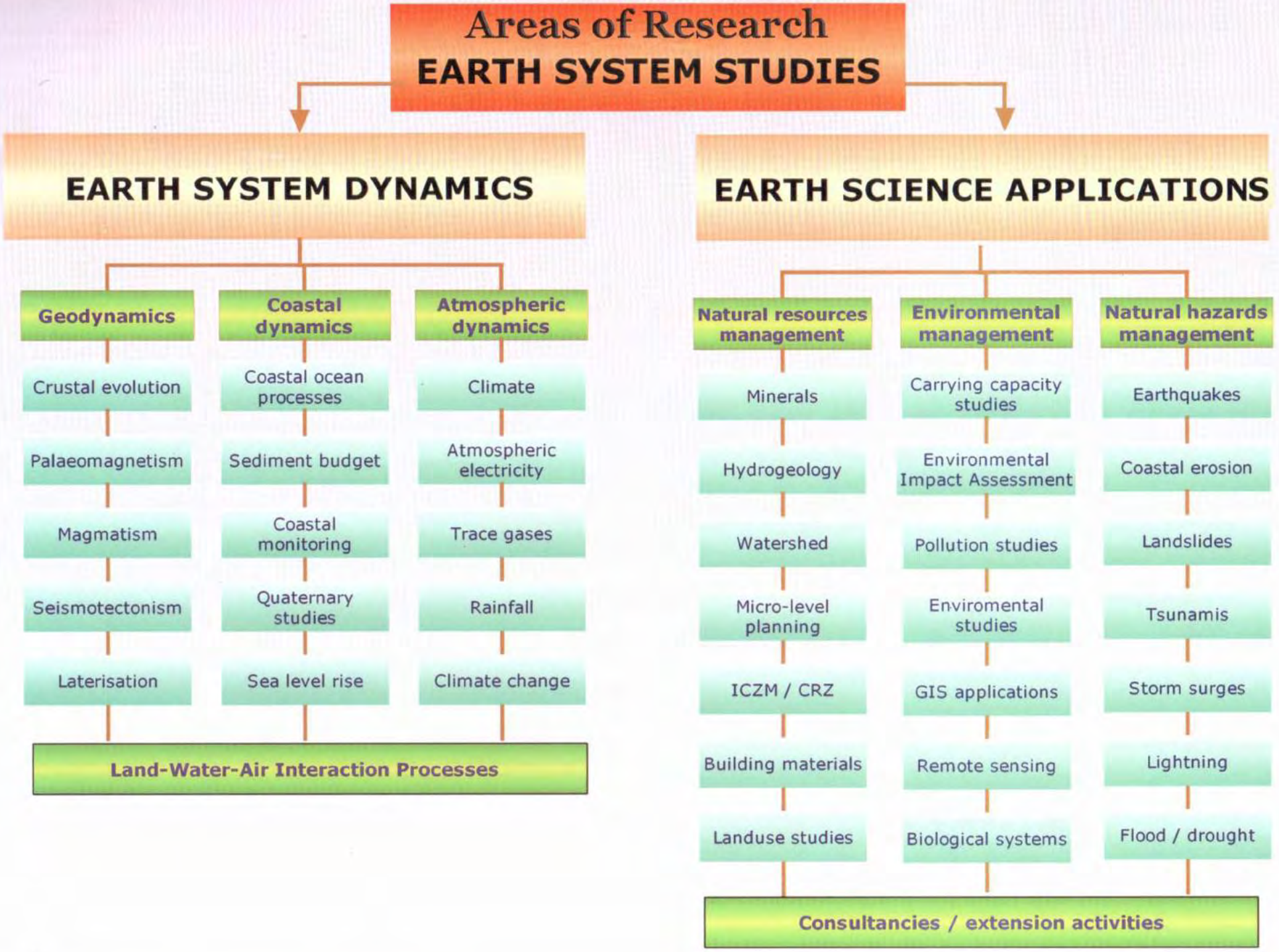
Annual Report 2012-'13

Centre for Earth Science Studies

Committed to Our Earth Our Future


Areas of Research
EARTH SYSTEM STUDIES
EARTH SYSTEM DYNAMICS
Geodynamics
Crustal evolution
Palaeomagnetism
Magmatism
Seismotectonism
Laterisation
Coastal dynamics
Coastal ocean processes
Sediment budget
Coastal monitoring
Quaternary studies
Sea level rise
Atmospheric dynamics
Climate
Atmospheric electricity
Trace gases
Rainfall
Climate change
Land-Water-Air Interaction Processes
EARTH SCIENCE APPLICATIONS
Natural resources management
Minerals
Hydrogeology
Watershed
Micro-level planning
ICZM / CRZ
Building materials
Landuse studies
Environmental management
Carrying capacity studies
Environmental Impact Assessment
Pollution studies
Enviromental studies
GIS applications
Remote sensing
Biological systems
Natural hazards management
Earthquakes
Coastal erosion
Landslides
Tsunamis
Storm surges
Lightning
Flood / drought
Consultancies / extension activities

ANNUAL REPORT 2012-2013

Centre for Earth Science Studies
Akkulam, Thiruvananthapuram - 695031, india

Contents

Preface

I am pleased to present this Annual Report of CESS for the year 2012-13. The period under report is notable for the progress achieved in the proceedings on takeover of CESS by the Ministry of Earth Sciences (MoES), Government of India. The proposal submitted by the Government of Kerala in February 2012 for takeover of CESS by the MoES was examined by the MoES through an Expert Committee constituted for the purpose. I take pride in reporting that the Expert Committee recommended takeover of CESS, and the MoES in turn accepted the recommendation of the Committee and initiated necessary steps to seek the approval of the Union Cabinet. A R & D programme entitled "Earth System Dynamics and Resources Evaluation" comprising of four sub-projects viz. Crustal Processes, Coastal Processes, Cloud Microphysics and Lightning, and Natural Resources and Environmental Management was prepared and submitted to MoES. Establishment of state of the art laboratories such as ICP-MS, Laser Ablation Microprobe, C^{14} and TL dating, Clean Chemistry, etc. under the Sophisticated Analytical Facility and procurement of several field survey/ measurement equipment such as GPR, Video Imaging systems, Differential GPS, etc. were proposed as part of the R & D proposal.

Our R & D programme during the year focused on four broad themes viz. Crustal Evolution and Geodynamics, Coastal Processes and Management, Atmospheric Processes, and Natural Resources and Environmental Management. In spite of sizable reduction in strength of scientists due to superannuation the R & D activities under the above core themes were sustained. Activities under crustal evolution and geodynamics focused on topics like petrology, palaeomagnetism, fluid inclusion and land subsidence. Studies on petrology dealt with origin and evolution of K-rich gneisses of Kerala Khondalite Belt in relation to Proterozoic supercontinent events. The results show that the gneisses are the meta granitoids derived from high-K calc-alkaline suites typical of igneous suites, in departure from the metasedimentary origin proposed earlier. Palaeomagnetism results on the Proterozoic Mafic igneous units have been synthesized and mean characteristic magnetizations have been computed for discrete phases of dyke intrusions in the Indian shield for the Palaeoproterozoic age. A new project proposal in collaboration with Bundelkhand University to understand the Palaeoproterozoic large igneous provinces in India has been approved for funding by the Department of Science and Technology, Government of India.

Under a project on Palaeo fluids in the petroliferous basins of western offshore, funded by the MoES, side wall cuttings and core samples from three offshore wells from the core library of the RGL (ONGC) were collected. Petrographic and fluid inclusion studies have revealed Hydrocarbon Fluid Inclusions in quartz grains at a depth of 3055m-3060m from the RV-1 Well. A new Project funded by the MoES has been initiated to study the heavy minerals in the source rocks and the coastal sedimentaries towards understanding provenance and processes involved in their formation. Under a research project on soil piping funded by the NDMA, a comprehensive study of soil piping and related problems has been undertaken.

Our pursuits under the theme on Coastal Processes and Management were aimed at understanding the evolution, structure and dynamics of the coastal zone with the ultimate objective of sustainable development and management of the coastal zone. A Shoreline Management Plan was proposed to control the severe erosion north of the Muthlapozhi tidal inlet through a combination of artificial dunes, short groins and beach nourishment. Site specific numerical models were developed for Vizhinjam, Neendakara, Cochin and Kavaratti for different seasons. Integrated Island Management Plans (IIMPs) for Agatti and Chetlat islands of Lakshsadweep have been prepared in accordance with the guidelines of the Island Protection Zone Notification of the MoEF, 2011 and discussions with the Chairman and Experts of the Committee constituted by the Hon'ble Supreme Court. We are part of the Ocean State

Forecast project of MoES and maintained a station off Kollam to collect real time data on sea state.

Activities under the theme of atmospheric processes continued in spite of superannuation of several scientists. CESS maintained continuous recording of weather parameters at a number of locations in Kochi, as well carried out mobile traverse surveys as part of the studies on Urban Heat Island. Continuous monitoring of carbon monoxide concentration, solar UVB, ozone and water vapour were carried out. A ready reckoner on the climatological features of Kerala was prepared.

Our pursuits in the field of Natural Resources and Environmental Management provided the much needed technical inputs to the developmental programmes of the State. The thrust of the work in this field was to investigate terrain character both in macro and micro scales and to understand spatio-temporal dimension of human-environment relationship, changing trend of land use and impact of land use change on environment particularly water quality. Assessing environmental impacts of development projects, resource extraction like sand mining, hard rock quarrying, clay mining, and sand auditing of rivers of Idukki district were some of the multifarious activities undertaken. CESS prepared an Inventory of the Wetlands of Kerala required under the Wetland Conservation and Management Rules (2010) in collaboration with KFRI and CWRDM for the Government of Kerala.

CESS continued to provide consultancy to Government Departments and Public/Private Sector Undertakings on earth science related problems, particularly delineation of High Tide Line and Low Tide Line, thus assuring a role for CESS in the developmental programmes of the country. The revenue earned from consultancy projects helped in tiding over the deficit in the grant-in-aid to meet the establishment and infrastructure costs.

The National Facility for Fluid Inclusion Research funded by the MoES was commissioned with the installation of Micro Laser Raman Spectrometer. The broadband seismic station under the national seismic network programme continued to function at Peechi. The laboratory infrastructure of the institute has been upgraded with new instruments/software such as Heave Compensator, Ceeducer, High score plus software for XRD, Hypack for bathymetry survey, etc. CESS Library added 39 books and subscribed to 28 international and 25 national journals during this period. More than 930 full text journal titles were available online through EBSCO data base. CESS publication record was moderately good with 24 papers in national/international journals, 28 papers in books/proceedings, 2 edited volumes of journals and as many as 37 project reports.

Our academic programme continued to be vibrant with as many as 36 Ph.D students and 4 Ph.D awards during the year. Besides, 35 students did their BTech/MTech/MSc dissertation out of whom 10 students received assistantships, and 29 students underwent internship. Several of our scientists served as members and national experts in committees of DST, MoES and MoEF. Ms. Dhanya V, UGC SRF under Dr.Srikumar Chattopadhyay was one of the 25 winners of the Green Talent Competition 2012, instituted by Federal Ministry of Education and Research, Germany.

CESS organized several seminars/workshops/outreach programmes. The 34th meet of the Institute of Indian Geographers (IIG) was organised during 13-15 December 2012. A Conference on Natural Resources Management and Decentralised Planning was organized as part of the IIG meet. A pre-conference symposium was also held on 12th December 2012. The 11th Professor C. Karunakaran Endowment Lecture was delivered on 10th August 2012 by Prof. Vinod K. Gaur, Distinguished Professor, Indian Institute of Astrophysics on "Earthquake Hazard in India: Knowledge and Response". Observation of Earth Day and Science Day, participation in Exhibitions, Invited Lectures, etc. were the highlights of our outreach programmes.

I will be failing in my duty if I don't place on record the valuable guidance and unstinted support received from the Research Council, Management Committee and the KSCSTE, and the unrelenting cooperation and support from the scientists and staff of CESS. With the takeover of CESS by MoES, I am confident that the infrastructural facilities and human resources will be developed on par with other national institutes, paving the way for significant accomplishments in R & D in the realm of earth system sciences.

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), located at southern tip of the Indian Peninsula, is a product of arc-continent collision and is evolved through several orogenic cycles. The evolution of lower crustal granulites within KKB is generally attributed as a product of multiple phases of tectonics initiated by subduction-driven convergence and tectonic accretion and/or collision processes and age relations. This phase was followed by crustal thickening, structural and/or erosional exhumation, and syn- to post-convergence transpression and transtension triggering underthrusting of materials rich in radiogenic heat-producing elements and emplacement of alkaline magmatic bodies leading to heat advection in the lower crustal regions of the KKB. Metamorphic mineral assemblages formed at greater crustal depths (~25–40 km) representing high- to ultrahigh-temperature (HT/UHT) metamorphism accompanied by partial melting and plutonism is a common feature in such orogenic belts and are well documented within KKB, representing poly-phase metamorphic evolution of the lower crustal granulites. However, pervasive granulite-facies metamorphism acted during the Pan-African time obliterated the mineralogical (and P–T) records of earlier metamorphic trajectories, thereby reducing our ability to understand and propose unambiguous links between various phases of thermal events and geodynamic processes. The results of the research project (Fig. 1.1.1.1) highlights complex poly-metamorphic history of the high-grade granulites of KKB in light of emerging concepts of subduction–accretion–collision tectonics, and attempt to establish a link between the observed poly-metamorphic pattern, geodynamic process and age relations.

Magmatic components (orthogneisses) of KKB

Our studies in KKB demonstrated occurrence of contrasting granitoid groups (orthogneisses) comprising (i) tonalites with characteristic Archaean tonalite–trondhjemite–granodiorite (TTG) affinity and (ii) high-K granites showing geochemical patterns archetypal of the post-Archaean granites. The orthogneisses of KKB consist mainly of quartz, feldspar, biotite, and opaque minerals. They show formation of neoblastic garnet. The main accessory phases are zircon together with scarce crystals of apatite. The petrographic studies allow us to classify the orthogneisses into two distinct types: (i) metatonalites and (ii) high-K metagranites, following the sodic and potassic gneisses scheme proposed by Chacko et al. (1992).

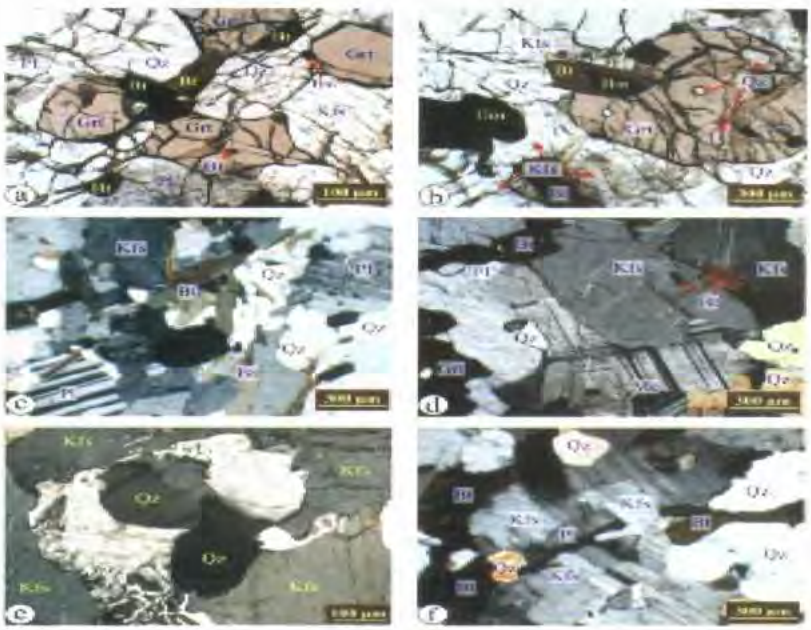


Fig. 1.1.1.1 Thin section photomicrographs showing various mineral assemblages and textures observed in KKB orthogneisses: (a–b) structural varieties of quartz, such as pheonocrysts, drop-like inclusions, and fine-equant grains in metagranitoids. Note the close association of ilmenite and magnetite with biotite and garnet and inclusions of biotite, plagioclase, and quartz in garnet; (c) subhedral to anhedral feldspars with sutured boundaries; (d) phenocrysts of K-feldspar with inclusions of other minerals; (e) development of myrmekitic or granophyric intergrowth of K-feldspar and plagioclase grains with quartz; and (f) micro-perthites showing inclusions of plagioclase indicating early crystallisation of Na-plagioclase.

The major and consistent petrographic differences between these orthogneisses are: (i) the high-K metagranites are enriched in relatively homogeneous K-rich micro- to meso-perthites, while the alkali feldspar of the metatonalite is a Na-rich perthite and antiperthite; and (2) the metatonalites are considerably poorer in ferromagnesian minerals.

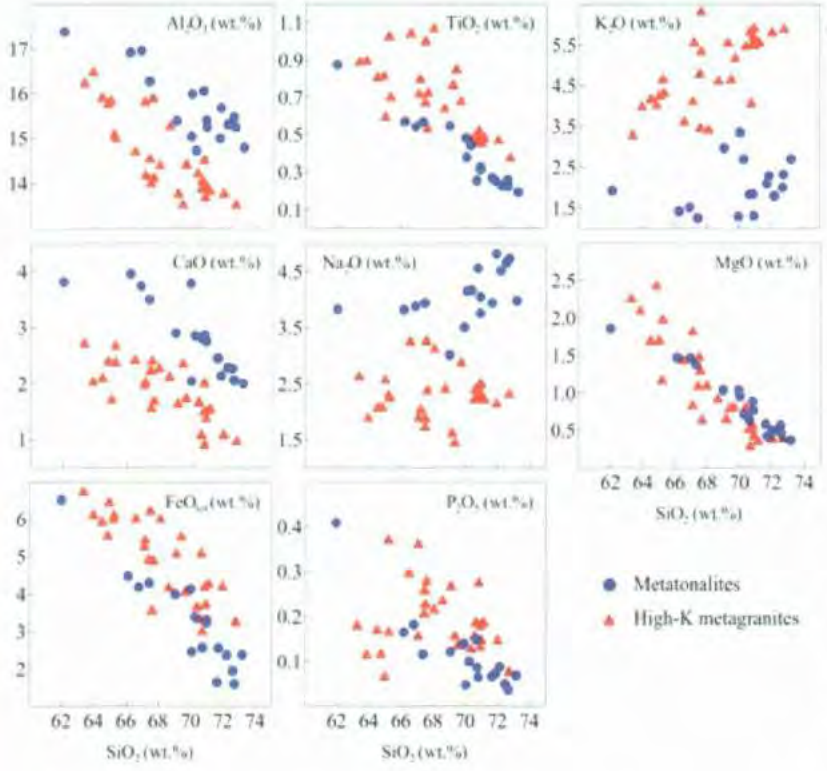


Fig. 1.1.1.2a Harker variation diagrams for selected major oxides.

Geochemistry

The general geochemical pattern observed in orthogneisses of the KKB show coherent trends of negative correlation of silica with the major oxides: TiO_2, Al_2O_3, CaO, MgO, FeO_{tot} and P_2O_5 (Fig. 1.1.1.2a). Although, silica *vs.* K_2O shows limited positive correlation, the data exhibit considerable scattering. Similar type of scattered trend is observed in the case of Na_2O. Similarly, distinct correlations are observed in trace element variation diagrams also (Fig. 1.1.1.2b). The distinct grouping observed in geochemical diagrams substantiates the classification of orthogneisses into metatonalites and high-K metagranites.

In terms of the normative An–Ab–Or compositions, the metatonalitic rocks show granite-monzogranite to granodiorite characteristics. Their strong calc-alkaline nature is reflected in the K–Na–Ca diagram (Fig.1.1.1.3), indicating a distinction in the general trondhjemitic trend observed in Archaean TTGs (shown by metatonalites) and calc alkaline differentiation series of post-Archaean granites (high-K metagranites).

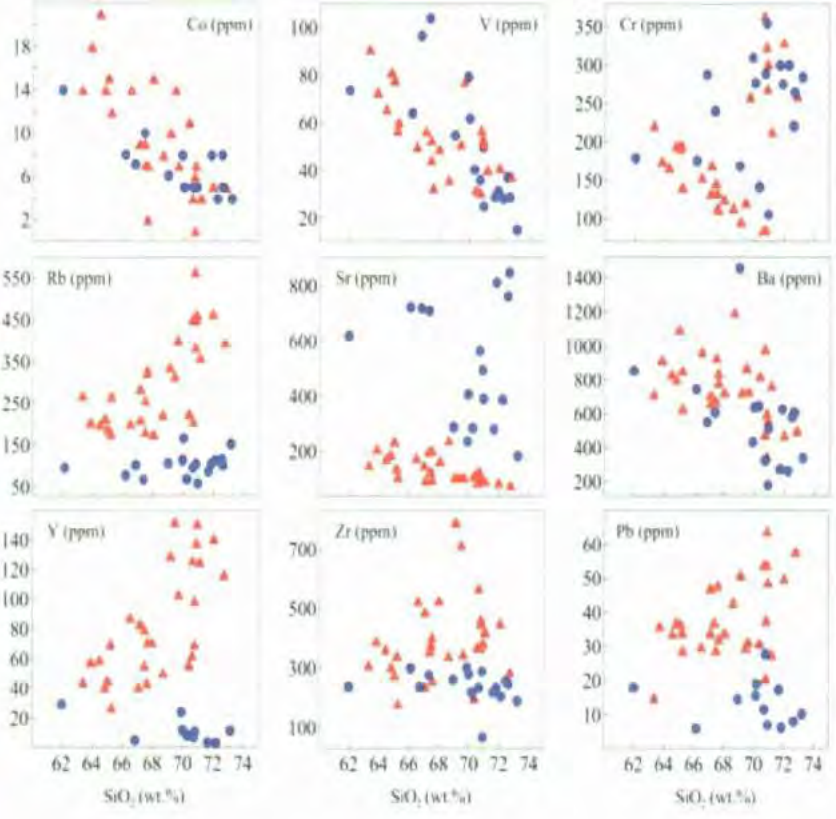


Fig. 1.1.1.2b Harker variation diagrams for selected trace elements.

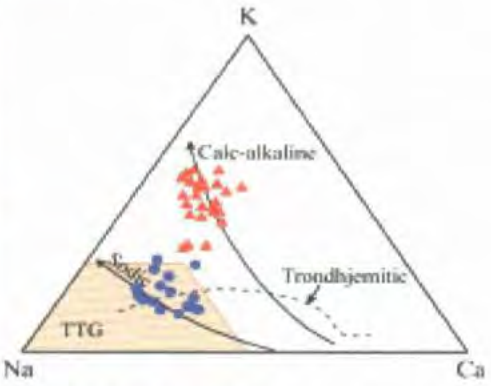


Fig.1.1.1.3 Cationic K–Na–Ca diagram showing Archaean TTG groups with typical sodic trend and post-Archaean granites with calc-alkaline trend of evolution.

Geodynamic evolution

The compositional variations and generally inverse geochemical pattern shown by the two rock groups in fact invoke different models in their petrogenesis. The geochemical characteristics of metatonalites are typical of the Archaean TTGs with pronounced calc-alkaline affinity, whereas the geochemistry of high-K metagranites indicates magmatic fractionation produced by reworking of early crust.

The geodynamic model based on metamorphic phase relations of melt-bearing assemblages of the KKB proposed a two-stage process for the crustal evolution initiated with thickening of the crust in relation to a continental-arc setting, followed by exhumation along a high-temperature stable geotherm. A very recent contribution discussing the production of voluminous high-K metagranites within the KKB modified and extended the early view proposing the crustal evolution as a product of magmatic accretion (Fig.1.1.1.4) followed by intracrustal differentiation in an episodic manner.

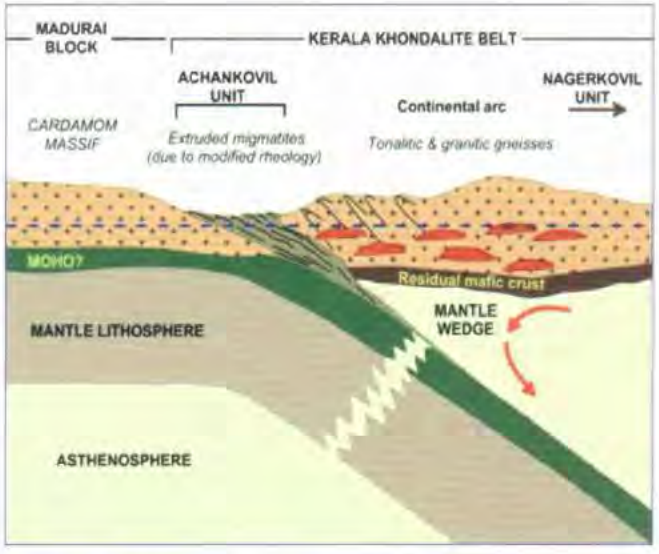


Fig.1.1.1. 4 Schematic diagram showing the simplified and generalised evolution of the arc-accretion along Achankovil suture zone

Reported model ages (T_{DM} and Hf_c) for the central Ponmudi (PU) and southern Nagerkovil (NU) units of the KKB indicate crustal accretion as a prolonged process initiated as early in Meso-Archaean (~3 Ga.) and extended till Palaeoproterozoic (ca. 2.1 Ga.) age. This was followed by collisional orogenesis attaining high geothermal gradients leading to intracrustal melting and differentiation process generating high-K metagranites in the Palaeoproterozoic (~1800 Ma). The crystallization of high-K metagranites is highly comparable with the doubted Palaeoproterozoic granulite-facies metamorphic age (Bartlett et al., 1998; Braun et al., 1998) and possibly indicates intracrustal melting as a consequence of this high thermal event formed in a collisional setting. The younger magmatic crystallization ages (ca. 1.56 Ga) of K-feldspar megacryst granites (Kröner et al., 2012) are correlated in terms of subduction cessation of the convergent continental margin in a continent-arc setting. The latest phase of crustal addition is the felsic magmatism occurred in the form of granites, syenites, and pegmatites throughout the east Gondwana province during Pan-African time. These are essentially alkaline in nature and are interpreted as a product of post-collisional rifting indicating a phase of orogenic collapse and extension tectonics. Though the geochronological data represent a wide time span for crustal growth in the KKB from the Mesoarchaean era and continuing to the Pan-African, each event is restricted to a distinct period representing a complex tectono-metamorphic history of KKB. The reported magmatic and/or metamorphic ages of KKB are comparable with the major global orogenic cycles and crustal growth events. Therefore, it can be assumed that the crustal growth and evolution within the KKB are of episodic nature.

G. R. Ravindra Kumar and C. Sreejith

Funding: DST, GoI

1.1.2 Mafic dykes

Integrated palaeomagnetic and geochemical investigations constitute an ongoing long-term program for understanding the geodynamic evolution of the Earth during the Proterozoic and Phanerozoic times with special reference to the Indian shield. Further, geochemical studies unravel the petrogenetic history of the continental magmatism and the evolution of the mantle processes under the Indian shield. During the reporting period emphasis is given to the mafic dyke intrusions of the Bundelkhand and the Bastar cratons. The palaeomagnetic results obtained from 610 samples in the previous years have been further evaluated to define the characteristic remanent magnetisations. These results are the potential sources for tracing the location of the Indian shield within Palaeoproterozoic supercontinent reconstructions. The derived palaeopoles are integrated with recently reported U–Pb isotopic ages from the Bundelkhand and Bastar cratons and correlated with palaeopoles from the mafic dykes in the Dharwar craton, South India. characteristic remanence identified in these dykes are classified into (i) steep upward/downward components further sub-grouped as ca. 2.37 Ga steep 1 (? = 10.2°S; Ö = 75.0°E; A_{95} = 18.1°

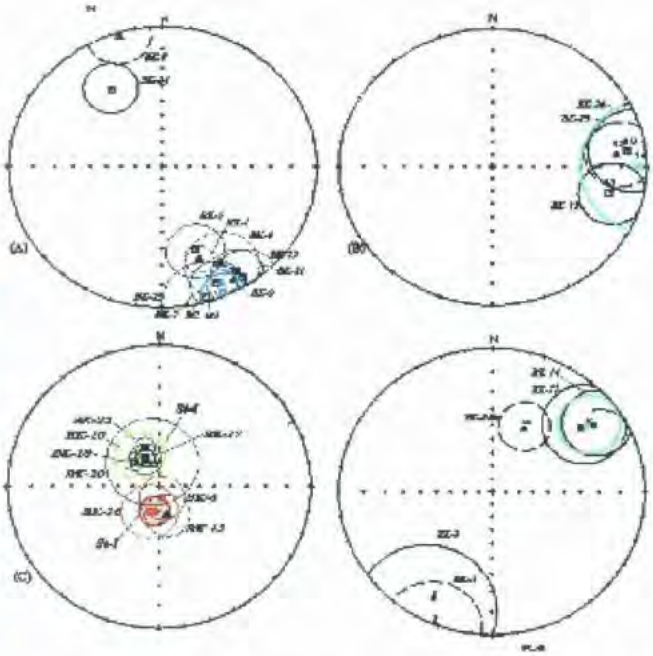


Fig. 1.1.2.1 Equal-area projection of Palaeoproterozoic dykes of Bundelkhand craton showing mean ChRMs with A_{95} confidence circles for the distinct groups of northwest/ southeast shallow (A), near easterly/ westerly (B), steep (C) and northeast/ southwest shallow (D) directions. Circles of continuous and broken lines represent lower and upper hemispheres, respectively. M1 and M2 in (A) are the mean of our study and the mean of combined results of our study and Pradhan et al. (2012). BK-Mo is the Neoproterozoic Mohaba dyke direction (Pradhan et al., 2012).

in Bundelkhand and ? = 22.3°N; Ô = 71.4°E; A_{95} = 21.6° in Bastar), component comparable with ca. 2.4–2.45 Ga steep 2 group from one dyke in Bundelkhand (?= 14°S; Ô = 101°E; A_{95} = 26.1°) and one dyke in Bastar (? = 6°N; Ô = 113°E; A_{95} = 26.5°). A steep component (? = 60.4æ%N; Ô = 45.3æ%E; A_{95} = 9.7æ% in Bundelkhand and a comparable component ? = 49æ%N; Ô = 129æ%E; A_{95} = 15.1æ% from one dyke in Bastar) is not assigned an age at present. (ii) ca. 2.18 Ga shallow easterly and antipodal shallow westerly components (? = 0.4°S; Ô = 347°E; A_{95} = 21.6° in Bundelkhand and ? = 18.0°N; Ô = 344.0°E; A_{95} = 8.1° in Bastar) and (iii) 1.99 Ga shallow northwest and antipodal shallow southeast (? = 57.5°N; Ô = 309.0°E; A_{95} = 4.7° in Bundelkhand and ? = 39°N; Ô = 321°E; A_{95} = 28° in Bastar). A group (iv) of <"2.2 Ga northeast shallow components (? = 36.0°S; Ô = 357.0°E; A_{95} = 9.4°) is found only in the Bundelkhand craton (Fig. 1.1.2.1).

The distinct groups of palaeomagnetic pole determinations from dykes of the Bundelkhand and Bastar craton exhibit a remarkable match with palaeomagnetic poles determined from Precambrian mafic dykes in the Dharwar craton. The close comparison of mafic dyke magnetisations between the cratons suggests close proximity since 2.45–2.5 Ga.

These results are interpreted that models suggesting amalgamation of crustal blocks along the Central Indian Tectonic Zone at 1.8 Ga or at 1.0 Ga collision along this zone to form Rodinia are untenable. The results further suggest that proposed NeoArchaean-Palaeoproterozoic supercontinent reconstructions showing a north China–India linkage or India's close proximity to Slave craton to form a supercraton 'Sclavia' are not supported. Instead, the data are compatible placing India in close proximity to the Yilgarn block of Western Australia (Fig. 1.1.2.2).

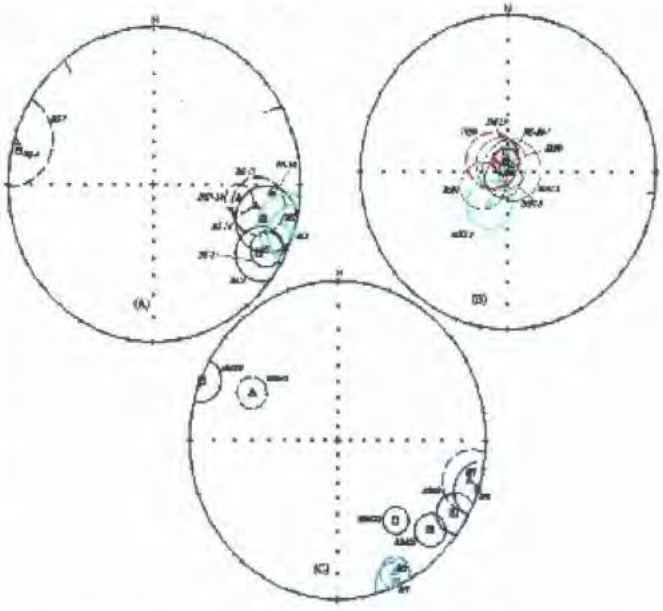


Fig. 1.1.2.2 Equal-area projection of Palaeoproterozoic dykes of Bastar craton showing mean ChRMs with A_{95} confidence circles for the distinct groups of near easterly/ westerly (A) and steep (B) directions. In (C) the directions reported by Meert et al. (2011) are projected; two sites (1532 and 1527) spatially closer to the southeast shallow confidence circles from Bundelkhand craton (M1 and M2 sky blue). The other three directions have better overlap with the confidence circles of near easterly shallow (or antipodal) directions shown in Neptune blue. Circles of continuous and broken lines represent lower and upper hemispheres, respectively.

Archeaomagnetism

Determination of new Archaeo Intensity data from all over the world is recognised to be a very important topic of research because these data may help to better constrain the available global geomagnetic field models over the past few millennia. Unfortunate-ly reliable Archeo/paleo intensity and palaeodirec-tion data are very few from the Indian subcontinent (Fig. 1.1.2.3). We have taken a new initiative to employ artifacts for studying the long term behavior of the Earth's magnetic field. Archaeological materials like pottery can acquire, under certain conditions, a stable magnetization and can be used for AI research. The sample selection criteria for more reliable palaeointensity determinations is very rigorous and

appropriate materials for reliable determinations are very rare and hence accurate estimations are extremely difficult. The work is done in collaboration with Department of Physics, Annamalai University.

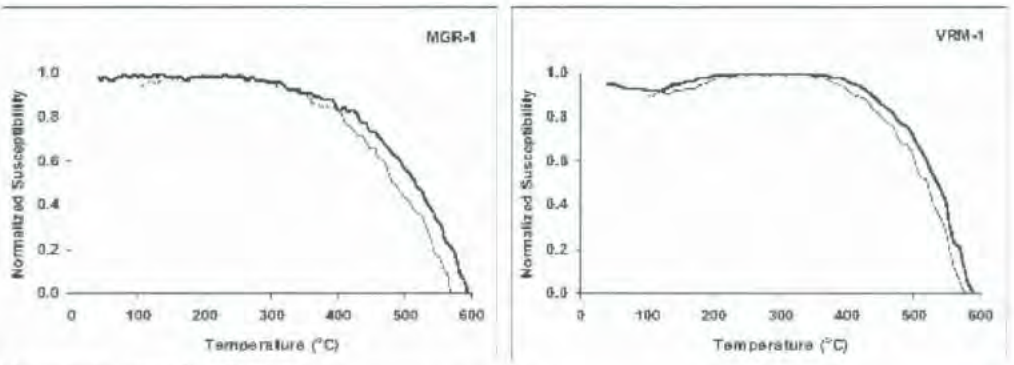


Fig. 1.1.2.4 High temperature behavior of the magnetic susceptibility-temperature curves for Marungur (MGR) and Vadaharirajapuram (VRM) sites sample. Thick line and thin line represent heating and cooling curves respectively

The present study investigates 60 archaeological pottery samples from two different archaeological sites of Marungur:1°27'43"N; 79°24'01"E and Vadaharira-japuram:10°27'140'N; 79°25'08"E in Tamilnadu. The inscriptions suggest 200-300 BC and 200-100 BC for both the sites respectively. Various rock magnetic analyses (include magnetic susceptibility, frequency susceptibility- temperature-susceptibility experiments and isothermal remanent magnetisation) have been used to screen the suitability of samples for reliable AI measurements. Thermo-magnetic (ð-T) curves for most of the samples during the heating-cooling cycle indicate the presence ofstable magnetite as the main magnetic mineral. Typical heating-cooling curves are shown as examples in Fig. 1.1.2.4. AI values were estimated using Zero field/infield (ZI) method, which is a modified Thellier -Thellier technique. Sample data processing and interoretations are in progress.

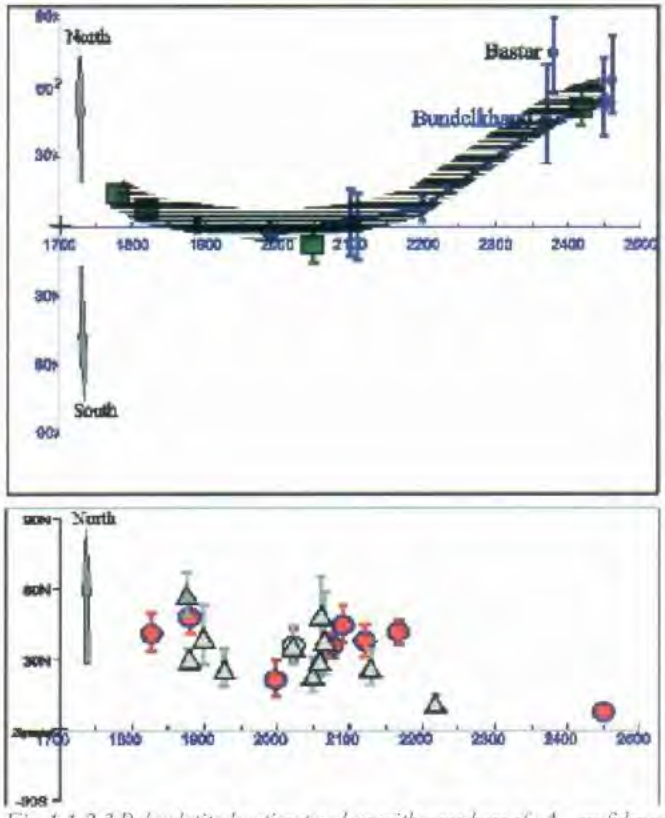


Fig. 1.1.2.3 Palaeolatitude estimates along with error bars of A_{95} confidence limits from (A) the Palaeoproterozoic dykes of Bundelkhand and Bastar cratons (blue) compared with the palaeolatitude data from western Australia (green). In (B) the palaeolatitude estimates for the same period from Kaapvaal (grey) and Laurentia (red) are also plotted for comparison. Palaeolatitude estimates from 2.03 Ga Lac de Gras diabase dykes in the Slave craton is marked in yellow.

T. Radhakrishna
Funding: DST, GoI

1.1.3 Tracing source to sink link in placer deposit formation of Kerala (MoES 8)

Studies over the years on beach placers of the Kerala coast have apparently delineated the crystalline rocks of the Western Ghats as provenance. In spite of long history of commercial heavy mineral exploration and mining of Kerala beach placers, information on heavy mineral assemblage and geochemistry are meagre for provenance analysis. Our recent petrological and geochemical studies of the lower crustal granulites from southern India suggest time-space and compositional variation in various rocks that constitute the crystalline rocks of the Western Ghats. We recognise mineral compositions and mineral chemical variation with respect to protolith composition is important and can provide infallible guide in understanding source, transportation and deposition of placer mineral. From our preliminary studies we also noted that the compositional signatures of heavy minerals of the beach placers along the coast faithfully reflect various petrographic units of the source area. This petrogenetic diversity provides an ample scope to re-examine the source-to-sink relation between heavy minerals in the placers and provenance. Unfortunately there has been no study of geochemistry of heavy-mineral grains in understanding the provenance

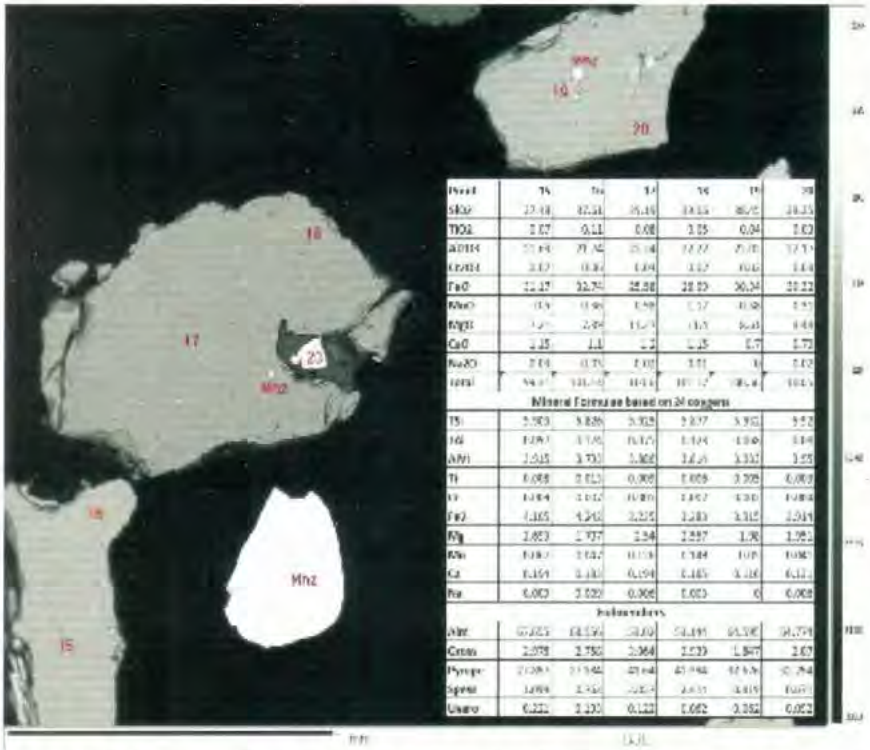


Fig.1.1.3.1 Backscattered image and microprobe results of garnets. Points are of individual spots analysed. Distinct variation in the mineral composition of individual grains, indicating differing source rock composition is seen.

decided to use garnet chemistry, with its composition potential as solid-solution between seven principal end-members, in characterising compositional variation in different types of garnet bearing lithology and comparing the same with chemistry of garnets in beach sediments.

