation to the Centre for Earth Science Studies (CESS). The project envisages establishing one GTC in each local body to facilitate the installation, service and practice of the green technology, develop and popularize green technology products and processes, popularize and establish the practice of 'Reuse and Recycling' of

Dr. M. K. Muneer, the Hon'ble Minister for Panchayats and Social Welfare formally inaugurating the launch of the project on Green Technology Centres at Grama Panchayats at CESS

materials, propagate high efficiency (smokeless or otherwise) cooking stoves, hot boxes, solar water heaters etc, reduce waste generation and energy consumption, safeguard local environment from increasing pollution, toxicity and natural resource crunch, optimize the use of building materials by promoting green building technology, promote organic farming, homestead farming, energy plantation and micro mechanization in agriculture and organize qualified and trained Green Technicians at local bodies in the form of Green Technology Groups.

The project, to be implemented initially in selected Grama Panchayats, will be given hand-holding support during the initial period through organizations with experience in green initiatives and participatory actions at the local level. The project was formally launched by Dr. M. K. Muneer, the Hon'ble Minister for Panchayats and Social Welfare on 25th August 2011 at CESS. A plan meeting to discuss and decide the way-forward of the project was also organized on the same day. Scientists from various R&D Centres in the State, representatives from experienced non-governmental organizations namely, Peerumedu Development Society, Kuttanad Vikasana Samithi, Mythri, Uravu, Integrated Rural Technology Centre and officials of development departments participated.

9.6 Workshop on Vembanad Management Plan

An interactive workshop on Vembanad Management plan in collaboration with the World Bank was held on 1st November 2011. Dr. N. P. Kurian, Director, CESS welcomed the gathering and introductory remarks were given by Mr. Roy Paul, consultant, MoEF.Twenty eight participants attended the meeting and fourteen presentations were made on various themes.

9.7 Brainstorming workshop on 'Philosophy and Research Methodology and Geography'

A National Brain Storming workshop on 'Philosophy and Research Methodology and Geography' was held during 7th and 8th December, 2011. Eighteen senior professors and academicians from different parts of India attended the workshop and deliberated on the present state of Indian geography and a syllabus for research training of Ph.D scholars.

9.8 National Wetlands Day

CESS and the KSCSTE jointly observed the National Wetlands Day at Kanakakunnu Palace, Thiruvananthapuram during 1st - 2nd February 2012. The event was marked by competitions for School children conducted in Painting, Elocution and Quiz. Lectures by eminent scientists were also organized on 2nd February 2011.

9.9 Invited Lectures

Dr. N. P. Kurian

Dr.N.P. Kurian an Invited talk on coastal processes and management in the OSICON 2011 conference held at National Institute of Ocean Technology at Chennai on 14th July 2011.

Chaired a Technical Session in the workshop on Coastal Hazards and Lighting by SDMA on 14th October 2011 at Thiruvananthapuram.

Delivered presidential address in the National Science Day celebrations organized by KSCSTE at Science & Technology Museum, Thiruvananthapuram on 24th February 2012.

Delivered a talk on 'Status of hazard, vulnerability and risk assessment studies in Kerala' in the International Workshop on Disaster Risk Reduction and Contingency Planning, organised by State Disaster Management Authority and ILDM on 10th March 2012 at Thiruvananthapuram.

Dr. Srikumar Chattopadhyay

Delivered a lecture on Sustainable management of common property natural resources: macro perspective and micro act in the International Geography Congress held at CWRDM, Kozhikode, May 6, 2011.

Delivered a lecture on Disaster management and Role of Local Self Government for the delegates from Bihar, Jharkhand & West Bengal.

Delivered two lectures for participants of the Refresher's Course in Environmental Science organised by Academic Staff College, Kerala University on 13th February 2012. The lectures were on 'Main streaming environmental issues for sustainable development' and 'Environmental ethics'.

Panel presentation on "Disaster Management : Learning nature' s law and apply them correctly" in the International workshop on Disaster Risk Reduction and Contingency Planning organised by ILDM on 10th March 2012.

