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Preface

CESS has taken up several missions during the period under report. In tune with its vision the studies were focused on natural hazards, natural resources, environment, coastal zone and earth system dynamics. Some highlights of the progress and achievements are given below.

Geodynamics and Crustal Evolution

The key to the understanding of the formation and evolution of the lower crust of the earth lies in the knowledge of the processes that lead to the development of granulites. The southern Indian granulite terrain (SGT) provides 'windows' to the lower crust. CESS has made contributions to the better understanding of these rocks and the processes that are active at the lower part of the earth's crust. The Indo-French project on palaeointensity and reunion/marion plume activity in India was initiated. Strain data processing in connection with a programme on 'GPS constraints on strain rate across the Andaman – Nicobar islands: kinematics of subduction zone tectonics and plate margin deformation was carried out. CESS has conducted some of the pioneering works on paleoseismology and palaeo-tsunami, results of which now provide a reference for similar studies in other regions of the country. Some studies on the characterization of the Indian placer deposits and on the sand budgeting for Manavalakuruchi coast was taken up under a national programme sponsored by CSIR.

Natural Hazards

The great Sumatra earthquake and the devastating tsunami of December 2004 posed several challenges and gave a few opportunities to the Centre. A deep insight into the processes associated with tsunami generation, travel and transformation at the coast could be explored for the first time by the Centre. Towards this CESS could work in close association with various departments and agencies both at the State and National level. The results of these studies have attracted international attention as could be seen from the publications emanated from it. CESS took up a programme to model coastal inundation due to tsunami and storm surges and could obtain the advice of Dr. Tad Murty, the international expert in the area. The Ministry of Earth Sciences, Govt. of India later supported this programme. As a part of the efforts to understand earthquake processes and for the regional seismic hazard assessment, investigations in classic areas like Gujarat, Andamans, northeast India and other parts in India were also taken up. CESS was also operating and maintaining its broadband seismological observatory at Peechi. In connection

with the 'understanding of the lightning phenomena' the high land field station at Braemore was in continuous operation. The coastal erosion related programmes included continuous monitoring of some sectors in Kerala and Lakshadweep islands. The year saw the completion of a project on landslide hazard zonation of Kozhikode district. Based on the data gathered from the above studies, CESS initiated the preparation of natural hazard zonation atlas of Kerala.

Natural Resources

Sustainable economic development of any region depends largely upon the availability and the optimal utilization of natural resources without endangering the environment and ecosystem of that region. A dependable database of the resource availability and an excellent long term resource management plan, thus become imperative for steady progress of the economy. The preparation of a micro level digital database using satellite data for the entire stretch of the State of Kerala that could be readily utilized by the planners, administrators and the society at large for better utilization of the natural resources, protection of the environment, creation of awareness etc. was taken up. A cadastral level decision support system for management of natural resources in Thiruvananthapuram district and the work on developing an application software 'Athiyannur Health Information System (AHIS)' have been initiated during the period. A digital database generation on the five municipal corporations of the State had reached the final stage. The Thirurangadi block database and information system (CESS PRINCE) was handed over to the Panchayat. A digital resource data bank was established in CESS during this period.

Environmental Studies

Work was undertaken in the entire coastal waters of the project area (Kerala, Karnataka & Lakshdweep) for identifying environmental hotspots under the sponsorship of the Ministry of Earth Sciences. As part of the climate change studies the methane (CH_4) emission flux in the wetland areas of Kerala was taken up. A LASER induced multi-wave length fluorescence imaging system developed in CESS was efficiently utilized for oral health and malignancy testing along with the Dental College and Regional Cancer Centre respectively. CESS initiated the preparation of the state of the environment report of Kochi. CESS has also provided EIA consultancy services for the mining, harbour, quarrying and other industrial sectors.

Coastal Zone Management

'Shoreline Management Plan' a project to develop sustainable measures for coastal protection for a 120 km stretch between Munambam and Kayamkulam was taken up with the support of the Ministry of Earth Sciences (MoES), Government of India. Another project with MoES - Council support was to develop alternate coastal protection strategy for Panathura coast.