Fig. 1.1.3.1 shows backscattered image of garnets in one of the sample locations and microprobe data for major elements. Distinct variation in the garnet composition, indicator of differing source rock composition is seen. Also seen are grains and inclusions of monazite (mnz) in garnets, being studied for REE and chemical ages.

G.R. Ravindra Kumar, T.N. Prakash and V.N. Rahul
Funding: MoES, GoI

as this could help in in the better identification and differentiation of source rock, and has potential to provide a deeper knowledge of the provenance history. This idea prompted us to examine the chemical composition and chemical ages in selected heavy minerals in placer deposits of Kerala coast in relation to petrogenesis and time of formation of probable host rocks in the hinterlands.

Detailed petrographic analysis of major rock types in the source region and analysis of grain mounts of beach sediments collected from Pozhiyoorkara to Alleppy were carried out as part of the Ministry of Earth Sciences sponsored project. More than 30 samples were collected. The study revealed provenance can be traced by comparing the orthopyroxene, hornblende, ilmenite, garnet and zircon populations. Since mere physical comparison would not help in tracing to the specific source we embarked on analysis of major, trace and REE of minerals. Of all the minerals present in placer deposits, garnet is the most useful in provenance studies as it is present in all the rock types of source region, possesses wide compositional range, strong relation to whole rock composition, and stability and ability to withstand.Garnet is a common accessory mineral accounting to about 10-15% in the hinterland rocks. They are important accessories in rocks occurring to the south of AKSZ. In beach sediments of the southern province of Kerala garnet is very abundant. Therefore we

1.1.4 Palaeo Fluids in the Petroliferous Basins of Western Offshore, India (MoES-7)

This research project on palaeo fluids in the sedimentary fill of the petroliferous basins of western offshore is a micro-scale effort to utilise the tool of fluid inclusion micro thermometry to verify and compare the fluid regimes including hydrocarbons that were in play in the offshore sedimentary formations especially in the Mumbai offshore and the Kerala offshore basins. It is a collaborative effort of Centre for Earth Science Studies and Oil and Natural Gas Corporation (ONGC). The project aims at acquiring various technologies in India to employ fluid inclusion technique in oil exploration activities.

In sedimentary basins, during the diagenetic evolution of sandstones, fluids are trapped as inclusions during the growth of cements or micro-fracture healing in detrital grains. They are assumed to be closed systems whose volume and composition have not changed since the time of trapping. If they are located in a single fluid inclusion assemblage (i.e. a group of fluid inclusions that come from the most finely discernible event of inclusion entrapment), their micro thermometric values would be consistent and would represent a single event. Hydrocarbon inclusions are manifestations of hydrocarbons present at the time of cement crystallization or trapped during a later on fracturing

cum fluid flux events and can be used as a tool for studying HC migration.

During 2012-13, sophisticated equipments like automated disc polisher, double disc polisher, etc., procured for the project were practically put to test, protocols for analyzing the core samples were set, fluid inclusions in the sandstone reservoirs including Hydrocarbon Fluid Inclusions (HCFIs) entrapped in the post crystallization fractures in quartz grains were located. Polished fluid inclusions micro thin wafers were prepared in the 'lapidary facility' of CESS. Petrographic, micro-spectroscopic as well as micro-thermometric studies were performed on the fluid inclusion plates prepared from the ONGC RV1 Well sample (Offshore to Ratnagiri, south Mumbai Basin). Petrographic studies were performed using a automated digital microscope. The bright field as well as the fluorescent images of the fluid inclusions were taken.

Fluid inclusions observed could be categorised into mono phase, bi phase and multiphase depending on the phases present in the cavity. The primary fluid inclusions are mono phase as well as bi phase. The secondary fluid inclusions (bi phase and multi phase) were also found largely in the quartz and feldspar grains of siltstone / sandstone and might have been trapped along the fracture after the formation of the host mineral by re-healing process. It can be recognized by their occurrence in trails or cluster that often cut across grain boundaries (Fig.1.1.4.1 A-C). Shapes of the biphase fluid inclusions were also observed and were varied from rounded, sub-rounded to slightly elongated in nature and the size fluid inclusion ranges from 2 to 20 µm. Gas bubbles showed pseudo-brownian motion in most of the bi phase fluid inclusions. Bi phase fluid inclusions are dominated over mono phase fluid inclusions in the same grain of the host minerals. Multi fluid inclusions are also present in the grain of the host minerals and show solid, liquid and gas phases (Fig. 1.1.4.1 D).

Fluid inclusions are generally fluorescent if they contain cyclic or aromatic hydrocarbons or fluorescent daughter minerals. The hydrocarbon fluid inclusions (HCFIs) are shown in Fig. 1.1.4.2 The fluorescence colour of the inclusions were examined using D-filter- long pass 470 nm and band pass 355 - 425 nm filters. The bluish colour observed are from HCFIs from deeper horizons (3270-3275 m) of Eocene sandstone reservoir beds. The colour is an indirect measure of maturity of HC in lower horizons. The fluid inclusions observed in samples from *Panna Formation* offshore of Ratnagiri were primary as well as secondary. The primary and secondary inclusions include both mono phase and bi phase inclusions. Hydrocarbon inclusions showing strong fluorescence were observed. Secondary fluid inclusion trails which are of hydrocarbon in nature were observed. The HCFIs we observed are from deeper horizons of Palaeocene – Eocene sandstone siltstone reservoir beds in the RV-1 Well. Lot more wafers have to be looked into especially middle to late Eocene and early Oligocene carbonate deposits and Early to middle Miocene limestone beds with a caution of poor sightings of fluid inclusions in calcite.

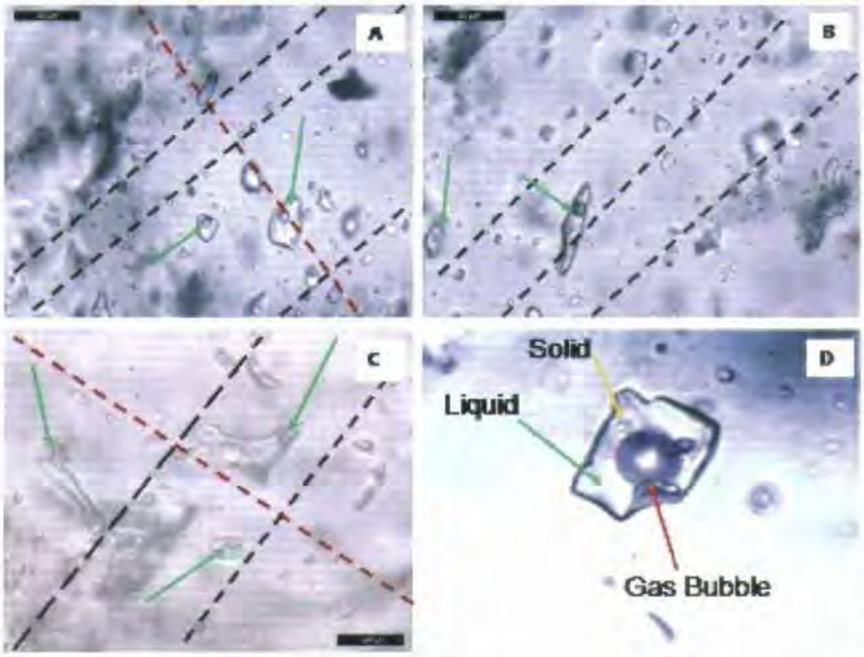


Fig.1.1.4.1 Photomicrographs showing trail of fluid inclusions over the planes of quartz. Biphase fluid inclusions are shown in A, B and C and multiphase fluid inclusions D

Microthermometric studies were performed using automated Linkam Heating freezing stage fitted on a microscope in the Geo Fluids Research Laboratory (GFRL). Microthermometric studies were performed on both non - HCFIs as well as HCFIs. Studies confirmed the presence of the carbonic inclusions, aqueous inclusions as well as hydrocarbon inclusions. The temperature of first melting (T_{FM}), temperature of last melting (T_{LM}) and the homogenisation temperature (Th) (both liquid to vapour and vapour to liquid) of different inclusions were measured in GFRL.

Homogenization temperature T_H of aqueous inclusions ranges between 120 and 140°C. Petroleum inclusions show T_H values between 20 to 160°C (Fig. 1.1.4.3 a). The salinity value of the aqueous inclusions

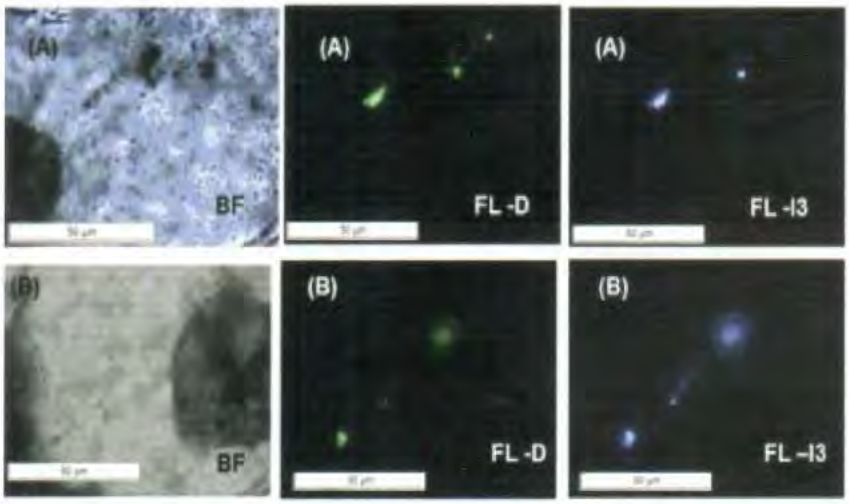


Fig. 1.1.4.2 Hydrocarbon inclusions in bright field (BF) and fluorescent light (FL) using D and I3 filter cubes

environment conducive for oil and gas generation in the geological past. The homogenization temperature of the HCFI, with the available data, indicates that a high level of maturity has been achieved in oils and the bluish white fluorescence colour also is indicative of commercially most viable lighter oils in the Panna Reservoir horizons.

V. Nandakumar, H. Upadhayay, N. Babu, R. Sreeja, S. Arun Lal & S. S. Anoop

Funding : MoES, GoI

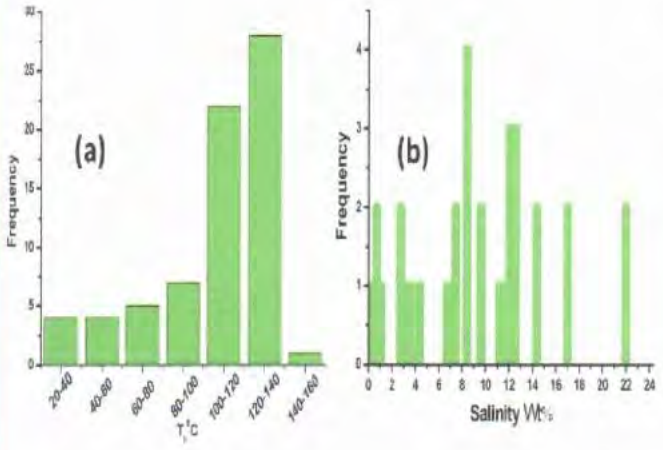


Fig. 1.1.4.3 Variation of Homogenisation temperature T_h (a) and salinity of fluid inclusions (b).

varies from 2 to 22 (Fig.1.1.4.3 b). The observed homogenisation temperature range of 80 -160^{0}C range observed for the criss-crossing secondary trails for the fluid inclusions in some sample indicate that there were several episodes of thermal cracking conducive for oil and gas generation.

Some inclusions appearing to be isolated primary as well as secondary ones also show $T_H > 160^0$C. These inclusions are interpreted to be the inherited ones from the provenance of the detritals, with no relation to the oil genesis or could be due to deep burial based on a later tectonic episode.

Micro thermometric observations corroborate with the petrographic observations. Microscopically we are observing the presence of oil and gas inclusions and micro-thermometrically we are proving the existence of a palaeo-

1.1.5 Graphitization process in Kollam District, Kerala, India

Graphite is a widespread and common accessory mineral, which occurs in a variety of rocks, formed under different geological settings. The most predominant way in which it is formed is the highgrade metamorphism of organic matter, trapped in sediments. It can also be formed by the decarbonation of carbonate rocks and by magmatic processes. Its source can be inferred from the content of ^{13}C. Graphite once fully crystallized is highly inert and has the role of index mineral in determining the grade of metamorphism.

Fig.1.1.5.1 Representative SEM Photomicrographs

The multi-parametric approach envisaged under this project is the first of its kind to bring to light the various aspects of graphite mineralization in the study area. Detailed and systematic field and laboratory-based studies are to be

undertaken to achieve the following objectives: (1)To identify and classify different types of graphite, associated with different environment, based on their physico-chemical characteristics (Field associations), (2) To elucidate the P - T conditions and formative environment of the graphitization process by examining their structural variability and morphological features by Scanning Electron Microscopy (SEM), degree of crystallinity by X-Ray Diffraction (XRD) technique and thermal decomposition pattern by Thermo-Gravimetric Analysis (TGA) and (3) To find out the source of carbon for graphitization using Stable Carbon Isotope Studies as a tool.

Extensive field work was conducted in three taluks of Kollam district and graphite bearing rock samples having different mineral assemblages were collected from khondalite suite of rocks or khondalite and its variants like Quartzo-feldspathic gneiss, Garnet-Biotite gneiss, Garnetiferrous Biotite Sillimanite gneiss. Graphite is associated mainly with garnet and biotite and in some cases, there is an association of sillimanite also. All the processed samples were analysed for XRD, SEM, TGA and Stable Carbon Isotopes. The processing is a very hard, tedious and time consuming task. The samples were crushed to separate the graphite flakes, which were handpicked and treated with 1:1 HCl and kept on a hot plate at about 100° C, to remove iron oxides and carbonates, several times till the supernatent solution becomes colourless.

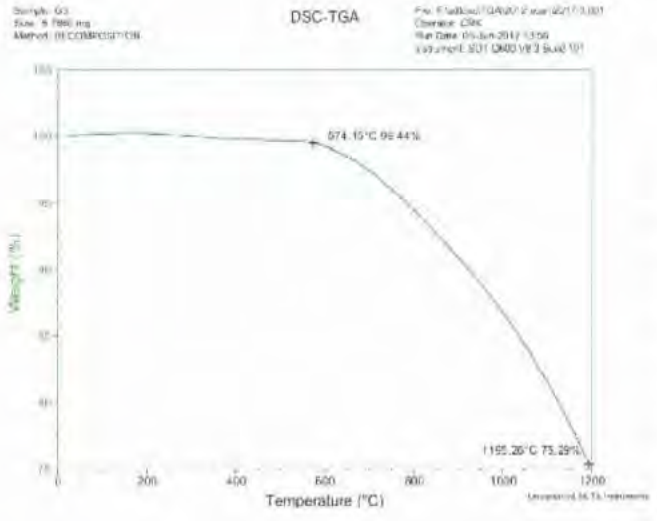


Fig. 1.1.4.2 Representative Thermograms

This was followed by heating with HF to make them free of silicates. The samples thus treated were washed thoroughly, dried and powdered in agate mortar. The XRD results reveal the orderly nature of graphite as evidenced by sharp and well defined peaks, having inter-planar spacing (d_{002}) values between 3.34A° to 3.35A° & 1.67A° to 1.68A°. The values are strictly in concordance with thosefor highly ordered standard graphite, crystallized with a hexagonal frame work having perfect hexagonal layers of carbon atoms showing parallelly ordered stacking sequence. The SEM photomicrographs (Fig. 1.1.5.1) display a unique morphology of six-sided basal sections, perfect micaceous cleavage and the arrangements of well formed individual layers in a regular book - type stacking sequence.

The Thermal decomposition pattern shows that the starting decomposition temperature for most of the samples is around 575 °C and the maximum thermal decomposition temperature is 1195 °C. The stable carbon isotope values fall in the range of -6.4 $^{0}/_{00}$ to -22.3 $^{0}/_{00}$. In general, the graphite samples from all the localities are flaky in nature which show that they are of very good quality. Since the analytical technique for stable carbon isotope is not available in India, the same was done in collaboration with Prof.Tony Fallick of Scottish Universities Environmental Research Centre (SUERC), UK. The results show that the samples from Manjappara, Nilamel, Cherukara, Eyyappacha, Ottumala and Karalikonam have a tendency of remobilized origin whereas the samples from Chithara, Boundarymukku, Azhanthakuzhi have a tendency of sedimentary origin. The sample from Arayil has a value which strictly falls in line with that of standard graphite of sedimentary origin. The remaining work is in progress.

Ansom Sebastian

1.1.6 Quaternary Geology and Geomorphic Evolution of the coastal lands, Kollam district and its adjoining areas, SW India

Like other parts of the tropical and sub-tropical coasts, the southwest coast of India also witnessed exceptional climate and sea level changes during the Late Quaternary period. These changes were well recorded in the 50 – 60m thick deposits of the South Kerala Sedimentary Basin (SKSB) and adjoining coastal lowlands. For the present study, sedimentary deposits in the coastal lands between Pallikkal River in the north and Ayroor River in the south have been chosen for decoding the palaeoclimatic and sea level changes recorded in these sediments. In the study area, the Late Quaternary sediments rest over the Neogene deposits (Quilon and Warkalli Formations) and/or the Precambrian crystalline rocks.

The Late Quaternary deposits are represented by alluvial clays, sandy clays, peat and coastal sands. Patches of shells with marine and brackish water affinity are recorded at

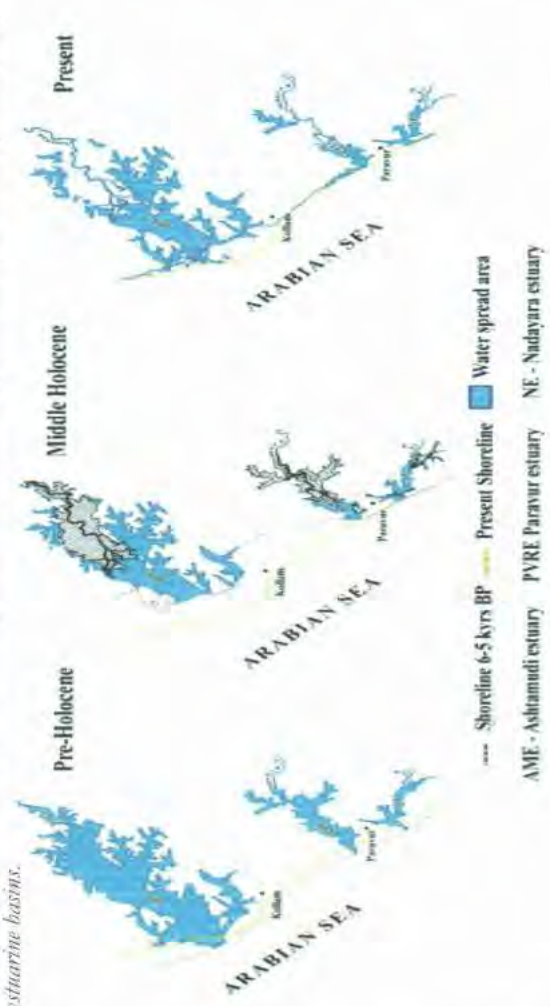


Fig. 1.1.6.1 Pre - Holocene, Middle Holocene and Present day scenarios of the coastal lowlands of Kollam district and adjoining areas showing the evolutionary phases and formation of fresh water bodies in the upstream end of estuarine basins.

certain places. The borehole cores collected from the river confluence zones are composed of silty clay and sand. The older coastal plains are covered generally by fine to very fine, quartzose sands whose base is marked either by laterite, lateritic pebble bed or by weathered crystalline rocks. The study reveals that the Early Holocene was characterised by heavy rainfall and excessive input of terrigenous sediments into the coastal wetlands which is separated from the nearby sea by barrier beaches. Marine transgression that affected the area attained its peak at 6 - 5 kyrs BP (Fig. 1.1.6.1). The climatic and sea level conditions of the Early Holocene were favourable for the development of Bay Head Delta in the landward end of the estuarine basins while Flood Tide Delta in its seaward end. Progradation of alluvial sediments and river meandering over its own deposits during Early-Middle Holocene were instrumental in the cut-off of some of the prominent arms of the Pre-Holocene basins into separate wetland bodies like Sasthamkotta and Chelupola lakes, and Chittumalachira wetland in Ashtamudi basin, Kotta lake and Polachira wetland in Paravur basin, and Poovankal wetland in the Nadayara basin. In short, the present configuration of the wetlands and the associated landform features in the Kollam coast is the outcome of the combined effects of sea level and climate changes to which the coast has been subjected during Late Quaternary period.

D. Padmalal and K. Maya

1.1.7 Investigation of landslides and land subsidence

Land degradation due to land subsidence by soil piping or subsurface (tunnel) erosion has become a regular feature during monsoon months in the highlands of our state. There are many incidences of land subsidence occurring in the state, most of them often remain unreported. Recent incidences occurred in Upputhara locality (Fig. 1.1.7.1) of Idukki district and Kuttikol locality of Kasaragode district evoked wide media attention.

During the last decade many piping incidences were reported from different parts of the state. CESS had investigated many such incidences reported by the Revenue department. Subsidence due to piping have been reported from places like Cherupuzha (Taliparamba taluk, Kannur district), Thirumeni (Taliparamba taluk, Kannur district), Palakkayam (Mannarkkad taluk, Palakkad district), Pasukkadavu (Vadakara taluk, Kozhikode district), Padinjareathara and Kunnamangalam Vayal (Vythiri taluk, Wayanad district), Venniyani mala (Todupuzha taluk, Idukki district), Peringassery(Thodupuzha taluk,Idukki district),Thattekanni (Thodupuzha taluk, Idukki district), Udayagiri (Udumbanchola taluk, Idukki district), Ranni (Ranni, Pathanamthitta taluk).

Fig. 1.1.7.1.Opening of a tunnel resulted from land subsidence (Upputhara, Idukki-2013)

A project to study this phenomenon funded by the National Disaster Management Authority (NDMA) was intiated during this period. The study aims to document piping affected localities, envisaging methods to delineate piping, analysis of physical and chemical parameters to determine

the causative factors, devising mitigation etc.

Tunnel erosion (Fig. 1.1.7.2) also known as "Piping", is the subsurface erosion of soil by percolating waters to produce pipe-like conduits below ground especially in non-lithified earth materials. This is a type of mechanical soil movement where by fine subsurface sediment moves in underground channel ways through permeable materials. Piping can affect materials ranging from clay-size particles (less than 0.002 mm) to gravels (several centimeters), but is most common in fine-grained soils such as fine sand, silt, and coarse clay. During rain percolating waters carries finer silt and clay particles and forms passage ways. The resulting "pipes" are commonly a few millimeters to a few centimeters in size, but can grow to a meter or more in diameter..

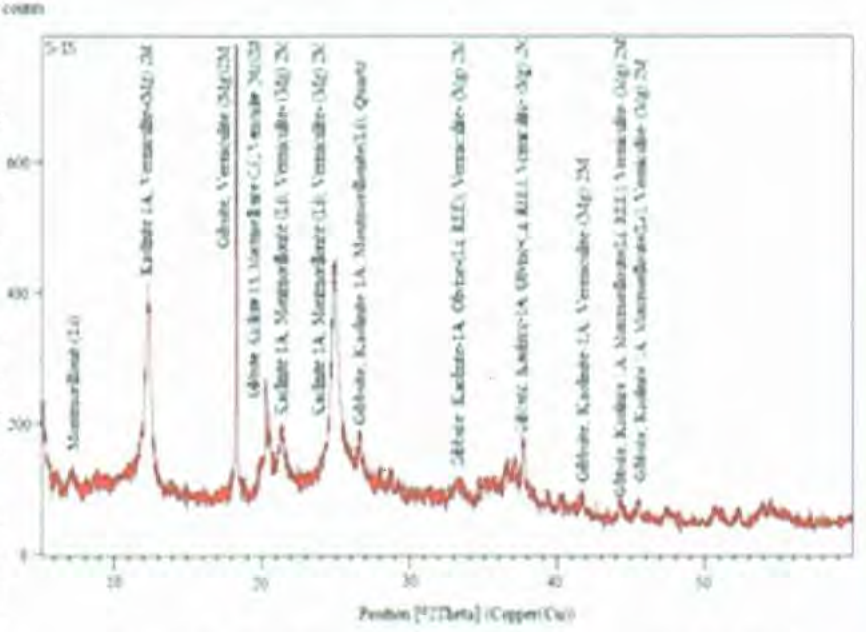


Fig. 1.1.7.3 XRD Main Graphics Analyse View of a sample from Idukki

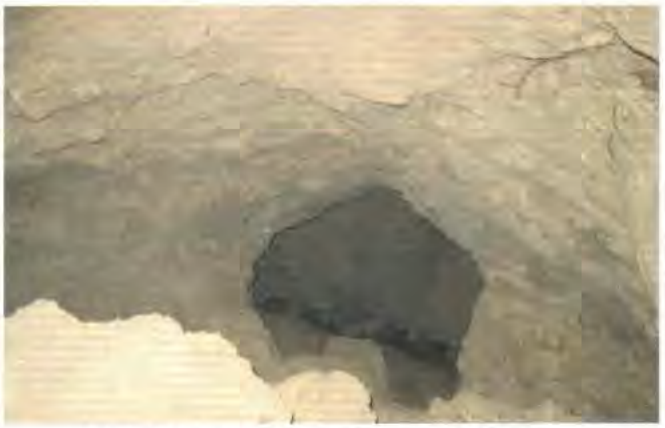


Fig. 1.1.7.2 Inside the tunnel (Tattekanni, Idukki)

Field investigations were initiated in the affected localities of Kannur and Idukki districts. Detailed field investigations were started in the Kottathalachimala near Cherupuzha in the Taliparamba taluk of Kannur district. Field work was carried out to collect soil samples from different soil horizons in the affected area. Electrical resistivity surveys using analogue resistivity meter were carried out to know the subsurface pattern of the tunnels. Soundings and profiling were carried out using different electrode spacings to locate the pipes/voids located below the ground surface. 2D Electrical Resistivity Imaging was experimented using a digital DC Resistivity/IP Meter.

Sediment samples were subjected to XRF and XRD analyses, textural analysis, dispersion tests etc. For hydrological and meteorological data collection, a V-notch weir was constructed and an Automatic Weather Station was installed in one of the selected watersheds in Kottathalachi mala, Kannur district.

According to the XRD results (Fig. 1.1.7.3), minor amount of gibbsite and kaolinite are more dominant minerals followed by minor amount of Quartz, Muscovite ($KAl_2(AlSi_3O_{10})(F, OH)_2$) and Vermiculite.

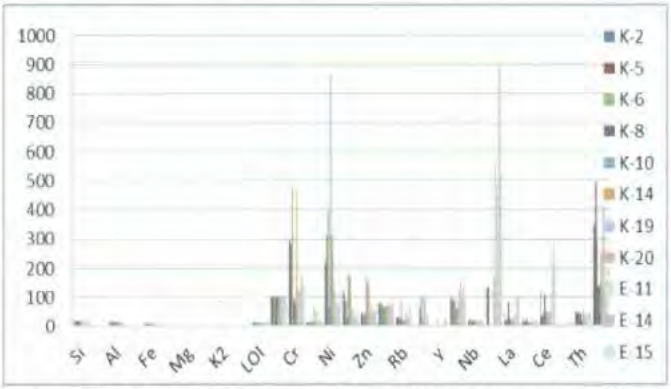


Fig. 1.1.7.4 Graphical representation - XRF analysis (samples: K – Kannur; E – Idukki) major elements of oxide (%), Trace elements (ppm)

Fig. 1.1.7.5 Electrical resistivity survey in progress

Fig. 1.1.7.6 Construction of a v-notch

XRF analysis (Fig. 1.1.7.4) of samples show significant presence of Si, Al, Mn and Fe. There is no appreciable quantity of Na in the samples. Usually Na plays an important role in the chemical erosion process.

Experiments were conducted using various geophysical tools like resistivity surveys (Fig. 1.1.7.5) and geophones to locate and map underground pipes. Hydrological and meterological data collection were started during this period. Met-station was established with an AWS at Kannur and a v-notch (Fig. 1.1.7.6) was constructed with flow meter to collect data of hydrologic parameters. The mitigation trials are expected to commence soon in a piping affected locality in Ranny. The project is expected to be completed in 2015.

G. Sankar
Funding: NDMA

1.1.8 Monitoring Indian Shield Seismicity with 10 BBS to understand seismotectonics of the region using V/Sat connectivity

Centre for Earth Science studies operates a broad band observatory at Peechi in the campus of KFRI since 1999. It is one of the 10 Broadband stations setup by DST (now funded by MoES) to strengthening earthquake monitoring in the peninsular India and for improving the detection and location capabilities of earthquakes in the shield region. The data recorded here is used for the studies of local/ regional earthquakes. The observatory plays host to a remarkable 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 have been routinely carried out and the details have been sent to the IMD on half-yearly basis. Data up to July 2013 were sent to National Seismic Database Centre of IMD. The continuous data are being transmitted online to NGRI, Hyderabad through V-Sat connectivity.

The Observatory is maintained well. During March 2012 - February 2013, the station recorded 2062 earthtremors. There were 1886 global events, 29 events from other parts of India (mainly from-Maharastra, Sikkim-Nepal border, Rajastan, Madhyapradesh, Hariyana, Assam, Uttaranchal) and 29 from Andaman-Nicobar region. Among the regionalevents, 16 events are from the neighboring area of Tamil Nadu (mainly from Vallakovil, Dharapuram, Thiruchirappily, Chettikurissy, Kambam, Thenkasi), 7 from Karnataka (Madikkeri, Dommanagodu, Mysore), 3 from Andra Pradesh (Prakasam Dist.). There were 9 global earth

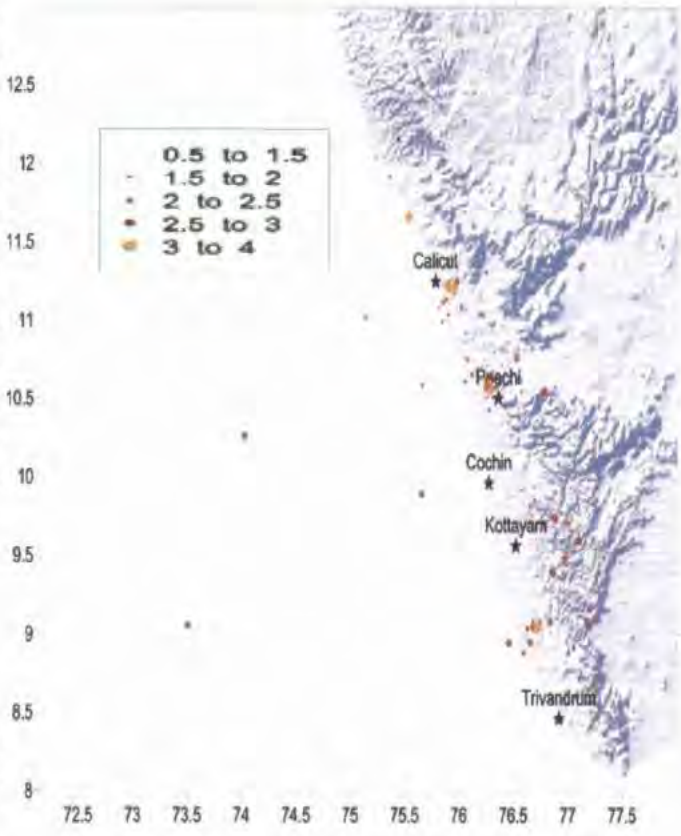


Fig. 1.1.8.1 Tremor recorded in Kerala during 2012-13

quakes having magnitude >=7. These were from Chile, Mexico, W cost of N Sumatra, Banda sea etc. Other than earthquakes, the observatory recorded local explosions.

There were 105 tremors from Kerala during this period. A few of them were not recorded/non-locatable due to low magnitude from distant places. The local events recorded in Kerala state are are shown in Fig. 1.1.8.1 The events were mainly from Thrissur, Kollam, Kozhikode, Malappuram and Idukki District. In the Thrissur district, the tremors were mainly from Thannikudam region. The main event that occurred on 19th July 2012 at 07:45:12 pm has a magnitude of 3.8 M_L. The location of the event is at Latitude 10.565°N and Longitude 76.271°E which is ~8.5 NW of Peechi station (1 km SE of Thanikkudam). The ground shaking, trembling and loud noise lasted for a few seconds. There was no serious damage, but developed minor hair line cracks in poorly constructed buildings roofs and walls in close vicinity to the epicenter and also in Kodassery village which is ~16 NE of the epicenter. The trembling and sounds similar to that of thunder caused panic among people in and around the epicenter. There were several aftershocks for this event. Field investigations were carried out and the investigation report was submitted to the Government of Kerala. Even though several tremors were felt from nearby regions from 2009 onwards, there is

minor increase in magnitude and frequency during this year. Tremors from Idukki have magnitude range of 0.5 to 2.7. Many of these events were felt by people near Venjurmedu. In Kollam district tremors were recorded from Kulathupuzha, Mannady, Konni, Pathanapuram, Puthur areas. Their magnitude ranges between 1.5 to 3.1.

Sreekumari Kesavan
Funding: MoES, GoI

1.1.9 Geophysical studies for locating tunnels near Sree Padmanabha Swami Temple, Thiruvananthapuram

Sree Padmanabha Swami Temple (Fig. 1.1.9.1) is one of the most famous temples in Kerala and is believed to be 5000 years old. A recent inventory of the Sree Padmanabha Swami Temple revealed the storage of vast treasure in the temple necessitating tight security measures to protect the same. One of the requirements for ensuring total security cover is to explore/ map the existence of tunnels, if any, in and around the temple.

Fig. 1.1.9.1 View of Sree Padmanabha Swami Temple

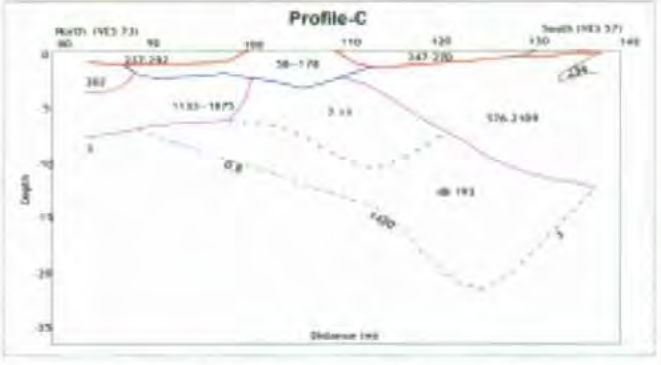


Fig. 1.1.9.2 Subsurface geo-electric model along profile-c (Inside Temple)

In order to locate this, a detailed geophysical survey was carried out in the Special Security Zone using electrical resistivity sounding and profiling. A total of 164 Vertical Electrical Sounding (VES) were performed out of which 73 were within the temple compound and the rest were outside. Making use of VES data, 9 Electrical Resistivity Profiles (ERP) were laid outside the temple compound and 14 inside. The VES data were used for generating apparent resistivity contour maps for different depth levels. The ERP

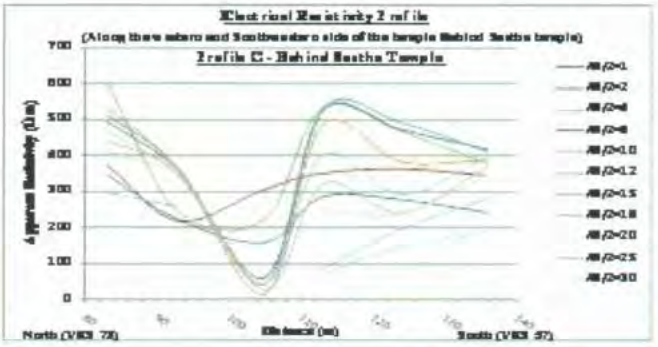


Fig. 1.1.9.3 Apparent resistivity variation along profile-c (Inside temple)

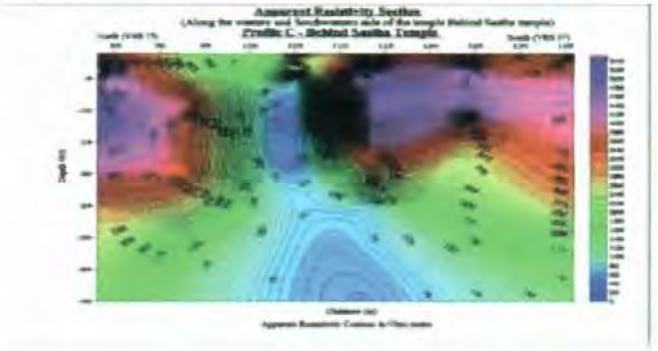


Fig. 1.1.9.4 Apparent resistivity section along profile-c (Inside temple)

data were used to generate apparent resistivity graphs and apparent resistivity sections along the 23 profiles to understand the lateral and vertical geo-electric characteristics. Further, the VES data were interpreted using a forward modeling software to estimate the layer resistivity and depth/thickness. Making use of the layer parameters, synthetic VES curves were generated and compared with the field VES curves for obtaining the best-fit and deducing the most appropriate layer parameters. The layer parameters, thus obtained, were used to develop geo-electric models along the pre-fixed profiles.

Fig. 1.1.9.5 Study area showing Electrical Resistivity profiles and sounding locations

The geoelectric mapping of the area revealed certain distinctive features characterized by conspicuous resistivity anomaly. The findings are to be validated / confirmed through controlled excavation at selected locations.

R. Ajayakumar Varma
Funding:Home Department, GoK

1.1.10 Quaternary evolution studies of Ernakulam District

Kerala state is endowed with fairly thick blanket of Quaternary deposits along the coastal plain. The Quaternary period spans roughly the last 2 million years of geologic time and is of critical importance in earth's history. It was during this period the major climatic events like the glaciations, sea level rise, emergence, submergence, transgression, regression, and the changes in the depositional environment occurred and the same has resulted in the development of backwater system, estuaries, river mouth migration, development of ridges, swales and formation of cities and towns. The Quaternary period is therefore very important and is closely associated with human development.

The Quaternary deposits in Kerala are scarce and their depth of occurrence is limited to 100m bgl. Ernakulam district in Kerala bears the richest manifestation of these deposits. A total of 17 bore-hole sediment samples were collected and detailed sedimentological and geochronological studies were conducted. Besides 25 surface sediments collected from different coastal plains were also studied for the textural and mineralogical characteristics. The present study has brought to light the presence of a large sedimentary basin along the coastal plains around Cochin estuary. The thickness of these dposits varies from place to place. Peat beds containing decayed wood having ~2 meters thickness were identified at locations surrounding the Cochin inlet at Willington, Mullavukad, Bolgatty, Vallarpadam, and Vaduthalla. Apart from peat, amber (wood-resin) were also collected from depths ranging from 45 to 50m at Willington, Mullavukad, Bolgatty, and Vaduthalla. However, thin bands of Peat, decayed wood, and black-clay rich in organic matter, yellowish-to redish-brown clay under various stages of its formation were also noticed from Maradu, Vyttila, Cheranellore, Panampalli Nagar, and Paravur.

We have carried out extensive chrono-stratigraphic and litho-stratigraphic studies on the bore-hole deposits using organic and inorganic proxies. The archival set up of the palaeo-environment that prevailed in the sedimentary basin for the formation of peat and decayed wood at depths 15-20m, 36-42m, 50-55m bgl respectively at Willingdon

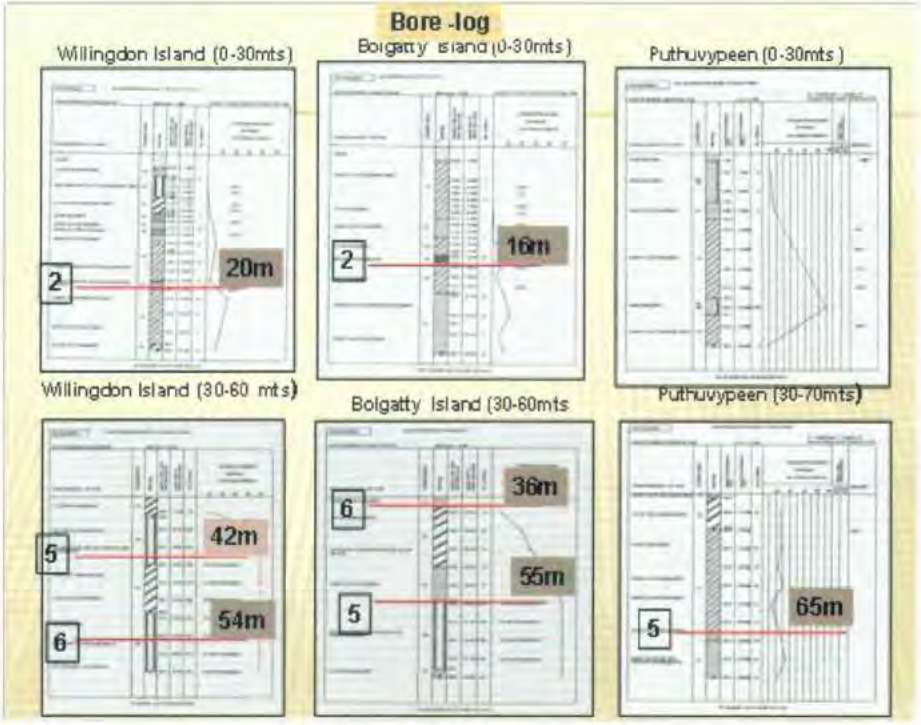


Fig. 1.1.10.1 Bore-log of three locations

island, Bolgatty Island, and at Puthuvypeen are provided (Fig. 1.1.10.1) during the Quaternary period.

Age determination by C^{14}methods was carried out for organic remnants (peat & shell fragments). C^{14} dating indicated age ranging from 52,300 YBP to 4,044 YBP.