Delivered a lecture on "Why study geography" for the P.G Students and conducted field study on "Role of panchayats for sustainable land use planning: Exploring the frontiers with examples from Kerala" in Department of Geography and Environment Management, Vidyasagar University, Medinipore on 17th & 18th March 2012. Also delivered key note presentation on "Natural Resource Management: A frame work" on19th March 2012.

Dr. K. V Thomas

Delivered an invited talk on coastal hazards in the workshop on Coastal Hazards and Lighting organized by SDMA on 14th October 2011 at Thiruvananthapuram

Chaired a session in the National seminar on Climate Change and Variability organized by Dept. of Atmospheric Sciences, CUSAT at Kochi during 26-27th March 2012.

Sri. John Mathai

Delivered an invited talk on natural hazards scenario of Kerala in the workshop on Coastal Hazards and Lighting organized by SDMA on 14th October 2011 at Thiruvananthapuram

Delivered a talk on natural hazard prone areas in Kerala in the Workshop on Disaster management held on 31st October 2011 at Kochi organized by the Institute of Engineers India.

Dr. Ajayakumar Varma

Delivered a talk on 'Technology Options for Solid Waste Management' in the National Seminar on Municipal Solid Waste Management- Issues & Prospects organized by MA College, Kothamangalam and sponsored by the University Grants Commission during 2nd and 3rd March 2012.

Delivered a talk on 'EIA- A Case Study' in the National Seminar on Environmental Impact Assessment organized by the Department of Environmental Sciences, Kerala University on 31st March 2012.

Attended the Focus Group Discussion (FGD) meeting on Vembanad Wetland system convened for the Senior Officials of the Ministry of Environment & Forests, Govt. of India, The World Bank and development depts. & agencies of Govt. of Kerala on 21st March 2012 and made three presentations on 'Summary of the FGD held on November 1, 2011; Inventory of pollution load & mitigation measures and Land use management covering Vembanad & its immediate catchment'.

Dr. P. V. S. S. K. Vinayak

Delivered a lead talk on "Global Warming and Climate Change" in a National Seminar at Acharya Nagarjuna University, Guntur on 28th and 29th October 2011.

Dr. A. S. K. Nair

Delivered lectures on 'Water Resources and Irrigation Issues in Kerala' and 'Remote Sensing and GIS' during the STP Training Programme on GIS at the IMG, Thiruvanathapuram on 2nd September, 2011.

Delivered a lecture on "Participatory Rural Appraisal" in the one day training programme under the Westernghat Development Programme on 29th September, 20111 at VJT Hall, Thiruvananthapuram.

Delivered an invited lecture on 'Global warming – A Myth or Reality" and chaired the session on "Role of Remote Sensing in Biodiversity Monitoring' in the International Seminar on emerging Threats and Challenges to Biodiversity Policy Framework for Sustainable Management, held at Sri.Venkateswara University, Tirupati during 2 – 4 March, 2012.

Sri. B. K. Jayaprasad

Delivered a lecture on Remote Sensing and GIS as a tool for Bio-resource Assessment on 29th July, 2011 at Kerala Agricultural University.

Delivered a lecture at College of Engineering, Trivandrum on 2nd November, 2011 for the teachers in Civil Engineering from the approved Engineering colleges in the state on 'Applications of Geospatial Data in Urban Planning and Other fields,' in connection with a short term course on 'Geoinformatics for Civil Engineering' sponsored by Directorate of Technical Education, Kerala.