Transitional groins were designed in association with the Ocean Engineering Department (IITM) as part of the programme. An Integrated Coastal Zone Management Plan for Lakshadweep was completed with the support from the Ministry of Environment and Forests, Government of India. This was aimed at managing the overall coastal development as well as conservation of natural resources while addressing the concerns of all relevant sections of the society. Coastal Regulation Zone (CRZ) status reports were prepared for different coastal locations of the country on consultancy mode.

Major Meetings

CESS along with the Institute of Land Management (ILM) have hosted a training cum field workshop on 'Geo-information for Landslide Hazard and Risk Assessment' during Jan. 15-27, 2007. The programme was organized by the United Nations University-International Institute for Geo-information Science and Earth Observation (UNU-ITC) School for Disaster Geo-information Management, Enschede, the Netherlands and Geological Survey of India Training Institute (GSI TI), Hyderabad. The seventh Prof. C. Karunakaran Endowment lecture was delivered by the eminent geologist Prof. S. K. Tandon.

Awards & Honours

Dr. G. R. Ravindra Kumar, scientist, was awarded the prestigious Prof. M. R. Srinivasa Rao Award for the year 2006 by the Geological Society of India, Bangalore for his outstanding contributions in the field of Petrology. Four scientists were awarded Ph.D for their work in CESS. Out of the 39 research papers published 24 were in journals of repute.