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 at different Quaternary layers. The presence of these clay minerals assemblage at various depths in the bore-holes denote its relationship with the bedrock and soils of the drainage basins during its deposition. Fluctuations in the depositional environment ranging from high rainfall and good drainage condition leading to the formation of Kaolinite and poor drainage conditions leading to the formation of Montmorillite are evident. The presences of freshwater and saline depositional environment are reflected in the repeated

occurrence of these beds. The younger Holocene beds deposited at shallow depths are rich in shell deposits while the older peat deposits occuring at depths ranging from 40 to 60 m are devoid of any shell fragments. The Pleistocene clays are compact and denser and are rich in terrestrial sediments and plant debris formed under heavy rainfall conditions. The Holocene clays are less compact and / or semi-consolidated in nature.

In addition to the above area, the section from Tripunithura to Alwaye, covering a distance of 26 km, where the Cochin Metro Rail Project is being implemented has also been taken up for detailed study. Extensive drilling at a close interval of 250 m is progressing under the Metro Project. Collection of subsurface samples from these bore holes for dating are also being carried out. The additional data generated from this area will provide a golden opportunity to compare and derive comprehensive conclusions on the paleo-environmental conditions of Quaternary period.

John Paul & D.S. Suresh Babu

1.2 Atmospheric Processes

1.2.1 Measurement of cloud parameters and cloud modelling

Clouds have an extremely important and complex effect on climate due to their effect in modulating both incoming and outgoing radiation and strongly influence heat transfer in the atmosphere through the transport of moisture and hence its latent heat. Cloud base height was measured using a Ceilometer which employs the LIDAR setup at CESS in the Akkulam campus and at Braemore, a medium altitude hill station in Thiruvananthapurm district. Automatic Weather Stations installed at Braemore and CESS are used to record air temperature, wind speed, wind direction, relative humidity, rain, pressure and solar radiation. The cloud condensation nuclei are measured with a Water-based Condensation Particle Counter (WCPC) that can detect airborne particles from 5 nm to 3 μm in diameter An Electric Field Mill developed in CESS is used to record the Electric Field intensity.

G. Mohan Kumar

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

An empirical model for rain DSD(Drop Size Distribution) was developed and tested using data from a Microwave Rain Radar installed and operated at Thiruvananthapuram. A method to distinguish stratiform and cumuliform precipitation from ground-based observations was developed. A rain drop charge sensor was developed in CESS and operated. Data from optical disdrometer installed at Braemore were obtained and analysed. Optical disdrometer was installed at Augumbe, a rainforest station in Karnataka. The data were compiled and analysed.

Achievements:

1. A MRR was installed at Thiruvananthapuram and data collection was done.
2. An empirical model for rain DSD was developed and tested
3. Using the MRR data Z-R relationships and its variation with altitude was done and compared with international result and found good agreement.
4. Developed a method to distinguish stratiform and cumuliform precipitation from ground-based observations.
5. Designed & developed a rain drop charge sensor in the CESS Electronics Lab.

Highlights:

1. The rain DSD was found to fit well with a log normal distribution pattern compared to gamma and Marshall – Palmer distributions.
2. Using the log normal distribution, an empirical relation between DSD and rain rate has been derived and tested.
3. Characteristics of rainfall in the southern peninsula have been studied using the one minute rain rate data from disdrometer. The results show that the south west monsoon rainfall characteristics are similar at all these four stations.
4. The radar reflectivity factor variation with rain rate has been evaluated. The behaviour has been compared with standard Z – R relations.
5. The variation of Z – R with altitude has been studied.
6. The rain rate obtained from the disdrometer, MRR and manual rain gauge has been compared with the TRMM satellite data. The agreement between satellite and ground based data is good. The monthly data agrees better compared to daily data and this is better than the 3-hourly data.

Gap areas identified:

In-situ measurements of the rainfall parameters are few and have so many limitations, especially in the tropics, since the deployment of instruments and data collection is difficult due to extensive forest cover. Satellite measurements solve these types of problems. But the measurements and the retrieval of the parameters have

some limitations that the models and the algorithms developed so far use the data obtained from the in-situ measurements. Continued efforts are required in this area to overcome the above.The Project was completed in March 2013, and report submitted.

G. Mohan Kumar
Funding: Space Applications Centre, Ahmedabad

1.2.3 In-situ Bioremediation of Landfill Pollutants: Maximising the Remediation Potential of Select Indigenous and Exogenous Microorganisms

A study on the technique of in-situ bioremediation in reducing the toxicity of landfill pollutants is taken up under the Women Scientist Scheme, Department of Science and Technology, Government of India.

Fig. 1.2.3.1 Waste dumb near Chalai in Thiruvananthapuram

This study aims to determine the performance of a consortium of indigenous and exogenous microorganisms in reducing toxicity of landfill leachate and generated landfill gases.The Municipal Solid Waste (MSW) is an important issue world-wide and various waste management measures like recycling, composting, incineration etc, have been used. Sanitary landfilling is the predominant waste disposal alternative, but raises environmental concerns in the form of generation of landfill gas (LFG) containing methane and leachate which is an obnoxious effluent with many toxic compounds.

The in-situ bioremediation technique considers landfill as a bioreactor in which the stabilisation of waste is accelerated by incorporating various interventions like leachate recirculation, controlled aeration and use of a consortium of microrganisms. The methane from LFG will be reduced due to assimilation by methanotrophic bacteria.The organics, inorganics and heavy metals in leachate will be reduced using select chemoauto-trophic bacteria as well as fungal species. This technique does not require costly installations for recovery and purification of LFG or for leachate treatment units.

Fig. 1.2.3.2 Setting up of Model

The study will estimate the quantity and composition of LFG and leachate produced from each of the landfill models, the oxygen/air requirement for optimal remediation of landfill pollutants, the growth rate of select indigenous and exogenous microorganisms in the system and their efficiency. The exogenous microorganisms were selected based on their source, prospective remediation capability and growth conditions and were procured from Microbial Type Culture Centre, Chandigarh. These microorganisms will be cultured in the laboratories and inoculated into two of the landfill models for enhanced bioremediation and accelerated waste stabilization. A comprehensive procedure to reduce the toxicity of landfill pollutants will be developed based on the remediation efficiency of the above interventions.

Deepa Nair K
Funding : DST, GoI

1.3 Coastal Processes

1.3.1 Shoreline Management Plan for Kerala coast

The Shoreline Management Plan for Kerala is undertaken under a programme coordinated by ICMAM Project Directorate, Ministry of Earth Sciences, Chennai to develop coast specific management plans to address coastal erosion and related morphological modifications. Under this project coastal processes at Muthalapozhi (Veli-Varkala), Vatanappally (Munambam-Chettuwa), Kozhikode (Beypore-Puthiyapa) have been studied. Management options to control erosion and other coastal problems have been proposed for the above coastal stretches based on numerical model studies.

With the construction of the breakwaters for the fishing harbor at Muthalapozhi tidal inlet, significant beach build up on the south and severe erosion on the north of the breakwaters are observed. The harbour mouth is getting choked with sediment deposition and spit formation in the mouth making the harbour unusable. The Vatanappally coast is part of the Munambam-Chettuwa coast with harbor breakwaters at Munambam and Chettuwa. Mudbanks occur along this coast every year during monsoon. Over the years the location of mudbank occurrence has changed. Presently mudbanks occur along the Arattukadavu-Bhajanmadom-Kaipamangalam coastal sector.

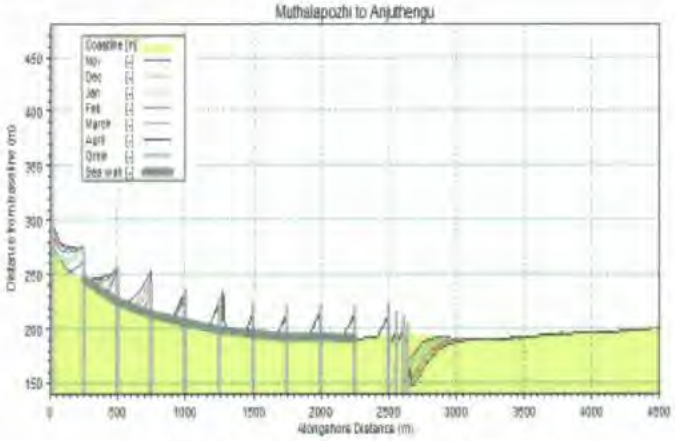


Fig. 1.3.1.1 Shoreline evolution along north sector of Muthalapozhi with groin field.

The coastal stretch from Vatanappally to Chettiwa has been identified as the most vulnerable coast. Kozhikode coast is confined between the harbor breakwaters at Beypore and Puthiyapa. Mudbanks form at Puthiyapa-Vellayil sector. Mudbanks reappeared in this sector in 2010 after a gap of about 10 years. The coast from Beypore to Valiangadi (south of Kozhikode beach) has been eroding and different coastal protection structures such as seawalls and groins are already in place. Based on the process studies and numerical modeling, Shoreline Management Plans have been proposed for the above sectors.

Fig. 1.3.1.2. Shoreline evolution along Vatanapally - Chettuwa sector with groins.

A combination of seawalls and groin fields is found to be effective in controlling erosion north of Muthalapozhi harbor. A groin field consisting of 10 groins of 30 m length along the seawall sector and a transitional groin field of 3 groins of lengths of 30, 15 and 10 m further north of the seawalls are proposed to contain erosion north of Muthalapozhi (Fig. 1.3.1.1). Artificial dunes using sediment dredged from the harobur are also recommended at the open coast immediately north of Muthalapozhi which will provide additional protection and also act as a sediment reserve for the northern sector.

The presence of mudbanks and beach build up north of Munambam breakwaters help the Munambam – Chettuwa coast, except the Vatanappally-Chettuwa sector, free of major erosion problems. Seawalls already exist in the Vatanappally-Chettuwa sector. Sinking seawalls and end erosion are proposed to be talked with a groin field of short groins of 30 m at a spatial interval of 500 m (Fig. 1.3.1.2). The groin cells need replenishment with sand when dredged from Munambam or Chettuwa harbor. Beypore to Valiangadi (Kozhikode beach) was an eroding coast which is now being protected by seawalls and groins. There is no need for any more intervention along this sector except for proper maintenance of the existing structures. Kozhikode to Puthiyapa is stable or accreting with the presence of mudbanks and beach build up south of Puthiyapa breakwater. But the mining of beach sediment from Puthiyapa under the authorization of Harbour Engineering Department is adversely affecting the stability of the Kozhikode coast. The erosion at Vellayil is only during monsoon which could be addressed through temporary measures like stalking of sand filled bags immediately prior to the onset of monsoon and continuous maintenance during monsoon. The excess sand available at Puthiyapa could be used to replenish the beach sediment at Vellayil and adjoining areas.

K. V. Thomas

Funding: MoES through ICMAM P.D., Chennai

1.3.2 Sediment Budgeting studies for Mining sites of Kerala Minerals and Metals Ltd., Chavara

The project was taken up to study sediment budgeting for the mining sites of Kerala Minerals and Metals Ltd (KMML), Chavara. The sediment budget can be estimated from the data on waves, tides, winds, sediment and thebeach processes of the area as input. The area of study was fixed alongshore from Neendakara to Kayamkulam inlet and cross shore up to 20 m water depth. A field experiment was designed to measure the parameters of waves, tides,

currents, winds, sediments, bathymetry in precision in the offshore, nearshore and the beach adjoining the Vellanathuruthu and Kovilthottam mining sites of KMML at Ponmana (Fig. 1.3.2.1). The data on waves, tides, currents and suspended sediment were collected seasonally by deploying recordable equipments in the offshore and nearshore. The wind data was collected throughout by establishing a weather station at the mining site. The beach volume changes were calculated from the monthly beach profile measurements. The major equipments employed for the work were Directional and Non-Directional Wave and Tide Recorders, Acoustic Doppler Current Profiler, Global Positioning System, Echosounder, Ceeducer, Sediment Traps, Van-Veen Grab, Piston Corer, Dumpy Level and Staff, etc.

Fig. 1.3.2.1 Scheme of deployment of equipments

The waves approaching the coast are mostly swells, except during the peak monsoon period between June and August/ September, when the wave-generating zones are in the Arabian Sea. The highest wave was observed on 4th September 2011 with a maximum height of 3.54 m, which falls short of the highest expected due to weak monsoon during 2011.

A relative deepening of the whole innershelf barring the offshore of Kayamkulam is evident from the comparison of the bathymetry collected about a decade back. The deepening is more pronounced in the shallower portions of the innershelf upto 15 m depth. The observed changes in the innershelf morphology can be mainly attributed to the intensified mining in the beach and the December 2004 tsunami onslaught.

To explore the circulation pattern in the offshore study area, 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 (Pre-monsoon, Monsoon and Post-monsoon) 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, alongshore directions and thus the beach sediment budget was carried out.

T. S. Shahul Hameed
Funding: KMML, GoK

1.3.3 Monitoring of Sea Level Rise and Shoreline analysis

One of the key concerns with respect to global warming and climate change is sea level rise, resulting from melting of glaciers and thermal expansion of oceans. Recent estimate of sea level rise along the Indian coast gives a value of 1.75 mm/year for Kochi. Derivation of realistic estimates of sea level rise for the coast and backwaters of Kerala and bringing out scenarios of inundation based on impact analysis are required for long term and short term management measures to tackle the issues resulting from expected sea level rise. The impact of sea level rise is dependent on many factors in the coastal zone like morphology, population density, industries present, structures built, etc. Vulnerability to sea level rise is dependent on the impact due to exposure to seas, estuaries and backwaters. Morphological hotspots to sea level rise

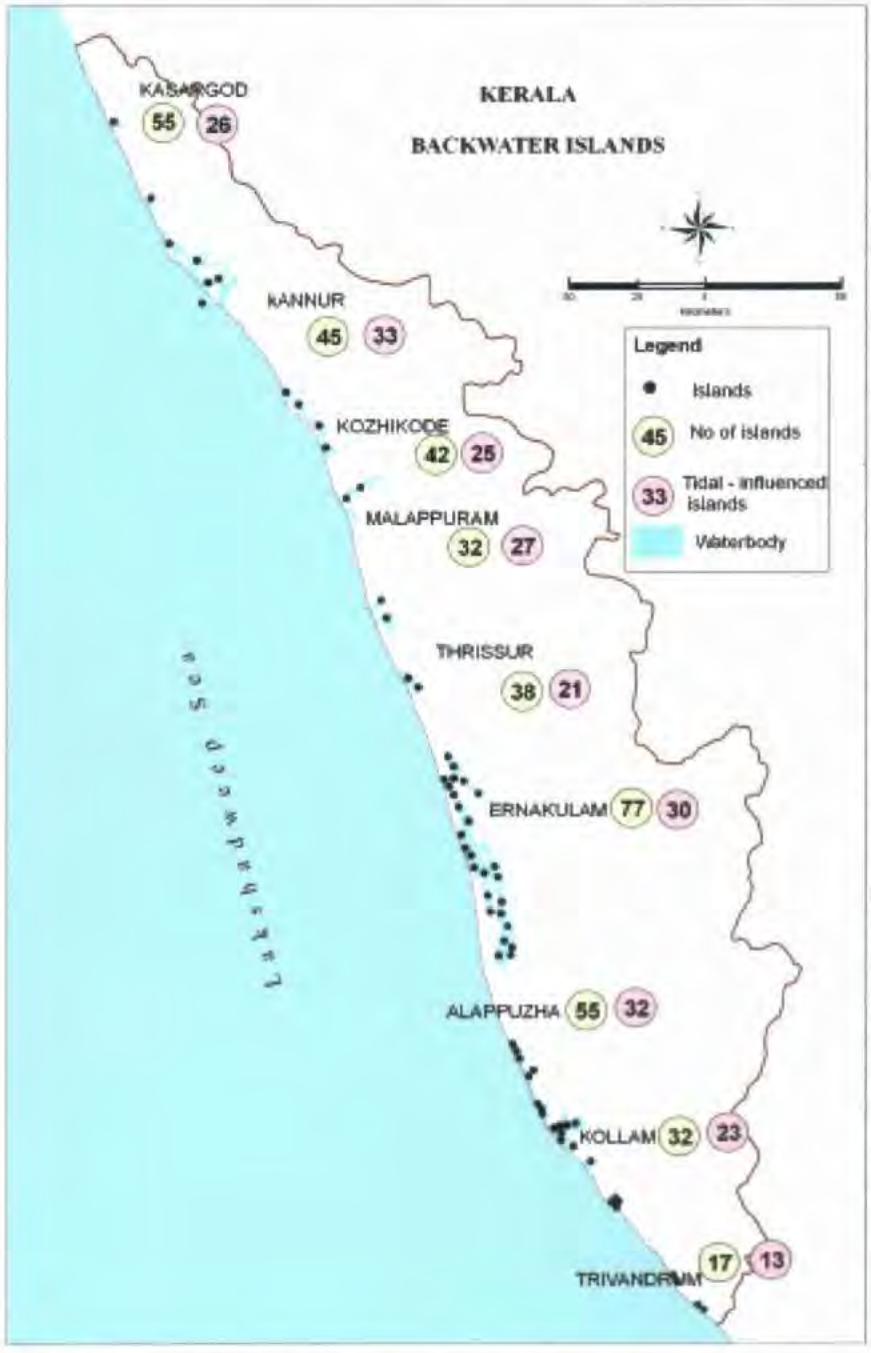


Fig. 1.3.3.1 Identified morphological hotspots of sea level rise:backwater islands & filtration ponds

are determined based on the varying levels of resistance offered by morphological forms to the impacts due to sea level rise. Morphological units along the Kerala coast have been identified using toposheets, high resolution imageries – Google, IKONOS, Quickbird (visual interpretation), supplemented with GPS observations, image processing and GIS techniques.

Beaches, barrier beaches, spits, cliffs, headlands, seawalls, breakwaters, backwater islands and filtration ponds are the morphological units identified. Major hot spots of sea level rise are low lying backwater islands and adjoining filtration ponds, since they would suffer inundation from all sides (Fig. 1.3.3.1). A total of 393 backwater islands have been recognized, out of which 230 are within saline systems. Sandy beaches, especially barrier beaches are the next set of hot spots. Total length of sandy beach in Kerala has been estimated as 343 km. Low lying coastal plains, barrier beaches and spits are also vulnerable to sea level rise. Overtopping and flooding on the landward side makes coast protected with seawalls unsafe. Coasts fronted with cliffs and headlands are very safe from the impacts of sea level rise. Separate management plan is required for each of the different sets of morphological units in order to deal with sea level rise.

A program has been coded using Matlab software for tidal analysis and identification of significant tidal constituents. This applies Fourier analysis (Fast Fourier Transform method) to obtain the amplitudes and phases of constituent frequencies. It has been tested using sample data, previously collected by CESS, and the amplitudes of all constituents have been extracted. The resulting power spectrum was plotted and validated. An algorithm has been designed for construction of tidal signal from the calculated amplitudes and phases of the tidal components, filtering of noise and high frequency signals, extraction of residual sea level data by filtering the tidal signatures and linear regression analysis of the residuals for the computation and future projection of sea level trend. The program code needs to be fine tuned accordingly.

As part of monitoring the impact of sea level rise, arrangements were made to establish a tide station at Valiathura, Thiruvananthapuram with the support of NIO, Goa. Downward looking microwave radar sensor developed by NIO Goa has also been proposed at the site. The site was jointly inspected along with scientists from NIO and the procedures such as MoU with NIO have been worked out. Discussions were also initiated with Port Department and Harbour Engineering Department, when it was informed that Port Department has already initiated installation of tide gauges and weather stations at 10

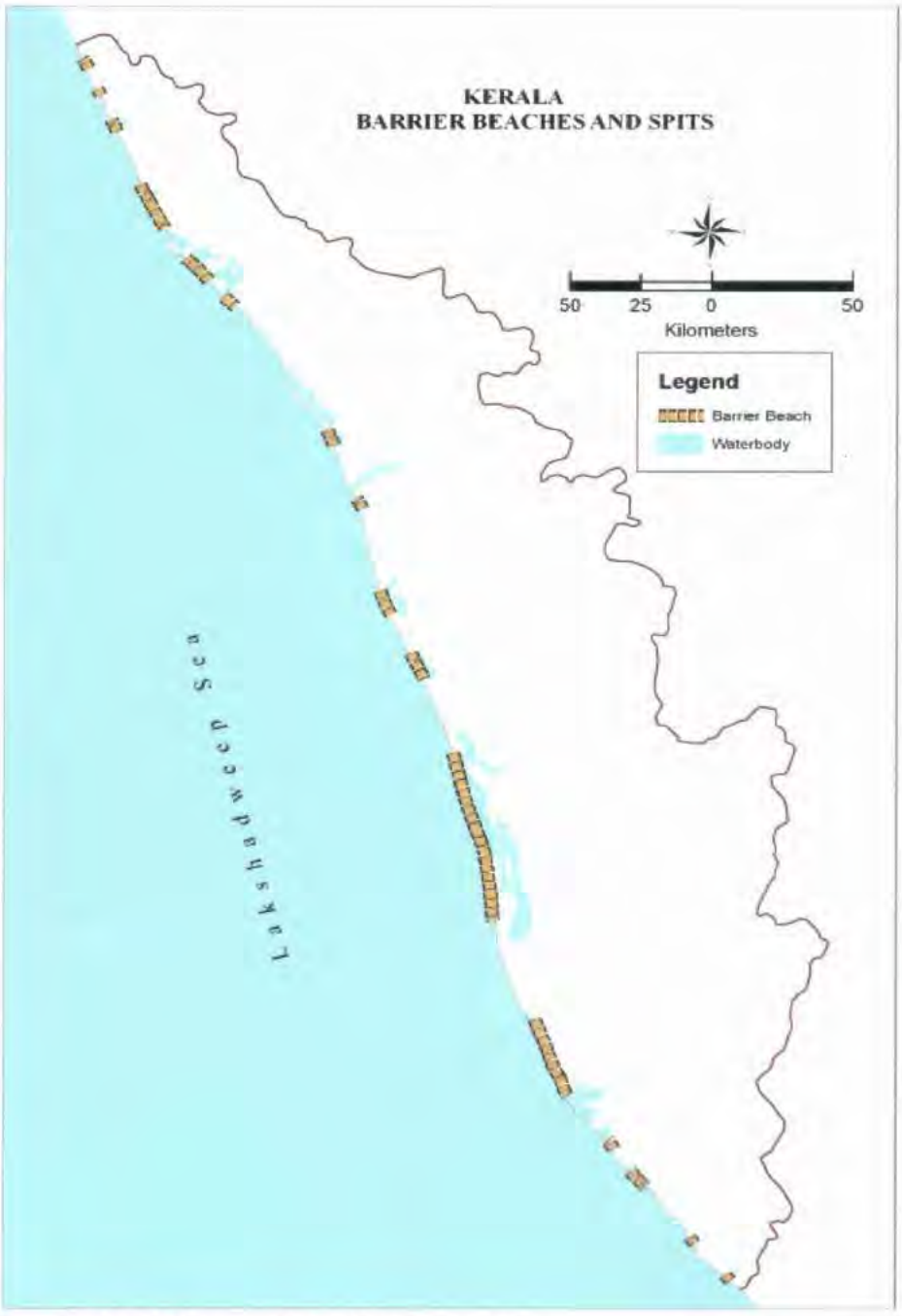


Fig. 1.3.3.2 Identified morphological hotspots of sea level rise: barrier beaches and spits

locations so as to get the tide data continuously and validate the data with Survey of India standards. Hence it may not be necessary to install any more tide stations along the sea coast. Interactions with Port Department are being continued. Tide data proposed to be collected from new tide stations along Kerala coast together with that from Kochi (Cochin Port) could give a regional trend in sea level rise. Sea level rise information will be updated initially with the updated data from Kochi. The data from other stations will help to establish sea level trends after tide data is collected for sufficient duration. When all the tidal and non-tidal signals, along with noise are filtered out from the data, the sea level change can be obtained and projected for future. Corrections for local uplift/submergence and other factors have to be applied to the residual sea level data. Impact modelling has to be done in order to simulate the area that will be inundated in future for the entire Kerala coast using interpolation techniques, mapping and modelling software.

Preparation of inundation maps has been initiated for studying shoreline changes and the impacts of different scenarios of sea level rise. Bathymetric and elevation maps are to be prepared for studying the impact analysis. Shoreline data available from old maps, imageries and observations will be compared for coastal erosion trends after eliminating possible changes due to anthropogenic and other reasons. This will be linked to present trends in shoreline changes and future scenarios will be assessed with suitable software.

T. S Shahul Hameed

Funding: KSCSTE, GoK

1.3.4 Tsunami inundation modelling and mapping for the coasts of Kerala, Karnataka, Goa and Lakshadweep

This project forms part of the national project on tsunami inundation modelling coordinated by ICMAM Project Directorate, Chennai. Centre for Earth Science Studies has been entrusted with the tasks of numerical modelling of tsunami inundation for the coastal stretches of Kerala, Karnataka, Goa and Lakshadweep. The final report of the project was prepared and is being submitted to the funding agency.

Fig. 1.3.4.1 Typical examples of tsunami inundation maps for Karnataka

The globally accepted TUNAMI N2 model was used for model computations with reference to two known tsunami sources and a hypothetical potentially worst case as the third source. The known sources are the Sumatra 2004 and Makran 1945 tsunamis. As Makran is reported to be the source for a future tsunami, a tsunami with Sumatra like intensity in Makran was selected as the hypothetical case.

The simulation results for all the three scenarios show varying responses for the three states and the Lakshadweep Islands. The model was earlier calibrated for the worst affected region of Kerala coast during the 2004 Sumatra borne tsunami and it should be specifically mentioned that the model has exactly reproduced what was observed on the field during the tsunami. In Kerala the southern locations and certain locations in the central part of the state's coast are more vulnerable for Sumatra tsunami compared to Makran.

However, sectors pertaining to the northern Kerala coast shows more vulnerability to 1945 Makran Tsunami. The simulation up and inundation along the coast followed by Makran 1945 and Sumatra 2004. The proximity of the sectors with the source can be attributed to the increased values in the run-up and inundation. Run-ups even exceeded 4 m in certain locations of Goa and Karnataka coasts for the hypothetical case whereas run-ups were in the range of 2-3 m for the other two sources.

It is deduced from the results of simulation for Lakshadweep that the tsunamis may not make an impact on Lakshadweep islands. This may be due to the very high steepness of the continental shelf resulting in practically very less shoaling and causing direct reflection of the waves

Fig. 1.3.4.2 Typical examples of tsunami inundation maps for Kerala

Fig. 1.3.4.3 Typical examples of tsunami inundation maps for Lakshadweep

that hit the islands. But the shallow lagoons, wherever present, can cause some shoaling and resultant amplification of tsunami causing higher run up. When compared to the mainland, the tsunamis from Sumatra and Makran have produced only negligible inundation in the islands. Moreover, no noticeable inundation is seen along the islands since the backshore is higher than the run-up level. Even the potentially worst case cannot inundate the islands due to the same reason.

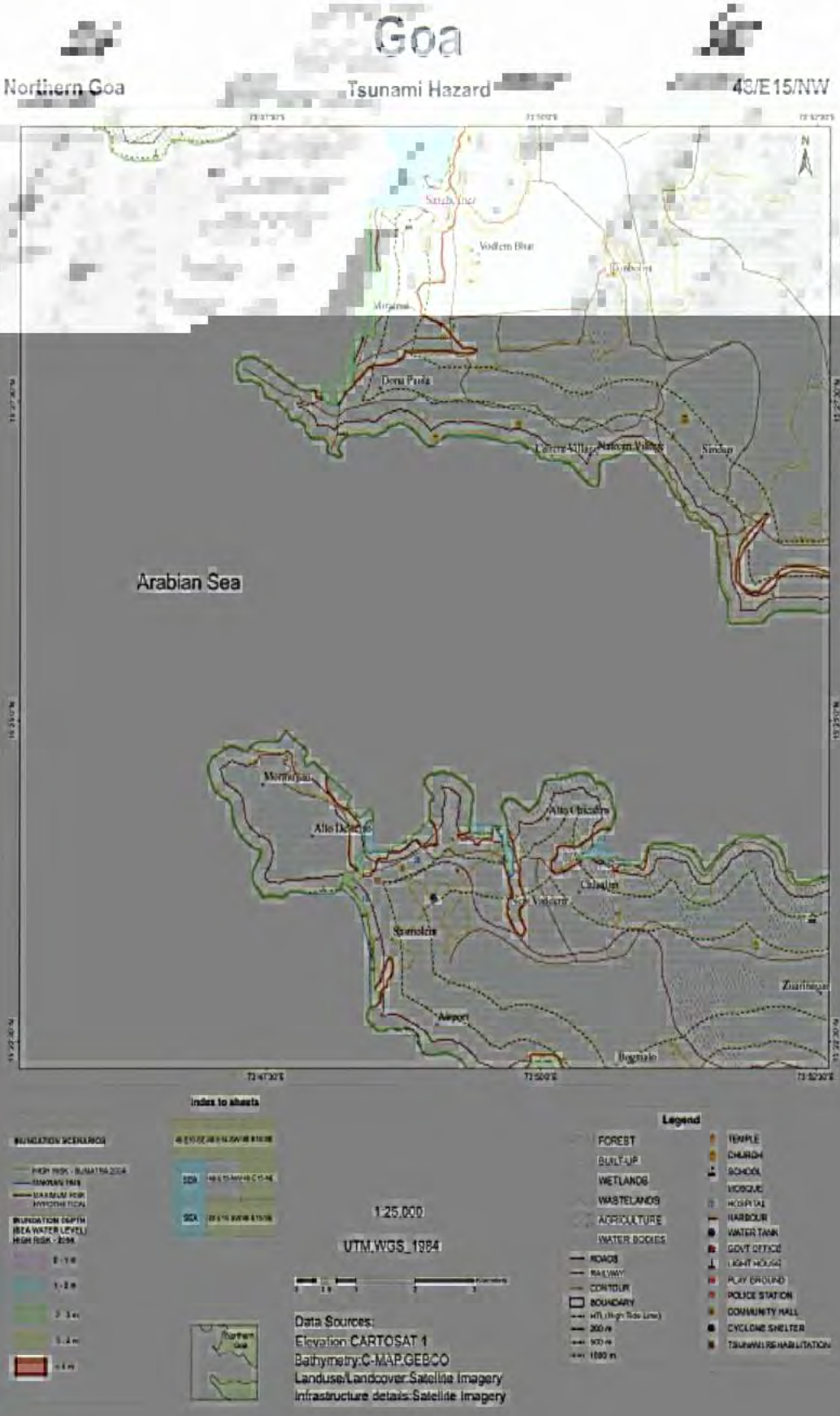


Fig. 1.3.4.4 Typical examples of tsunami inundation maps for Goa

T. S. Shahul Hameed

Funding: MoES, GoI

1.3.5 Establishment of wave gauge stations along the coastal waters of Kerala

This is a project of the Ministry of Earth Sciences implemented through INCOIS. The main objective of the project is to establish Wave Rider Buoys (WRB) at pre-defined locations along the Kerala coast. The project was initiated in 2011 with the deployment of the first WRB off Valiathura coast in Trivandrum at 30 m water depth on 4th May. Later in 2012 the buoy was shifted to Kollam and deployed off Ponmana coast at 22m water depth on 2nd May. A new shore station was established at Thangassery, Kollam to receive the data from the WRB through the High Frequency (HF) receiver and to store the data. Arrangements were made for the shore station at CESS to remotely access and communicate with the Thangassery station and also to transfer the data to INCOIS server at Hyderabad at regular intervals. The real time data (Fig. 1.3.5.1) from the WRB is being used by the INCOIS for the validation of the daily Ocean State Forecast given for the Kollam coast.

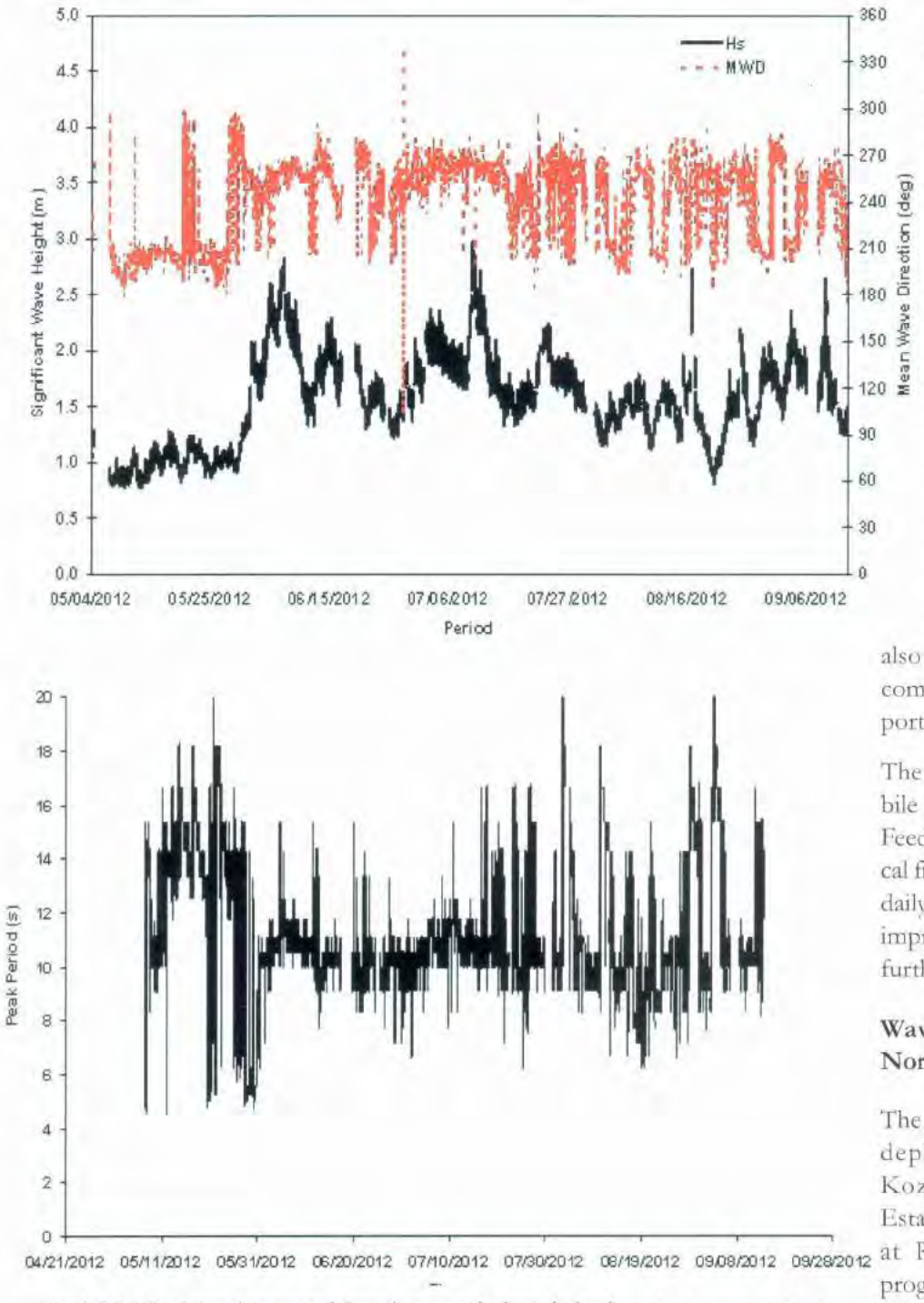


Fig. 1.3.5.1 Real time data received from the wave rider buoy deployed off Kollam

Dissemination of Ocean State Forecast (OSF)

The dissemination of the daily OSF for the Kollam coastal community was inaugurated at a function organised at Thangassery harbour on 16th February 2013 (Fig. 1.3.5.2, Fig. 1.3.5.3). Since then the data is being disseminated through the Village Resource Centres of Quilon Social Service Society (QSSS), Kollam and also by e-mail to the State Government departments like Port, Harbour Engi-neering , Disaster Mangement, etc. Short Message Service (SMS) facility is also made available for the coastal community and also for other important government officials.

The daily OSF SMS through mobile is now available in Malayalam. Feed back is collected from the local fishing community to validate the daily site specific OSF and also to improve the dissemination system further.

Wave Rider Buoy (WRB) for North Kerala

The second WRB was scheduled for deployment off Puthiyappa in Kozhikode during April 2013. Establishment of local shore station at Puthiyappa harbour was in progress. It was decided to deploy the buoy off Puthiyappa harbour at about 20m water depth

Fig. 1.3.5.2 Inauguration of Village Resource Centre & SMS Dissemination of OSF for Kollam by Shri. Shibhu Baby John, Minister for Labour, Govt. of Kerala.

Fig.1.3.5.3 Inauguration of PA & VHF based Announcement of Ocean Information Services at Kollam on 16th February, 2013 by Smt. Prasanna Earnest, Mayor of Kollam.

and the location has been tentatively fixed as towards south of Puthiyappa inlet. With the deployment of the WRB off Kozhikode, the OSF SMS facility would be extended to the north Kerala coast also.

L. Sheela Nair

Funding: INCOIS (MoES), GoI

2.1 Water Resources

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

The main aim of this project is to ascertain the role of springs as a large scale source of drinking water and to suggest measures for the maintenance of existing spring resources to prevent their extinction. The study area lies between 9° 03' and 10° 23' North Latitude & 76° 37' and 77° 30' East Longitude i.e, nearly 9995 km^2 in Central Kerala {Southern Western Ghats Region} covering Pathanamthitta, Kottayam and Idukki districts. Springs are selected for seasonal monitoring of physico-chemical analysis and discharge potential based on a set of properties. Spring water qualities were determined in terms of physical, chemical and bacteriological properties using standard methods. The geochemistry and terrain characteristics of the spring watersheds were examined.

Fig. 2.1.1.1 Identified spring locations in Pathanamthitta, Kottayam and Idukki district

Total of 140 springs were identified and analysed from Central Kerala. Spring water in the study area is generally acidic in nature with pH ranging from 4.81 to 6.67 with an average of 5.77. The chemical quality of water satisfies BIS/WHO (2006) drinking water specifications except pH. Electrical Conductivity ranges from 22.14 to 330.40 µS/cm with an average of 57.50 µS/cm and indicated the low range of dissolved salts disclosing the swift movement through the bearing geology/aquifers. Total Dissolved Solids (TDS), varies between 15.81 and 236.00 mg/L with an average of 41.06 mg/L. Increased nutrient fluxes are observed in various spring sources. However, most of the spring sources are affected by microbial pathogens due to the human and cattle settlement in the nearby areas of springs. The dissolved heavy metals such as Zn (0.006-4.432µg/L), Pb (BDL-0.184µg/L), Cd (BDL-0.002µg/L) and Cu (BDL-0.887µg/L) were noticed in spring waters and it may be due to diverse geo-envirofactors.

K. Anoop Krishnan

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

The exponential growth of industrialization and urbanization has resulted in undesirable enrichment of toxic contaminants in aquatic environments. Monitoring systems of aquatic environments reveal that most of the world's water bodies are under stress consequent to the uncontrolled discharge of toxic contaminants far above the desirable limits set by various international agencies. The situation is not different in the southwestern coast of India, especially in Kerala-a coastal state having a fast developing economy. Studies reveal that there is an imminent need for continuous monitoring of the pollution status of all the important aquatic systems of the state that are located close to major development centers.

Among various types of pollution, the one caused by heavy metals is of prime importance as the region is getting more and more urbanized. Discharge of heavy metal rich effluents causes serious impairments not only to human beings but also to the other organisms in the food web as well. Therefore, a better understanding of the variability of heavy metals in various phases of the aquatic environments is of considerable importance in order to take corrective measures as and when required.

The present study has been undertaken with an objective of assessing the seasonal variability and cyclicity of heavy metals in water and sediment phases of the Periyar river and Cochin estuary. The sediments and water samples taken from 22 locations of the Periyar river and Cochin estuary during pre-monsoon, monsoon and post-monsoon seasons were analyzed for heavy metal concentration. The sampling

stations were grouped under four different zones- background zone (BZ), industrial zone (IZ), marine zone (MZ) and harbor zone (HZ) for high-resolution assessment of the pollution status of the region. Metal concentration in sediments varied seasonally and significantly within wide range of values -Pb (8 ppm to 150 ppm), Zn (17 ppm to 2600 ppm), Cu (7 ppm to 549 ppm), Cr (84 ppm to 583 ppm), Ni (7 ppm to 218 ppm) and Fe (1% to 23%). The estuarine reach of the river is blanketed essentially by fine sediments which in turn contain relatively high concentration of heavy metals. On the other hand, the lower reaches of the Periyar river dominated by coarser sediments showed relatively low heavy metal contents.

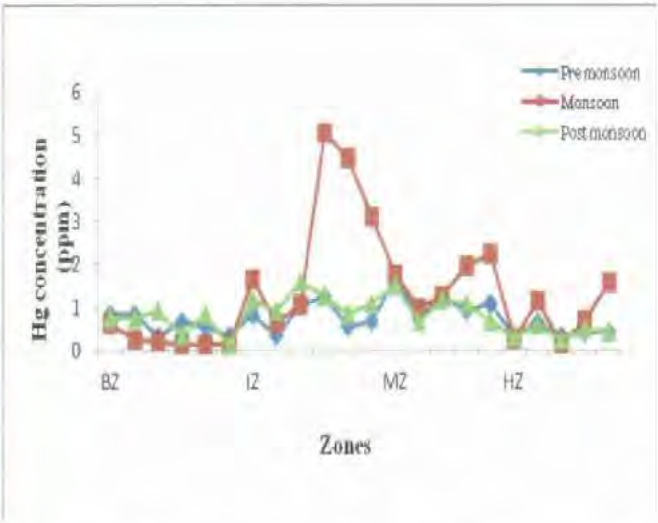


Fig. 2.1.2.1 Spatial variation of mercury (Hg) in sediments Note the anomalous increase in mercury values in the rive reach close to the industrial zone. (BZ- Background Zone IZ- Industrial Zone, MZ- Marine Zone, HZ- Harbour Zone)

Studies on the mercury concentration in the sediments o this study area reveals marked variation around th industrial hub and further downstream, especially durin monsoon season as depicted in Fig. 2.1.2.1. This might b resulted from the mercury rich effluent discharges fron the chemical industries in the region. The background zon yielded mercury value of 0.11 ppm against the higher valu of 5.06 ppm in the industrial influenced zone. Th recommended value of mercury content in the estuarin sediment is 0.81 ppm. Mercury is one of the major toxi heavy metals that undergo methylation in the aquatic environment by both biotic (microorganisms) and abiotic processes. Therefore, necessary measures are to be taken to bring down mercury levels in sediments of the river reach downstream of the industrial zone within the recommended levels.