Delivered a talk on the methodology adopted to prepare 'Agro-Ecological Unit wise Atlases for Kerala' on 5th March, 2012 in connection with the workshop on 'Agro-Ecological Planning for Agricultural Development in Kerala ; A paradigm shift' at Mascot Hotel, Thiruvananthapuram , organized by the Kerala State Planning Board, Govt.of Kerala

9.10 Conference/ Workshop / Symposium / Seminar Attended

Name	Confernce/Symposium/Seminar	Title of the Paper
Anoop Krishnan K	National Seminar on Recent Trends in Chemical Sciences: Frontiers and Challenges (RTCSFC – 2011) organized by Department of Chemistry, University of Kerala, Kariavattom campus on 25-26 August 2011	Microbial Analysis of Charcoal and its Application in Removing 2,4-Dinitrophenol from Aqueous Phase
Rahul A.R		Hydrochemistry as a tool to Portray the Geochemical Milieu and the Magnitude of Pollution of the Neyyar River Basin, Southern Kerala, SW India
Arya S		Major and Trace Element concentration in sediment of Kochi Harbour Region and its Relation to Texture and Nutrients
Narendra Babu K., Baiju R.S, Anoop Krishnan K and Liji T.M,	International Conference on Material Processing Technology, MPT – 2011 held in Udaipur, Rajasthan, 20-22 October 2011	Quality and Management Aspects for the Conservation of Untapped Coastal Springs of southern districts of Kerala, India
Anoop Krishnan K Ajmal K, Arunima R Liji T.M Narendra Babu K		Equilibrium Modelling of Liquid-Phase Adsorptive Removal of Methylene Blue onto China Clay.
Sajeer S Arunima R Anoop Krishnan K Baiju R.S Liji T.M Narendra Babu K	National Conference on "Emerging Trends in Biodiversity Conservation & Sustainable management" Department of Zoology, Christian College, Chengannur, during 25-26 August 2011	Removal of Pb (II) from aqueous solution using activated carbon: An overview of batch adsorption studies
Jayaprasad B.K	INCA International Seminar at Chandigarh during 16 October 2011	Fragility Mapping for a strip of the western ghats using GIS-A case study in Amboori Grama panchayat in Thiruvananthapuram district of Kerala State
John Mathai	Workshop on Disaster Management held on 31October 2011 at Kochi organized by the Institute of Engineers India	Natural hazard prone areas in Kerala
Prakash T. N Thomas K.V Badarees K.O	National Seminar on Geospatial Solution forResource Conservation and Managemetn (GEOS- 2012) organized by Karnataka State Remote Sensing Application Centre (KSRSAC), Bangalore during 18-20 January 2012	Application of GIS and Remote Sensing for the Preparation of Integrated Island Management Plan for Lakshadweep Island

Name	Confernce/Symposium/Seminar	Title of the Paper
Raji S. Nair, Aparna G Nair Subash N Vandana M Arun R Anooja S Padmalal D Remya S I Anooja S Vishnumohan S Baijulal B Anoopa Prasad C Vishnu Thilakan M Vimal K C Sreeraj M K Thomas K V Noujas V Badarees K O	24th Kerala Science Congress at Kottayam during 29-31 January 2012	Herbicide Stress Detection in Colocasia Esculenta Plants by Multi-spectral Solar Reflectance Imaging Evolution of micro level land forms in Kabani river basin, Wayanad plateau, Kerala Application of RS and GIS in detecting palaeoo channels: A case study in the part of Pamba-Manimala interfluve, Kerala, India Provenance of Late Quaternary Sediments in the coastal lands of Kollam district, Kerala Textural dependence of C_{-org} C_{-inorg} in the borehole sediments of coastal wetlands of Kerala – a case study Mining induced shoreline changes and morphological modifications Numerical model studies on siltation of a harbour at Muthalapozhi along southwest coast of India
Vandana M	33rd National Association of Geographers India Congress held at Burdwan, West Bengal	River sinuosity and its linkage with lithology and structure – A case study of Cherupuzha – Chundal puzha segment Kabani river basin, Kerala
Dhanya V	33rd Indian Geographic Congress held at Burdwan, West Bengal	Evolution of Achankovil River basin: A geomorphic approach
Arunima R Noufal K N Fiasal A K Sreejith M I AryaS Liji T M Baiju R S, Anoop Krishnan K	National Seminar on Frontiers in Chemistry, held at IIST, ISRO, Valiyamala, Trivandrum on 7-8 December 2011	Natural springs-A promising solution for water scarcity in future
Mahamaya Chattopadhyay	3rd International Conference on Climate Change Forest Resource and Environment ICCFRE-2011 and 6th National Environment Conference during 9-11 December 2011 organised by the Department of Environmental Sciences, University of Kerala, Thiruvananthapuram	Natural Resource Evaluation and a case study of the Vellayani Lake, Thiruvananthapuram District.
Anu Baburaj, Subhash N Nisha Unni Anil M K, Rani Mary George	9th Indian Fisheries Forum, Chennai, 19-23 December 2011	Laser- induced fluorescence imaging: A potential tool for early detection of coral bleaching