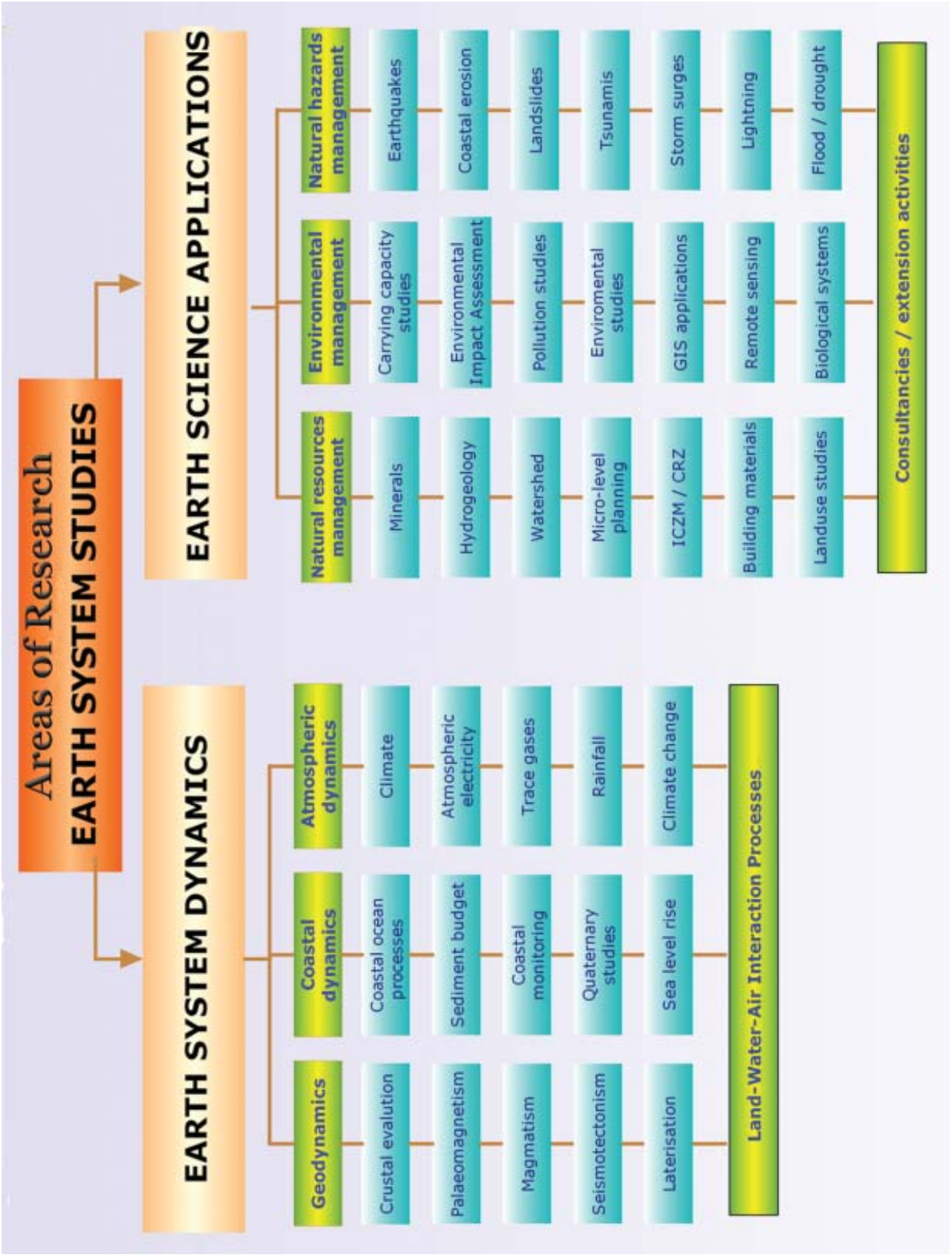
Funding

CESS received Rs. 745 lakh as grant-in-aid from the Kerala State Council for Science, Technology and Environment. The grant-in-aid receipt from the other State and Central Government sources was Rs. 208 lakh. The consultancy receipts during the year recorded a high of Rs. 92 lakh.

Acknowledgements

The constant support from the Council and other peers are greatfully acknowledged. The achievements made by the Centre during the year are dedicated to its staff, project/research fellows and students.

Dr. M. Baba


Areas of Research
EARTH SYSTEM STUDIES
EARTH SYSTEM DYNAMICS
Geodynamics
Crustal evalution
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

1. Earth System Dynamics

1.1 Crustal Evolution and Geodynamics

1.1.1 Evolution of supracrustal rocks and associated gneisses of Wayanad Schist belt, northern Kerala

The Schistose rocks of the Cannanore and Tellichery regions of Kerala were not studied in detail for a long time. Only general references were made in the literature about rock types and their status in the geology of peninsular India. This region acquired much significance when studies in the geological formation of Dharwars by the Geological Survey of India documented schistose formations older than Dharwar in areas south of Mysore around HD Kote, Sargur. Since the schistose rock types of Kerala appear to be structural continuations to those in the southern Mysore, interest in Cannanore and Manantoody was rekindled. The Geological Survey of India

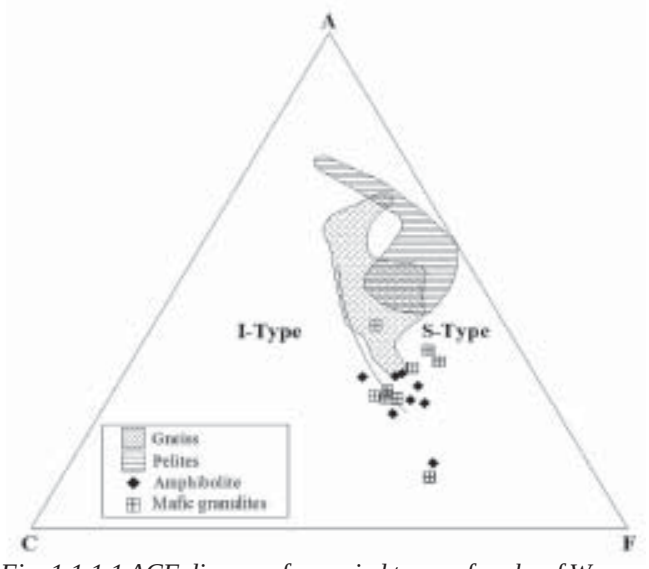


Fig. 1.1.1.1 ACF diagram for varied types of rocks of Wyanad Schist Belt. Solid line represent boundary between I-type and S-type granitoids after White and Chappel (1977)