P. K. Omana

2.1.3 State of drinking water resources in Thiruvananthapuram district, Kerala- A situation analysis

Drinking water scarcity is not an uncommon problem run over several decades in rural and urban areas of many developing countries including India. In spite of concerted efforts at different levels to find a permanent solution at national and regional levels, drinking water problem continues and gets aggravated at several places due to increased population pressures, rapid urbanization and industrialization process. The situation is getting further complicated year after year due to factors such as erratic and unequal distribution of rainfall, temperature, continued deforestation etc. The present study has been taken up in order to assess the availability and distribution of drinking water resources and their management status for Thiruvananthapuram district. Primary and secondary data on water resources and associated parameters were collected and compiled. A spatio-temporal analysis and preparation of thematic maps were derived using GIS software. The study area is mainly served by Kerala Water Authority through protected drinking water supply schemes, with network of reservoirs, pumping stations and pipeline distributions in several urban and suburban areas. In rural areas elected panchayat bodies manage drinking water supply distribution with public support. Most of the rural areas depend on surface dug wells and bore wells. The study showed that 68% of the district's population depend on dug wells or bore wells for fresh water (Fig. 2.1.3.1).

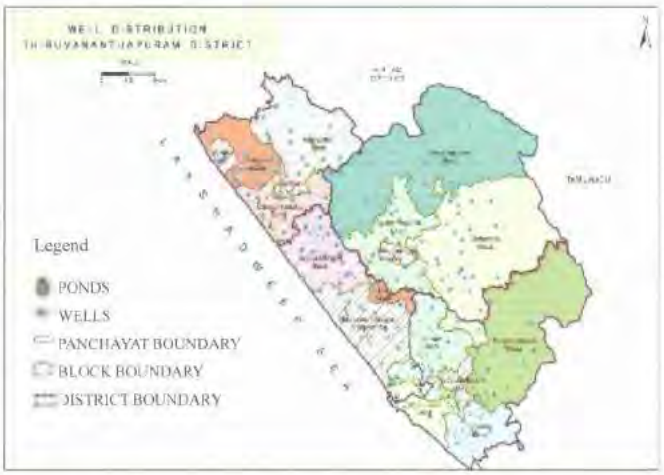


Fig. 2.1.3.1 Well distribution in Thiruvananthapuram district

As many as 27 villages in the district have been identified as drought prone area. Athiyanoor, Parassala and Chirayinkeezhu blocks are the top three drought-prone blocks in the district. Muthukal, Pazhayakunnummel, Navaikulam and Kilimanoor panchayats are likely to get affected by water scarcity in near future (Fig. 2.1.3.2).

Groundwater condition in central and eastern part of the district can be categorized under safe category indicating presence of potential aquifer, which can be harnessed.

Athiyannur block is categorized under over-exploited category as significant decline in water level during pre and post-monsoon periods has been observed. There is urgent need for a digital database in GIS format of all water related issues and improved coordination among various water resource development agencies with suitable scientific and technological interventions, ensuring least minimum disturbance to the surrounding natural environments with public involvement and support. For ensured quality services in water resource development and sustenance, regular educational programmes on water resource utilization and maintenance through public awareness programme involving communication media is essential.

Fig 2.1.3.2. Panchayaths showing drinking water scarcity in Thiruvananthapuram district

V. Shravan Kumar

2.1.4 Assesment of water source for the Vandichira RWSS, Parasuvakkal, Thiruvananthapuram district

Project Background

The existing water supply scheme of Kerala Water Authority at Vandichira draws 2MLD of water to meet the demand of its supply network. At present the scheme depends mainly on the release of water availability of the left bank canal of Neyyar Irrigation Project. However, in the present condition, the capacity of Vandichira pond is hardly equivalent to the volume of water required for supplying seven days in a month. Therefore, the Irrigation department is forced to release water through the canel on every week during summer to meet the water requirements of the people in the area. Since the frequent release of water through the canal affects periodic maintenance as well as supply schedule, Irrigation department raise their concerns. Under these circumstances, the grama panchayat and KWA have jointly decided (a) to augment the storage capacity of pond, (b) control the leakage of the pond to the bearest minimum level and (c) to improve the groundwater-surface water feeding to the pond. The present study is undertaken in this context.

Evaluation of the catchment and the source

The catchment of the stream (2.5 sq.km) draining to the Vandichira pond area receives water from the elevated region west of Kannumammodu and south of Kunnathukal and converges at Parasuvakkal (Fig. 2.1.4.1). One of the main reasons of frequent filling of the pond by the canal water is the excessive seepage loss. This can be connected by the construction of a sub-surface dyke which will augment groundwater availability in the locality.

Sub-surface dyke

The construction of the dyke involves following steps:-

1. Clear the site and mark the central line of alignment of the dyke on the ground leaving 4 m distance from the base of the existing bund so that it is not disturbed.
2. Three pits to be taken in the proposed trench path, one in the middle and two others 30 m on either side of the central pit to ascertain the depth to hard rock. The depth to hard basement rock is expected at about 4m from the existing floor of the pond.
3. Remove the top soil and stack it on the floor of the pond so as to form a temporary bund to prevent entry of water into the trench.
4. Excavate the trench with a width of 5 m to a depth of 2 m. Stack this material as above to form a wider bund.
5. Deepen the trench all along the central line with a width of 1.25 m and to reach the basement rock. The material must be kept on the pond floor for refilling the trench.
6. The surface of the basement is likely to be uneven and a uniform excavation may not be possible by machinery. So, remove all loose material manually to expose the rock.

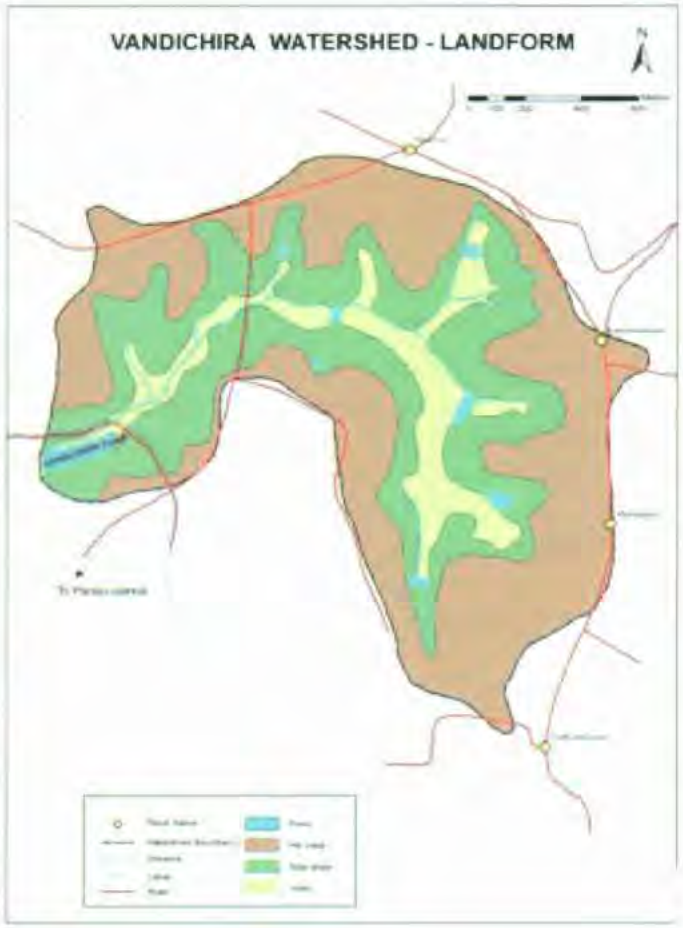


Fig. 2.1.4.1 Parasuvakkal watershed area and the pond at Vandichira

7. Dress the exposed surface of the bund so that rough surfaces are smoothened.
8. Level the bottom of the trench with cement concrete in the ratio of 1:3:6 using 20 mm aggregate.
9. Lay the LDPE film at the bottom and roll it up on the trench wall adjacent to the present bund. The LDPE film normally has a width of 6 m and a length of 40-50 m. The bottom of the levelled trench should be covered by 75 cm width and the balance to be rolled up. It may be required to join the film and can be done by pressing 1 m length of adjacent films width wise and rolling it to have a tight bondage. In this way lay the next layer of the film. It must be ensured that the line of joints of the films are not placed adjacent and must have sufficient overlap.
10. After placing the film at the bottom, provide a 20 cm thick cement concrete layer over it so that it is tightly held at the bottom and the bottom is sealed.
11. The other edge of the 6 m wide film may be again joined by rolling together as mentioned above length wise. Care must be taken to avoid the joined surfaces of the two layers being placed adjacent to each other. Care must also be taken to lay the film in a loose manner with minor folds. It should not be tightened to avoid breakages while refilling with the excavated material.
12. Provide a concrete rib at the places where the film is jointed so that the film acts as one unit.
13. Roll the film over to the bund so as to reach its top. Fix it firmly with a layer of cement concrete.
14. Refill the trench with the excavated material.
15. Provide a covering to the film with earth on the exposed part of the bund. This filled material in the trench and on the slope of the bund is likely to settle by a few cms initially. Once it is settled provide stone pitching at the lower 2/3 rd and grass cover in the upper 1/3 part.
16. Provide a retaining wall of 1 m height so as to retain the filled material. This may be required after the material has settled. The ultimate height of the bund may be kept 1 m above the MFL of pond.
17. The level of over flow structure provided on the northern side near the foot bridge on the stream bed may be kept at about 50 cm above the over flow level of the present pond.
18. The dyke has to cut across the stream. At this point a check dam structure may be required with an over flow mechanism.

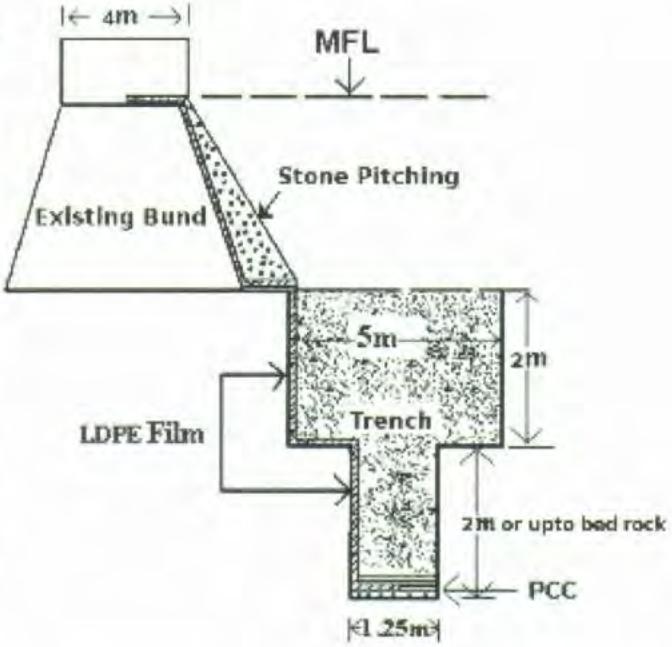


Fig. 2.1.4.2 Cross section view of sub-surface dyke

19. Near the over flow section side strengthening is required to prevent scouring. The length of side protection may be worked out based on site condition.
20. Detailed estimate can be worked out by taking into consideration the site conditions and above recommendations.

Optimisation of the storage potential of the pond would require desilting and deepening. The sides may be provided with stone pitching wherever necessary. The periphery of the pond may also be provided with fencing.

John Mathai & D. S. Suresh Babu
Funding: Kerala Water Authority

2.2 Terrain Analysis and Landuse Studies

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

The project on "Landuse/ land cover change as linked to climate change in Central Kerala" was a part of Climate Change project sanctioned by KSCSTE, Govt. of Kerala. Considering importance of the study some of the data have also been analysed for the entire State. Central Kerala formed original study area. Subsequently it was extended to the entire State. The Central Kerala stretching from Achankovil river basin in the south to the Bharathapuzha river basin in the north is of special significance. This area is characterized by extreme topographic variations in Kerala ranging from the lowest point (-2m) in Kuttanad to the highest point, Anaimudi peak (2695m). The largest lagoon in the south west coast of India, Vembanad lake, relatively wide coastal plain, undulated mid land, scarp slope and the plateau, all together provide this stretch a diverse landscape / ecological set up. Landuse and human habitation also show significant diversity in this stretch.

The work has been taken up with the following objectives: (i) to assess landuse/land cover change in the study area covering forests, agricultural landuse and urban areas, (ii) to measure trend of change in natural vegetation cover, (iii) to measure change in paddy land and area under other selected crops, (iv) to assess change in wetlands, (v) to collect and process available rainfall data and identify the trend and to study linkage between landuse change and climatic parameters, particularly rainfall and (vi) Collection and analysis of data on land utilisation pattern, area, production and productivity of important crops from secondary sources like Department of Economics and Statistics, Government of Kerala. These data are available since 1956-57.

Analysis of old topographical maps has been done for extracting data on forest coverage and land use information of 1967 from Survey of India topographical maps for the selected districts of Kerala. Current landuse information from IRS LISS III and LISS IV images using visual interpretation in a digital environment were undertaken and preparation of landuse change map for selected district by Union Overlaying old and current landuse map in GIS environment were taken up. Data on climate and its variability were collected from IMD and would be depicted through suitable graphs and charts. Analysis of secondary data on landuse highlighted the change experienced by Kerala. The changes vary spatially as manifested by the district level data. Rainfall data are yet to be fully analysed. Preliminary results indicated that there were symptoms of climate change well expressed in the State. Landuse change affects micro climate, however, its impact on overall climate is yet to be ascertained conclusively. Future activities include completion of landuse maps covering rest of the districts, assessment of wetlands, and analysis of climatic data and finally to rigorously correlate landuse and rainfall change and to draw meaningful conclusions.

Srikumar Chattopadhyay

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

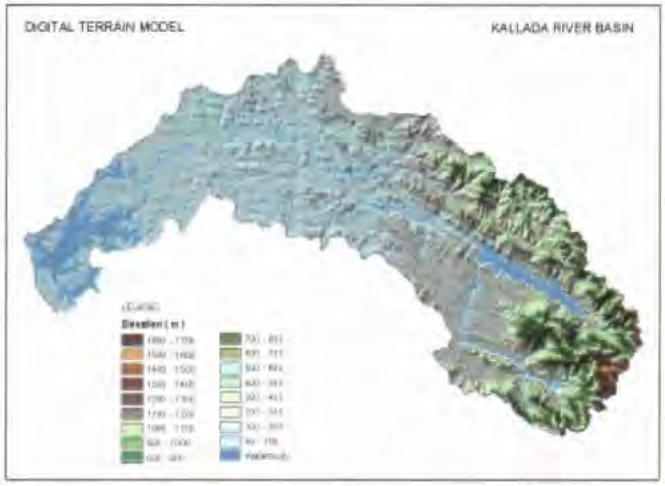


Fig.2.2.2.1 Digital Terrain model (DTM) of Kallada river basin

This project aims to understand formation of river valleys and geomorphic processes under tropical wet and dry climates from eight selected river basins in Kerala. Classifications of these eight river basins are based on their differences in geomorphic and climatic settings, morphology, sediment character and morpho-tectonic feature. Valapattanam, Bharathapuzha, Periyar, Kabani (east flowing), Achankovil, Kallada, Ithikkara and Neyyar river basins were studied. The major objectives are (i) elucidation of geomorphic setting of various valley types within the same river basin, (ii) characterization/differentiation of valley types in different rivers as linked to geomorphic and climatic variations, (iii) to link valley formation with terrain evolution processes in different physiographic units in

Kerala and its relation to the river morphosis widely observed in the low-level regions of Kerala, (iv) assimilation of data through GIS application.

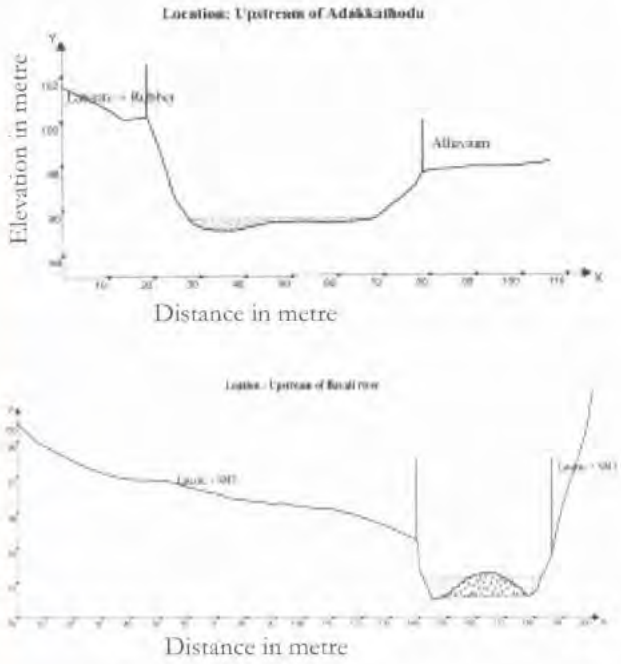


Fig. 2.2.2.2 Valley profiles of selected segments of Valapattanam river basin

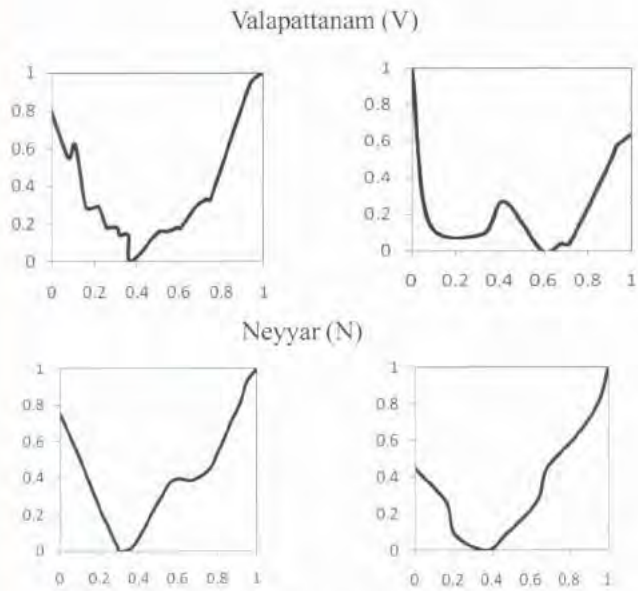


Fig. 2.2.2.3 River valley profiles of Valapattanam and Neyyar river basins

Base maps of the river basins and selected thematic maps were prepared. Valley profiles were surveyed in selected sites of Ithikkara, Achankovil, Periyar, Kabani, and Valapattanam. Prepared Transverse river valley profiles (TRP) of Ithikkara, Kallada, Neyyar, Achankovil and Valapattanam river basins. Flow and velocity measurements have been undertaken for Valapattanam (5 stations) and Kabani (3 stations), Achankovil (10 stations) and Periyar (5 stations) rivers. Digital Terrain Model (DTM) of Kallada basin is given in Fig.2.2.2.1 Valley profiles (Fig. 2.2.2.2) along with transvers river profiles of selected stretches of Valapattanam and Neyyar river basins are depicted in Fig. 2.2.2.3 and Table 2.2.2.1.

Table 2.2.2.1 Calculated parameters of the TRPs

Profile		Ea%	Ch	Eh lb	Eh rb	Eh $_{(a+c)}$	Eh rb/Ch	Eh*	Eh*Ln	B.S	VWh	Vs in degree		
												LB	RB	Va
V	A-B	55	0.92	0.50	0.56	0.54	0.61	0.53	0.256	0.2	3.28	50	33	17
	E-F	62	0.80	0.80	0.40	1.0	0.50	0.60	0.472	0.09	3.96	52	51	1
N	A-B	87.5	0.82	0.53	0.39	0.65	0.47	0.46	0.226	0.20	3.27	52	22	30
	K-L	77.5	0.65	0.44	0.25	0.68	0.38	0.34	0.083	0.13	5.93	42	53	11

**Ea = area under erosion, Ch = channel incision rate, Bs = basin symmetry, Va= valley slope, VWh= valley floor width height ratio, Eh/Ch = role of factors other than tributary and mass wasting, lb = Left bank side, rb =right bank side.*

From TRP analysis of six rivers, it is seen that Kabani and Kallada basins have got higher Ea (Area under erosion), indicating higher down cutting in response to uplift in neotectonically active domains. Ch (Channel incision) values of Neyyar basin indicate that channel incision rate is higher in this basin, with value ranging from 0.59 to 0.94. Maximum Bs (Basin symmetry) values of Kabani basin range between 0 and 0.1, which is an indication of basin symmetry and Va (Valley symmetry) values range from 2° to 10° which is an indication of high valley symmetry. Eh/Ch (average valley side incision) ratios of both banks show that tributary stream action is active in Valapattanam basin. Anomalous TRP parameters of Achankovil river also indicate that the basin has undergone different deformational events like tectonic activities and eustatic changes.

Mahamaya Chattopadhyay

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

The major objectives of the project are (i) to assess and monitor the land quality for sustainable agriculture in Kannur district with GIS based approach coupled with technology intervention, and (ii) to prepare the Soil Geochemical Atlas of Kannur district for sustainable agriculture. Contours, drainage, roads and other details are digitized in 1:50,000 scale using ArcGIS and Map Info softwares. Landuse land cover map is derived from satellite imagery by digital image processing method using ERDAS and ENVI image processing software.

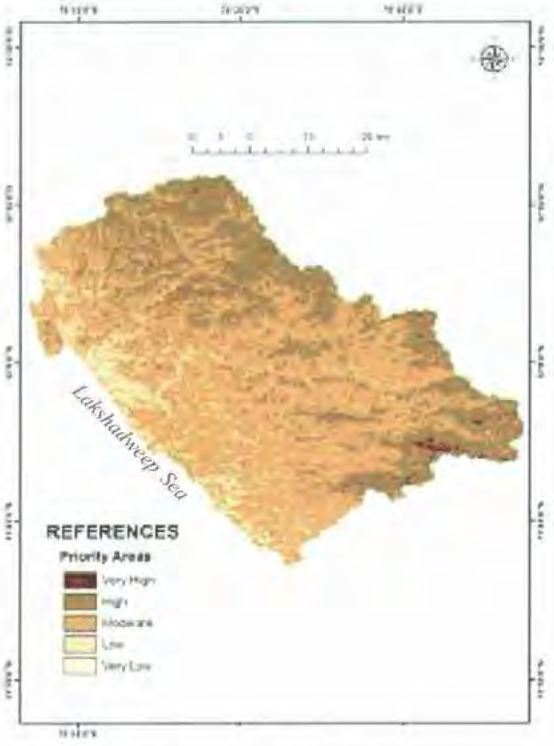


Fig. 2.2.3.1 Priority areas for watershed management

Agricultural drought prone area is derived from the middle infra-red bands using ETM+2002 and 2005 data. Questionnaire survey was conducted among the farmers using random sampling method to have an idea about their views on current agricultural practices in Kannur district. Normalised Difference Vegetative Index (NDVI) and soil moisture maps were prepared using all the six bands of Landsat ETM+imagery of the study area. All thematic maps depicting natural resources of the districts were integrated to generate derivative maps like erosion and flood prone areas. In each map classification was made and ranked according to the suitability. All the maps were converted into raster in spatial analyst and 3D modules were used for land evaluation and assessment. Finally weighted overlay analysis was performed to get priority areas for sustainable agriculture in the district (Fig. 2.2.3.1).

Physical parameters like pH, electrical conductivity, texture of major and minor trace elements were determined for soil samples from different locations in the districts. In general, soil samples revealed nutrient deficiency. Mild soil acidity, harmless soil conductivity, sandy texture and deficiency of major nutrients like nitrogen, phosphorus, potassium are observed in the study area (Fig. 2.2.3.2). The results of the study are incorporated in GIS environment for modelling. Soil Geochemical. Atlas prepared as part of this project will be useful for all those who are concerned with the agricultural development in Kannur district.

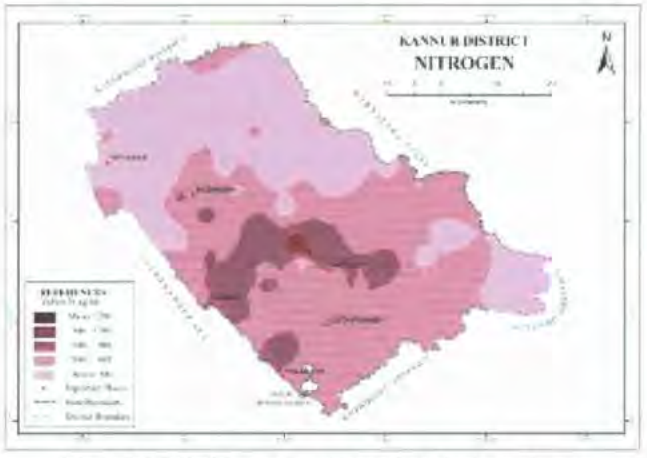


Fig. 2.2.3.2 Deficiency of major nutrients in the study area

Abalya Sukumar

2.2.4 Geomorphic evolution and terrain characteristics- A case study of Achankovil River basin, Kerala

Kerala with its high density of river basins and physiographic characteristics including high gradients manifests a number of geomorphic features different from the rest of South India and hence offers an excellent opportunity for the study of landform evolution and interrelationship between geomorphology and landuse with the drainage basin as focal point. With this conceptual background the work on 'Geomorphic evolution and terrain characteristics of Achankovil river basin' has been taken up with the following objectives: Mapping and characterisation of the drainage system of the Achankovil

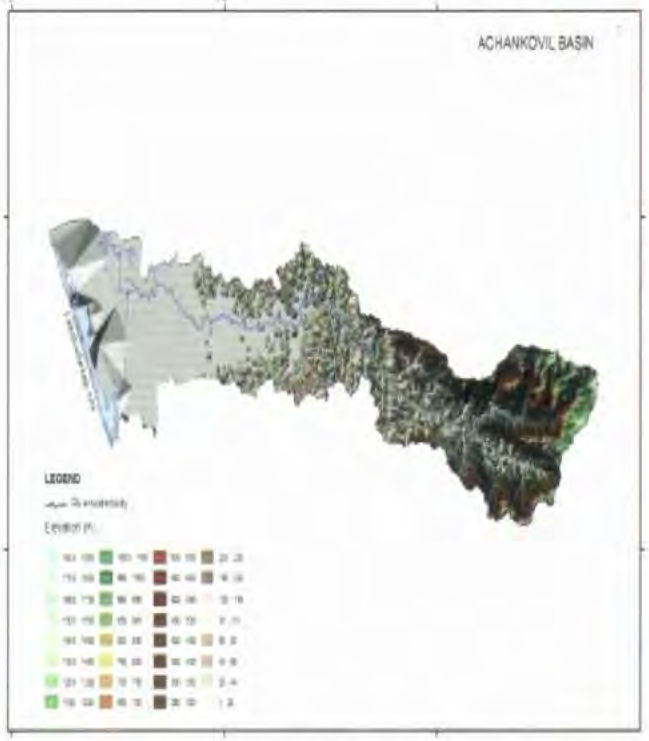


Fig. 2.2.4.1 Digital Terrain Model of Achankovil River basin

basin, analysis of drainage network including linear form, areal form and relief form, time-series landuse mapping, mapping of geomorphic features pertinent to evaluation of terrain especially Achankovil Shear Zone (ASZ), computation of hypsometric analysis, profile analysis (longitudinal, cross profiles and transverse river valley profiles) to identify the stages of evolution, marking of planation surfaces, and application of GIS to synthesize and integrate the attribute data. Basic thematic maps like drainage, slope, relief, drainage density were prepared using topographic sheets. Lineament map is prepared from drainage map along with digital terrain model supported by satellite imagery (Fig. 2.2.4.1).

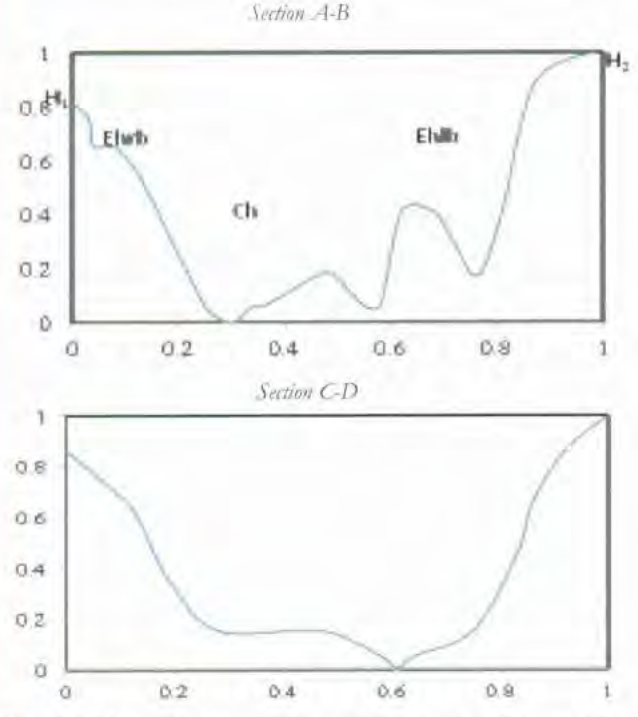


Fig. 2.2.4.2 Normalized transverse river valley profiles along Achankovil River

Table 2.2.4.1 Physical characteristics and annual discharge of the sub watersheds - Achankovil River

Sub Water sheds	Catchment area (km^2)	Channel length (km)	Channel width (m)	Channel slope	Avg. annual discharge (m^3/y)	Yield rate (m^3/h)	Basin gradient ratio	Stream frequency (km/km^2)
I	27.14	12.32	7.2	0.0438	5.9	0.185	0.0682	8.55
II	187.96	34.66	96	0.0479	17.3	0.092	0.0531	6.40
III	29.12	16.38	18	0.0269	4.7	0.162	0.0269	5.98
IV	16.61	10.29	5.0	0.0428	3.0	0.18	0.0447	6.50
V	64.78	14.13	8.2	0.0113	4.0	0.061	0.0142	1.96
VI	4.89	5.02	4.0	0.0239	1.3	0.258	0.0279	2.66

Table 2.2.4.2 Calculated parameters of transverse river valley profiles

TRP Locations	Ea (%)	Ch	Ehlb	Ehrb	Eh*	Ehlb/ Ch	Ehrb/ Ch	Bs	Va	VWh	Eh*Ln
A-B	81.55	0.67	0.35	0.58	0.47	0.52	0.86	0.39	33^0	8.18	0.46
C-D	93.05	0.95	0.55	0.58	0.57	0.58	0.61	0.11	17^0	4.86	0.23

** Ea = area under erosion, Ch = channel incision rate, lb= left bank side, rb= right bank side, Bs = basin symmetry, Va= valley slope, VWh=valley floor width height ratio, Eh/Ch = role of factors other than tributary and mass wasting*

Geological map was compiled from 1: 250,000 scale GSI maps. Time-series landuse maps were prepared using toposheets of 1967 and IRS LISS III images of 2008. Profiles – River cross profiles (10 on tributary streams and 5 on main stream channel) and transverse profiles (26 locations) have been done in each segment of the river stretch. Seasonal discharge measurements were done using Current Meter in 10 stations covering mainly foothill region to downstream reaches of the watershed area (Table 2.2.4.2).

Drainage discharge variation in different segments in comparison with the rainfall availability indicates that rainfall is the primary determinant of catchment yield in these areas. Besides that several physical (catchment area, channel length, channel width, channel slope) and natural (topography, rock types, soil and landuse/land cover) features also contributed to variations in drainage discharge. The TRP analysis shows that the river shows a deviation from the normal behaviour that is expressed by the basin indices. The incision rate should decrease downwards in case of a normal river, while Achankovil shows increase in incision rate in the midland as well as lowland areas that is attributed to the tectonic as well as eustatic changes (Table 3.2.4.2). Different land use categories have been identified for the study area based on SOI toposheets (1967), of which settlement with mixed tree crops occupies 571 km^2 of area i.e. 41% of the total area. The next prominent category is forest which covers an area of 415 km^2 (30% of the total area) and cultivable land (paddy) covers about 196 km^2 of the total area. From land use map 2012, settlement with mixed tree crops occupies about 679 km^2

of the total area and forest cover has been converted to forest plantations(268 km^2). Forest cover occupies about 139 km^2 of the total area. The river basin has got some interesting characteristic features in each stages of its development. It gives evidences of both exogenetic and endogenetic processes. More river profiling (cross and transverse profile) has to be taken and terrain mapping will be done and through this, the correlation of physiographic features with landscape evolution could be understood.

Mahamaya Chattopadhyay

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

The major objectives of the study are (i) to analyse the geomorphic processes acting on land system in Kabani river basin and (ii) to identify the geomorphic indicators which help to understand the geomorphic system and predict landform changes. Methodology involves data extraction from topographical maps of 1:50,000 scale, IRS image and field analysis of data using available techniques and application of GIS. Morphometric data and hypsometric data have been extracted from toposheets. Data pertaining to terrain and current landuse have been extracted from images, supported by field work. Soil samples were collected from field and analysed in Soil Testing Laboratory of the Government of Kerala. SRTM and ASTERDEM data were used for developing DTM. Aerial photographs were used for preparing land system maps for selected segments. GIS was applied mainly for spatial analysis and synthesizing spatial and attribute data.

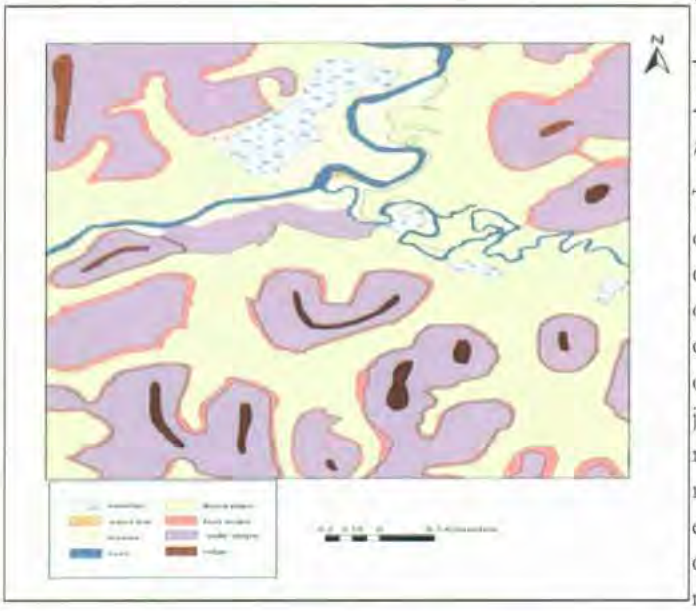


Fig. 2.2.5.1 Land system map of selected segment in Kabani basin

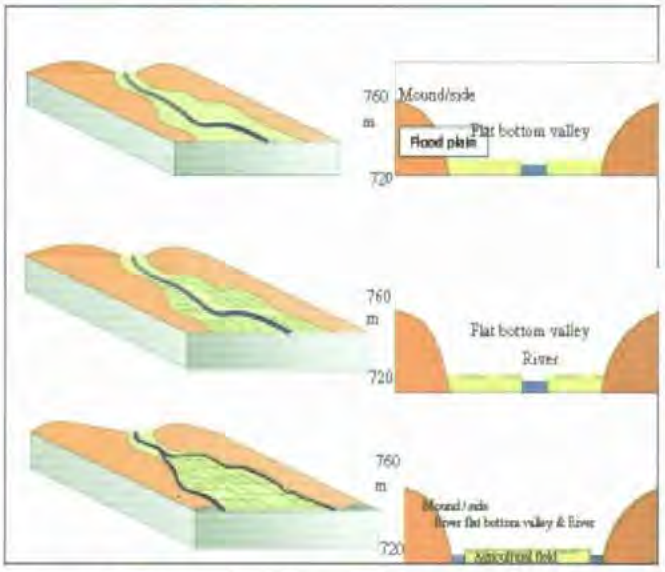


Fig. 2.2.5.2 Stages of landform modification through anthropogenic activities

Kabani is an east-flowing river originating from Wayanad plateau and it drains the States of Karnataka and Tamil Nadu and confluences with the river Cauvery. It covers an area of 1648 km^2. Geomorphology, slope, geology, land use, soil and climate are the determining factors used for land system classification. Seven land systems units are identified (Fig. 2.2.5.1). These are floodplain/ valley fill and alluvial basins, low rolling terrain, moderately and highly undulating terrain, residual/ elongated hills, scarp slope and hummocky terrain. Human modifications through anthropogenic activities are very common in these land systems (Fig. 2.2.5.2). During the reporting period land management plan for each land system has been undertaken.

Srikumar Chattopadhyay

2.2.6 River bank atlas of Karamana and Ithikkara river

The Revenue Department is vested with the responsibility of managing river systems in the State. Every district has created a River Management Fund (RMF) under the control of Revenue Department. The Department initiated the captioned project in order to assess the minable quantity of sand from each river within the administrative jurisdiction of each panchayat and developing appropriate river bank protection and management plans for eroding river banks. The ultimate goal of this programme is ecorestoration of the rivers, balancing resource use and conservation to facilitate informed decisions so far as river management is concerned. Work on the Karamana and Ithikkara rivers was undertaken with the following objectives: (i) Mapping of river banks following the

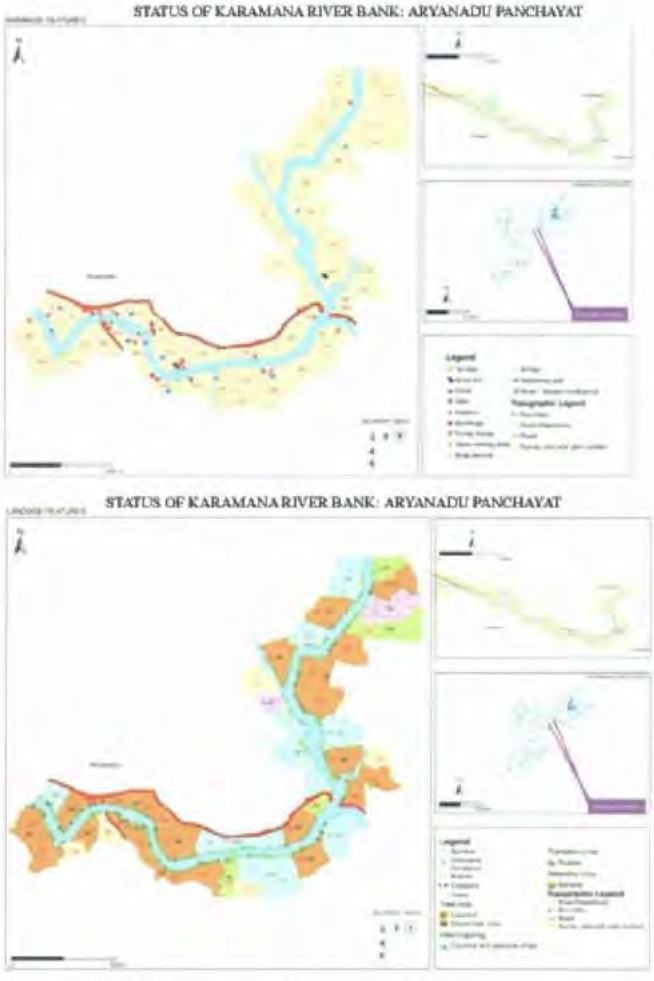


Fig. 2.2.6.1 Karamana River bank Atlas

guidelines issued by the Revenue Department, (ii) measurement of cross-sections at selected locations, digitisation of river bank maps, and (iii) preparation of river bank Atlas. This work proposes to generate all primary data through fieldwork.

Field mapping covering 100 m stretch from the bank on both side of the river in cadastral scale (1:3960) to collect all details as specified in the instructions of the Revenue Department, filling up of data format covering all information about the river bank, measuring of cross sections at an interval of 500 m by using dumpy level, replotting of all data in a fresh cadastral map in laboratory, preparation of three thematic maps, namely landuse, manmade features and physical features, use of topographical sheets in 1: 50, 000 , 1: 250, 000 and 1: 25, 000 scale to have an idea about the catchment, for georeferencing cadastral maps and also to extract other relevant data, digitisation of all cadastral maps and plotting of data to work out three thematic maps of landuse, manmade features and physical feature. Arc-GIS 10.1 software has been used for GIS analysis and to format the maps.

Karamana river

Karamana river emerges from the Chemmunji Mottai hill of the Western Ghats at an elevation of 1420 m above mean sea level and flows 68 km westward and merges into the Arabian Sea at Thiruvallom-Karumam area near Kovalam. Bank mapping of the Karamana river was taken up as a pilot study based on the Government order. The Civil Engineering Department of Mar Basilious College of Engineering, Trivandrum took up the field work of this pilot study following a methodology worked out by CESS. As this is a pilot study and no such work has been attempted earlier, CESS volunteered to take up digitization work and map preparation.

River bank mapping of Karamana river covered a stretch of 33 km spreading over seven panchayats from Aryanadu to Vilavoorkal. Portion of the river flowing through Trivandrum Corporation was not taken up at this stage. The entire length is divided into five frames. Frames of II and III have three sub frames each and frame V is divided into two sub frames (Fig. 2.2.6.1).