Name	Confernce/Symposium/Seminar	Title of the Paper
Padmalal D Tiju.I.Varghese Neelima. T	National Seminar on Coastal Zone Processes, Resources and social Relevance held at CUSAT, Kochi on 17 February 2012	Holocence climate and sea level proxies in the borehole cores of southern Kerala with special reference to the evolution of the coast Depositional environment of inland, lagoon and offshore sediments of Kayamkulam region, Kerala Geospatial studies of shoreline variation along Thiruvananthapuram coast.
Vishnu. S Faisal. A.K	National Seminar on conservation of the marine environment and management of marine fisheries organized by P.G. and Research, Dept. of Zoology, N.S.S. College, Changanachery during 24 – 27 February 2012	Monthly and daily variation of hydrography in relation with upwelling and vertical oscillation on marine waters of Port Blair (Eastern side), Andaman & Nicobar island, Bay of Bengal, India'. Sewage pollution and hydrologic impacts on the estuarine ecology; A case study from Ashtamudi estuary, Kollam District, Southern Kerala
Vishnu Mohan. S	National seminar on Coastal Zone – Processes, Resources & Social Relevance, held at CUSAT, Kochi on 17 February 2012	Textural and heavy mineralogical studies of a small catchment river in the southern Kerala-its implications in coastal evolution
Padmalal D	National seminar on Recent Advances and Future challenges in Geochemistry and Geophysics: The Indian Scenario, held at the Dept. of Geology, Centre of Advance study, B H U, Varanasi, during 22-24 February 2012	Hydrochemical characterization and Water quality assessment of the coastal springs of southern Kerala, India
Srikumar Chattopadhyay	International workshop on Disaster Risk Reduction and Contingency Planning organised by ILDM on 10 March 2012	Disaster Management : Learning nature' s law and apply them correctly (Presentation)
Srikumar Chattopadhyay	International Conference on 'Dimensions of Development and Resource Conservation' organised by the Department of Geography, Calcutta University, 11 March 2012	Strategic land use planning for climate change adaptation: A case of Kerala
Dhanya V Vandana M	International Conference on Population Dynamics and Sustainable Resource Development held at Aligarh Muslim University, Aligarh, Uttarpradesh during 17-25 March 2012	Water yield variation as linked to catchment parameters: A micro level analysis of South Kerala river basins Resource base environmental degradation and poverty: Exploring the interrelationship at micro level- A case study of selected panchayats in Wayanad district, Kerala
Srikumar Chattopadhyay	National seminar on 'Reorienting Geography to meet present and future challenges' organised by the Department of Geography, Banaras Hindu University on 15 March 2012	Safe operating space for humanity and geography (Discussion note)
Srikumar Chattopadhyay	National conference organised by Town and Country Planning Department on 23 March 2012	Urbanisation in Kerala (Discussion note)

Extension

10.1 World Wetland Day 2012

Hon'ble Chief Minister of Kerala Shri. Oommen Chandy inaugurating the World Wetland Day 2012 celebrations at the Kanakakkunnu Palace by lighting the lamp. Shri. K Muraleedharan MLA, Prof. V. N. Rajasekharan Pillai, Executive Vice President of KSCSTE and Ex-Officio Principal Secretary, Science & Technology Department, Ms. Meera Mehrishi, Additional Secretary, Ministry of Environment and Forests, Government of India, Dr.Siddharth Kaul, Advisor, Ministry of Environment and Forests, Dr. K. K. Ramachandran, Member Secretary, KSCSTE and Dr. N. P. Kurian, Director, Centre for Earth Science Studies are also seen.