provided the first description of rock types of this region (Nair et al., 1976). Centre for Earth Science Studies (CESS) took initiatives to study the region in details on aspects related to field relations between different rock units, pressure and temperature conditions of metamorphism of metapelites and mafic granulites and petrochemical characteristics of igneous plutons. These studies (Ravindra Kumar, 1980; Sinha Roy and Ravindra Kumar 1985; 1986) corroborated with observations made by Nair et al (1976) and correlated the western part of the belt as similar to the Bababudan Group and the eastern half around Manatoddy to the Sargur Group of Karnataka.

New initiatives were taken up again (2003-2006) recently to relook at the geological evolution of the belt in the light of application of new laboratory techniques and new understandings in the evolution of ancient schistose rocks. Following are the salient points from this project.

Wynad schist belt is composed of a wide variety of rock types like metapelites, quartzite, amphibolite, pyroxene granulite, variety of unclassified gneisses constitute the high grade region. These rocks exhibit tectonic structures of polyphasal deformation accompanied with high degree of migmatization and mylonitization. Fragments of ultramafic rocks, amphibolites and pyroxene granulites were also observed within highly mylonitised units. Microscopic and field study supports a deformation episode in the area younger than the alkali pluton and older than the second generation dolerite dykes.

Careful study of conglomerates occurring along Anjarkandi river near Vengad indicated that conglomerates contain clasts of granite+quartzite occur around Vengad. Quartz pebbles show intense deformation and alignment of quart-feldspar with minor amount of micas in an elongated manner. Granite pebbles on the other hand are weakly foliated. Age data would have proved very useful in deciphering erosional provenance and its characteristics. Important inference that can be drawn from granite pebble is the evidence of plutonism before deposition of Dharwar sediments, weak fabric can be related to the tectonic disturbances conglomerates have undergone post depositional or unroofing and erosion of relatively young pluton while it is being emplaced.

Among metapelites sillimanite-garnet assemblages are common in the study area than kyanite-garnet assemblage, which is characteristic of Kasaragode-Jalsore-Mercara belt. The sillimanite-garnet assemblage is a low pressure assemblage than kyanite-garnet assemblage indicating probable contrasting features between the study area and the Kasaragode-Jalsore-Mercara belt. Garnetiferous pyroxene granulites near Manantoddy shows typical retrogression resulted in the breakdown of garnet to vermiform intergrowth of second generation opx and plagioclase. The texture implies an uplift of the terrain and consequent breakdown of garnet in the presence of clinopyroxene and quartz to produce vermiform intergrowth of orthopyroxene

and plagioclase. Reactions around garnet described by Ravindra Kumar and Srikantappa (1988, 1989) and our own present results suggest Bavali fault recorded a metamorphic history of upper amphibolite facies and at places retrogressed lower amphibolite-facies to greenschist-facies. An unexplainable complexity exists regarding how granulite grade fragments in the orientation different from those that is generally shown by Bavali faults rocks and lower intensity of deformation in granulites. Several tectonic mechanisms have been examined for explanation.

Earlier studies noted that the rocks along Bavali fault and those exposed to the north around Manantoddy have structural and metamorphic features that are similar to pelitic gneisses seen in Sargur Group of rocks of Karnataka. It is therefore possible that all these rocks may have formed in response to same metamorphic event. From the two independently calibrated thermometers which use different metamorphic assemblages, it is evident that PT path and the record of PT conditions are consistent between the methods and is comparable to equivalent records for the similar assemblages from the entire region. The question that is to be addressed is whether they developed in same tectonic setting. Since the Bavali fault separates deep crustal rocks in the NE from intermediate to high level rocks to the SW, it is interpreted that Bavali fault is essentially a fault boundary which was rejuvenated as a ductile shear in late Proterozoic or early Paleozoic times, subsequent to emplacement of igneous plutons.