Ithikkara river

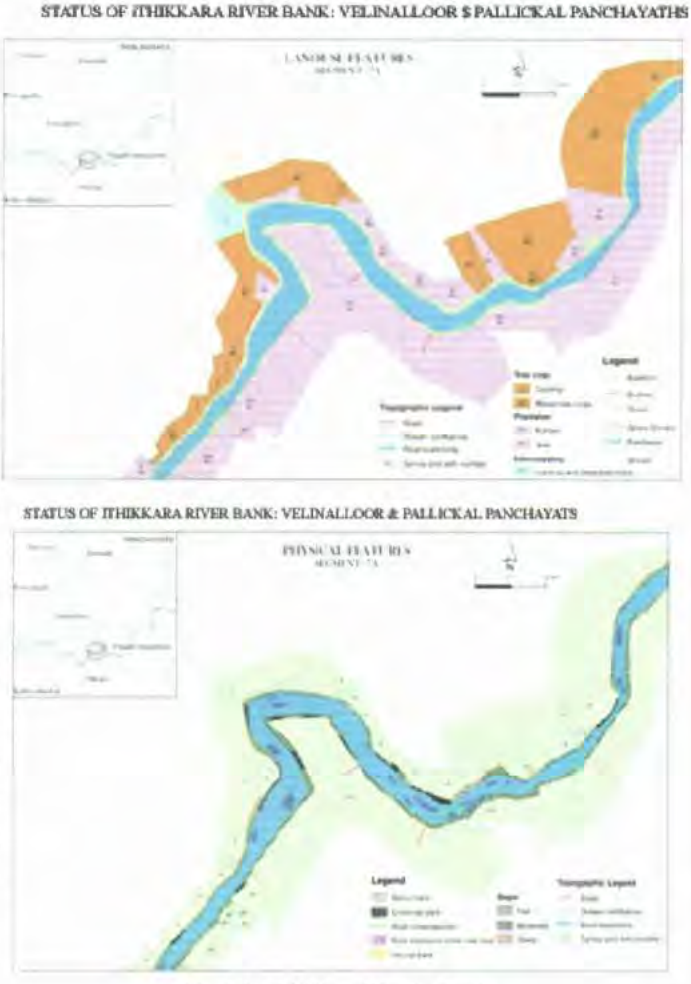


Fig. 2.2.6.2 Ithikara River bank atlas

Mapping of Ithikkara river bank was entrusted with the Centre for Earth Science Studies (CESS) vide MoU signed by the District Collector, Kollam and the Director, CESS. The Ithikkara drainage basin occupies the southern sector of Kollam and a small portion of Thiruvananthapuram districts and it extends from 8°44' 10" N to 90°0' 50" N latitudes and 76°37' E to 77°22' E longitudes. The river Ithikkara originates from the low hills of Karakunnu (250 m above msl) adjacent to Madathara in the foothill region of the Western Ghats and flows through Yeroor Reserved Forest area in a straight north-westerly course. It is a 6th order stream with a length of 56 km (main channel) and draining a catchment area of 642 km^2. Out of the total length of 56 km from the source to mouth a stretch of 42 km, which is flowing through midland and low land with a possibility of sand accumulation has been mapped. The mapped part of Ithikkara river is traceable through 11 segments and is spreading over 11 panchayats from Anchal to Adichanalloor. This Atlas of Ithikkara river bank comprises 82 plates.

The maps produced gives necessary details about the river bank and adjacent land. Large scale mapping showing status of river banks with particular reference to physical features, manmade features and land use features are the salient characteristics of river bank mapping (Fig. 2.2.6.2). Large scale map will help detailed planning. Maps will also be useful to understand encroachment along the river banks. Information on erosion/ depositional status of the river bank will be useful for bank protection measures. Ecorestoration activities of the channels can be planned based on these maps. Each panchayat supplied with a copy of this map showing river stretch in their jurisdiction can chalk out development plans. These maps will be useful to take up any work related to river management. Revenue Department, Water Resource Department, PWD, Local Self Government Department and all those interested in river health management will find this map useful.

Srikumar Chattopadhyay

Funding: Department of Revenue, GoK

2.3 Environmental Assessment

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

Urban heat island (UHI) makes cities significantly warmer than its surrounding rural areas. Major causes of UHI are the storage of solar heat in the urban fabric and its slow release at night; impeded wind flow; reduction in evapo-cooling due to impervious surfaces; blockage of outgoing radiation due to reduced sky view factor; etc. Heat Stress caused by UHI is known to precipitate heart disorders in vulnerable persons. UHI also significantly increases energy consumption for space cooling in warm climates. Unlike global warming, UHI is a local micro-climate modification and can be corrected or reduced at the local level.

This study proposes a modified LCZ classification with additional zone properties, leading to a better understanding of the variation of UHI intensity of same classes with different surface area and diverse adjacent zones. The role of wetlands in the control of the microclimate is also brought out indicating the possible use of constructed wetlands in micro-climate control. Kochi urban area is found to be a net emitter of methane gas, ground level concentrations being significantly higher than background values in industrial areas and municipal waste yards.

E. J. Zachariah

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

Poverty- environmental degradation nexus is an important topic of interdisciplinary research at the global level mostly attempted by environmental economists. This study has been set within the framework of interactive human system and environmental system.

Objectives of this study are to evaluate the extent of degradation of environmental resource base through mapping and data analysis both in the macro and micro level, analysis of driving factors leading to environmental degradation, socio- economic survey to understand the extent of poverty, and to map the distribution of poverty affected areas/ settlements, and study of spatial interrelation between environmental degradation and poverty (Fig. 2.3.2. 1). Maps have been analysed to extract biophysical data and assess broad change in landuse. Detailed field survey was conducted to verify geomorphology and landuse maps and to collect field data on environmental issues. A structured questionnaire was prepared and household level survey was conducted to assess incidence of poverty and environmental condition. Environmental conditions of the Panchayats were rated based on a set of parameters and incidence of poverty in each panchayat was assessed to understand the poverty environmental degradation nexus. GIS was used for map analysis and data synthesis. Data have been generated from primary and secondary sources and field survey.

increase in future.

Ahalya Sukumar

2.3.4 Study on environmental effects of human interventions in the Periyar river basin, Central Kerala.

The concern for the environment has grown up in the last few decades due to 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 drastically changed over the past 4-5 decades due to the rise in foreign remittances and subsequent economic developments. The present project "Study on the environmental effects of human interventions in the Periyar river basin, central Kerala" addresses the various issues related to mining and quarrying of natural resources like hard rocks, sand from instream and floodplain areas, soil, laterite and clay in one of the important river basins of Central Kerala – the Periyar river basin. The river basin hosts the Kochi city, the fast developing urban-cum-industrial centres in South India. Mining and quarrying activities are taking place in the basin in all the three physiographic regions- the highland, midland and lowland. Major mining/quarrying activities noticed in this river basin are hard rock quarrying, soil quarrying, laterite block cutting, instream sand mining and clay mining. Limeshell mining is confined only to the Chendamangalam gramapanchayat of Ernakulam district. The indiscriminate mining and related processes were rampant in the area which in turn create many environmental issues. Creation of scars on the earth's surface, fallow land, pitlakes, etc., could adversely affect the biophysical components of the river basin environment. The impacts of mining, in most cases, leave permanent mark on the land leading to modifications in the actual geomorphological setting of the area. Unsupported mines often promote soil erosion and changes in soil texture and compaction. Hard rock quarrying is also widespread in many sub-basins of the Periyar river. Unscientific mining activity has adversely affected the surface water hydrology of many micro watersheds. Out of the total water falling annually into the basin, a substantial propotion is detained in the quarries as pitlakes which do not reach the master channel for fulfilling its geological and ecological functions.

K. Maya & D. Padmalal

2.3.5 Environmental management plan for Alappuzha-Sherthalai canal and Kanjikuzhy Grama Panchayat

The main aim of the project was to prepare environmental management plans for the Alappuzha- Sherthalai (A-S) canal and for Kanjikuzhy Grama Panchayat. Detailed investigations were carried out on water quality and other environmental issues for A-S canal. Environmental management action plan envisaged for the A-S canal includes eco-restoration, use of canal water resources for irrigation, household purpose and fisheries, post-renovation work and maintenance, organizational issues and monitoring. Environmental status was assessed at ward level for Kanjikuzhy Panchayat based on detailed investigation, cadastral level data and Participatory Rural Appraisal. Environmental management action plan proposes watershed based approach. Control for water logging, prevention of salinity intrusion, pond renovation and enhancement of land productivity are important sectors of intervention. The project report was submitted to the Kerala State Council for Science, Technology and Environment, Government of Kerala.

Srikumar Chattopadhyay

2.3.6 Socio-economic study of impact on traditional fishing community particularly due to operational stage-I of Rajiv Gandhi Combined Cycle Power Project (RGCCPP) and Stage-II, Phase-I in Kerala

The NTPC Limited has established naphtha based Rajiv Gandhi Combined Cycle Power Plant (RGCCPP) at Kayamkulam in Alappuzha district. The plant site is located in a reclaimed land within the Kayamkulam lake. The present study was commissioned by the NTPC Ltd, and was taken up by CESS. Establishment of the thermal power plant might have triggered certain changes in the lake environment and have impacted the livelihood of fishing community living around the lake. This study has been taken up with the following objectives: to assess and identify the various types of traditional fishing communities around the Kayamkulam lake in the vicinity of NTPC project, to assess the overall impact on their traditional livelihood pattern (karanila system), if any, prior, post setting up and during operation of Kayamkulam project, to assess the production of different categories of edible fishes including prawns, crabs and mollusks before setting of project and during operational stage, to assess the income of these communities and income pattern since last 15 years, to assess the change in occupational pattern, if any, in the traditional fishing communities due to operation of Kayamkulam project, to assess the health conditions, educational avenues etc. and the changes thereon due to operation of project, if any, to assess the migration pattern (inward and outward), if any, specially due to operation of the plant and reason thereof and to

analyze and conclude the overall impact on traditional fishing community particularly due to operational stage of the Project.

Fig. 2.3.6.1 Satellite(IRS LISS III, 2005) image of Kayamkulam lake and surroundings

The study area covers sixteen Panchayats and Kayamkulam Municipality falling within the area of 10 km radius around NTPC Project site (Fig. 2.3.6.1, 2.3.6.2). Considering location of the plant, nearness to the Kayamkulam lagoon and fishing in the lagoon, all panchayats have been arranged into three groups: Core area, Inner Periphery and Outer Periphery. Fishermen in the core area fish solely in Kayamkulam lake. Arattupuzha Grama Panchayat in Core area is the main fishing hub, where all five fish landing and auctioning centres (locally known as *Kadavu*) are located. Traditional 'Karanila' system is not practised here. People in the project area voice their concern mainly about the environmental issues of dredging and waste water disposal.

Fig. 2.3.6.2 Study area

This study attempted to bring out socio-economic impact of Kayamkulam NTPC project on traditional fishermen (Fig. 2.3.6.3). Sample survey conducted in the study area indicates that the demographic condition of the fishermen here is different from the average district scenario. Sex ratio among sample households is 885 females per 1000 males. This is in sharp contrast to general trend of Kerala having sex ratio in favour of females. Only 9% people are illiterate. Average income of the fishermen family as reported during survey varies from Rs. 500 to Rs. 2500 per week. Houses are mainly brick built with 2 to 3 bedrooms and all houses are electrified. Ninety one per cent of sample households have mobile phone and television. Health problem is not so serious. Incidence of skin allergy has been reported.

Fig. 2.3.6.3 Environmental Impact Assessment (EIA) Diagram

The NTPC Project contributes to the power security of the State, which is the main direct positive social impact having cascading effects on development process. There are certain perceived negative impacts. Fifty seven percent of respondents opined that there is decrease in fish catch, while 34% felt there is no change on account of NTPC although there is general decline in fish catch. Weekly migration of fishermen is reported. Fishermen are also looking for income earning jobs in other sectors. Apart from weekly migration there is no perceptible change in life style or social set up. Negative socio-economic impact of NTPC- Kayamkulam project on traditional fishermen are localized. Opinion about reduction of fish catches due to NTPC changes with distance from the Core area. There is reduction in fish catch, however it cannot be solely attributed to NTPC as water pollution from various point and non-point source may also contribute to decrease in productivity. This issue of dwindling fish stock in Kayamkulam lake warrants a detailed study. The traditional fishermen are facing hardship and are rightly concerned about their livelihood security. Their apprehension about negative impact of NTPC project on fish resource may be coincidental. Nevertheless their concern may be addressed and aspirations of traditional fishermen need to be fulfilled. NTPC Ltd. may interact with the Panchayats for introducing development packages and for future monitoring.

Srikumar Chattopadhyay

Funding: NTPC, GoI

2.3.7 Coastal Ocean Monitoring and Prediction System (COMAPS)

The coastal ecosystem of our country particularly the south west coast of India is facing unprecedented threats from rampant population growth, growing urbanization, declining fisheries and multiple impacts due to climate change. In order to assess the seasonal variations of chemical, biological and microbiological aspects of coastal milieu, the Ministry of Earth Sciences, Govt. of India initiated a project "Coastal Ocean Monitoring and Prediction System (COMAPS)", the prime objective of which is to assess the sources, levels, pathways and effects of various pollutants in identified hot spots along the coastal areas of Kochi, Mangalore (Karnataka) and Kavarathi island.

Fig. 2.3.7.1 Total nitrogen content in shore waters from Magalore during different seasons.

Fig. 2.3.7.2 Concentration of mercury in bottom sediments at Kochi during different seasons.

Kochi and Mangalore shore waters recorded higher values of all the nitrogen forms (Fig. 2.3.7.1). The presence of inorganic phosphorus and total phosphorus, may be directly attributed to the degree of discharge of industrial effluents, agricultural run–off, sewage outfall, other natural (riverine flux) and anthropogenic activities. Higher concentration of nitrogen forms in the lagoon waters of Kavaratti may be attributed to the allochthonous sources. In Kochi and Mangalore, the cumulative effects of massive riverine flux contribute mainly to the higher concentration of silicates, whereas, the uptake by phytoplankton and the slow rate of regeneration of silicates from the sediments is the reason for the relatively lower silicates in coastal waters in Kavaratti. The DO exhibit an inverse relationship with temperature during post-monsoon.

It is seen that the unscientific dredging activities also impose drastic changes in the sediment dispersal pattern in the hotspots of Kochi and Mangalore. The sediments in both these hotspots are polymodal and the size shifts between medium and very fine silt. Among the heavy metals analyzed, lead is the most dominant pollutant observed in both Kochi (10.0µg/g to 37.40µg/g) and Mangalore (04.0 µg/g to 29.0 µg/g) sediments. Concentration of mercury in the Kochi and Mangalore sediments are as high as 0.9 mg/kg (Fig. 2.3.7.2) and 5 mg/kg respectively, which is well above the prescribed limit of 0.2 mg/kg as stipulated by USEPA (2000). Higher level of mercury may be due to the discharge of effluents from heavy metal processing industries such as FACT, HIL etc. During the study period, Cd ranged from 0.30µg/g to 3.41µg/g and 0.17µg/g to 3.41 µg/g in Kochi and Mangalore sediments respectively.

On the basis of chlorophyll concentration, Kochi can be classified as more or less eutrophic (78 mg/m^{-3}), Mangalore as mesotrophic region (2 mg m^{-3} to 8 mg m^{-3}) and Kavaratti as oligotrophic region (values< 2 mg m^{-3}). In all the three stations, general decreasing trends of chlorophyll are reported from shore to offshore region. Presence of floating plants like *Eichornia crassipes* contributes to comparatively higher chlorophyll values at Kochi bar mouth region (Fig.2.3.7.3).

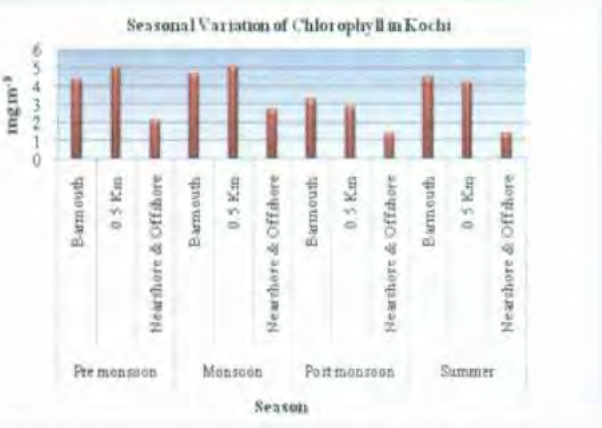


Fig. 2.3.7.3 Seasonal variation of Chlorophyll in Kochi region.

Kochi hot spot recorded maximum number of phytoplankton species (> 138 nos.) followed by Mangalore and Kavaratti. In Kavaratti, poor nutrient enrichment facilitates low distribution of phytoplankton. No HAB's

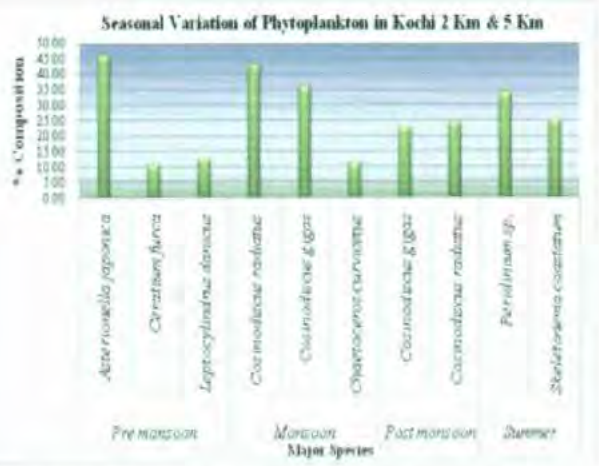


Fig. 2.3.7.4 Seasonal variation of Phytoplankton in Kochi

are reported from any of the three stations. Diatoms are the dominant group of phytoplankton in all the three hot spots. In Kochi, the dinoflagellates dominates whereas in Kavaratti, a nocturnal bloom of blue green algae befell. Major dominating diatom species reported from Kochi are *Skeletonema coastatum*, *Cosinodiscus gigas*, *Biddulphia reticulata* and *Chaetoceros lorenzianus* and among dinoflagellates, *Ceratium furca*, *Peridinium sp.*, *Pyrophacus steinii* and *Prorocentrum sp.* are the dominant ones. Bloom of *Leptocylindrus danicus* during summer season of 2012 accounts for highest cell density of plankton (> 200000 cells litre^{-1}) (Fig. 2.3.7.4).

Though the species *Leptocylindrus danicus* is not toxic, the overabundance of the species may deplete oxygen in the coastal waters, which can further cause decrease in dissolved oxygen values. *Chaetoceros indicus*, *Chaetoceros curvicetus*, *Asterionella japonica* and *Skeletonema coastatum* were the dominant group of plankton distributed in Mangalore water throughout the study period.

In Kochi, species richness and diversity of zooplanktons was found to be high during summer and pre-monsoon. In Kochi bar mouth region, summer season indicated dominance of zooplankton species such as *Calanopia minor*, *Acartia danae*, *Candacia discaudata*, *Copepod nauplii*, *Fish eggs*, *Polychaete larvae*, *Acartia spinicauda*, and *Tintinnopsis cylindrica*. In Mangalore, *Fish eggs*, *Copepod eggs* and *Copepod nauplii* dominated in 0.5 km transect and the open sea during pre-monsoon season. *Copepod nauplii* (50.76%) and *Candacia discaudata* (29.6%) dominate in the open sea of Kavaratti waters during pre-monsoon and post monsoon season, whereas, *Cypridina sp.* and *Acanthomentron sp.* contributes a major percentage composition in monsoon season. *Cypridina sp.*, (Fig. 2.3.7.5) the luminous tiny shelled *Ostracoda* species found in the lagoon area of Kavaratti, ejects a blue luminous secretion , which dominated the zooplankton population during the monsoon nocturrial sampling.

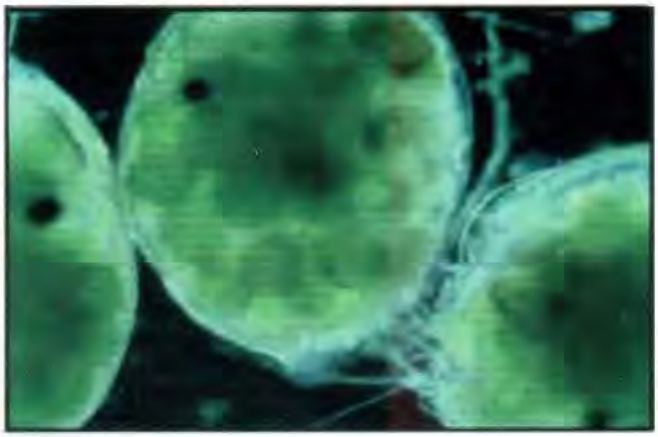


Fig. 2.3.7.5 Bioluminescent Zooplankton: Cypridina sp. in Kavarathi Lagoon (Monsoon)

Among the macro benthos *Villorita cyprinoides*, *Anadara rhombea*, *Trochidae sp*, *Modiolus sp*, *Anadara granosa*, *Dendronereis estuariana*, *Phyllodocea castanea*, and *Capitella capitata* dominate the Kochi bar mouth, shore, nearshore and offshore regions. Macro benthos such as, *Anadara granosa*, *A. rhombea*, *Donax serotum* and *Dentalium* species dominate in the Mangalore shore region in pre/ post monsoon season while their occurence reduces during summer season. In the beach sand in Mangalore meiofauna such as *Viscosia sp.*, *Oxystomina sp* and *Ammonia tepida*, *Enoploides sp.* are dominant in summer and post-monsoon. The meiofauna of Kavaratti lagoon includes nematodes and symbiotic bearing benthic foraminiferans. Higher calcium carbonate content of the sediment favoured an abundant percentage composition of benthic foraminifera such as *Spiroloculina depressa* and *Bolivina tortuosa* in the summer season of 2013.

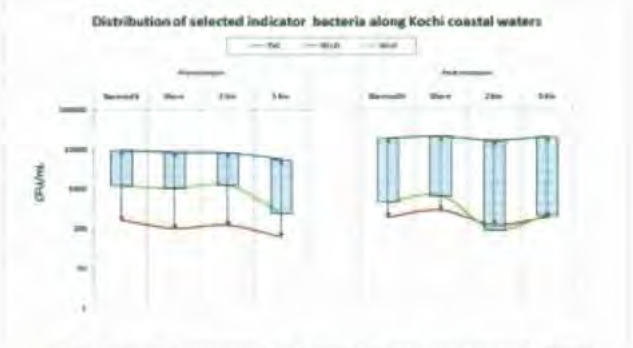


Fig. 2.3.7.6 Distribution of selected indicator bacteria along Kochi coastal waters

In Kochi waters *E. coli* and *Streptococci* averaged 249.81±506.50 and 406.98 ±549.56 CFU/ml respectively (Fig. 3.3.7.6), whereas Mangalore waters recorded values of 127.75±159.30 and 165.46±292.26 CFU/ml respectively during the study period. The monsoon season documented a prominent increase in the bacterial load in all the three locations (mean value for Total Viable Count: Kochi-24831 CFU/mL, Mangalore-26077 CFU/mL and Kavaratti 6800

CFU/mL). A higher incidence of all indicator bacteria is noticed in the inshore regions. Activities such as, discharge of illegal sewers especially from markets and septic tank and dumping of animal carcasses are contributing to the gross contamination of the eco-system with the ever increasing growth of coliform as well as pathogenic bacteria.

M. Samsuddin & K. Anoop Krishnan

Funding: MoES, GoI

2.4 Coastal Zone Management

2.4.1 Integrated Island Management Plans (IIMPs) for Lakshadweep islands

Lakshadweep is a cluster of enchanting small coral islands in the Arabian Sea. The limited land area, fragile environment, limited resources etc., are some of the major environmental constraints faced by the islands. Keeping the developmental perspective of these islands, the Union Territory (UT) of Lakshadweep has entrusted the Centre for Earth Science Studies to develop 'Integrated Island Management Plans (IIMPs) for Lakshadweep islands' in accordance with the guidelines of the Island Protection Zone (IPZ) Notification, 2011 of the Ministry of Environment and Forests, Government of India. The IIMP envisages the preparation of a detailed spatial plan of the islands on 1:4000 cadastral scale covering (i) the entire island area landward from High Tide Line (HTL); (ii) the land area between HTL and Low Tide Line (LTL) which is termed as the intertidal zone and (iii) the lagoon area within the territorial water limit (12 Nautical miles or 20 km).

Data Collection and Approach

The data gathered as per the IPZ, 2011 notification during different field visit to the island were integrated with the digital data base which were prepared as part of ICZMP (Integrated Coastal Zone Management Plan) during 2002-2005 on cadastral scale map for mapping the different physical characteristics of the island. The point information in the islands such as dwelling units including some of the infrastructural facilities was mapped using Global Positioning System (GPS). The conservation and preservation zones which are one of the key components of the plan were mapped separately. The entire island including the lagoon aquatic area has been considered for the plan preparation. The data from the eco-geomorphology of coral reef mapped using high resolution satellite images in 2007 was used. The entire field data sets were organized in ARC-GIS platform. Though the MoEF guidelines direct to prepare the IIMP in 1:10,000 scale, the final map was prepared in 1:4000 scale considering the small size of the island and for better clarity of the plan.

Major Thrust of IIMP

The major thrust of IIMP is to conserve and preserve zones which are basically the major coastal habitats of the island ecosystems. The management of these habitats is based on well understood linkages among human activities and changes within a natural system. The known uses of the coastal habitats are classified as non-extractive, extractive and transformative. Non-extractive uses refer to activities such as recreation, research and education which do not involve removal of material from the habitats or do

Fig.2.4.1.1 Map showing the contour elevation of Kavaratti island which ranges between 0.5 and 6 m above msl. High elevation is noted on the north-western part of the island.

not have serious impacts. Extractive uses involve removal of renewable resources such as fish, ground water, mangrove wood, etc. Transformative uses (such as coral extraction, waste disposal without treatment, etc) result in negative changes in habitat characteristics and function. Sometimes there is a degree of overlap among the uses. The major coastal habitats of the island are coral reefs, sea grass beds, sand dunes, lagoons, sandy beaches, etc.

In the island extensive coral reef formation is seen both inside and outside the lagoon waters. These coral reefs are present in the depths exceeding 1-2 m depth in the lagoons and also beyond the wave breaker zone. In the outer reef areas it is present up to 30 to 40 m depth. The biophysical survey of coral reefs conducted during 1999-2002 has indicated the presence of live corals which is ranging between 14 and 24%. The area bordering the above zones is declared as buffer zones and remaining areas is classified as non-coral reef areas. A similar classification applies to sea grass areas also.

Weightages in IIMP

While preparing the IIMP, weightage is also given for upgrading the physical and social infrastructure in the island. Some of the physical infrastructures required in the islands are primary health care facilities, high schools, primary schools, nursery schools, etc. A college /ITI with hostel facilities are possible in only one of the larger Islands. The emergency / cyclone shelters can be built on stilts or can be identified in the elevated area having double story building. Primarily, the existing provisions have to be upgraded in terms of land built space and facilities. Organized open spaces for settlement and neighborhood (ward) level parks / play grounds exist and are being upgraded often with built facilities / equipment for different resident age groups. The same applies to the island level sports ground. In terms of physical infrastructure, potable water is generally in short supply in most of the islands. Desalination plants fill up the gap in Kavaratti, Agatti and Minicoy. This facility is to be installed in all islands. For sewage disposal two pit flush septic tanks are in place. Oxidation ponds / bio-toilets offer alternatives according to soil conditions.

Solid waste disposal / management pose problems and alternatives to sea dumping / incineration needs are also being explored. Electricity is generated through diesel. These needs being supplemented by alternate sources, of which solar panels and windmills are favored alternatives.

Demand for new private housing / households is not in the UT as the decadal growth rate has been and continues well below the national average. In fact the bulk of the demand for new housing is in the government sector through standardized houses and at two storeys. Private houses are being constantly upgraded and incrementally extended through permanent material and often at two storeys. In this scenario, households seek direct access from roads or common pathways. They seek better social / physical infrastructure, other amenities and better livelihood avenues. Also, as land is primarily with the community, home stay facilities are possible only through expansion of houses and not through new houses within the habitation zone. Even these should have the majority concurrence of the grama sabha before being considered.

High Power Committee

The high power committee constituted by the Hon'ble Supreme Court of India under the chairmanship of Justice R.V.Raveendran (Retd.) has looked into some of the issues concerning the development of tourism and vulnerability issues in the islands. Further the committee has also examined in detail the criteria for fixing the coastal setback area, i.e. 'No Development Zone' (between High Tide Line and Setback line) where developmental activities are eitherrestricted or prohibited. The objects of providing such a No Development Zone (NDZ) as provided in the CRZ Notification are (i) Protection of life and property against erosion, storm surge and sea level rise due to global warming; (ii) Protection of ecologically vulnerable coastal habitats, special, natural or scenic sites; (iii) Ensuring public access to the beaches; (iv) Avoidance or minimising the cost of investment on coastal protection work and adoption of eco-friendly methods; (v) Prohibition or regulating the different types of activities taking place in the coastal zoneto maintain the balance between developmental goals and environmental objectives.

Fixing Setback Area or No Development Zone (NDZ)

As part of the plan preparation, a scientific method of recognizing the set-back line or no development zone in the islands has been formulated. The two measurable criteria are the horizontal shoreline displacement (erosion/ accretion) and elevation. The shoreline erosion / accretion pattern being a dynamic process can be attributed to several factors which include both natural and anthropogenic activities. These can cause both temporal and spatial variations in the shoreline position which may eventually result in an eroding coast becoming accreting coast and vice versa. Hence the shoreline changes independently may not give the correct measurable criteria for identifying the setback line. The other parameter is the elevation of the island with respect to HTL. By considering all these aspects a distance up to an elevation of 0.5 m above HTL is taken

Fig. 2.4.1.2 Draft IIMP for Kavaratti island, one of the main islands in Lakshadweep, with proposed conservation, preservation and development zones and recommended action plans.

as a general parameter for fixing the setback line.

It has been noted that some parts of the island is thickly populated and highly developed. To cater to the greater demands of coastal area in the developed zones it may not always be acceptable if a uniform setback is provided for the entire island. Taking clue from the criteria adopted in categorizing the coastal zone as CRZ-II and CRZ-III and allowing more development in CRZ-II in the original CRZ Notification, the setback in the island is determined based on the criteria whether the portions of the island are developed or undeveloped, availability of free space and differential exposure to natural hazards. Based on these criteria a moderate setback distance is considered for the developed area. The portion of the island which has a sparse settlement or undeveloped area with more open space, is provided maximum setback distance as a conservative measure. The Fig. 2.4.1.2 is a draft IIMP for Kavaratti island, one of the main islands in Lakshasweep, with proposed conservation, preservation and regulated development zones, and recommended action plans.

T. N. Prakash

Funding: DST, UT Lakshadweep

2.5 Biophotonics

2.5.1 Inactivation of Pathogenic Bacteria in Periodontal Diseases – Fluorescence Diagnostics and Photodynamic Therapy

This is a collaborative programme with the Bulgarian Academy of Sciences (BAS). Scientists from BAS visited CESS and carried out joint studies. A Diffuse Reflectance (DR) based point monitoring system was utilised for in-vivo monitoring of gingival inflammation. A method for quantitative analysis of the data using DR intensity ratio (R620/R575) was proposed, which was also utilised for in-vivo imaging of periodical inflammatory conditions in patients. In-vivo clinical trials of a PDT were carried out at the GDC, Thiruvananthapuram and the DR imaging

system was utilized to monitor the effectiveness of PDT non-invasively. In-vitro PDT rails on gram negative as well as gram positive perodontal pathogens were conducted using new age cationic photosensitizers. The following chapters present the appliction of point monitoring and imaging techniques for detection of oral cancer in a clinical setting and the results obtained.

In this study the applicability of spectral intensity ratio (R620/R575) for the quantification and discrimination of disease (gingivitis and periodontitis) from healthy cases was demonstrated by recording the DR spectra from papillary gingiva. An individual's risk for periodontal disease could be linked to gingival inflammation in response to plaque accumulation. The immune-inflammatory response that develops in the gingival and periodontal tissues in respose to the chronic presence of plaque bacteria results in the destruction of structural components of the periodontium leading to clinical signs of peridontitis. Therefore, by measuring the erythema it is possible to evaluate the presence of plaque accumulation in subgingival pockets. Earlier studies demonstrated that DR spectroscopy can be utilized to discern the properties of light absorbed by skin chromophores and help diagnose the degree of erythema.It has been found that cucutaneous eryhtema correlates well with the relative concentration of oxygenated hemoglobin. Even though these findings were reported for the skin, gingival tissues has a similar structure. The external layer is the epithelium and there is an underlying layer and the connective tissue where most of the microvasculature is embedded. This is the first report on the use of DR intensity ratios involving the oxygenated hemoglobin absorption peaks for discrimination between healthy and diseased gingiva. These findings demonstrate the feasibility of using DR spectroscopy for quantitatively classifying/ distinguishing healthy gingiva from diseased gingiva in a clinical environment from the spectral ratio R620/R575. The study results shows that the exact extent of underlying inflammation which may not be clinically visible could be detected using DR spectral features. Furthermore, these investigations could pave the way for development of non-invasive methods for periodontal disease screening and monitoring. More measurements are required using multispectral imaging in a larger population to explore the applicability of ratio techniques for non-invasive screening of periodontitis and to improve the diagnostic accuracies for discrimination of gingival inflammation. Longitudinal studies are needed to prove the usefulness of this proposed techniques for prediction of disease risk and future disease progression in periodontitis

Diffuse Reflectance imaging of periodontal inflammation utilizing oxygenated hemoglobin absorption peak at 575 nm has shown to efficiently discriminate healthy periodontal tissues from mild, moderate and severe inflammation in the periodontal region. In order to screen the entire diseased area and its surroundings instaneously, DR images were recorded with an EMCCD camera at 620 and 575 nm. It was 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 high diagnostic accuracy obtained in this study underline the potential use of this method in routine clinincal practice.

Cationic porphyrins PyP and ImP were synthesized, characterised and utilized for inactivation of the Gram-negative and the Gram- positive periodontal pathogenic bacteria associated with various infectious diseases. The photophysical properties including the singlet oxygen quantum yield, flurescence quantum yield, triplet lifetime, absorption and flurescence spectra of the sensitizers were studied. The in vitro photo inactivation studies on Gram-positive aerobe E.faecalis, Gram-negative anaerobe F. Nucleatum and microaerophilic Gram-negative A. actinomicetemcomitans showed promising results. As compared to PyP porphyrin, ImP showed no dark toxicity, which was observed for PyP on E. faecalis strain. Confocal microscopy was used to study the distribution of both the sensitizers in artificially grown biofilms for both Gram-positive and Gram-negative strains. The present study contributes significantly to the knowledge base related to the development of new age porphyrins, such as PyP and ImP, as photosensitizers for antimicrobial PDT. These porphyrin compounds appear to be effective against dental pathogens, especially the Gram- negative species.

The clinical outcomes of conventional SRP may be improved by adjunctive antimicrobial photodynamic therapy in patients with chronic periodontitis. Photodynamic therapy is effective in treating periodontal abscess without the use of any antibiotics. DRS imaging is a powerful tool in evaluating tissue morphlogy thereby validating and assessing the photodynamic therapy outcome of diseases associated with erythemal response. The periodontal pocket formation due to bacterial activity makes the situation largely irreversible. Therefore, early detection of disease facilitates the treatment response thereby restoring the periodontium to its early stage. DRS imaging is useful in detecting disease in its early stage. The usefulness of photodynamic therapy adjunctive to scaling

can be attributed to its efficiency in killing pathogens deeper inside the subgingival pockets compared to treatment.

N Subhash

Funding: DST, GoI

2.6 GIS and Remote sensing Applications in Natural Resources Management

2.6.1 Glimpses of Kerala through maps

Fig. 2.6.1.1 Transport network drape on DEM

The volume on 'Glimpses of Kerala through maps' is a special type of Atlas consisting of 32 maps in 1:2 million scale. Apart from the administrative map, 31 maps are arranged under different biophysical, demography, social infrastructure and levels of development set up which is indicative of the rich natural resource base of the State of Kerala (Fig. 2.6.1.1). Explanatory notes with attribute tables, were completed for the volume.

The Atlas with the multi-themes covering physical, socio-economic and human development aspect will be useful for the planners, academicians and also common people interested in the development of Kerala.

Srikumar Chattopadhyay

2.6.2 Wetlands of Kerala

This work was undertaken jointly by CESS, KFRI and CWRDM. The objective was to prepare a brief document with maps of the wetlands of Kerala under the Wetlands (Conservation and Management) Rules 2010, by incorporating geographical delineation of each wetland, demarcating their zone of influence, calculating the size of each wetland, and prepare a brief account of the pre-existing rights and privileges consistent or not consistent with the ecological health of the wetland as per the directive of the Department of Environment and Climate change, Government of Kerala. The wetlands of the State were dealt under two broad categories namely inland wetlands and coastal wetlands; important wetland units identified being estuaries, backwaters/*kayals*, aquaculture ponds, chemmeenkettu, pokkali fields, creeks, mudflats, abandoned quarries, waterlogged, areas, sand/beach/ spit, tanks, lakes, ponds and reservoirs. The methodology adopted was by integrating the spatial distribution of wetlands in 1:50,000 scale.

Survey of India topographical sheets with latest IRS P6 satellite imagery of 5.8 m spatial resolution were used. As per the above rule of 2010, the minimum size of the wetlands that could be notified was 5 ha on a scale of 1: 50,000 in a high altitude wetland / wetland complexes at or above an elevation of + 2500 m. The size of the wetlands/ wetland complex that could be mapped below that elevation would have an area equal to or greater than 500 ha as per the national norm. However, we utilised this opportunity to make an up-to-date inventory of the entire wetlands of the state, in the digital format, and collected and analysed all environmental problems consistent or non consistent with the ecological health of each of them. This was mainly for the user agencies like the Ministry of Environment and Forests to plan proper conservation and management action plans. The work identified 1,25,822.4 ha wetlands in the state covering 14 districts against 1,27,930.07 ha identified in the previous survey. An interesting aspect of the study was the mapping of the entire wetlands in 92 plates, and mangroves (46 km^2) from almost all the coastal districts with approximate areal extension. This study recommended notification for conservation of all the wetlands in the state, with three priority areas viz., Vellayani, a freshwater body situated very near to the capital city, Thiruvananthapuram, Kuppam-Valapattanam estuary and the Kavvai backwaters in north

Kerala.

C. N. Mohanan
Funding:DoECC, Gok

2.6.3 Digital Resource Atlas of Kerala

Fig. 2.6.3.1 Tourism map of Kerala

The project aims to bring out digital resource Atlas of Kerala producing thematic maps in 1:1,000,000 scale with updated information and preparing new thematic maps in 1:250,000 scale. The themes cover land, water, climate, agriculture, demography, socio-economy, infrastructure and similar other aspects within the broad spectrum of natural resource distribution (20 maps), human resources (50 maps), infrastructure (12 maps), and resource development (206 maps). These maps will be useful for planning and other purposes.

Abalya Sukumar

2.6.4 GPS facilitation, GIS mapping and customization for soil mapping and soil nutrient management plan preparation for Vegetable and Fruit Promotion Council, Kerala

This project forms part of a State-level program on participatory development model for Kerala Horticulture Development Project (KHDP) funded by the Vegetable and Fruit Promotion Council, Kerala. The participatory development model of KHDP comprises of three components viz., soil sample collection and analysis of micro and macro nutrients (nearly 13 parameters), weather data collection and installation of automatic weather stations. As a part of the KHDP programme, CESS has been entrusted with a program to carry out GPS training, GIS mapping and development of customized application software enabling preparation of soil nutrient management plan for the VFPCK.

Objective of the CESS component is to generate base maps in the scale of 1:10,000 in WGS 84 Datum and UTM Zone 43N projection for the selected 162 local bodies spread over 14 districts of Kerala. Geo-coordinates of the soil sample locations, natural resources and environmental digital database generated by CESS and KSREC, ancillary data collected from concerned local bodies, spatial distribution of macro and micro soil nutrients and VFCK market locations are the principal database used for the study. Imparting training to the State-level Agricultural Officers / Resource persons in the use of GPS for locating the soil sample sites and marking coordinate values with unique codes for post field data linking, development of GIS application in open source for developing site-specific comprehensive crop-specific nutrient management plan through detailed analysis of macro and micro soil nutrients also form part of the project. As part of the program the base maps have been generated in 1:10,000 scale and the post field attribute data were linked with reference to the sample sites in a GIS platform, enabling generation of derivative maps for the preparation of soil fertility and nutrient management plan for the selected 162 local bodies of Kerala.

A web based customized GIS application software has been developed using UMN Map Server 4 Web server (Apache-HTTP), PHP 5.2, JavaScript, PostGIS enabled PostgreSQL 8.4 and Quantum GIS 1.8.0 for map display, map query and map layout generation (Fig. 2.6.4.1). Hosting the programme in intranet/internet is in the final stages of completion. The macro and micro nutrient parameters of the soil samples received from the analytical laboratories are being integrated with the customized application.

Fig. 2.6.4.1 Customized Vegetable and Fruit Information System

The software has been developed and the testing and debugging process is ongoing. Once ready, the web based software shall be hosted in intra-net/internet. As the software is developed wholly on an open platform, no deployment license is required.

B. K. Jayaprasad
Funding:VFPC, GoK

The geo-spatial digital layers landuse, transport, drainage and relief available in CESS are also integrated with the data pertaining to the micro and macro nutrients supplied by VFPCK. The customized application has menus such as pan, zoom-in, zoom-out, measure, query, display current extent and map legend. It has the facility to identify the attributes of a theme by using a mouse click. The application has the provision to add the coordinates of latitude/longitude values in degrees, minutes and seconds (DMS) for inserting a point shape (soil sample sites) into the map-extent. Apart from functions such as "Query", "View data", "View legend", "Export attributes in .xls format" are also available.

The location based variation of micro and macro nutrients distribution of the soil parameters can also be displayed and visualized in the form of bars, graphs and charts. Graphical representation of location specific nutrient distribution of a sample in a agricultural plot of a specific local body can also be visualized. A module has also been developed for adding GPS coordinates of the new soil sample location and value of micro and micro nutrients into the master database for managing and monitoring the nutrient quality.

2.6.5 Geographic Information System of the Particularly Vulnerable Tribal Groups(PTDs) of Kerala

The tribal communities of the State are at varying degree of socio-economic educational and political advancements. A few of them are very much adapted to the main stream life and are living as part of it. However, there are certain communities who are still leading more or less an isolated life either within the rural society or away from it in the forest terrain. The Particularly Vulnerable Tribal Groups (PTGs) are the most under-privileged communities among the Scheduled Tribes of the country. Five among the 36 Scheduled Tribe (ST) communities of the State are categorized as PTGs since they are the most vulnerable sections among ST's of the State. The communities that are coming under the PTGs are Kattunayakan, Cholanaickan, Kadar, Koraga, and Kurumbar constituting about 5.7% of the total tribal population of the State.