The National Celebrations of World Wetland Day 2012 was jointly organised by CESS and KSCSTE at Kankakunnu Palace, Thiruvananthapuram on 2nd February 2012. As part of the celebrations a seminar on *Wetlands and Tourism* was inaugurated by the Hon'ble Chief Minister of Kerala, Shri. Oommen Chandy. The Chief Minister in his inaugural address stated that Kerala will give special consideration to set up the State Wetland Authority mooted by the Centre. During his inaugural speech, he stressed the need for paying serious attention to utilize our rivers, lakes and wetlands for the development of the State. He declared that the Wetland Institute will be headquartered at Kottayam and also give top priority to the Vembanad Development Authority to make Vembanad Lake and the six rivers debouching into it viz. Achenkovil, Manimala, Meenachil, Muvattupuzha, Pamba and Periyar, pollution free. Shri. K. Muralidharan MLA presided over the function. Ms. Meera Mehrishi, Additional Secretary, Ministry of Environment and Forests, Government of India, Dr.Siddharth Kaul Advisor, Ministry of Environment and Forests and Dr. N. P. Kurian, Director, Centre for Earth Science Studies spoke on the occasion. Prof. V. N. Rajasekharan Pillai, Executive Vice President of KSCSTE and Ex-Officio Principal Secretary, Science & Technology Department, welcomed the gathering and Dr. K. K. Ramachandran, Member Secretary, KSCSTE proposed vote of thanks. Earlier on 1st February 2012 painting, elocution and quiz competitions were held for school children and the winners received certificates and trophies from the Hon'ble Chief Minister.

10.2 Earth Day 2011

Earth Day 2011 was observed in CESS on 28th April 2011. Students from different schools in Thiruvananthapuram visited

the laboratories of CESS and interacted with the scientists. An elocution competition for students was held on the topic 'Green

Earth'. An invited talk on the same topic was also arranged for the students, which was delivered by Shri. P. Narayana Kurup, noted Environmentalist. Certificates, cash awards and mementoes were distributed to the winners by Director, CESS.

10.3 National Science Day 2012

National Science Day was observed on 29th February 2012. A lecture on 'Dynamics oscillations in nature' was delivered by Prof. M.S. Gopinathan IISER, Thiruvananthapuram and another lecture on 'Solar terrestrial physics: Emerging perspectives' was delivered by Dr. Tarun Kumar Pant, Space Physics Laboratory, VSSC.

10.4 Exhibition

CESS participated in the exhibition organized in connection with the 'Karshika Mela' (Agricultural fair) held at Thodupuzha Newmans College ground from 26th December 2011 to 1st January 2012. Every day nearly 20000 people visited the exhibition stall. Experts from various fields delivered talks and conducted interaction sessions. CESS pavilion presented posters and models highlighting the research activities. Malayalam brochure titled 'Bhuchalanam: Ariyenda vasthuthakal' and a hand book on CESS vision were distributed among the public.

A view of the exhibition stall of CESS at the agricultural fair held at Thodupuzha

B.K.Jayaprasad demonstrated two customized GIS Applications entitled "District Resource Information System" and "Cadastral Level Decision Support System" developed in CESS in connection with the 24th Kerala Science Congress Expo during 28-31 January 2012.

10.5 Lectures for students

Dr. Srikumar Chattopadhyay delivered two lectures for participants of the Refresher's Course in Environmental Science organised by Academic Staff College, Kerala University on 13th February 2012. The lectures were on Main streaming environmental issues for sustainable development and Environmental ethics.

Senior secondary students from the Bishop Hodges Higher Secondary School, Mavelikkara visited CESS on 27th July 2011. Scientists Sri. G. Sankar, S.Sidharthan, B.K. Jayaprasad and Ms.V. Dhanya gave talks on Natural Hazards Management, Remote Sensing, Geographic Information System and Natural Resources.