The hamlets of almost 90% of the PTG communities residing at various parts of the forest areas of the Western Ghas are either isolated or semi-isolated. Communication, transportation, and other facilities have not yet reached

Fig. 2.6.5.1 Customized Tribal Settlement Information System

the doorstep of these communities owing to a multitude of factors. Sustainable socio-economic development of any community depends largely upon the knowledge about the availability of the natural resources and a systematic planning for their optimal utilization, without endangering the environment and ecosystem of that region. Lack of geo-eco-social information and a database of the communities is one of the major hindrances that decelerate the planning process and proper execution of various development schemes in these areas. A dependable database of the resource availability and a long-term resource management plan are necessary for the steady progress and growth of the tribal community of the State.

The present work is an outcome of the study undertaken jointly by the Centre for Earth Science Studies and Kerala Institute for Research Training and Development Studies of Scheduled Castes and Scheduled Tribes (KIRTADS) for generation of a digital database pertaining to the hamlets of the PTGs spread across five districts of the State in order to work out livelihood and formulate plans to accelerate the development process among these tribal communities. The primary objective of the project is to: (i) impart training for selected resource persons/ volunteers of KIRTADS to collect coordinates of the PTG household using hand held GPS, (ii) generate a customized application software to track the distribution of selected PTGs in the Kerala State for viewing, analyzing, editing and updating information, (iii) linking digital map themes on drainage, administrative boundaries, transport network, soil, land use/land cover and attributes of post field data with reference to the sample sites (location of PTG household) including socio-economic data in a GIS platform to generate desired information and (iv) development of customized application for viewing, analyzing, editing and updating information.

A customized computer-based system that makes use of GIS, remote sensing and RDBMS software is being developed (Fig. 2.6.5.1) for creation, updating and analysis of spatially indexed resources database on a Windows platform. The Tribal settlement Information System (TSIS) provides detailed information on the PTGs and their physical environment.

Archana M. Nair

Funding:KIRTADS, Gok

2.6.6 Setting up of Kerala State Spatial Data Infrastructre for Spatial data sharing and dissemination through interoperable OGC compliant web services

Spatial data acquired/developed by different agencies are not in an interoperable format as they differ in projection system, datum, coordinate system, file formats etc. Even if they follow the same standard, they are not consistent with each other datasets. Inconsistency in layers creates significant issues when data from different sources have to be used for seamless integration. To avoid these issues, a single standard procedure

Fig. 2.6.6.1 Web portal of the Kerala State Spatial Data Infrastructure

has to be specified and all available data has to be converted in to the globally acceptable interoperable standard, so that the user agencies can access the data without any hassles. Setting up of Spatial Data Infrastructure (SDI) which is a collection of technologies, policies and institutional arrangements to facilitate exchange and sharing of spatial data between stakeholders from different jurisdictional levels in the spatial data community is the right decision in these lines.

The Government of Kerala, with the technical support of CESS has set up Kerala State Spatial Data Infrastructure (KSDI) for delivering spatial information services through a web gateway. The KSDI GeoPortal and Clearinghouse with a user-friendly, bilingual interface of Malayalam and English, is envisaged to function as a connecting point and act as a primary intermediary between the data producers of geospatial data content, geo-related services and users, where the data providers retain intellectual right to their own data. The KSDI is conceived as a single window-access and delivery mechanism for the use of spatial/non spatial data by utilizing an open standard, interoperable and decentralized architecture accessible from a common web portal, with data streamed in XML-based standard encoding. The descriptive information known as metadata, collected in a standard format of National Spatial Data Infrastructure uses readily available web technology and standards for search through query of results to the Web across multiple participating sites. All that a user need is a internet connection and a browser.

The KSDI Geoportal solution is hosted at the Kerala State Data Centre with capability to handle data storage, retrieval and update the geospatial information both in automatic and manual forms. With the facility of data crawlers, the data can be automatically harvested and published in OGC Formats (WCS, WPS, WTS WMS, Etc). The KSDI solution is based on the Service Oriented Architecture (SOA) of ERDAS APOLLO Enterprise Solution that provides a "publish, find and bind" workflow. The web-based geo-portal allow the users spread across the internet, to view the data availability, query the spatial information, download the data if required and various spatial and non-spatial functions and analysis.

The KSDI geoportal allow the users spread across the internet, to have access to the spatial data stored in

PostGresSQL database through definite interactive query based search engine with facility to search, locate, access and perform geoprocessing and analysis across the internet through the KSDI network. All that a user need is a internet browser and a internet connection. The KSDI Geoportal and the Clearing House have been implemented (Fig. 2.6.6.1) and handed over to the Kerala State IT Mission under the Information Technology Department, Government of Kerala.

M. Samsuddin
Funding:KSDI

2.6.7 Updating the Natural Resource and Environmental Data Base Covering the Coastal Agro-Ecological units of Kerala

Centre for Earth Science Studies, Kerala State Remote Sensing & Environmental Centre and Kerala State Planning Board in collaboration with the Department of Space have generated digital thematic layers for entire state using IRS P6 (2004) satellite imagery with a spatial resolution of 5.8 m and other ancillary databases during the year 2008. In addition, based on the agro-ecological units demarcated by National Bureau of Soil Survey and Landuse Planning (NBSSLUB), CESS has produced agro-ecological unit wise atlases utilizing the NREDB database. NBSSLUB has delineated 23 Agro-ecological units for the State based on climate variability, landform and soils, out of which 9 are in the coastal zone which require unique management strategies. The Fig. 2.6.7.1 present the spatial distributon of the AEUs in the coastal zone of Kerala.

In continuation with the Atlas project, Kerala State Planning Board (KSPB) has awarded this project to CESS in order to update the coastal parameters which are influencing the agriculture, fisheries, industries, infrastructure and urbanization within the 9 coastal agro ecological units of Kerala viz., Southern Coastal Plain, Northern Coastal Plain, Onattukara Sandy Plains, Kuttanad, Pokkali Land, Kole Land, Kaippad Land, Southern Laterite and four urban

Fig. 2.6.7.1 Customized District Resource Information System

habitation units covering an approximate area of 6420km^2 in 1:10,000 scale. Identification and computation of arable land available in the coastal agro ecological units and CRZ data integration based on updated database also form part of the study.

In addition to the administrative divisions, revenue divisions and the thematic layers such as transport network, drainage network, watersheds, landform, landuse categories have been updated in 1:10,000 scale using the 2011-2012 QuickBird satellite data in WGS 84 Datum and UTM Zone 43 N projection system in the GIS platform. The spatial framework of the population census 2001 has also been integrated to the database. Integration of digital database and identification and computation of areas of the arable land available in the coastal units and integration of CRZ categories are being carried out. CZMP data available in CESS is also being integrated for generating maps for the constituent local bodies of coastal agro-ecological units.

Displaying the digital map layers and retrieving the required information can be achieved through the District Resources Information System (DRIS) developed by CESS using MapObjects and Visual Basic software (Fig. 2.6.7.1). A Personal Computer with Windows Operating System, 1GB Random Access Memory and a minimum of 2 GB Hard Disk space is required to install the DRIS. The application can be started either by clicking the desktop shortcut or navigating the program menu and clicking on the item DRIS. Spatial data is organized separately by district, block and local bodies (panchayats/municipalities) with option for displaying attributes in Malayalam font. The spatial data generated under this project can be directly integrated in the customized GIS application software. This stand-alone application can be made executable and can be deployed in any system having Microsoft Windows operating systems.

B. K. Jayaprasad

Funding: Kerala State Planning Board

3.1 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 from 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, (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, ('Hazard line' is 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) area between HTL and Low Tide Line (LTL),which is the inter-tidal zone, (e) water and the bedarea between the LTL and 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 distance up to which development along 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. 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.

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 coastal zone of the state is included in CRZ V category requiring special consideration. Under this CRZ (on the landward side) in the islands within the backwaters in Kerala have been defined as 50 m from the High Tide Line. 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 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 2012-13 is given in Table 3.1.1

Table 3.1.1 List of CRZ Reports completed during the year 2012-13

Sl No	Institution / Agency	Location	Project
1	FIRMA, Govt. of Kerala	Puthuvypin	Oceanarium and Marine Biological Park
2	Officina	Chowara	Resort development
3	Rohan Developers Pvt Ltd	Mumbai	Redevelopment of site for commercial complex
4	SCS Constructions Pvt.Ltd	Mumbai	Redevelopment of site for commercial complex

Sl No	Institution / Agency	Location	Project
5	Rohan Developers Pvt.Ltd	Mumbai	Redevelopment of Site
6	Sai Palace Hotels	Mumbai	Redevelopment of Site
7	Malabar Commercial Plaza, Calicut	Chacka	Proposed shopping Mall
8	Aegis Logistics Ltd	Pipavav, Gujarat	Proposed Tank Farm at Pipavav Port
9	Heera Construction Co. Pvt. Ltd	Attipra	Residential Project
10	Kerala Maritime Society, Govt. of Kerala	Neendakara	Maritime Acadamy
11	NTPC, Govt. of India	Kayamkulam	Power Project Expanision
12	K.T. Nicholas	Alangi, Kanyakumari	Resort Development
13	Dewa Projects Pvt.Ltd	Gida Land, Kochi	Housing Project
14	Rainbow Realtors Pvt.Ltd	Kannur	Apartment Project
15	Hazira LNG Pvt.Ltd	Gujarat	LNG Terminal
16	NIO, CSIR	Visakhapatnam	Laboratory Building
17	FACT, Govt. of India	Kochi	Acid Storage Tank installations
18	Clarity Aqua Systems Pvt Ltd	Ernakulam	Desalination Plant
19	Tata Power company Ltd	Mumbai	Modernisation of Trombay Thermal Power Station
20	LBS Centre for Science and Technology, Govt. of Kerala	Parapanangadi	Integrated Institute of Science and Technology
21	KSTP, Govt. of Kerala	Kannur	New Bridge
22	Mangal A Gogte	Ratnagiri	Proposed to develop a Survey No
23	KINFRA, Govt. of Kerala	Kozhikode	To develop a land at Beypore
24	M/s. T.Vinay Kumar	Ernakulam	To construct a building
25	Malabar Port Pvt.Ltd	Malappuram	Development of Port
26	Department of Tourism, Govt. of Kerala	Kannur	Develop a Beachwalk
27	Global Village, Paravoor	Kollam	Hospital Development
28	KGL Builders Pvt, Ltd	Kozhikode	Residential Project
29	Yespeesons Enterprises	Thiruvananthapuram	Proposed Commercial Complex
30	Pentagon Builders	Kozhikode	Residential Project
31	CMLRE, MoES, Govt. of India	Puthuvypeen	Establish a Research Station
32	KMML, Chavara	Neendakara	Prepared for the Mining blocks
33	Sea Cliff Resorts Pvt.Ltd	Varkala	Resort Development

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

Funding: Various Agencies

List of Projects

4.1 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.	Landslide stabilization schemes of Agricultural Department (AGRI 3)	Soil Conservation Unit, Dept. of Agriculture	Sri. G. Sankar	Geosciences	—	2009-10	0.19	0.00
2.	Coastal ocean monitoring and prediction system along the coast of Kerala, Karnataka and Lakshadweep islands. (COMAPS 3)	Ministry of Earth Sciences, GoI	Dr. K. V. Thomas	Chemical Sciences	Dr. K. Anoop Krishnan	2008-13	222.50	1.07
3.	Monitoring of water sediment quality parameters in the back waters of Cochin Port Trust (CPT 3)	Cochin Port Trust	Dr.P.K.Omana	Chemical Sciences	Dr. K. Anoop Krishnan	2012-17	25.20	4.55
4.	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	1.44
5.	Inventory of Wetlands of Kerala (DECC 1)	Directorate of Environment & Climate Change	Dr.C.N.Mohanan	Environmental Sciences	Dr. A. Krishnakumar	2011-12	7.61	0.05
6.	Inactivation of pathogenic bacteria in periodontal disease: Fluorescence diagnostics and photo-dynamics therapy (DST 77)	Dept. of Science & Technology, GoI.	Dr. N. Subhash	Atmospheric Sciences	Dr. Ajayakumar & Dr. E. Sreekumar (RGCB) Dr. N. Nandakumar (ADC), Dr. L. Arramov (BAS, Bulgeria)	2008-11	5.27	-0.09
7.	Spatio-temporal shore changes during Holocene and tracing the evolutionary history of the Ashtamudi estuary, Southern Kerala (DST 78)	Dept. of Science & Technology, GoI	Dr. T. N. Prakash	Marine Sciences	Dr. M. Samsuddin Prof. Nagendra, Anna University	2009-12	30.38	0.06
8.	In-situ bioremediation of land fill pollutants: maximizing the remediation potential of select indegenours and exogeneous microorganism (DST 79)	Dept. of Science & Technology, GoI	Smt. K.Deepa Nair	Atmospheric Sciences	---	2013-16	20.00	6.70
9.	Identification of tunnels near Padmanabha Swamy temple (HD 1)	Home Department	Dr.R.Ajayakumar Varma	Environmental Sciences	Sri. G. Sankar, Sri. B. K. Jayaprasad	2012-13	6.23	6.32
10.	Hazard Vulnerability and Risk Assessment (HVRA) of the State as Part of preparing disaster management plan for the state. (HVRA)	HVRA Cell	Sri. G. Sankar	Geosciences	—	2011-13	1.45	0.02

11	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	0.03
12	Study on Depletion of Heavy Mineral content in the Beach washings of IREL, Chavara (IRE 3)	Indian Rare Earths Ltd., Chavara	Dr. T. S .Shahul Hameed (Since 1-1.2011)	Marine Sciences	Dr. N. P. Kurian Mrs. L. Sheela Nair Dr. T. N. Prakash Dr. K. V. Thomas Dr. Reji Srinivas	2010-11	49.00	4.91
13	Continuous measurement of atmospheric carbon monoxide at Thiruvananthapuram, a Tropical site (ISRO 2)	Indian Space Research Organisation, GoI	Dr. G. Mohankumar	Atmospheric Sciences	---	2002-06	11.73	0.02
14	Generation of Geographic information system of five particularly vulnerable tribal groups (PTG's) (KIRTADS)	KIRTADS	Dr. Archana M. Nair	Central Geomatics Lab	Mr. B. K.Jayaprasad	2010-11	1.86	0.02
15	Generation of tribal information system for Mannan & Urali communication for KIRTADS (KIRTADS 2)	KIRTADS	Dr.Archana M Nair	Central Geomatics Lab	Sri. B. K. Jayaprasad	2012-13	1.47	1.47
16	Sediment 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	---	2010-12	39.50	15.90
17	Cadastral scale CRZ maps for Urban areas in Kerala; Phase 1-Kozhikode, Kollam & Trivandrum Corporations and Varkala Municipality (KSCS 6)	Kerala State Council for Science Technology & Environment	Dr. K. V. Thomas	Marine Sciences	D. Raju, Sri. S. Mohanan, Sri. M. Rameshkumar	2006-07	6.99	0.06
18	Environmental Management Plan for Alappuzha-Sherthalai Canal and Kanjikuzhy Grama Panchayat-A participatory action research programme (KSCS 11)	Kerala State Council for Science, Technology and Environment	Dr. Srikumar Chattopadhyay	Resources Analysis	---	2008-10	7.50	0.00
19	Cadastral scale CRZ maps for urban areas in Kerala: Phase 2-Kochi Corporation, Maradu & Kanhangad Muncipalities (KSCS 17)	Kerala StateCouncil for Science Technology & Environment	Dr. K. V. Thomas	Marine Sciences	D. Raju, S. Mohanan, M. Ramesh Kumar M. K. Sreeraj M. K. Rafeeque	2011-14	25.00	0.36
20	Sea level Changes and its Impacts (KSCS 18)	Kerala State Council ffor Science Technology & Environment, GOK	Dr. K. V. Thomas	Marine Sciences	Dr. T. S. Shahul Hameed	2011-16	81.54	0.07
21	Landuse/ Land cover changes as linked to climate changes 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	0.03

22	Solar UV-B radiation and atmospheric trace constituents measurements (KSCS 20)	Kerala State Council ffor Science Technology & Environment, GOK	Dr. G. Mohan Kumar	Atmospheric Sciences	Dr. E. J. Zachariah	2011-14	23.19	0.12
23	Monitoring global changes impacts in Sahyadri (Western Ghats) (KSCS 21)	Kerala State Council ffor Science Technology & Environment, GOK	Dr. C. N. Mohanan	Environmental Sciences	Dr. A. KrishnaKumar Sri. B. K. Jayaprasad	2011-14	63.46	0.13
24	Greenhouse gases monitoring (KSCS 22)	Kerala State Council ffor Science Technology & Environment, GOK	Dr. E. J. Zachariya	Atmospheric Sciences	Sri. C. K. Sasidharan	2011-14	36.90	0.39
25	Geomorphic evolution and terrain characteristics: A case study of the Achankovil River Basin, Kerala (KSCS 23)	Kerala State Council for Science Technology & Environment	Dr.Mahamaya Chattopadhyay	Resources Analysis	Dr. K. Raju	2011-13	7.86	0.08
26	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	Dr.D.Padmalal	Environmental Sciences	Dr. K. Maya	2011-13	10.54	0.09
27	Establishment of national early warning system for Tsunami and storm surges in Indian ocean (MoES 1)	Ministry of Earth Sciences, GoI	Dr. T. S. Shahul Hameed (Since 1-1-2011)	Marine Sciences	Dr. N. P. Kurian Dr. T. N. Prakash, Dr. K. V. Thomas, Sri. B. K. Jayaprasad,	2006-08	27.80	0.00
28	Nitrous Oxide and methane in coastal ocean and estuaries (MoES 2)	Ministry of Earth Sciences, GoI	Dr. E. J. Zachariah	Atmospheric Sciences	--	2007-10	18.48	-0.30
29	Shoreline Management Plan for Kerala (MoES 3)	Ministry of Earth Sciences	Dr. K. V. Thomas	Marine Sciences	Dr. T. S. Shahul Hameed, Mrs. Sheela Nair L, Dr. Reji Sreenivas	2008-12	176.63	0.07
30	Oil Spill Modelling for selected locations of Kerala and Lakshadweep (MoES 4)	Ministry of Earth Sciences, GoI	Smt. L. Sheela Nair	Marine Sciences	Mrs. Sheela L. Nair, Dr. T. S .S. Hameed, Dr. K. V. Thomas	2009-11	75.00	5.08
31	Monitoring Indian Shield Seismicity with 10 BBS to understand seismotectonics of the region using V-sat connectivity (MoES 5)	Ministry of Earth Sciences, GoI	Srikumari Kesavan (Since26-07-2011)	Geosciences	--	2010-13	13.93	3.68
32	Establishment and maintenance of wave gauge stations in the coastal waters of the SW coast in India (MoES 6)	Ministry of Earth Sciences, GoI	Mrs. L. Sheela Nair	Marine Sciences	Dr. T .S. Shahul Hameed, Dr. K. V. Thomas	2010-12	27.18	17.47

33	Paleo fluids in the petroliferous basins of Western Offshore India (MoES7)	Ministry of Earth Sciences, GOI	Dr. V. Nandakumar	Geosciences	Dr. K. Narendra Babu	2011-14	265.67	6.02
34	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	Dr. T. N. Prakash	2012-15	18.36	0.11
35	Research on soil piping in the High-lands and foot-hill of Kerala to avoid the disaster (NDMA 1)	National Disaster Management Authority	Sri.G.Sankar	Geosciences	Dr. R. Ajayakumar Varma, Dr.Sekhar L. Kuriakose (Head, HVRA Cell), & Eldhose, K.	2012-15	49.73	33.00
36	Application of Space Technology for the development of Kerala (PLG 13)	Kerala State Planning Board	Sri.V.N.Neelakandan	Central Geomatics Lab	Mr.B.K.Jayaprasad	2008-11	12.62	0.00
37	River Bank Mapping (RBM 1)	Revenue Department, GoK	Dr.Srikumar Chattopadhyay	Resources Analysis	Mr. John Mathai	2011-12	5.40	0.00
38	River Bank mapping of Ithikkara river (RBM 2)	Revenue Department, GoK	Dr.Srikumar Chattopadhyay	Resources Analysis	Mr. John Mathai, Dr. Mahamaya Chattopadhyay	2011-12	4.89	0.97
39	GIS map preparation and hard copy generation for Chalakkudi & Kabani river (RBM3)	Revenue Department	B.K.Jayaprasad	Central Geomatics Lab	Dr. K. Raju, Dr. Archana M. Nair	2012-13	5.54	5.58
40	River Sand auditing-Periyar (RSA 1)	Revenue Dept., GoK	Dr. D. Padmalal	Environmental Sciences	Dr. K. Maya	2009-10	24.66	0.12
41	Sand auditing of Rivers (Manimala, Periyar & Muvattupuzha) in the Idukki district (RSA 3)	Revenue Department	Dr.D.Padmalal	Environmental Sciences	Dr. K. Maya	2012-13	9.84	9.93
42	Rainfall validation & characterization and cloud physics studies using megha tropiques data (SAC 13)	Space Applications Centre	Dr.G.Mohan Kumar	Atmospheric Sciences	---	2007-10	31.82	0.05
43	Optical characterization of coral reef diversity for understanding the impact of changing environmental conditions (SAC 14)	Space Applications Centre	Dr. M. Samsuddin	Central Geomatics Lab	Dr. T. N. Prakash	2009-13	15.00	-1.04
44	Soil based plant nutrient management plan for agro ecological zones (SPB 2)	State Planning Board	Sri. B .K. Jayaprsad	Central Geomatics Lab	---	2010-12	13.6	0.14
45	Updating Natural Resource and Environment Data Base Covering Coastal AEZ (SPB-3)	State Planning Board, GoK	Sri. B. K. Jayaprasad	Central Geomatics Lab		2012-13	8.00	0.10
46	Physical, chemical & biological monitoring study at dredging site in Vembanad lake (TCL 2)	Travancore Cements Ltd.	Dr. P. K. Omana	Chemical Sciences	---	2008-10	1.15	0.58

47	Conservation and nourishment of beaches of selected tourism locations of Kerala (TD 2)	Dept. of Tourism, GoK	Dr. K. V. Thomas	Marine Sciences	---	2006-07	20.04	0.00
48	Preparation of Integrated Island Management Plans for Agatti and Chetlat Islands U. T. of Lakshdweep (UTL-6)	UT of Lakshadweep	Dr. T. N. Prakash	Marine Sciences	Dr. K. V. Thomas Sri. D. Raju Sri. M. K. Sreeraj Sri. M. K. Rafeeque	2011-13	45.33	22.57
49	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	11.98	4.97
50	CWSS to Kanjiramkulam, Thirupuram and Karumkulam villages feasibility study of source (WRD 2)	WRD	Sri. John Mathai	Geosciences	---	2013	0.89	0.89

4.2 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.	Rapid EIA study on Kannur International Airport	Kannur International Airport	Dr. C. N. Mohanan	Environmental Sciences	2012-13	9.80	9.80
2.	Socio Economic study for assessment of Impact on traditional fishing community particularly due to operational stage -1st of Rajiv Gandhi Combined Cycle Power Project (RGCCP) & stage 2nd , phase-1st in Kerala	NTPC	Dr.Srikumar Chattopadhyay	Resources Analysis	2012-13	13.95	6.21
3.	Delineation of HTL/ LTL and preparation of CRZ Status Report	ESSEL World, Mumbai	Dr.K.V.Thomas	Marine Sciences	2012-13	1.06	0.00
4.	-do-	Mundra PSEZ Ltd	Dr.K.V.Thomas	Marine Sciences	2012-13	25.50	0.00
5.	-do-	The Kerala Minerals & Metals Ltd.	Dr.K.V.Thomas	Marine Sciences	2012-13	7.35	0.00

6.	-do-	Public Works Department - Vizhinjam	Dr.K.V.Thomas	Marine Sciences	2012-13	0.68	0.00
7.	-do-	Edava Grama Panchayat	Dr.K.V.Thomas	Marine Sciences	2012-13	0.50	0.00
8.	-do-	Manjeshwaram Grama Panchayat	Dr.K.V.Thomas	Marine Sciences	2012-13	0.68	0.00
9.	-do-	NTPC, Kayamkulam	Dr.K.V.Thomas	Marine Sciences	2012-13	3.15	0.00
10.	-do-	Aegis Logistics	Dr.K.V.Thomas	Marine Sciences	2012-13	3.98	0.00
11.	-do-	Kerala State Industrial Development Corporation Limited	Dr.K.V.Thomas	Marine Sciences	2012-13	4.50	0.00
12.	-do-	Focus	Dr.K.V.Thomas	Marine Sciences	2012-13	9.00	0.00
13.	-do-	Kalpatharu Resorts	Dr.K.V.Thomas	Marine Sciences	2012-13	1.50	1.47
14.	-do-	Larsen & Toubro Limited, Gujarat	Dr.K.V.Thomas	Marine Sciences	2012-13	2.40	0.00
15.	-do-	IMC Limited	Dr.K.V.Thomas	Marine Sciences	2012-13	0.98	0.00
16.	-do-	Waterline	Dr.K.V.Thomas	Marine Sciences	2012-13	2.85	0.00
17.	-do-	MIR Builders (Additional work)	Dr.K.V.Thomas	Marine Sciences	2012-13	0.68	0.00
18.	-do-	Mundra Port and Special Economic Zone (Additional work)	Dr.K.V.Thomas	Marine Sciences	2012-13	9.00	0.00
19.	-do-	Focus	Dr.K.V.Thomas	Marine Sciences	2012-13	3.68	0.00
20.	-do-	NPCI	Dr.K.V.Thomas	Marine Sciences	2012-13	0.98	0.00
21.	-do-	Reliance Industrial Infrastructure Jnpt,Navi Mumbai	Dr.K.V.Thomas	Marine Sciences	2012-13	0.98	0.00
22.	-do-	Essar (Kadia Bet)	Dr.K.V.Thomas	Marine Sciences	2012-13	7.65	0.00
23.	-do-	Essar (Additional Hazira)	Dr.K.V.Thomas	Marine Sciences	2012-13	9.60	0.00
24.	-do-	Naresh Kumar, PMC Rail	Dr.K.V.Thomas	Marine Sciences	2012-13	22.50	0.00
25.	-do-	Kent Constructions	Dr.K.V.Thomas	Marine Sciences	2012-13	3.15	0.00
26.	-do-	Kerala Maritime Institute, Neendakara	Dr.K.V.Thomas	Marine Sciences	2012-13	1.32	0.13
27.	-do-	Adani Hazira Port Private Limited (Sankalp)	Dr.K.V.Thomas	Marine Sciences	2012-13	10.80	0.00

28.	-do-	Liquefied Natural Gas (LNG) Terminal (Paliwal)	Dr.K.V.Thomas	Marine Sciences	2012-13	15.00	7.50
29.	-do-	Long Island Nature Hotel & Resort Private Limited (CGH)	Dr.K.V.Thomas	Marine Sciences	2012-13	4.50	0.00
30.	-do-	Orange County	Dr.K.V.Thomas	Marine Sciences	2012-13	3.68	0.00
31.	-do-	MCZMA	Dr.K.V.Thomas	Marine Sciences	2012-13	16.50	0.00
32.	-do-	Mangal A. Gogte	Dr.K.V.Thomas	Marine Sciences	2012-13	3.68	0.00
33.	-do-	Waterline, Thrissur	Dr.K.V.Thomas	Marine Sciences	2012-13	3.15	3.15
34.	-do-	Essar, Vadinar Ports and Terminals Ltd	Dr.K.V.Thomas	Marine Sciences	2012-13	7.65	7.65
35.	-do-	Kozhikode Corporation	Dr.K.V.Thomas	Marine Sciences	2012-13	0.91	0.01
36.	-do-	Kollam Educational Trust	Dr.K.V.Thomas	Marine Sciences	2012-13	0.98	0.98
37.	-do-	FACT	Dr.K.V.Thomas	Marine Sciences	2012-13	3.15	3.15
38.	-do-	Vasai-Virar Muncipal Corporation	Dr.K.V.Thomas	Marine Sciences	2012-13	30.00	26.7
39.	-do-	M.Sathyan	Dr.K.V.Thomas	Marine Sciences	2012-13	1.32	1.32
40.	-do-	Malabar Port Pvt.Ltd	Dr.K.V.Thomas	Marine Sciences	2012-13	4.50	4.50
41.	-do-	T.Vinaykumar	Dr.K.V.Thomas	Marine Sciences	2012-13	1.44	1.44
42.	-do-	KSUDP, Kochi	Dr.K.V.Thomas	Marine Sciences	2012-13	3.15	3.15
43.	-do-	Koyilandy Municipality	Dr.K.V.Thomas	Marine Sciences	2012-13	0.89	0.91
44.	-do-	Kanhangad Municipality	Dr.K.V.Thomas	Marine Sciences	2012-13	0.89	0.89
45.	-do-	FIRMA, Puthuvypeen	Dr.K.V.Thomas	Marine Sciences	2012-13	1.50	1.50
46.	-do-	Malabar Commercial Plaza Pvt.Ltd	Dr.K.V.Thomas	Marine Sciences	2012-13	0.83	0.83
47.	-do-	Mira-Bhaindar Municipal Corporation	Dr.K.V.Thomas	Marine Sciences	2012-13	15.57	15.58
48.	-do-	GAIL (Uran - Thal)	Dr.K.V.Thomas	Marine Sciences	2012-13	15.00	15.00
49.	-do-	Kerala State Transport Project (Valavupara-Thalasserry road)	Dr.K.V.Thomas	Marine Sciences	2012-13	3.15	3.15

50.	-do-	Tata Power Company Ltd.	Dr.K.V.Thomas	Marine Sciences	2012-13	3.00	3.00
51.	-do-	CMLRE	Dr.K.V.Thomas	Marine Sciences	2012-13	1.05	1.05
52.	-do-	Sealord Containers Ltd.	Dr.K.V.Thomas	Marine Sciences	2012-13	2.25	2.25
53.	-do-	Kerala Irrigation Infrastructure Development Corporation Ltd. (KIIDC)	Dr.K.V.Thomas	Marine Sciences	2012-13	1.32	1.32
54.	-do-	Club Mahindra	Dr.K.V.Thomas	Marine Sciences	2012-13	1.32	1.32
55.	-do-	Global Village, Paravur	Dr.K.V.Thomas	Marine Sciences	2012-13	1.50	1.50
56.	-do-	Thane - Sindhudurg Muncipal Corporation	Dr.K.V.Thomas	Marine Sciences	2012-13	147.74	147.74
57.	-do-	Payyambalam BeachWalk	Dr.K.V.Thomas	Marine Sciences	2012-13	1.35	1.35
58.	-do-	KGL Builders Pvt Ltd, Kozhikode	Dr.K.V.Thomas	Marine Sciences	2012-13	3.15	3.15
59.	-do-	Pentagon Builders, Kozhikode	Dr.K.V.Thomas	Marine Sciences	2012-13	3.15	3.15
60.	-do-	Yespeesons Enterprises	Dr.K.V.Thomas	Marine Sciences	2012-13	0.83	0.83
61.	-do-	Sea Cliff, Varkala	Dr.K.V.Thomas	Marine Sciences	2012-13	1.32	1.32
62.	-do-	Karuvanthala Hotels, Thrissur	Dr.K.V.Thomas	Marine Sciences	2012-13	3.15	3.15
63.	-do-	Mr. Joseph P. George	Dr.K.V.Thomas	Marine Sciences	2012-13	4.05	4.05

4.3 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. S. Muralidas	Atmospheric Sciences	Dr. G. Mohan Kumar	2005-12	187.37	4.82
PLAN 250	Exploring interrelationship between environmental degradation and poverty: selected micro level case studies across Kerala	Dr. Srikumar Chattopadhyay	Resources Analysis	Mr. C. K. Sasidharan, Mrs. C. Sakunthala	2007-10	24.28	3.58
PLAN 254	Quaternary geology and geomorphic evolution of the coastal lands of Kollam district, SW India	Dr. D. Padmalal	Environmental Sciences	Dr. K. Narendra Babu, Mr. B. Sukumar, Dr. K. Maya	2007-10	19.00	0.79
PLAN 255	Tropical Freshwater Myristica swams of Kerala and its ecological and evolutionary significance	Dr. C. N. Mohanan	Environmental Sciences	Dr. D.S. Suresh Babu,	2007-10	15.00	1.88

PLAN 257	Study of Urban Sprawl – stretch between Kochi and Thrissur Corporations	Mrs. Ahalya Sukumar	Resources Analysis	Mr. B. Sukumar, Dr. K. Raju	2008-10	11.68	0.19
PLAN 266	Quaternary evolution of the coastal plains of southern Kerala	Mr. John Paul	Marine Sciences	Dr. A. S. K. Nair	2007-10	36.50	1.69
PLAN 267	Digital Resource Atlas of Kerala and Environment Atlas	Mrs. Ahalya Sukumar	Resource Analysis	Dr. E. Saravanan, Mr. V. Shravan Kumar	2008-12	37.40	1.06
PLAN 268	Agricultural Atlas of Kerala	Dr. E. Saravanan	Training & Extension	Mr. B. Sukumar, Mr. V. Shravan Kumar	2008-10	27.48	6.00
PLAN 270	Water, sediment quality monitoring and assessment of estuaries of Kerala: A case study from Kochi estuary and Periyar River	Dr. P. K. Omana	Chemical Sciences	---	2008-10	10.87	2.22
PLAN 273	Assessment and monitoring of land quality for sustainable agriculture: A GIS based approach coupled with technology implementation	Mrs. Ahalya Sukumar	Resources Analysis	Dr. A .S. K. Nair, Dr. G. Mohan Kumar, Dr. E. Saravanan, Mr. G .Sankar, Dr. P.V.S.S.K Vinayak, Mr. V. Shravan Kumar, Mr. V. Vasudevan, Mr. K. Vijayakumar, Dr. Ansom Sebastian, Mr.. K. J. Mathew, Mr. John Paul.	2008-11	8.82	2.43
PLAN 274	Kerala Resources Information System & Services (KRISS)	Sri. V. N. Neelakandan	Central Geomatics Lab	Dr. K. K. Ramachandran, Dr. M. Samsuddin	2009-10	102.00	1.07
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	3.34
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	0.34
PLAN 280	Tectonothermal history of the Kerala Khondalite Belt	Dr. V. Nandakumar	Geosciences	---	2009-12	22.20	0.37

PLAN 281	Climatological features of Kerala- a ready reckoner	Dr. P.V.S.S.K. Vinayak	Camp Office, Kochi	Mrs. Sreekumari Kesavan	2009-11	7.51	0.30
PLAN 282	Graphitization Process in Kollam District, Kerala	Dr. Ansom Sebastian	Training & Extension	---	2010-13	4.49	2.85
PLAN 283	Valley formation and geomorphic processes under tropical wet and dry climate; examples from Kerala	Dr. Mahamaya Chattopadhyay	Resources Analysis	Smt. Sakumthala. C	2011-14	3.13	4.99
PLAN 284	Land system analysis of Kabani river basin	Dr.Srikumar Chattopadhyay	Resources Analysis	---	2011-13	2.44	1.20
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	4.48
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	4.93
PLAN 287	Long- term Environmental and Socio-Economic Impacts of landslides: A study in selected parts of Western Ghats region in Kerala	Dr.K.Raju	Training & Extension	Shri.G.Sankar	2012-15	9.65	2.31
PLAN 288	Hydrological modeling of Greater Cochin urban agglomerate in the context of Sustainable Urban Water Resource Development	Dr.Archana M.Nair	Geosciences	Dr.Reji Srinivas & Dr.A Krishnakumar	2012-15	21.23	---
PLAN 289	Assessing the biotic and abiotic stress through chlorophyll fluorescence and reflectance in tropical root and tuber crops	Dr.N.Subash	Atmospheric Sciences	Dr.C.N.Mohanan	2012-13	5.8	1.32

4.4 R & D Plan Laboratory Infrastructure Projects

Project Code	Project Title	Coordinator	Division	Expenditure during the year (Rs. in lakh)
PLAN 101	XRF Facility	Dr. G. R. Ravindra Kumar (SIC)	Geosciences	8.05
PLAN 102	Upgradation of Geosciences laboratories	Head - GSD	Geosciences	17.49
PLAN 103	Strengthening of Ecological laboratory	Head - ESD	Environmental Sciences	6.81
PLAN 104	Upgradation of Atmospheric Sciences laboratories	Head - ASD	Atmospheric Sciences	16.16
PLAN 105	Upgradation of Chemical laboratory	Head - CSD	Chemical Sciences	17.20
PLAN 106	Upgradation of Library facilities	Librarian	Training & Extension	58.89
PLAN 107	Publication of monographs / memoirs / annual report/newsletter	Director	Publication Committee	2.80
PLAN 108	Outreach/ training / extension /exhibition/LAN and other technical facilities	Head - TED	Training & Extension	6.29
PLAN 110	Seminars/workshops/meetings	Director	—	6.57
PLAN 111	Marine laboratory infrastructure development	Head - MSD	Marine Sciences	57.19
PLAN 112	Geomatics laboratory infrastructure development	Head - CGL	Central Geomatics Lab	8.87
PLAN 117	Upgradation & Maintenance of CESS LAN	Director Dr. C. M. Harish (SIC)	Central Geomatics Lab	3.45
PLAN 118	Development of laboratory for Resource Analysis Division	Head - RAD	Resources Analysis	7.38
PLAN 100	Research & Development general expenditure	Director	—	150.48

4.5 R & D Plan Building Infrastructure Projects

Project Code	Project Title	Co-ordinator	Expenditure during the year (Rs.in lakh)
PLAN 120	Upgradation of centralized Air Conditioning & facilities of CESS buildings	Registrar	8.10
PLAN 128	Upgrading electrical installations and facilities	Registrar	-1.58
PLAN 150	Construction of Water tank and modification to the WSS	Registrar	2.08
PLAN 153	Upgradation of security area and rooms	Registrar	0.00
PLAN 155	Upgradation of the canteen	.Registrar	0.00
PLAN 157	Construction of additional floor in the scientists blocks	Registrar	122.40
PLAN 158	Estate development	Registrar	1.96
PLAN 160	Construction of I floor (record room) above the parking shelter	Registrar	16.04
PLAN 161	Construction of compound wall & road	Registrar	0.00
PLAN 163	Construction of storage facility for unserviceable items	Registrar	0.00
PLAN 165	Earth Watch Geopark, Museum and Dynamic Earth Pavilion	Dr.V.Nandakumar	1.75
PLAN 166	Campus Greening	Chairman, Campus Green Committee	0.42
PLAN 122	Construction of Parking Shelter	Registrar	0.18

Honours, Awards & Academic Activities

5.1 Honours & Awards

Dr. Jayanthi J. L. has been awarded Ph.D. Degree under the Faculty of Atmospheric Sciences, Kerala University, for her thesis 'Autofluorescence and diffuse reflectance spectroscopy for noninvasive detection of oral cancer'. Dr N Subhash, Scientist-G & Head (Rtd), Atmospheric Sciences Division was her supervising guide.

Dr. R.Vishnu has been awarded Ph. D. Degree under the Faculty of Science, University of Kerala for his thesis 'Investigations on formation and characteristics of thunder clouds in a region of high lightning incidence'. Dr. S. Muralidas, Scientist (Rtd), Atmospheric Sciences Division was his supervising guide.

Dr. V. S. Sudhananth has been awarded Ph.D. Degree under the Faculty of Sciences, University of Kerala for his thesis 'Studies on Pathogenic enteric bacteria and their seasonal distribution with special reference to public health along the Southern Kerala coast. Dr. P. P. Ouseph, Scientist F (Rtd), Chemical Sciences Division was his supervising guide.

Dr. Anjali R. has been awarded Ph.D. Degree under the Faculty of Atmospheric Sciences, MG University for her thesis 'Study of Ambient Atmospheric Carbon Monoxide in the Tropics'. Dr. G Mohan Kumar, Scientist-F (Rtd), Atmospheric Sciences Division was her supervising guide.

Ms. Dhanya Vijayan, Senior Research Fellow & PhD Research Scholar under Dr. Srikumar Chattopadhyay, Scientist-G and Head, Resources Analysis Division, won the Green Talent-Competition 2012, Ministery of Education and Research, Germany. She is one of the 25 winners selected from among 403 applicants from 69 countries. Her project was "Environmental management plan at micro level: A participatory action research programme for Kanjikuzhy Grama Panchayat". This project executed under supervision of Dr. Srikumar Chattopadhyay was sponsored by the Kerala State Council for Science, Technology and Environment, Government of Kerala.

The award was distributed by Prof. Dr. Annette Schavan, Federal Minister of Education and Research in the meeting of 9th BMBF Forum for Sustainability (FONA) at Berlin. This award has been constituted since 2009. The winners are awarded for their creative and intelligent solutions in the fields of climate protection, sustainable resource and landuse management as well as energy efficiency. This award also brings recognition to Kerala's initiatives in participatory action research.

5.2 Membership in Committees

Dr. C. M. Harish

Member of the Board of Studies in Environmental Studies at CUSAT.

Dr. C. N. Mohanan

Member, State Expert Appraisal Committee, Government of Kerala, under the State Level Environment Impact Assessment Authority (SEIAA) Kerala.

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

Member, Committee formulated by Govt. of Kerala to study the Botanical Garden ,Trivandrum Museum and Zoos

Dr. E. J. Zachariah

Member, Research Advisory Committe of Sophisticated Test & Instrumentation Centre, Kochi.

Dr. G R Ravindra Kumar

Member, PAC-ES, Department of Science & Technology, Govt. of India, New Delhi (2012-2015).

Dr. A. Krishnakumar

Member, Expert committee for the scientific study of Wayanad.

Dr. K. V. Thomas

Member, Project Advisory Committee of INCOIS, Hyderabad.

Invited Member, Expert Committee, constituted by the Hon'ble Supreme Court of India under the chairmanship of Justice R V Raveendran, Former Judge, Supreme Court for the preparation of Integrated Island Management Plan (IIMPs) for Lakshadweep.

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

Member, Lakshadweep Coastal Zone Management Authority.

Member, Project Advisory Committee of the ICZMP project of Odhisa.

Dr. N. Subhash

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

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 and Member, Faculty of Marine Sciences, Cochin University of Science and Technology, Kochi.

Member, Project Appraisal and Monitoring Committee on Ocean Sciences and Resources of the Ministry of Earth Sciences, Governmemt of India.

Vice-Chairperson (Research), Hazard Vulnerability and Risk Assessment Cell, ILDM, Thiruvananthapuram.