Scientist conducting interactive session with students of Bishop Hodges Higher Secondary School, Mavelikkara

Dr.K.Anoop Krishnan conducted an interactive lecture programme for the PG students of University College, Trivandrum , MES College Ponnani on the topic"Quality aspects and Viable Remedies for the Restoration of Water Resource in Indian Subcontinent" on behalf of Earth Science Forum (ESF), CESS, on 27th August 2011.

Shri. BK Jayaprasad demonstrated the capabilities of GIS in solving Earth related problems and delivered a lecture on "GIS Applications" for PG Students from the Departments of Geology, University College, Kariavattom , and MES College Ponnani.

Shri. G. Sankar delivered a lecture on disaster management at Cotton Hill GHS on 17th October 2011.

Dr.EJ Zachariah delivered a lecture at Kendriya Vidyala, Pattom in connection with the observance of the National Science Day 2012.

Dr. R Ajayakumar Varma attended the National Seminar 'Municipal Solid Waste Management- Issues and Prospects' organized by MA College, Kothamangalam and sponsored by the University Grants Commission during 2-3 March 2012 and delivered a talk on Technology Options for Solid Waste Management on 2nd March 2012.

Dr. R Ajayakumar Varma attended National Seminar on Environmental Impact Assessment organized by the Department of Environmental Sciences, Kerala University and delivered a talk on 'EIA- A Case Study' on 31st March 2012.

Dr. Archana M Nair delivered a talk on 'Remote Sensing and Geophysical Methods for Geoexploration' at Dept. of Civil Eng. IIT Guwahati on 2nd March 2012

10.6 Earth Science Forum

The Earth Science Forum initiated interactive sessions on frontier areas of Earth Sciences for the benefit of 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. The following lectures were delivered: 'Quality aspects and viable remedies for the restoration of Water Resources in Indian subcontinent' by Dr. K. Anoop Krishnan, Scientist, CESS; 'GIS Applications' by Mr. B. K. Jayaprasad, Scientist, CESS; 'Satellite communications for societal applications' by Dr. K. S. Das Gupta, Director, IIST, Trivandrum; 'Assessment of heavy metals in the environmental compartments of the central and northern coast of Kerala, by Sri. Udaya Kumar P, Research Scholar, CESS and 'Numerical modelling of tsunami propagation in the South East Arabian Sea (SEAS) and inundation along the Kerala coast' by Mr. Praveen S.S., Senior Research Fellow, CESS.

Pictures taken on the occasion of the Onam celebrations organized by the CESS Recreation Club on September 2, 2011

10.7 Earth Watch Centre

Efforts are on to establish an Earth Watch Centre (Museum & Park) intended to take the visitors on a journey through our planet's past, present and future, with interactive exhibits and impressive technology, including a 4D and 3D experience. Children and adults alike can appreciate the creation of the Earth, follow the planet through its evolution and even catch glimpses of its future. It is hoped that a journey through the Earth Watch Centre will be an exciting and engaging experience for all as the Earth Watch Centre is intended to unravel all aspects of the planet we live in. Population growth, concepts of time and the realities of climate change could also be presented. Survey of the CESS campus was carried out to physically ascertain the extent of land available at present with CESS.

Committees

11.1 Statutory Committees

11.1.1 Research Council

Dr. Shailesh R Nayak *Secretary, Ministry of Earth Sciences, Government of India* *Prithvi 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 *Director,* *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*
Executive Director *Centre for Water Resources Development & Management, Kunnamangalam, Kozhikode*	*Member*
Sri. T. P. Vijayakumar *Additional Secretary* *General Administration Department* *Government of Kerala*	*Member*
Dr. T. Radhakrishna *Head, G S D* *Centre for Earth Science Studies* *Thiruvananthapuram*	*Member*
Member Secretary *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. C. M. Harish *Central Geomatics Laboratory*	*Member*
Dr. P. K. Omana *Chemical Sciences Division*	*Member*
Dr. C. N. Mohanan *Environmental Sciences Division*	*Member*
Dr. T. Radhakrishna *Geosciences Division*	*Member*
Dr. K. V. Thomas *Marine Sciences Division*	*Member*
Dr. Srikumar Chattopadhyay *Resources Analysis Division*	*Member*
Dr. Srikumar Chattopadhyay *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 Material Purchase Committee