Chairman, Independent Expert Committee to evaluate the progress of work carried out during the 11th Plan period for the "Studies on Cobalt Crust', constituted by the Ministry of Earth Sciences, Govt. of India.

Member, Task force on Coastal Erosion, Narmada Water Resources, Water Supply and Kalpsar Department, Govt. of Gujarat.

Dr. R. Ajayakumar Varma

Chairman, Committee 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.

Member, Committee for preparing Project Report for modernization of the Department of Mining and Geology, Government of Kerala.

Chairman, Expert Committee to assess the impact of blasting operations in the tunnel of Thottiyar Hydro Electric Project, Kerala State Electricity Board.

Member, Expert Committee for Drafting guidelines for the preparation of District Development Plan, Kerala State Planning Board.

Dr. T N Prakash

Invited Member, Expert Committee, constituted by the Hon'ble Supreme Court of India under the chairmanship of Justice R V Raveendran, Former Judge, Supreme Court for the preparation of Integrated Island Management Plan (IIMPs) for Lakshadweep.

Sri. John Mathai

Member, State Expert Appraisal Committee, Government of Kerala, under the State Level Environment Impact Assessment Authority (SEIAA) Kerala.

Sri. G. Sankar

Member, Technical Committee for validation of security schemes at Sree Padmanabha Swami Temple- constituted by Govt. of Kerala.

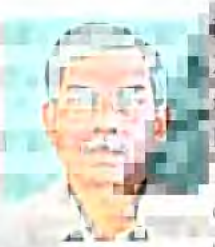
Member, EFL-CDRC, Chalakudy division, Govt. of Kerala.

Member, Expert committe for making recommendations in the modernisation of Kerala foresr department, Govt. of Kerala.

Member, Research and Management Committee of HVRA Cell, Department of Revenue, Govt. of Kerala.

Sri. P. Sudeep

Member, Board of Studies under the Faculty of Social Sciences (social work), University of Kerala.



Dr. Srikumar Chattopadhyay visited ZMT, Bremen, Germany on invitation from the Centre for Tropical Marine Ecology for a period of three weeks from 14th May 2012. The purpose of visit included developing and furthering discussion on the proposed collaborative project between CESS and ZMT, Bremen on "Interdependencies between Kerala rivers and backwaters: Consequences for water quality, ecology, economy and environmental governance'.

Dr. V. Nandakumar visited the International School on Raman Spectroscopy applied to Earth Sciences and Cultural Hearitage at the Faculty de Sciences, Nancy, France during 14-16 June 2012 and held discussions with Prof. Jean Dubessey on a granulite based monazite research project with the Department of Geology, University of Lorraine.

Dr. D. Padmalal visited Japan for attending the XIII IPC / IX IOPC Conference Tokyo and presented the paper 'Sedimentological, palynological and stable isotope evidences of paleoclimate and sea level records in the Holocence sedimentary archives of Central Kerala, SW India' during 23-30 August 2012.

Dhanya V., UGC-SRF Scholar of RAD visited Federal Ministry of Education and Research (BMBF), Germany and attended the ' Green Talents- International Forum for High Potentials in Sustainable Development' constituted by the Federal Ministry of Education and Research, Gemany from 9th October to 24th October 2012.

5.4 Ph. D Students

Student	Title of the thesis	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
George Thomas	The development of Urban heat Island in a tropical Coastal City	Dr. E. J. Zachariah	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
Raji S. Nair	Multi Spectral Imaging	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 reefs, 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
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 Mohan S.	Quaternary Geology of the Coastal Lowlands of Southern Kerala, SW India	Dr. D. Padmalal	CUSAT
Aparna G. Nair	Solar UV-B insolation and Atmospheric Trace Gases at ground: Comparison with satellite data in climate change scenario	Dr. G. Mohankumar	Kerala
Ganapathy	Impact of Human Activities in the generation of Land Disturbances in Humid Tropical Highland Areas- A case study in Idukki district, Kerala	Dr. K. Raju	Kerala
Ragi N. P.	Causes and Impacts of landslides in Panamaram and Mananthavadi watersheds of Kabani river basin, Kerala	Dr. K. Raju	Kerala
Sheikha E. John	Mining and Quarrying in the river catchments of Central Kerala around Kochi city, SW India- Consequences and sustainable development strategies	Dr. K. Maya	Kerala
Arun Lal	Geofluids within the sedimentary basins of Western Offshore, India	Dr. V. Nandakumar	Kerala

Student	Title of the thesis	Research Guide	University
Soumya G. S.	Lithosperic Processes (Neoproterozoic Anthrosites in South India, a comparative study to delineste petrogenesis and India's position in Rodinia Assembly)	Dr. T.Radhakrishna	Kerala
Shaji J.	Coastal Zone Management: A case study of Thiruvananthapuram coast	Dr. Srikumar Chattopadhyay	Kerala
Unnikrishnan U.	Common Property Resources (CPR) Management in the lowlands of Thiruvananthapuram district with special reference to surface water resource	Dr. Srikumar Chattopadhyay	Kerala
Jayalekshmy S. S.	Urbanization trend of Kerala over a period of 1961-2011.	Dr. Srikumar Chattopadhyay	Kerala
Revathy Das	Integrated geoenvironmental studies of the lacustraine wetlands of Kerala in climate change paredigms for conservation and management.	Dr. A. Krishnakumar	Kerala

5.5 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 2012-13, 64 applications were received from meritorious students from different parts of Kerala and Ten 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:

Sl. No.	Name of Student	Affiliation	Topics of Dissertation	Supervisor
1	Divya P.Nair	Kerala University	Changing landuse and cropping pattern of a tributary stream watershed of Karamana river basin, Thiruvananthapuram district, Kerala	Dr. Mahamaya Chattopadhyay
2	Rakhi Ravi	Kerala University	The spatial evaluation of human induced land use changes in Vellanad Gramapanchayat	Dr. K. Raju
3	Indu J. Kumar	Kerala University	Decentralized planning in Ithikara Block Panchayat with special refence to suburban growth in Kottiyam	Shri. B. K. Jayaprasad
4	Swathy T. V.	Kerala University	A Geo- spatial Analysis of Dengue Fever in Thrissur District	Shri. B. K. Jayaprasad
5	Sachin A. S.	Kerala University	Hydro-Geochemical characteristics of Spring water: A case study from Southern Kerala	Dr. P. K. Omana
6	Saranya Bose	Kerala University	Removal of congo red dye from aqueous solution using agricultural wastes (ragi husk, rice husk, chilli stalk) and metal oxide (TiO_2): Evaluation of adsorption parameters	Dr. K. Anoop Krishnan
7	Lekshmi L.	Kerala University	Application of tea waste, fruiting branches of pepper and kaolinite clay as adsorbents in removing methyl red from aqueous solution: Kinetic and isotherm studies	Dr. K. Anoop Krishnan
8	Archana S.	Sree Sankara University	Hydrogeochemistry and water quality assessment of Sasthamkotta Lake-A Ramsar site in SW India.	Dr. D. Padmalal
9	Sajina Kalathal	Kannur University	EIA of soil Quarrying-A case of Vengola Grama Panchayat, Ernakulam district, Kerala	Dr. K. Maya
10	Praseetha B. S.	Kannur University	Estimation of Water resources Potential of Kumily Spring in Thiruvananthapuram district.	Dr. D. S. Suresh Babu

Name of Student	Affiliation	Topics of Dissertation	Supervisor
Aswara T.	Calicut University	Geological setting, Geochemical characterization, Mining and EIA of silica sand deposits of Alapuzha-Cherthala belt, Kerala, SW India.	Dr. D. Padmalal
Nabila P. V.	Calicut University	Texture and Mineralogy of silica sand resources of Alappuzha-Cherthala belt, Kerala, SW India	Dr. D. Padmalal
Seema K. Nair	Kerala University	Removal of malachite green from aqueous solution using clay and cassava starch as adsorbents: Kinetic and isotherm modeling	Dr. K. Anoop Krishnan
Sonia M. G.	Kerala University	Geochemical characterization of recently deposited sediments of Ashtamudi Estuary, Kollam, SW India	Dr. P. K. Omana
Shalini N. Menon	MG University	Variation in hydrochemical characteristics over a decade: A study of Vellayani Lake in climate change context.	Dr. A. Krishnakumar
Smijimol P. P.	MG University	Communnity based Coastal hazard Management	Dr. K. V.Thomas
Thena T.	Bharathidasan University	Application of RS-GIS for integrated river basin analysis: A case study of Neyyar basin, Thiruvananthapuram district, Kerala	Dr.Mahamaya Chattopadhyay
Shabna Kahar	Kerala University	Petrology of the mafic and associated rocks of Attapady area, Palghat district , Kerala	Dr. V. Nandakumar
Sooryamol P. S.	MG University	Granulometric Analysis and Beach Profiling along coastal tract of the Parayur-Needakara area, Kollam district, Kerala	Dr. Reji Srinivas
Ratheesh Mon P.	Sree Sankara University	Identification of major landscape types in Chaliyar Rivr Basin, Kerala	Dr. K. Raju
Shalima M. S.	Sree Sankara University	States of Women in the Agrarian Society of Kerala-A case study	Dr. E. Saravanan
Shebeena N. M.	Kerala University	Texture and Mineralogy of offshore sediment between Neendakara and Thankassery, SW coast of India.	Dr. Reji Srinivas
Vishnusagar M. K.	Sree Sankara University	Geochemistry of the sediments of Sasthamkotta Lake, A Ramsar wetland in Kerala SW India	Dr. D. Padmalal
Nisha M. Nair	Kerala University	Hydroxyapatite from natural material: Preparation, characterization and application	Dr. K. Anoop Krishnan
Divya G. R.	Kerala University	Preparation, microchemical analysis and adsorption properties of tannic acid impregnated tamarind pericarp based adsorbents in removing lead from water and wastewater	Dr. K. Anoop Krishnan
Sheena V. S.	Kerala University	Hydrogeochemical reviews and modeling of Pb(II) adsorption at solid-liquid interface in the coastal waters of Kochi, south western India	Dr. K. Anoop Krishnan
Sukanya C.	Kannur University	EIA of clay mining-A case study of Sreemoolnagaram Gramapanchayat, Ernakulam district, Kerala	Dr. K. Maya
Sumayya P. M.	Kannur University	The Physico-Chemical characterization of Laterites around Perinthalmanna taluk, Malappuram district, Kerala	Dr. Narayana Swamy
Aswathy R. S.	Kerala University	Measurement of PPM concentrations selected urban and rural ambient air environments in Thiruvananthapuram	Shri. V. Muraleedharan

Beena P.	Kerala University	Study on the variations in FPM concentrations of ambient air environments at selected urban and rural locations in Nedumangad Municipal area	Shri. V. Muraleedharan
Sahila Beegum	Kerala University	Design of Urban Storm Water Drainage at Thampanoor	Shri. B. K. Jayaprasad
Dharmanandan S. L.	Kerala University	Environmental appraisal of an area of Outstanding Natural Beauty-A case study	Dr. D. Padmalal
Dr. Jinu George	Kerala University	Effect of Pectin, Alginate and Gum Arabic Polymers on Carbonated Drink induced Enamel Demineralilzation-An Invitro Study	Dr. N. Subhash
Sujithakumari	Kannur University	The Physico-Chemical characterisation of Laterites in Karadka Block, Kasargod, Kerala	Dr. Narayana Swamy
Mathew K. K.	Manipal University	Coagulation study and analysis of *Moringa oleifera* and its comparison with other natural and conventional coagulants in clay processed industrial wastewater treatment	Dr. K. Anoop Krishnan

5.7 Internship / Summer Training

Sl. No.	Name of Student	Affiliation	Name of Supervising Scientist
1	Stephy Thomas	IIT, Roorkee	Dr. T. Radhakrishna
2	Snigdharani Sahoo	Banaras Hindu University, Varanasi	Dr. T. Radhakrishna
3	Lipsa Chakra	Banaras Hindu University, Varanasi	Dr. T. Radhakrishna
4	Prasteena Nimmy Dawarave	Pondichery University, Pondichery	Dr. T. Radhakrishna
5	Remya J.	Kerala University	Dr. G. R. Ravindra Kumar
6	Parvathy M. M	National Institute of Technology, Surathkal	Dr. K. V. Thomas
7	Arun Kumar V. S.	National Institute of Technology, Surathkal	Dr. K. V. Thomas
8	Mubassir K.	Annamalai University, Tamil Nadu	Dr. D. Padmalal
9	Sathyaraj P.	Annamalai University, Tamil Nadu	Dr. D. Padmalal
10	Raja D.	Annamalai University, Tamil Nadu	Dr. D. Padmalal
11	Ulaganathan S.	Annamalai University, Tamil Nadu	Dr. D. Padmalal
12	Ankith A. K.	Kerala University	Smt. L. Sheela Nair
13	Jafeel S.	Kerala University	Smt. L. Sheela Nair
14	Pavankrishna	Kerala University	Smt. L. Sheela Nair
15	Aromal S.	Kerala University	Smt. L. Sheela Nair
16	Anu Jayamohan	Kerala University	Smt. L. Sheela Nair
17	Ganesh S.	Kerala University	Smt. L. Sheela Nair
18	Basil Paul	MG University	Shri. B. K. Jayaprasad
19	Mushina M.	MG University	Shri. B. K. Jayaprasad
20	Nibu Issac	MG University	Shri. B. K. Jayaprasad
21	Sooraj V. S.	MG University	Shri. B. K. Jayaprasad
22	Swathy Sunder	MG University	Shri. B. K. Jayaprasad
23	Tijo J. Kuruvila	MG University	Shri. B. K. Jayaprasad
24	Jayaram J.	TKM College of Engineering	Shri. B. K. Jayaprasad
25	Jidheesh Joshi	TKM College of Engineering	Shri. B. K. Jayaprasad
26	Mohammad P. Uwais	TKM College of Engineering	Shri. B. K. Jayaprasad
27	M. Nitin Ramakrishnan	TKM College of Engineering	Shri. B. K. Jayaprasad
28	Navami Sunil	TKM College of Engineering	Shri. B. K. Jayaprasad
29	Devika M. S	University of Madras	Shri. B. K. Jayaprasad

CESS Library is one of the special libraries in the field of Earth Sciences in terms of its collection and services. The library has a unique and rare collection of books, journals, back volumes, maps, atlas, theses, project reports, reference books, CDs, VCDs, CD ROM Databases, etc. Apart from this more than 930, full text journal titles are available in online through EBSCO database subscribed by the library. It also receives newsletters and Annual Reports from public and private organizations of India and abroad. During this year we procured 39 books and added to the collection. CESS subscribes 28 international and 25 national journals and receives many journals as gratis.

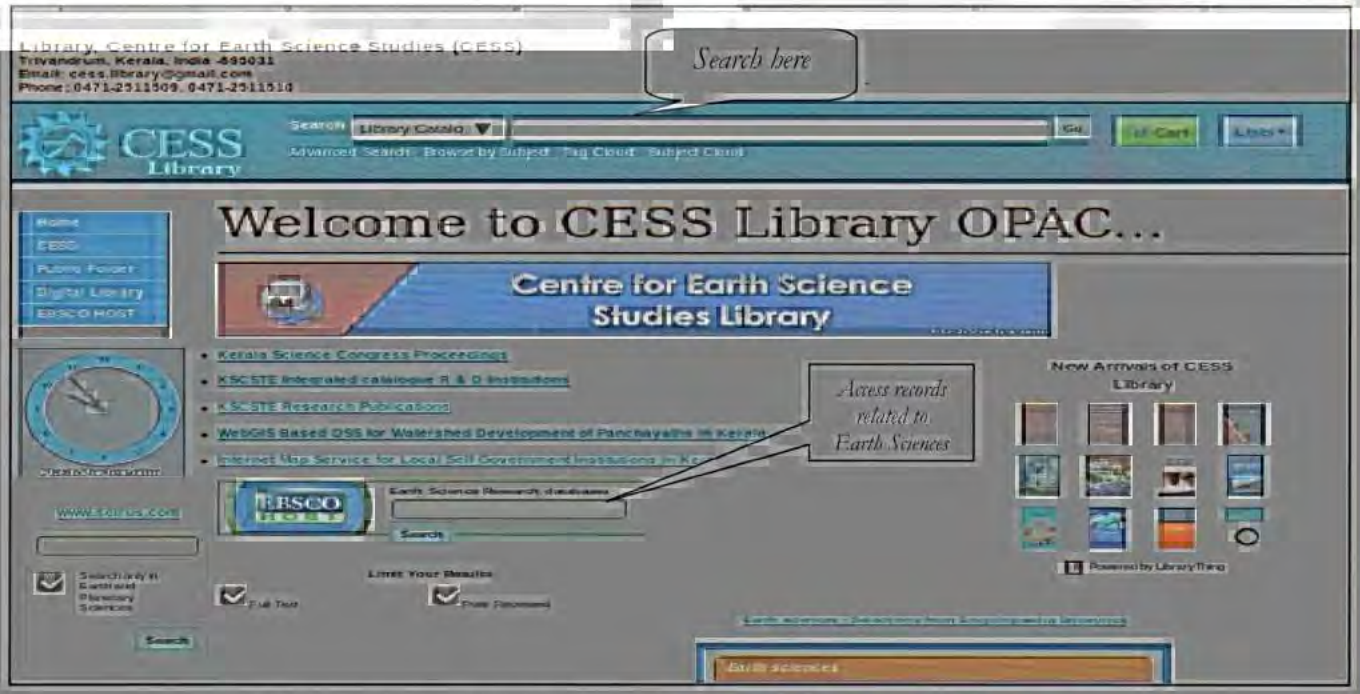


Fig. 6. 1 A screen shot of the Online Public Acess Catalogue (OPAC) software in CESS Library

The major services provided by library are Reference Service, Document Delivery Service, Membership, Reprint Service, Internet access to electronic full-text journals, Special access arrangements, and Online Public Access Catalogue (OPAC) to users. An e-mail alert is sent to the scientists who request new arrival of books and publications related to their fields. Library provides Inter Library Resource Sharing facilities with a number of major R&D and Academic institutional Libraries. User-education programmes targeting mini groups to improve the better use of Library are also carried out. A list of new additions of CESS publications, useful article, Fellowship information, forthcoming Conferences, Seminars are displayed. Books are arranged according to the Dewey Decimal Classification (DDC) system.

Circulation activities of the library has been automated using open source Library Management Software KOHA, customised and maintained by library staff. The resources of the library in terms of books, back volumes of the journals, project reports and Ph.D theses and other reports have been catalogued and the LAN based Online Public Access Catalogue (OPAC) of the library is available. At present, two computer terminals have been provided for the library users for OPAC.

Publications

7.1 Research Papers

7.1.1 In Journals

Babu Nallusamy, Reji Srinivas, Suresh Babu, D. S. and Bhima Rao, R. (2011). Beneficiation studies on two grade zircons by using Electrostatic Separator and Flotation: A Case study on Kayamkulam – Thottappally deposits, South West India, International Journal of Earth Sciences and Engineering, ISSN 0974-5904, V.4(4), pp. 738-742

Baburaj, B., Remya, S. I., Padmalal, D., Maya, K. and Lekshmi, I. 2012. DIN, DIP, DIC and SO_4 fluxes from the Neyyar River (Kerala) into the receiving coastal waters. Bonfring International Journal of Engineering and Management, Vol.2, pp. 1-7.

Chandra Sekhar Prasanth, Joseph Betsy, Jayaraj, L., Jayanthi, J. L.,Unni, G. Nisha, Janam Prasanthila, Narayanan Subash (2013). In vivo inflammation mapping of periodontal disease based on diffuse reflectance spectral imaging: a clinical study, Journal of Biomedical Optics, Vol.18(2), pp. 026019-1-026019-8.

Kusala Rajendran, Rajendran, C. P., Sreekumari Kesavan and Naveen, R., 2012. Recent microtremors near the Idukki Reservoir, Kerala, South India, Current Science, Vol.102, No.10, pp. 1446-1451.

Kusala Rajendran, Thulasiraman, N., Sreekumari, K. (2013). Micro earthquake activity near the Idukki Reservoir South India, a rare example of renewed triggered seismicity, Engineering Geology, Volume 153, pp. 45-52.

Maya, K., Santhosh, V., Aneeshkumar, S. R. and Padmalal, D. (2012). Impact of mining and quarrying in Muvattupuzha river basin, anover view on its environmental effects. Bonfring International Journal of engineering and Management, Vol.2, pp. 36-40.

Maya, K., Remya, S. I., Baburaj, B., Baijulal, B., Lekshmi, I., Nisha, U. R., Sangeetha, J. and Padmalal, D. (2013). Natural and anthropogenic determinants of water quality changes in a small tropical river basin, SW India, International Journal of Agricultural Sciences, ISSN: 2167-0447 Vol.3(1), pp. 363-372.

Padmalal, D., Maya, K., Narendra Babu, K., Baiju, R. S. and Baburaj, B. (2012). Hydrochemical characterization and water quality assessment of the coastal springs of Southern Kerala, India, Indian Journal of Applied Geochemistry, Vol.14. No.4, pp. 466-481.

Radhakrishna, T. and Mathew Joseph (2011). Late Cretaceous geodynamic evolution of the Indian Ocean region as evidenced from mafic dykes in Kerala, India, Deep Continenetal Studies in India Newsletter, DST, Vol.21(2), pp. 1-5.

Radhakrishna, T. and Mathew Joseph (2012). Geochemistry and paleomagnetism of Late Cretaceous mafic dikes in Kerala, southwest coast of India in relation to large igneous provinces and mantle plumes in the Indian Ocean region, Geological Society of America Bulletin, Vol.124, pp. 240-255, doi:10.1130/B30288,1.

Ratheeshkumar, M., Sudhanandh, V. S., Faisal, A. K., Raj Vishnu, S., Shibu, R., Sreejith, M. I. and Anoop Krishnan, K. (2012). Diurnal phototactic migration of phytoplankton in Cochin waters and its correlation with limiting nutrient flux, Prospects in Bioscience: Addressing the issues, DOI 10.1007/978-81-322-0810-5_31, Springer India.

Rajendran, C. P., Kusala Rajendran, Vanessa Andrade, Srinivasalu, S. (2013). Ages and relative sizes of pre-2004 tsunamis in the Bay of Bengal inferred from geologic evidence in the Andaman and Nicobar Islands, Journal of Geophysical Research, Vol.118, pp. 1-18, doi:1029/2012JB009541.

Reji Srinivasan and Kurian Sajan (2010). Significance of textural analysis in the sediments of Kayamkumam lake, southwest coast of India, Indian Journal of Marine Sciences, V.39(1), pp. 92-99.

Reji Srinivasan, Girish Gopinath, Laluraj, C.M., and Kurian Sajan (2010). Morphological features of an estuarine system on south-west coast of India, International Journal of Earth Sciences and Engineering, ISSN 0974-5904. V3(6), pp. 875-885.

Santhosh,V., Padmalal, D., Baijulal, B. and Maya, K. (2012). Brick and tile clay mining from the paddy lands of Central Kerala (southwest coast of India) and emerging environmental issues, Environ. Earth Sci, DOI: 10. 1007/s 12665-012-1896-4.

Sheela Nair, L., Sundar, V. and Kurian, N. P. (2013). Shore protection for a placer deposit rich beach of the southwest coast of India, International Journal of Ocean and Climate Systems, Vol.4, No.1, pp. 41-61.

Sheela, A. M., Letha, J., Joseph Sanu, Ramachandran, K. K. and Justus, J. (2013). Detection of extent of sea level rise in a coastal lake system using IRS satellite imagery, International Journal published for the European Water Resources Association (EWRA) DOI/s11269-013-0309-0.

Sreejith, C. and Ravindrakumar, G. R. (2012) MnNCKFMASH phase relations in cordierite-orthopyroxene migmatitic gneisses, southern India: implications for low pressure crustal melting under granulite-facies, Journal Geological Society of India, Vol.80, pp. 613-627.

Sreejith, C., Ravindra Kumar, G. R.. and Babu, E.V.S.S.K. (2010). Origin of granitoids of the Kerala Khondalite Belt, southern India: Biotite as potential tectonomagmatic indicator., Geochemica et Cosmochimica Acta, V. 74 (12/1), A 985 DOI: 1016/j.gca.2010.04.045.

Sreela Reghu, Reji Srinivas, Girish Gopinath and Kurian Sajan (2012). Spatial and temporal variations of groundwater quality of phreatic aquifers in central Kerala river basin, India, Journal of Ecology, Environment and Conservation,Vol. 18 (3), pp. 579-584.

Sreela Reghu, Reji Srinivas, Girish Gopinath, Rajesh Reghunath and Kurian Sajan (2012). A numerical weighted parameter rating (WPR) for artificial groundwater recharging in Bharathapuzha river basin: southern India. International Journal. of Earth Sciences and Engineering, 05(02), pp. 268-275.

Srikumar Chattopadhyay (2012). Natural resource management, National Geographical Journal, India, BHU, Varanasi. Vol.58. pt.1, pp. 1-8.

Sudhanandh, V. S., Arjun, V. K., Faisal, A. K., Ani, M. V., Renjini, V. S. and Narendra Babu, K. (2012). In-vitro antibacterial screening of selected folklore Indian medicinal plants with few clinical pathogens, Indernational Journal of Pharmaceutical Education and Research, 46(2), pp. 174-178.

Vishnu, R., Hamza Varikoden, Anil Kumar, V., Murali Das, S., Mohan Kumar, G.. and Subi Simon, V. N. (2012). Abnormal modulation of atmospheric parameters during tsunami of 2004, Current Science, 102 (11), pp. 1575-1580.

7.1.2 In Conference Proceedings/Books

Ajayakumar Varma, R. (2012). A Glimpse of the Vembanad Lake environment, Proc. of National Conference, Conservation and Management of Wetland Ecosystems, Lake-2012, Mahatma Gandhi University, Kottayam, pp. 3-6.

Ajayakumar Varma, R. (2013). Experiencing a movement towards waste-free Kerala, Proc. International Workshop on Waste, Wealth and Health, Indian Institute of Waste Management, Bhopal, pp. 21-27.

Akhilesh Vijay, S., Bijoy Nandan, Zachariah, E. J. (2013). Methane emission from organic and fertilizer aided rice paddy at different growth stages of rice cultivation from Padayatti wetland, Palakkad, Proc. of 25th Kerala Science Congress, Vol.2, pp. 18-20.

Anoop Krishnan K. (2013). Conservation of spring resources in the western ghats:focus on its quality and management for preserving the biodiversity, Proc. of Proc. of the UGC National Seminar on Western Ghats: Biogeography, Biodieversity and Conservation, 14-16, February 2013. pp. 152-160.

Arun, R. and Shreya, Bandhopadhyay (2012). Application of RS and GIS in detecting palaeo channels: A case study in the part of Pamba-Manimala interfluve, Kerala, Proc. 24th Kerala Science Congress, RRII, Kottayam, pp. 332-334.

Baburaj, B., Remya, S. I., Padmalal, D., Maya, K., and Lekshmi, I. (2012). DIN, DIP, DIC and SO4 fluxes from the Neyyar river (Kerala) into the receiving coastal waters, Proc. of UGC sponsored National Seminar on SGSDNDM held at MS University, Tamil Nadu, 23-24, Feb.2012, pp. 11-15.

Baburaj, B., Vishnu Mohan, S., Nair, K. M. (2013). Late Pleistocene land-sea interactions and coastal geomorphic responses: a case study from Kerala, Proc. of 25th Kerala Science Congress, Thiruvananthapuram, pp. 378-380.

Badarees, K. O., Vimal, K. C., Abhi Aravind, Neelima, T., Thomas, K. V. (2013). Sustenance of urban coastal ecosystems through Coastal Regulation Zone: case study of Kollam, Proc. of 25th Kerala Science Congress, Thiruvananthapuram, pp. 426-428.

Bindhu C. Thomas, Muhamed Anees P. (2012). Web based GIS river bank information system. Proc. of 34th IIG Conference on Natural Resource Management and decentralized planning organized by the Centre for Earth Sciences Studies, Thiruvananthapuram, 13-15 December 2012, pp. 292.

Dhanya V. (2012). Participatory environmental management plan at micro level. Proc. of 34th IIG Conference on Natural Resource Management and decentralized planning organized by the Centre for Earth Sciences Studies, Thiruvananthapuram, 13-15 December 2012, pp. 33.

Krishnakumar, A. (2013). Spatio-temporal changes of forests in the Western Ghat region of Neyyar and Karamana basins, Thiruvananthapuram district: a GIS based analysis. Proc. of the UGC National Seminar on Western Ghats: Biogeography, Biodieversity and Conservation, 14-16, February 2013. pp. 193-197.

Krishna Priya, N., Praveen, S. S., Prakash, T. N. (2013). Sediment transport and orbital velocity measurements for the selected transects off Quilon coast-a post tsunami scenario, Proc. of 25th Kerala Science Congress, Thiruvananthapuram, pp. 388-390.

Lijith P. Nair, Maneesh Yadav (2012). Tourism information system for Thiruvananthapuram district, Kerala. Proc. of 34th IIG Conference on Natural Resource Management and decentralized planning organized by the Centre for Earth Sciences Studies, Thiruvananthapuram, 13-15 December 2012, pp.197.

Maya, K., Santhosh, V., Aneeshkumar, S. R. and Padmalal, D. (2012). Impact of mining and quarrying in Muvattupuzha river basin – an over view on its environmental effects. Proc. of UGC sponsored National Seminar on SGSDNDM held at MS University, Tamil Nadu, 23-24, Feb.2012, pp. 78-81.

Nikhil Kannoth and Mahamaya Chattopadhyay (2012).Analysis of river valley profiles - A case study of Ithikara river, Kerala. Proc. of 34th IIG Conference on Natural Resource Management and decentralized planning organized by the Centre for Earth Sciences Studies, Thiruvananthapuram, 13-15 December 2012, pp.57.

of Solid Earth Geophysics, pp.933-944, DOI 10.1007/978-90-481-8702-7.

Ragi N. P., Sakunthala C., Mahamaya Chattopadhyay (2012). Transverse river valley profile analysis- A case study of Valapattanam river basin, Kannur district, Kerala. Proc. of 34th IIG Conference on Natural Resource Management and decentralized planning organized by the Centre for Earth Sciences Studies, Thiruvananthapuram, 13-15 December 2012, pp. 58.

Rajappan S., Indu P. Nair, Raju K. (2012). Influence of watershed characteristics on annual discharge of Achankovil river basin, Kerala. Proc. of 34th IIG Conference on Natural Resource Management and decentralized planning organized by the Centre for Earth Sciences Studies, Thiruvananthapuram, 13-15 December 2012, pp. 59.

Resmi P., Aneesh R., Arun Rajan (2012). Socio economic impact assessment of Kayamkulam thermal power project on traditional fisherman community: A case study from Kerala. Proc. of 34th IIG Conference on Natural Resource Management and decentralized planning organized by the Centre for Earth Sciences Studies, Thiruvananthapuram, 13-15 December 2012, pp. 273.

Santhosh, V., Padmalal, D., Sobha,V. and Baiju, R. S. (2012). Mining of tile and brick clays from the coastal lands of Chalakudy and Periyar rivers, Kerala, SW India, "Earth Resources and Environment"published by Research publishing, Singapore, pp. 328-334.

Sarath Raj, E. K., Prasad, R., Badarees, K. O. (2013). Efficient utilization of wave power at Kollam coast of Kerala, Proc. of 25th Kerala Science Congress, Thiruvananthapuram, pp. 444-446

Sheikha, E. John, Maya, K. and Padmalal, D. (2013). Impacts of hard rock quarrying: An environmental case study from Greater Kochi Region, Kerala, India, Proc. of 25th Kerala Science Congress, Thiruvananthapuram, pp. 67-69.

Silpa, A. S., Krishna Priya, N. and Prakash, T. N. (2013). Clay mineral distribution off Quilon coast, southern Kerala, Proc. of 25th Kerala Science Congress, Thiruvananthapuram, pp. 391-392.

Silpa, B. L., Sreeraj, M. K., Raju, D., Thomas, K. V., Prakash, T. N. (2013). Granulometric studies of selected beaches along Kerala coast, Proc. of 25th Kerala Science Congress, Thiruvananthapuram, pp. 396-398.

Shravan Kumar V., Muralidharan V., Resmi P., Dhanya V. (2012). Drinking water resources development and Management – a case study of Thiruvananthapuram district, Kerala. Proc. of 34th IIG Conference on Natural Resource Management and decentralized planning organized by the Centre for Earth Sciences Studies, Thiruvananthapuram, 13-15 December 2012, pp. 35.

Vandana M. (2012). Land system analysis of Kabani river basin, Wayanad district, Kerala. Proc. of 34th IIG Conference on Natural Resource Management and decentralized planning organized by the Centre for Earth Sciences Studies, Thiruvananthapuram, pp.56.

Vishnu Mohan, S., Padmalal, D., Sreebha, S. and Maya, K. (2012). Environmental effects of sand mining from Kallada river, Kollam district, Kerala State, "Earth Resources and Environment"published by Research publishing, Singapore, pp. 353-362.

Viji R. V., Thomas K. V. and Jayaprasad B. K.(2013). Coastal Regulation Zone Information System, Proc.of 25th Kerala Sceince Congress, Thiruvananthapuram, pp. 527-529

7.2 Project Reports

Ahalya Sukumar and Sukumar, B. (2012). Study of urbanisation between Kochi and Thrissur, Centre for Earth Science Studies Thiruvananthapuram, 53p.

Sukumar, B., Ahalya Sukumar, Shravan Kumar and Saravanan, E. (2012). Digital Resource Atlas of Kerala, Centre for Earth Science Studies, Thiruvananthapuram, 21 pages and 290 maps.

Sukumar, B., Balasubramonian, G., Mohan Kumar, G., Nair, A. S. K., Sankar, G., Vinayak, P. V. V. S. K., Saravanan, E., Shravankumar, V., Ahalya Sukumar , Vasudevan, V., Vijayakumar, K., Ansom Sebastian, Mathew, K. J., John Paul (2012a). Assessment and monitoring of land quality for sustainable agriculture in Kannur district: A GIS based approach coupled with technology implementation, Centre for Earth Science Studies, Thiruvananthapuram, 91 p.

Sukumar, B., Balasubramonian, G., Mohan Kumar, G., Nair, A. S. K., Sankar, G., Vinayak, P. V. V. S. K., Saravanan, E., Shravankumar, V., Ahalya Sukumar , Vasudevan, V., Vijayakumar, K., Ansom Sebastian, Mathew, K. J., John Paul (2012b). Soil Geochemical Atlas of Kannur district. Part of the project on Assessment and monitoring of land quality for sustainable agriculture in Kannur district: A GIS based approach coupled with technology implementation, Centre for Earth Science Studies, Thiruvananthapuram, CESS-PR-04-2012, 135 p.

Ajayakumar Varma, R., Sankar, G., Jayaprasad, B. K., Salaj, S. S., Eldhose, K. and Vinodhkumar, V. (2012). Report of the geophysical studies conducted in and around Sri Padmanabha Swamy Temple for locating tunnels, submitted to the Home Department, Govt. of Kerala, CESS-PR-05-2012, 112 p.

Jayaprasad, B. K. (2012). Agro-ecological atlas of Kerala, submitted to State Planning Board, Govt. of Kerala.

Krishnakumar, A. (2013). Report on the removal of sand and clay from Vilappil Village, Thiruvananthapuram district, submitted to the District Collector, Thiruvananthapuram.

Krishnakumar, A (2012). Report on sand extraction from Mannurkara V0illage, Thiruvananthapuram District, Submitted to Thiruvananthapuram Collector, Thiruvananthapuram.

Krishanakumar, A (2012). Report on the hardrock quarrying at Kinalur-Karinthalam Grama Panchayat, Kasargod district, submitted to Kerala State Council for Science, Technology and Environment, Govt. of Kerala.

Mathew, K. J. (2012). Application of Artificial Neaural Network in pattern classification of remotely sensed images, Centre for Earth Science Studies, Thiruvananthapuram, 57 p.

Maya, K., Padmalal D., Narendrababu K. and Santhosh V. (2012). Environmental degradation of Muvattupuzha river basin causes, consequences and strategies for river restoration, Centre for Earth Science Studies, Thiruvananthapuram, CESS-PR-07-2012, 110 p.

Mohan Kumar, G. (2013). Continuous measurement of atmospheric CO at Thiruvananthapuram, A tropical site, Report submitted to ISRO, Govt. of India, 22 p.

Mohan Kumar G (2013). Rainfall validation and characterization and cloud microphysics studies using megha-tropiques data, Report submitted to the Space Applications Centre, 11 p.

Mohanan, C. N. and Ajayakumar Varma, R. (2012). Environmental Assessment Report on the proposed Ozhakkal Granites and Quarry at Kizhakkemala, Thalappalam, Kottayam, submitted to the Thalappalam Grama Panchayat, May 2012, 7 p.

Mohanan, C. N. and Ajayakumar Varma, R. (2012). Environmental Assessment Report of the Malamel and Arakkal quarry and crusher unit at Edamulakkal, Kottarakkara, Rep. to the Legislative Committee on Environment, Kerala, June 2012, 6 p.

Mohanan, C. N., Jayaprasad, B. K., Krishnakumar, A., Rajimol, T. R., Vijayakumaran Nair, P., Harikumar, P. S. (2013). Inventory of the Wetlands of Kerala submitted to the Department of Environment and Climate Change, Government of Kerala, 48 p.

Nair, A.S.K. and Ramachandran, G. (2012). Mapping of coastal cliffs and their vulnerability between Kanniyakumari

and Mangalore, South west coast of India, Centre for Earth ScienceStudies, Thiruvananthapuram, 36 p.

Nandakumar, V. (2012). Technothermal History of Kerala Khondalite Belt, Centre for Earth Science Studies, Thiruvananthapuram, 99 p.

Narayanaswamy, Vinayak, P. V. S .S. K, Premachandran, P. N. (2012). Rejuvenating lateritic areas in Neyyar of Western ghat region in Thiruananthapuram using natural rock powder as geo-nutrient for sustainable agriculture: A technological intervention. Report submitted to Department of Planning & Economic Affairs, Government of Kerala, 65 p.

Padmalal, D., Maya K., Sukumar B. and K. N. Babu (2013). Quaternary geology and geomorphic evolution of the coastal lands of Kollam district, SW India, Centre for Earth Science Studies, Thiruvananthapuram, CESS-PR-01-2013, 100 p.

Ravindra Kumar, G. R. and Sreejith, C. (2012). Metasedimentary rocks of the Kerala Khondalite Belt, Southern India: petrology and geodynamics of their formation. Submitted to Department of Science and Technology, Government of India.

Samsuddin, M. et al. (2013). COMAPS Annual Report 1.4.2011 to 31.3.12, CESS-PR-03-2013.

Saravanan, E. (2013). Agricultural Atlases of Kerala, Centre for Earth Science Studies, Thiruvananthapuram, 523 p.

Saravanan, E. (2013). Studies on agro-ecological regions of Palakkad district, Kerala, Centre for Earth Science Studies, Thiruvananthapuram, 95 p.

Shahul Hameed, T. S. et al. (2012). Study on depletion of heavy mineral content in the beach washing. Sumitted to Indian Rare Earths Limited, CESS-PR-02-2012.

Shravan Kumar, V. and Muralidharan, V. (2012). State of drinking water resources in Thiruvananthapuram district-A situation analysis, Centre for Earth Science Studies, Thiruvananthapuram, 60 p.

Srikumar Chattopadhyay (2013). Socio-economic study of the impact on traditional fishing community particularly due to operational stage-I of Rajiv Gandhi Combined Cycle Power Project (RGCCPP) and stage-II, phase-I in Kerala, Centre for Earth Science Studies, Thiruvananthapuram, 144 p.

Srikumar Chattopadhyay (2013). Exploring interrelationships between poverty and environmental degradation-selected microlevel case studies across, Kerala, Centre for Earth Science Studies, Thiruvananthapuram, CESS-PR-02-2013, 191 p.

Srikumar Chattopadhyay and Dhanya, V. (2012). Environmental management plan for Alappuzha-Sherthalai canal and Kanjikuzhy grama panchayat: A participatory action research programme, Report submitted to Kerala State Council for Science, Technology and Environment, Government of Kerala, CESS-PR-03-2012, 125 p.

Srikumar Chattopadhyay, John Mathai, Mahamaya Chattopadhyay (2013). Karamana river bank Atlas, Report submitted to the Department of Revenue and Disaster Management, Government of Kerala, 45 figures and 4 pages explanatory notes.

Subash, N., Prakash, T. N., Syed Ismail Koya, M. S., Anu Baburaj (2012). Monitoring the impact of environmental changes in corals of Lakshadweep Archipelao by fluorescence imaging, submitted to Department of Science and Technology, Government of India, 36 p.

Subash, N., Ajay Kumar, R., Sreekumar, E., Nandakumar, K. and Prasanth, C. S. (2013). Inactivation of pathogenic bateria in periodontal diseases – fluorescence diagnostics and photodynamic Therapy, submitted to Department of

Science and Technology, Government of India, 86 p.

Subash, N. and Mohanan, C. N. (2012). Sunlight-induced multi-spectral fluorescence imaging system for vegetation assessment,Centre for Earth Science Studies, Thiruvananthapuram, 41 p.

Thomas, K. V. (2012). Awareness Training to officials of local bodies of the State on CRZ, CESS-PR-01-2012.

Thomas, K. V. (2012). CRZ report for CRZ of urban areas in cadastral Scale – Kollam, CESS-PR-06-2012.

Vinayak, P.S.S.S.K., Narayana Swamy, Sreekumari Kesavan and Premachandran, P. N. (2012). Monitoring of soil moisture under bare cropped conditions of tapioca and pineapple in the mid land-highlands of western ghat areas of Kerala, submitted to Planning & Economic Affairs Department, Government of Kerala, 33 p.

Vinayak, P.V.S.S.K and Sreekumari Kesavan (2012). Climatological features of Kerala-a ready reckoner, Centre for Earth Science Studies, Thiruvananthapuram.

7.3 Books / Edited Volumes

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

Srikumar Chattopadhyay and Mahamaya Chattopadhyay (Guest Editors), Journal of the Institute of Indian Geographers, Special issue on Philosophy and Research Methodology of Geography, December 2012, 118p.