Dr. E. J. Zachariah	*Chairman*
Dr. G. R. Ravindra Kumar	*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. G. Sankar	*Chairman*
Dr. Reji Srinivas	*Member*
Dr. Archana M Nair	*Member*
Sri. P. Rajesh	*Member*
Smt. K. V. Padmaja Kumari	*Convenor*

11.2.7 Plan Project Evaluation & Monitoring

Dr. S. Chattopadhyay	*Chairman*
Sri. John Mathai	*Member*
Dr. K. V. Thomas	*Member*
Dr. G. Mohan Kumar	*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*
Smt. L. Sheela Nair	*Member*
Sri. D. Raju	*Member*
Sri. K. Eldhose	*Member*
Smt. Indu Janardanan	*Member*
Smt. K. V. Padmaja Kumari	*Convenor*

11.2.9 Campus Green Committee

Dr. V. Nandakumar	*Chairman*
Dr. Tomson J Kallukalom	*Member*
Dr. Archana M Nair	*Member*
Sri. Shravan Kumar	*Member*
Sri. John Paul	*Member*
Sri. M. Ramesh Kumar	*Member*
Sri. S. Mohanan	*Member*

Staff Details

12.1 Directors office

Dr. N. P. Kurian	Director
Sri. N. Rajasekharan Nair	P. A to Director
Sri. C. K. Sasidharan	Scientist-E1 & SIC, TC
Sri. S. Sidharthan	Scientist-E1 & SIC, WIC
Smt. V. Geethamol	Stenographer (Gr. 1)
Sri. V. Chandran Nair	Helper (Gr. 2)

12.2 Atmospheric Sciences Division

Dr. N. Subhash	Scientist-G & Head
Dr. E. J. Zachariah	Scientist-F
Dr. G. Mohan Kumar	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 Sukumar	Technical Officer (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 (on deputation)
Dr. C. M. Harish	Scientist-F & Head
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
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
Smt. L. Sheela Nair	Scientist-E1
Sri. John Paul	Scientist-E1
Dr. D. S. Suresh Babu	Scientist-E1
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)

12.8 Resources Analysis Division

Dr. Srikumar Chattopadhyay	Scientist-G & Head
Sri. B. Sukumar	Scientist-F
Sri. Shravan Kumar	Scientist-E2
Smt. Ahalya Sukumar	Scientist-E2
Dr. Mahamaya Chattopadhyay	Scientist-E1
Smt. 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
Smt. K. K. Rimsy	Technical Officer (Gr. 1)
Smt. S. Najumunniza	Technical Assistant (Gr. 5)

12.10 Library

Smt. K. Reshma	Professional Asst. (Gr. 1)
Sri. P. M. Gopakumar	Clerical Assistant

12.11 Camp Office

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

12.12 Administration

Sri. P. Sudeep	*Registrar*
Sri. M. Philip	*Internal Audit Officer*
Sri. M. A. K. H Rasheed	*Deputy Registrar*
Smt. K. V. Padmaja Kumari	*Assistant Registrar*
Sri. T. D. Bashardeen	*P.A to Registrar*
Sri. R. Haridas	*Section Officer*
Smt. K. Viswabharathy	*Section Officer*
Sri. C. M. Yousuf	*Section Officer*
Sri. M. Madhu Madhavan	*Section Officer*
Smt. R. Jaya	*Section Officer*
Smt. G. Lavanya	*Section Officer*
Sri. S. Krishnakumar	*Office Asst. (Gr. 2)*
Smt. Femi R. Sreenivasan	*Office Asst. (Gr. 1)*
Sri. Rajesh P	*Office Asst. (Gr. 1)*
Smt. Rasi P. C	*Office Asst. (Gr. 1)*
Sri. Siju V	*Office Asst. (Gr. 1)*
Smt. S. R. Surekha	*Office Asst. (Gr. 1)*
Sri. K. M. Dinesh	*Office Asst. (Gr.*
Smt.Smitha Vijayan	*Office Asst. (Gr. 1)*
Smt. K. S. Anju	*Office Asst. (Gr. 1)*
Sri. P. H. Shinaj	*Office Asst. (Gr. 1)*
Smt. D. Shimla	*Office Asst. (Gr. 1)*
Sri. V. Subair	*Technical Officer (Gr. 1)*
Smt. Indu Janardanan	*Technical Officer (Gr. 1)*
Smt. P. Prabhavathy	*Stenographer (Gr. 1)*
Smt. N. J. Saramma	*Typist (Gr. 1)*
Smt. K. Prasanna	*Typist (Gr. 1)*
Smt. 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. N. Unni	*Helper (Gr. 1)*
Smt. 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)*
Sri. K. Sudeerkumar	*Driver (Gr. 1)*

12.13 New Recruitments

Smt. Indu Janardhanan
Technical Officer (Gr.1)
Estate Management

Smt. D. Shimla
Office Assistant (Gr. 1)
Administration

Sri. P. H. Shinaj
Office Assistant (Gr. 1)
Administration

Smt. K. S. Anju
Office Assistant (Gr. 1)
Administration

Smt. V. Geethamol
Stenographer (Gr. 1)
Director's Office

Sri. K. Sudeer Kumar
Driver (Gr.1)
Administration

12.14 Retirements

Sri. G. Balasubramanian
Scientist-F & Head, Training & Extension Division
superannuated on 30 April 2011

Dr. B. Sukumar
Scientist- F
Resources Analysis Division
superannuated on
30 September 2011

Dr. K. Narendra Babu
Head, Chemical Sciences Division superannuated on 31 November 2011

Dr. Narayanaswamy
Scientist-F, Geo Sciences Division superannuated on 31 January 2012

Sri. C. Surendran
Skilled Assistant,Administration superannuated on 30 April 2011

12.15 Obituary

Sri. K. R Unnikrishnan,
Scientist-F, Camp Office,
Kochi expired
on 26th June 2011

Sri. V. Vasudevan,
Scientist E2, Marine Sciences
Division, expired
on 24th March 2012

Balance Sheet

CENTRE FOR EARTH SCIENCE STUDIES, AKKULAM, TRIVANDRUM

(A unit of Kerala State Council for Science, Technology & Environment. Govt. of Kerala)

Consolidated Balance Sheet as on 31st March 2012

Liabilities	Sch No	*As at 31.03.2012*	As at 31.03.2011	Assets	Sch No	As at 31.03.2012	As at 31.03.2011
Reserves & Surplus	4	7,78,76,338	6,38,60,465	Fixed Assets	1	7,78,76,338	6,38,60,465
Current Liablities	5	40,08,077	16,75,822	Current Assets	2	11,89,53,452	7,18,64,217
Unspent balance				Loans & Advances	3	2,32,05,480	2,74,79,456
Grant in aid projects	6	3,72,35,585	72,85,325				
Divisional Core projects	6	61,49,733	46,07,229				
Service component projects	6	72,96,641	61,59,808				
Consultancy projects	6	3,09,10,187	2,11,51,709				
Corpus fund	6	5,68,86,249	4,90,04,354				
Grant (GOK)	6	(3,27,540)	94,59,426				
Total		**22,00,35,270**	**16,32,04,138**	**Total**		**22,00,35,270**	**16,32,04,138**

For Mohan & Mohan Associates
Chartered Accountants

Sd/-
R. Suresh Mohan
Partner
Membership No. : 013398
Firm Reg. No.: 002092S
Place : Thiruvananthapuram

For Centre for Earth Science Studies
Akkulam Trivandrum

Sd/-
(Regstrar)

Sd/-
(Director)

Place :Thiruvananthapuram