8.1 Institute of Indian Geographers' 34 th Meet and National Conference on 'Natural Resources Management and Decentralised Planning'

Dr. Shailesh Nayak, Secretary, Ministry of Earth Sciences, Government of India releasing the abstract volume of the National Conference organized during the 34th meet of Institute of Indian Geographers at the Centre for Earth Science Studies on 13th December 2012, by giving a copy of the volume to Prof. A C Mohapatra, President, IIG. Prof. V N Rajasekharan Pillai, Executive Vice-President, KSCSTE and Dr. N P Kurian, Director, CESS are also seen and Dr. Srikumar Chattopadhyay, Head, Resources Analysis Division Welcoming all the guests for this special event.

Centre for Earth Science Studies (CESS) hosted the 34th Institute of Indian Geographers' Meet and organized the National Conference on Natural Resources Management and Decentralised Planning during 13-15 December 2012. A pre-conference symposium, held on 12th December, mainly focused on 'Teaching and Research in Geography, in India'. The inaugural session of the three day conference was presided over by Dr. Rajasekharan Pillai, Executive Vice President, KSCSTE and the keynote address was delivered by Dr. Shailesh Nayak, Secretary, Ministry of Earth Sciences, Government of India & Chairman, Research Council, CESS. Dr. Nayak emphasized the role of the local panchayats to ensure water and ecological security by maintaining forest cover, air and water quality, and practicing scientific landuse. A special lecture on 'Political economy of natural resources and geography' was delivered by Prof. A C Mohapatra, President, IIG.

The symposium reflected on issues concerning geography curriculum, pedagogy, research and teaching materials relating to school, college and university education. The symposium was attended by 25 experts from universities and research institutes in India and abroad. The main conference started on 13th December, 2012. Total number of abstracts received for the conference was 223 out of which 166 papers were selected for presentation. 142 papers were presented under 16 sub-themes covering natural resources management, demography, health, health care and migration, landuse, industry, urban geography, biodiversity, EIA etc. Apart from this, there were 5 invited lectures by eminent academicians and 2 panel discussions. There were 7 contest papers presented by young geographers. One public lecture by Dr. Anil Bharadwaj, Scientist, ISRO on India's Moon Mission was delivered on 14th December, 2012.

The conference deliberated on 172 papers including 29 presentations under invited/special lecture categories. The annual meet of geographers was attended by 272 delegates from the 17 Indian States and one each from Germany and Australia. Ms. Mahima Chantranta of Himachal Pradesh University, Shimla, the author of the research paper entitled

Prof. A C Mohapatra, President, IIG, delivering the special lecture on 'Political economy of natural resources and geography' on 13th December 2012 at CESS during the inauguration of the National Conference on Natural Resources Management and Decentralised Planning

'Frontal recession of Gangotri glacier (1891-2010) using remote sensing' and Mr. Prasenjit Acharya of CSRD, Jawaharlal Nehru University, New Delhi, the author of the paper entitled 'Seasonal variation of aerosol optical depth and its effect on surface radiative forcing' were declared joint winners of 'Young Scholar Award'.

A career guidance session was also held and Dr. P V S P Prasad Raju of ADRIN, Hyderabad, Prof. Prem Chhetri from Australia and Mr. G Renoy from Geo Spatial Delhi Ltd. gave expert opinions. During the valedictory function the IIG secretariat officials felicitated Dr. Kurian, Director, Centre for Earth Science Studies, Dr. Srikumar Chattopdhyay, Convener and Dr. Mahamaya Chattopadhyay, Co-convener of the event.

8.2 Prof. C. Karunakaran Endowment Lecture

Dr. N. P Kurian, Director, CESS welcoming the gathering (left) and Prof. Vinod K Gaur, Distinguished Professor, Indian Institute of Astrophysics, Bangalore (right) delivering the 11th Professor C. Karunakaran Endowment Lecture on 10th August 2012.

Prof. C. Karunakaran Endowment Lecture, the eleventh lecture in memory of the founder Director of Centre for Earth Science Studies, was delivered by Prof. Vinod K Gaur, Distinguished Professor, Indian Institute of Astrophysics, Bangalore on 10th August 2012. Prof. Gaur talked on 'Earthquake Hazard in India: Knowledge and Response'. A galaxy of Scientists from various R & D Centres in the State and officials of the Disaster Management Department

attended the lecture. Prof. V. N. Rajasekharan Pillai, Executive Vice President, KSCSTE and Principal Secretary, Department of Science & Technology, Government of Kerala, presided over the function. Dr. R. S. Nair, Dy. Director General (Rtd), Geological Survey of India paid tributes to Prof. C. Karunakaran and Dr. Krishnamurthy, Director, SPL, VSSC, introduced the speaker. Dr. N. P. Kurian, Director, CESS welcomed the gathering and Dr. D.S. Suresh Babu, Scientist, CESS proposed the vote of thanks.

8.3 Invited Lectures

Dr. K. Anoop Krishnan

Delivered a talk on Ocean Acidification: Chemistry and Impacts in the National workshop on 'Ocean Acidification Research (OAR) 2012' held at Department of Marine and Coastal Studies, Madurai Kamaraj University, Madurai on 12th December 2012.

Delivered a lecture on Instrumental Methods of Chemical Analysis organized by Kannur University under the UGC-Visiting Faculty Programme 2012-13 during 25-29 September 2012.

Dr. N. Subhash

Attended the DAE-BRNS Symposium on Atomic, Molecular and Optical Physics 2012 during December 14-17, 2012 and delivered a talk on Diffuse reflectance spectroscopy for detection of periodontal inflammation.

Attended the national Workshop on Photonics in Medicine & Biology, organized by the Centre for Atomic and Molecular Physics, Manipal University, Manipal and delivered a talk on Diagnostic Applications of Diffuse Reflectance Spectroscopy and Multispectral Imaging during August 20-22, 2012.

Dr. R. Ajayakumar Varma

Delivered the lead talk "Revisiting waste-free Kerala" action plan in the Panel Discussion organized by Costford and Laurie Baker Centre for Habitat Studies at Thiruvananthapuram on 1st March 2013.

Delivered a lecture on Dam Break Analysis and Disaster Management Planning as part of the training programme to Engineers of Irrigation Department, Govt. of Kerala on Dam Safety organized by the Institute of Management in Government (IMG), 31st January 2013.

Delivered a talk " Waste Management- Issues and Solutions" in the seminar on sanitation, College of Agriculture, Padannakkad, Kerala Agricultural University, May 21, 2012.

Attended as a Chief Guest on inauguration of the Eco-club of Indian Institute of Space Science & Technology (IIST), Valiyamala on September 19, 2012 and delivered a talk on Sustainable Development & Green Technologies.

Dr. Srikumar Chattopadhyay

Delivered a lecture 'Sustainable Development- Concepts and Application" for the faculty members of IMG on 20th March 2013.

Dr. T. N Prakash

Delivered a lecture at the INSPIRE camp organised by DST, Govt. of India at KLE Society's College, Belgaum during 16 – 22 June 2012.

Dr. N. P. Kurian

Delivered the inaugural lecture entitled "Coastal Zone Management and Application of Geospatial Technologies" in the national workshop on Geospatial Technologies for Coastal Resouces Management held during 28-29 May, 2012 at IIST, Thiruvananthapuram.

Attended the National Seminar on 'Impact of Global Warming and Climate Change' and delivered a Key Note Address on 'Response to Climate Change: Need for Research Initiative' , organized by the Christ University, Bangalore on 22nd February 2013 at Thiruvananthapuram.

Delivered a talk entitled 'Impact of beach sand mining on beach-nearshore system: a case study' in the HYDRO 2012 Conference held at IIT, Mumbai during December, 6-7, 2012.

Sri. B. K. Jayaprasad

Delivered a lecture on 'The potential uses of GIS Technology in Public Health' at Achutha Menon Centre for Health Service Studies, Sree Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum on 16th May 2012.

8.4 Papers Presented in Conference/ Workshop / Symposium / Seminar

Name	Conference/Symposium/Seminar	Title of the Paper
Shibu R. Sudhanandh V. S. Ratheeshkumar M. Vishnu S. Raj Faisal A. K. Sreejith M. I. Anoop Krishnan K.		Biological Characteristics of Mangalore estuary, south west coast, India (2007-2011).
Ratheesh Kumar M. Sudhanandh V. S. Faisal A. K. Vishnu S. Raj Shibu R. Sreejith M. I. Anoop Krishnan K.		Diurnal phototaxic migration of Phytoplankton in Kochi waters and its correlation with limiting nutrient flux.
Vishnu S. Raj Shijimol K. P. Sudhanandh V. S. Shibu R. Sreejith M. I.	International Conference on Advances in Biological Sciences - ICABS 2012 held on 15-17 March 2012 at Department of Biotechnology and Microbiology, Inter University Centre for Biological Sciences, Kannur University, Kannur, Kerala.	
Faisal A. K. Ratheesh Kumar M. Suraj Krishna R. Baiju R. S. Tresa Radhakrishnan Benno Pereira F. G. Anoop Krishnan K.		Environmental impact assessement of Ashtamudi estuary-A comparative study with special reference to hydrography and sedimentology.
Faisal A. K. Sudhanandh V. S. Vishnu S. Raj Ratheeshkumar M. Sreejith M. I. Shibu R. Anoop Krishnan K.		Seasonal variation and prevalence of faecal indicator bacteria in Mangalore estuary, south west coast India.
Noufal K. N. Udayakumar P. Faisal A. K. Baiju R. S. Anoop Krishnan K.	National Seminar on Frontiers in Chemistry – NSFC 2012 held during 25-27 April 2012 at Department of Chemistry, Kerala University, Kerala.	Identification of Spatiotemporal Physico-chemical pattern in coastal waters of Kochi and Mangalore, Southwest coast of India.
Arya S. Noufal K. N. Baiju R. S. Anoop Krishnan K.		Major ion chemistry, dissolved metal concentration and drinking water potential of the perennial spring of Central Kerala.
Ahalya Sukumar Deepthi P. Savitha Vijayan Nadeer Bin Haneef	National workshop during 28-29 May 2012 at IIST, Thiruvananthapuram	Geospatial Technologies for coastal resources management
Anil Kumar V. Vishnu R. Subi Simon V. N. Mohan Kumar G.	39th Scientific Assembly of the committee on Space Research - COSPAR organized by ISRO during 14 - 22 July, 2012 at Mysore.	Concentration and characteristics of condensation Nucleie at Thiruvananthapuram, a tropical coastal site.
Subi Simon V. N. Anil Kumar V. Vishnu R. Mohan Kumar G.		Comparison of condensation particle concentration at two geographically different locations and its relation with weather parameters

Name	Conference/Symposium/Seminar	Title of the Paper
Sreekanth T. S. Vishnu R. Anil Kumar V. Mohan Kumar G. Sreekanth T. S. Anil Kumar V. Mohan Kumar G. S. Sasi Kumar V.	39th Scientific Assembly of the committee on Space Research (COSPAR) Organized by ISRO during 14 - 22 July, 2012 at Mysore, India.	Characterisation of tropical rainfall in terms of size distribution and its seasonal variations in a tropical coastal site. Size distribution and fall velocities of rain drops of convective & straitform rain events at a tropical coastal site.
Ajayakumar Varma R.	National Seminar on Changing Kerala Politics, Economics and Society organized by the Costford at Thrissur on the Occasion of C. Achutha Menon Centenary on 7th August 2012.	Waste management problems, prospects and possibilities.
Padmalal D. Kumaran K. P. N. Ruta B. Limaye Kumaran K. P. N. Ruta B. Limaye Padmalal D.	XIII IPC/IX IOPC Conference, Tokyo, Japan, during 23-30 August 2012.	Sedimentological, palynological and stable isotope evidences of paleoclimate and sea level records in the Holoscence sedimentary archives of Central Kerala, SW India. Holocene vegetation dynamics in southwestern India: terrestrial and marine archives.
Subhash N.	DST Cluster of Projects Meet on Non – invasive Healthcare Devices organized jointly by PIMS and NHHID, Anna University at Pondicherry during 27-28 September 2012.	Proposal on DRIS for Screening of oral precancers
Rajimol T. R. Mohanan C. N.	34th Indian Geography Congress, National Association of Geographers, Patna during 2 – 4 November 2012.	Spatial modeling for infrastructure development with Remote Sensing and GIS- A case study of an Airport project in North Kerala.
Ajayakumar Varma R.	National Conference on Conservation and Management of Wetland Ecosystem (LAKE - 2012)organized by School of Environmental Sciences, MG University, Kottayam on 7th November 2012.	A glimpse of Vembanad Lake Environment.
Padmalal D.	Annual Symposium of IGCP on Response of Asian Rivers to Climate Change- Past, Present and Future Scenario during 14 – 16 November, 2012 in NGRI, Hyderabad	Holocene climate and sea level records in the sedimentary archives of Southern Kerala, SW India- Its implication on coastal evolution.
Subhash N.	Society for Peridontistis and Implatologists of Kerala (SPIK), Mid- term Conference 2012 at Kottayam, December 2, 2012.	Light activated therapy and diagnosis of oral diseases.
Prasad R. Nair L. S. Nair L. S. Kurian N. P.	HYDRO 2012 Conference held at IIT Bombay during 7-8 December 2012.	Numerical Modelling of shallow water wave characteristics of a monsoon dominated coast. Southern Indian Ocean swells and its impact along the Kerala coast
Ratheesh Kumar M. Shibu R. Sudhanandh V. S. Vishnu S. Raj Faisal A. K. Vimexen V. Ajmal K. Aneesh K S. Sooraj Krishna R. Baiju R. S. Anoop Krishnan K	2nd Indian Biodiversity Congress (IBC 2012) held during 09-12 December 2012 at J. N. Tata Auditorium, IISc, Bengaluru, Karnataka	An investigation on phytoplankton community Structure and species diversity along south west coast of India.

Name	Conference/Symposium/Seminar	Title of the Paper
Vishnu S. Raj Sudhanandh V. S. Shibu R. Ratheesh Kumar M. Faisal A. K. Ajmal K Vimexen V. Aneesh K. S. Baiju R. S. Benno Pereira F. G. Anoop Krishnan K.		Effect of TTP effluents on the biological productivity with emphasis on biodiversity at Veli coast, Thiruvananthapuram
Shibu R. Sudhanandh V. S. Vishnu S. Raj Ratheesh Kumar M. Faisal A. K. Ajmal K. Vimexen V. Aneesh K. S. Baiju R. S. Sooraj Krishna R. Anoop Krishnan K.	2nd Indian Biodiversity Congress (IBC 2012) held during 09-12 December 2012 at J. N. Tata Auditorium, IISc, Bengaluru, Karnataka.	Biodiversity of Benthic Species in Kavaratti Lagoon- A case study from 2010-2012.
Sudhananth V. S. Vishnu S. Raj Shibu R. Ratheesh Kumar M.		Coastal pollution and biodiversity.
Subhash N. Prasanth C. S.	DAE-BRNS Symposium on Atomic, Molecular and Optical Physics during December 14 – 17, 2012.	Diffuse reflectance spectroscopy for detection of periodontal inflammation.
Padmalal D.	National Seminar on 'Sediments and sedimentary rocks□ Resource potential, depositional processes, implication to ecosystem and environmental changes' & XXIX Convention of Indian Association of Sedimentologists (IAS-2012) in Pondichery University, Pondichery during 20-22 December 2012.	Late Quaternary evolution of coastal wetlands of Kerala, SW India.
Krishna Kumar A.		Textural and heavy metal accumulation studies of Karamana River, South Kerala
Jayaprasad B. K.	International Conference on Democratic Decentralization and Peoples Participation at KILA, Trichur on 22nd December 2012.	Tax mapping utilizing high resolution satellite imagery
Arya S. Noufal K. N. Faisal A. K. Baiju R. S. Liji T. M. Anoop Krishnan K.	National Biodiversity Conference-2012 during 27-30 December 2012 at Thiruvananthapuram	Spring diversity of Kerala□ Attempt fo statewide approximation for these hidden traesures to challenge water scarcity in future.
Jayaprasad B. K.	International meet organized by NASA's LCLUC program, University of Maryland, CWRDM and Karunya University held at Kozhikode during 06-08 January 2013	Land cover and landuse change dynamics and its impacts in South Asia□ Focus in water resources.
Vandana M.	Workshop conducted by Bio DIVA research group, Hannover, Germany and M. S. Swaminathan Research Foundation, Wayanad held at Central Tuber Crops Research Institute (CTCRI), Thiruvananthapuram during 17-18 January 2013	Multi-stake holder dialogue on land use change-Transdisciplinary approaches to address landscape transformation in Kerala.

Name	Conference/Symposium/Seminar	Title of the Paper
Nandakumar N. Simon Hanley	International Conference on Granulites & Granulites 2013 in Hyderabad on 19th January 2013.	Inside – out ziron and long-lived melt residence in the Kerala Khondalite Belt, India.
Maya K. Padmalal D. Santhosh V. Vishnumohan S. Padmalal D.	Regional Seminar on Water Quality Assessment and Management of Kerala State, Thiruvananthapuram, Kerala during 5 – 6 February 2013	Response of anthropogenic pressure on the fresh water sources of Muvattupuzha river basin, Kerala, India. Chemical quality of fresh water sources in Kerala, SW India – An overview.
Ajayakumar Varma R	International Workshop on Waste, Wealth and Health organized by the Indian Institute of Waste Management, Bhopal during 15 - 17 February 2013.	Experiencing a movement towards waste-free Kerala
Srikumar Chattopadhyay	National Seminar on Revising Geography as a Sustainable Science organized by Jasmia Millia Islamia, New Delhi during 20 - 21 February 2013.	Geography in Environmental studies: Exploring research frontier with examples from Kerala.
Sibin Antony Arya S. Noufal K. N. Faisal A. K. Liji T. M. Baiju R. S. Anoop Krishnan K.	National Ramsar Sites Stakeholders meet and Wetland Conservation Seminar Ramsar India, during 3-5 March 2013 at Alleppy, Kerala.	Attempt for approximation of ecology sensitive natural springs and modelling associated spring head region in Central Kerala to challenge water scarcity in future.

9.1 Earth Day 2012

Observation of Earth Day 2012: Dr. R. Harikumar, Technologist, EMC, Trivandrum and Sri. G. Rameswar Rao, DGM, SBT special invities and Dr. N. P. Kurian, Director, CESS, Dr. V. Nandakumar, Scientist-E1, CESS (Left), Dr. N. P. Kurian, Director, CESS Presenting Memento to Quiz Master Dr. Biju Kumar, Head, Aquatic Biology Dept., KU, (middle) and Winners of the District level Quiz Competition conducted on April 25th 2012 (right).

Earth Day-2012 was observed in CESS on 25th April 2012 with an Open House programme. Laboratories in CESS were kept open for the students and public. Dr. R. Harikumar, Technologist, EMC Trivandrum gave a talk and a district level Quiz Competition was organized on the occasion. Dr. Bijukumar, Head, Department of Aquatic Biology, Kerala University was the Quiz master. Sri. Rameshwar Rao, Deputy General Manager, State Bank of Travancore was the Chief Guest of the programme. Dr. N. P Kurian, Director , CESS gave away prizes and mementos. Dr. V. Nandakumar, the convenor of the programme proposed the vote of thanks.

9.2 National Science Day 2013

Dr. Srikumar Chattopadhyay, Head, Resources Analysis Division welcoming special guest and students and Dr. N. M. Nair, Former Director, CTCRI, Trivandrum delivering a talk as the special guest on National Science Day 2013.

CESS observed National Science Day on 28th February, 2013. 48 students and teachers from Kendriya Vidyalaya, AFS, Akkulam participated in the event. A special invited talk by Dr.N.M. Nair, former Director, CTCRI, Trivandrum was arranged on the focal theme of 'Genetically Modified Crops and Food security - Issues and Prospects'.

9.3 Exhibition

CESS's stall at National Expo held as a part of 25th Kerala Science Congress held at Thiruvananthapuram

CESS arranged a stall in the 'National Expo' organized as part of 25th Kerala Science Congress held at Thiruvananthapuram. Display of posters and atlases, demonstration of working GIS software, and documentaries on 'Coastal erosion' and 'Landslides' were arranged for the visitors.

9.4 Lectures for students

Students of various schools attending the special talk from Dr. R. Harikumar, Energy Technologist, EMC, Trivandrum as part of the Earth- Day 2012 on 25th April 2012.

Dr. Archana M. Nair and Sri.B. K. Jayaprasad delivered two lectures on Remote Sensing, GIS & GPS for 60 Students and 5 Teachers from Bishop Hodges Higher Secondary School, Mavelikara who visited CESS on 20th July 2012 as part of their study tour.

Dr. R. Ajayakumar Varma delivered a lecture on the 'Role of Green Management and Green Technology in Sustainable Development' in the Academic Staff College of the Kerala University as part of a Refresher Course on Environment on 8th October 2012.

Dr. R. Ajayakumar Varma delivered a talk on environmental management in the one-day seminar organized by the SN College, Nattika, Trissur and interacted with the students on 12th December 2012.

Sri. Johan Mathai delivered lecture for the teachers and Students of the Good Shepherd School at Akkulam on 13th September 2012. The visit was as part of their study tour to know about earthquake hazards.

9.5 Earth Science Forum

Earth Science Forum organised interactive sessions with leading International and National experts in various Earth Science related disciplines. Mr. T. Harikrishnan, Nuclear Technology Specialist from International Atomic Energy Agency (IAEA), Vienna, Austria delivered a lecture on "Nuclear energy and fuel resources: Post Fukushima scenarios". Dr. (Mrs.) Kusala Rajendran, Centre for Earth Sciences (CESS), Indian Institute of Science, Bangalore delivered a lecture on "Earthquake recurrence through time: Indian Ocean experiences". Dr. Y. S. Rao, Associate Professor, Centre of Studies in Resources Engineering, Indian Institute of Technology, Mumbai delivered a lecture on "Geophysical Parameter Retrieval using Polarimetric SAR Data". Dr. Martin Whitehouse, Isotope Scientist, Swedish Museum of Natural History, Stockholm delivered a lecture on "Ion microprobe applications in the Earth Sciences – from Vesta to Diatoms". Prof. Raghu Murtugudde, Department of Atmospheric and Oceanic Sciences, Earth System Science Interdisciplinary Centre, University of Maryland, USA delivered two talks: (a) Do we really understand ENSO? and (b) Regional Earth System Prediction for Decision-Making. Dr. C S P Iyer, Emeritus Professor, Indian Institute of Information Technology & Management - Kerala (IIITM-K), and former Executive Committee Member of CESS also interacted with the Scientists of CESS.

In addition to eminent scientists, former Principal Secretary to Government of Kerala, Department of Revenue & Disaster Management Dr. K. B. Valsala Kumari I.A.S, delivered a lecture on the topic: "Need for interaction between Scientists and Administrators with particular reference to Disaster Management". Earth Science Forum also organised mock presentations of five papers from CESS accepted for the 25th Kerala Science Congress.

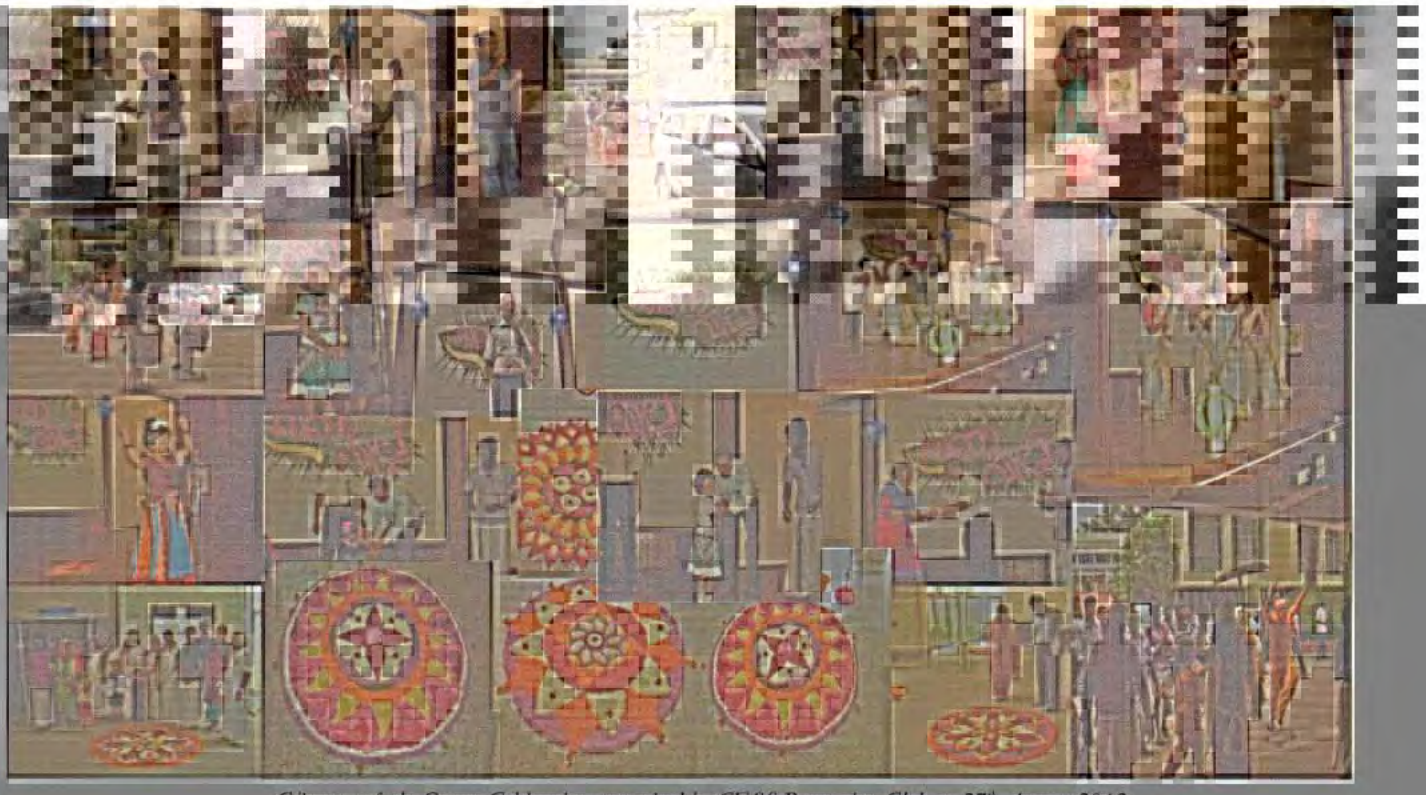
9.6 Campus Green Committe

The award ceremony of state level essay competition on Green Technology conducted jointly by CESS and State Bank of Travancore was organized in a function as part of Earth Day 2012. The function was inaugurated by Dr. N. P. Kurian, Director, CESS. Sri. Ramakrishna Rao G, DGM, SBT was the chief guest and Dr. R. Harikumar, Energy Technologist, EMC, Trivandrum delivered the earth day distinguished lecture. In the inaugural address CESS Director stressed the importance of green activities that has to be adopted in our daily lives. DGM, SBT explained different initiatives taken up by SBT to promote green ideas. Dr. V. Nandakumar, Chariman, Campus Green Committee, CESS elaborated on the various activities adopted in CESS to propagate green ideas among the general public. Dr. R. Harikumar explained to the students about various measures that can be adopted in homes to bring down energy expenditure. Cash awards and trophies were distributed to the winners of the State level essay competition-2011.

All routine campus cleaning activities connected with CGC were undertaken. A project proposal to infuse green technologies to CESS Campus was prepared jointly with ANERT. Out of 5 items of work ANERT could accomplish only one. Biogas unit in CESS was commissioned successfully and a biogas stove is operational in the CESS Canteen.

9.7 Earth Watch Centre / Dynamic Planet

Land Survey work was executed to demarcate the area currently available with CESS leaving behind a 100 m exclusion zone as stipulated by Indian Air Force in our campus. Efforts are on to find new area for the complex.



Glimpses of the Onam Celebrations organised by CESS Recreation Club on 27th August 2012

The activities of the Recreation Club of CESS continued to be vibrant. Onam and New Year Eve were celebrated with great fanfare with participation of staff members, students and family members.

Committees

10.1 Statutory Committees

10.1.1 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*

10.1.2 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*

10.2 Internal Committees

10.2.1 Heads of Divisions

Director, CESS	*Chairman*
Dr. T. Radhakrishna *Geosciences Division*	*Member*
Dr. K. V. Thomas *Marine Sciences Division*	*Member*
Dr. N. Subhash *Atmospheric Sciences Division*	*Member*
Dr. Srikumar Chattopadhyay *Resources Analysis Division & Training & Extension 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*
Sri. P. Sudeep *Registrar*	*Member*
Sri. C. K. Sasidharan *SIC, Technical Cell*	*Convenor*

10.2.2 Editorial

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

10.2.3 Material Purchase

Dr. E. J. Zachariah	Chairman
Dr. G. R. Ravindra Kumar	Member
Sri. P. Sudeep	Member

10.2.4 Library Management

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

10.2.5 Library Stock Verification

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

10.2.6 Canteen

Sri. G. Sankar	Chairman
Dr. Reji Srinivas	Member
Dr. Archana M Nair	Member
Sri. P. Rajesh	Member
Smt. K. V. Padmaja Kumari	Convenor

10.2.7 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

10.2.8 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

11.1 Director's office

Dr. N. P. Kurian	Director
Sri. N. Rajasekharan Nair	P. A to Director
Sri. C. K. Sasidharan	Scientist-E2 & SIC,TC
Sri. S. Sidharthan	Scientist-E2 & SIC, WIC
Smt. V. Geethamol	Stenographer (Gr. 1) (till October 2012)
Smt. Remani T.	Helper (Gr. 1)

11.2 Atmospheric Sciences Division

Dr. N. Subhash	Scientist-G & Head (till February 2013)
Dr. E. J. Zachariah	Scientist-F
Dr. G. Mohan Kumar	Scientist-F
Dr. P. V. S. S. K. Vinayak	Scientist-F (till August 2012)
Sri. V. Muralidharan	Scientist-F
Sri. K. J. Mathew	Scientist-E2 (till December 2012)
Sri. K. Vijayakumar	Scientist-E1 (till February 2013)
Sri. Mohammed Ismail	Technical Officer (Gr. 4)
Smt. Nita Sukumar	Technical Officer (Gr. 1)

11.3 Chemical Sciences Division

Dr. P. K. Omana	Scientist-F & Head
Dr. K. Anoop Krishnan	Scientist-B
Smt. T. M. Liji	Technical Officer (Gr. 2)

11.4 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 (till September 2012)
Sri. B. K. Jayaprasad	Scientist-E1
Dr. Archana M . Nair	Scientist-B
Sri. P. B. Vibin	Technical Officer (Gr. 1)

11.5 Environmental Sciences Division

Dr. R. Ajayakumar Varma	Scientist-G
Dr. C. N. Mohanan	Scientist-F & Head
Dr. D. Padmalal	Scientist-E2
Dr. K. Maya	Scientist-E2
Dr. A. Krishnakumar	Scientist-B

11.6 Geosciences Division

Dr. T. Radhakrishna	Scientist-G & Head
Sri. John Mathai	Scientist-G
Dr. C. P. Rajendran	Scientist-G (on long Leave)
Sri. G. Sankar	Scientist-F
Dr. G. R. Ravindra Kumar	Scientist-F
Dr. V. Nandakumar	Scientist-E2
Ms. Sreekumari Kesavan	Scientist-E1
Dr. Tomson J Kallukalam	Scientist-B
Sri. N. Nishanth	Technical Officer (Gr. 2)
Sri. S. S. Salaj	Technical Officer (Gr. 2)
Sri. K. Eldhose	Technical Asst. (Gr. 2)

11.7 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 (till May 2012)
Smt. L. Sheela Nair	Scientist-E2
Sri. P. John Paul	Scientist-E2
Dr. D. S. Suresh Babu	Scientist-E2
Dr. Reji Srinivas	Scientist-B
Sri. D. Raju	Technical Officer (Gr. 5)
Sri. S. Mohanan	Technical Officer (Gr. 5)
Sri. A. Vijayakumaran Nair	Technical Officer (Gr. 5)
Sri. M. Ajith Kumar	Technical Officer (Gr. 5)
Sri. M. Ramesh Kumar	Technical Officer (Gr. 5)
Sri. M. K. Rafeeque	Technical Officer (Gr. 1)
Sri. M. K. Sreeraj	Technical Officer (Gr. 1)
Sri. Louis Williams	Helper (Gr. 2)

11.8 Resources Analysis Division

Dr. Srikumar Chattopadhyay	Scientist-G & Head
Sri. V. Shravan Kumar	Scientist-E2
Smt. Ahalya Sukumar	Scientist-E2 (till August 2012)
Dr. Mahamaya Chattopadhyay	Scientist-E2
Smt. C. Sakunthala	Technical Officer (Gr. 5)
Sri. K. Surendran	Stenographer (Gr. 1)

11.9 Training & Extension Division

Dr. E. Saravanan	Scientist-E1
Dr. Ansom Sebastian	Scientist-E1
Dr. K. Raju	Scientist-E1

Smt. K. K. Rimsy	*Technical Officer (Gr. 1) (till September 2012)*
Smt. S. Najumunniza	*Technical Assistant (Gr. 5)*

11.10 Library

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

11.11 Administration

Sri. P. Sudeep	*Registrar*
Sri. M. Philip	*Internal Audit Officer (on deputation from AG's office)*
Sri. M. A. K. H Rasheed	*Deputy Registrar (on deputation to CDS)*
Smt. K. V. Padmaja Kumari	*Assistant Registrar*
Sri. T. D. Basheerdeen	*P.A to Registrar*
Sri. R. Haridas	*Section Officer*
Smt. K. Viswabharathy	*Section Officer*
Sri. C. M. Youseph	*Section Officer (on deputation to State Secretariate)*
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) (till December 2012)*
Smt. S. R. Surekha	*Office Asst. (Gr. 1) (till June 2012)*
Sri. K. M. Dinesh	*Office Asst. (Gr. 1) (till December 2012)*
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)*
Smt. S. Beena	*Office Asst. (Gr. 2) (on deputation from Revenue Dept.)*
Smt. Sajitha Kumari V.	*Office Asst. (Gr. 1) (from January 2013)*
Smt. Seeja Vijayan	*Office Asst. (Gr. 1) (from January 2013)*
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. M. K. Radha	*Typist (Gr. 1)*
Smt. K. Nirmala	*Clerical Assistant (till June 2012)*
Sri. N. Jayapal	*Clerical Asst. (Gr. 2)*
Sri. K. R. Satheesan	*Clerical Asst. (Gr. 2)*
Sri. M. Parameswaran Nair	*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)*
Sri V. Chandran Nair	*Helper (Gr. 1)*

11.12 New Recruitments

Smt. Remani T.
Helper (Gr. 1)
Dir. Office

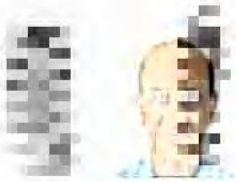
11.13 Mutual Transfer

(on transfer from CWRDM)

Smt. Sajitha Kumary V.
Office Assistanat (Gr -1) Accounts Section in place of Mr. Dinesh K. M. on mutual trasfer from CWRDM, Kozhikode

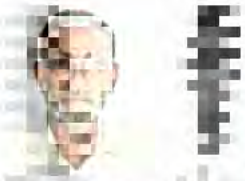
Smt.Seeja Vijayan
Office Assistant (Gr. 1) Accounts Section in place of Mr. Siju V. on mutual trasfer from CWRDM, Kozhikode

Dr. Nair A. S. K
Scientist-E2
Marine Sciences Division
superannuated on 31 May 2012



Dr. Vinayak P. V. S. S.K
Scientist- F
Geosciences Division
superannuated on 31 August 2012

Abalya Sukumar
Scientist-E2
Resouces Analysis Division
superannuated on 31 August 2012



Dr. Harish C. M
Scientist-F & Head
Central Geomatics Laboratory
superannuated on 30 September 2012

Matew K. J
Scientist-E2,
Atmospheric SciencesDivision
superannuated on 31 December 2012

Dr. Subhash N
Scientist-G & Head
Atmospheric Sciences Division
superannuated on 28 February 2013

Sri. Vijayakumar K
Scientist-E1
Atmospheric Sciences Division
superannuated on 28 February 2013

Sri. V. Shravan Kumar
Scientist-E2
Resources Analysis Division
superannuated on 31 March 2013

Smt. Nirmala.K
Clerical Assistant
Administration
superannuated on 15 June 2012

Smt. Surekha S. R
Office Assistant (Gr. 1)
Administration
Resigned on 20 June 2012

Smt. Rinsy K.K
Technical Officer (Gr. 1)
Training & Extension Division
resigned on 5 September 2012

Smt. Geethamol V.
Stenographer (Gr. 1)
Administration
resigned on 10 October 2012

Mr. Dinesh K. M
Office Assistant (Gr. 1)
Accounts
reslieved on 31 December 2012 on mutual transfer to CWRDM

Mr. Siju V.
Office Assistant (Gr. 1)
Accounts
resigned on 31 December 2012 on mutual transfer to CWRDM

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 2013

Liabilities	Sch No	As at 31.03.2013	As at 31.03.2012	Assets	Sch No	As at 31.03.2013	As at 31.03.2012
Reserves & Surplus	4	8,29,45,669	7,78,76,338	Fixed Assets	1	8,29,45,669	7,78,76,338
Current liabilities	5	2,04,69,873	40,08,077	Current Assets	2	10,87,17,452	11,89,53,452
Unspent balance				Loans & Advances	3	5,00,24,803	2,32,05,480
Grant in aid projects	6	2,72,01,663	3,72,35,585				
Divisional Core projects	6	84,00,910	61,49,733				
Service component projects	6	99,48,237	72,96,641				
Consultancy projects	6	3,30,72,654	3,09,10,187				
Corpus fund	6	5,44,52,484	5,68,86,249				
Grant (GOK)	6	51,96,435	(3,27,540)				
Total		24,16,87,924	22,00,35,270	Total		24,16,87,924	22,00,35,270

AUDITOR'S REPORT

As per our report of even date attached

For Mohan & Mohan Associates
Chartered Accountants
FRN: 20925

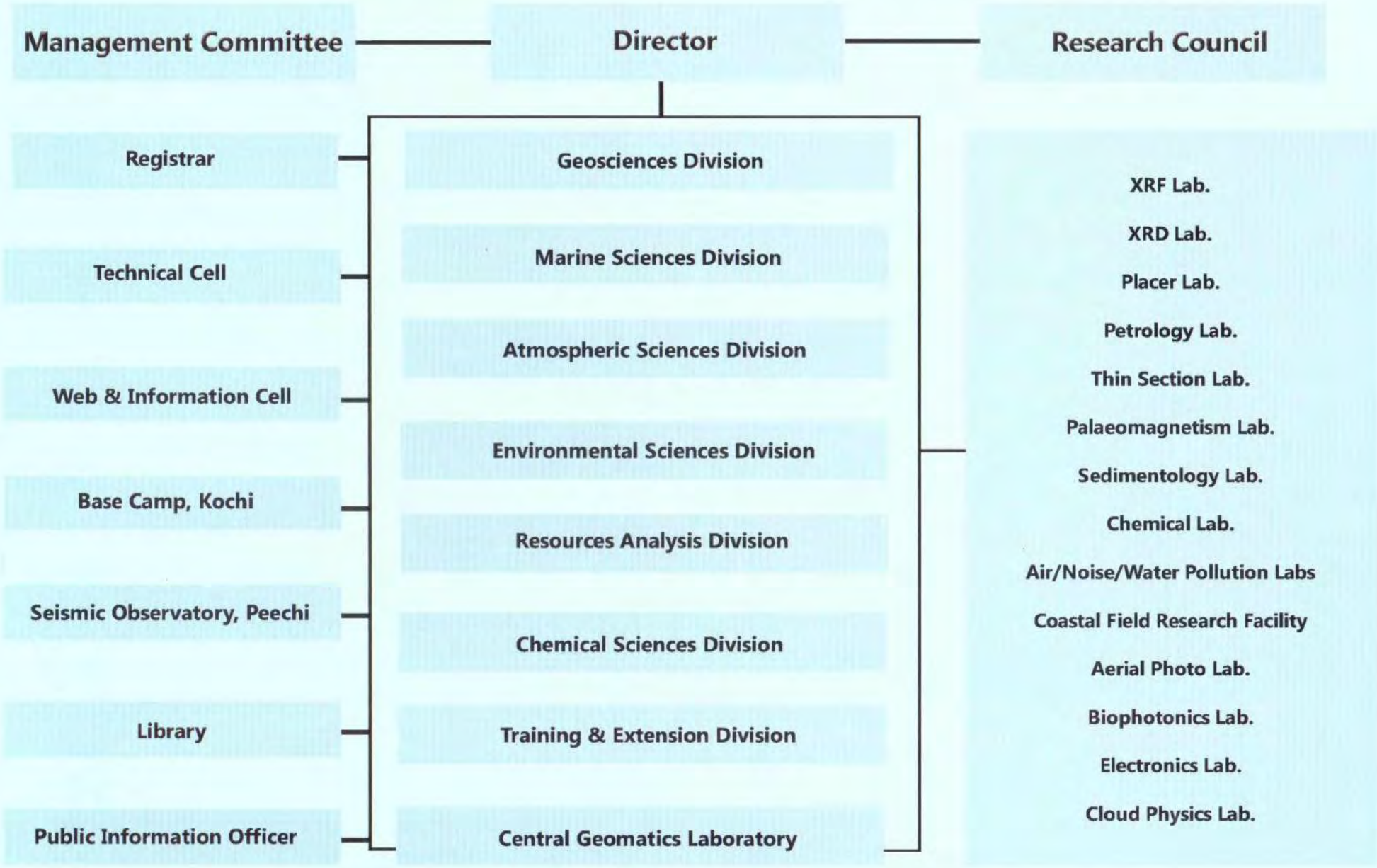
R.Suresh Mohan
Partner M No 013398

Registrar (Incharge)

Director (I/C)

Thiruvananthapuram
Date:

Centre for Earth Science Studies



Centre for Earth Science Studies
P.B. 7250, Thuruvikkal P.O.
Akkulam, Thiruvananthapuram-695 031
Tel: 0471-2511501-53; Telefax: 0471-2442280
E-mail: admin@cess.res.in; Web: www.cess.res.in