G. R. Ravindra Kumar
Funding: Department of Science & Technology, Govt. of India

1.1.2 *Metasedimentary rocks of the Kerala Khondalite Belt, Southern India: petrology and geodynamics of their formation*

In the last few years CESS has completed several projects (two projects sponsored by DST, one by the Institute and one DST-DAAD) in its quest to understand the origin of well exposed Khondalite belt in the southern parts of Kerala. In order to pursue further studies a new project sponsored by DST was initiated in December 2006 to address basic problem concerning the nature of relationships between metamorphic and tectonic processes by examining the metasedimentary rock formation of the Kerala khondalite belt (KKB) from the standpoint of its deposition, metamorphism and evolution and geodynamics. The project entitled " Metasedimentary rocks of the Kerala khondalite belt, southern India: petrology and geodynamics of their formation" is sanctioned with a total outlay of Rs 19.5 lakhs and new instruments like Isomet 1000 Precision cutter and expensive polishing disks to augment our thin section lab facilities and computer and digital camera for petrology lab.

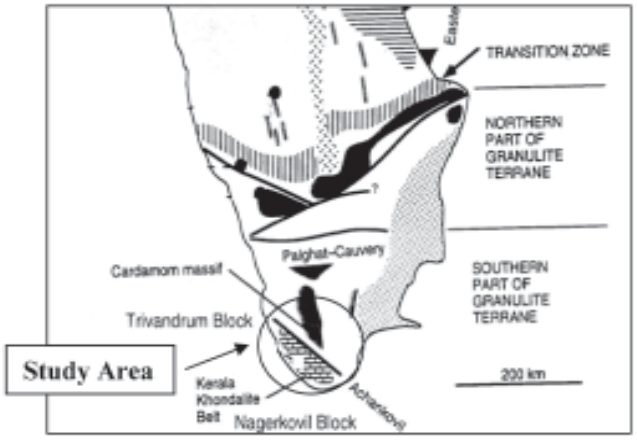


Fig. 1.1.2.1 A sketch map of southern India showing location of the study area: southern Kerala

The project is intends to address basic problem concerning the nature of relationships between metamorphic and tectonic processes by examining the metasedimentary rock formation of the Kerala khondalite belt (KKB) from the standpoint of its deposition, metamorphism and evolution and geodynamics. The geodynamic model would be based on integrating results obtained from field studies, textural studies, conditions of metamorphic rocks formation and their geochemical characteristics, analysis of the pre-metamorphic geodynamic settings of precursor rocks. The project also intends to reconstruct the Proterozoic sedimentary basins in southern India from the point of data from the KKB and their position before and during amalgamation of the Gondwana supercontinent.

The first phase of the project work involved extensive reference work and summarising of work so far carried out on the selected study areas in southern India. This was with a view to understand the gaps in the knowledge, data collection, missing field information and petrogenetic models.

As envisaged in the project we have completed first phase of field work in parts immediately north and north east of Trivandrum and in the southern parts stretching up to Nagerkovil region. Detailed information on the field relations between various rock types, interrelationship between major rock types and representative samples for petrography have been collected for laboratory work. Thin sections of selected rocks were pre-

pared and detailed petrographic study is in progress to classify the rock types, study the mineral reactions and paragenetic relations between different minerals and to select interesting assemblages for mineral chemical and thermobarometric work.

Major and trace element analysis of selected rock types, all across and width of the KKB, is being taken up. This is essential in knowing the chemical characteristics of the rock types and results are expected to shed light on (I) the nature of precursor material and (iii) tectonic setting of rock types. In order to accomplish this first batch of 60 samples were crushed and fine powders were prepared from over 2 kilo of samples. All samples have been analysed for major and informative trace elements at CESS XRF facility. Efforts are on to obtain rare earth elements (REE) data on selected samples from NGRI, Hyderabad.

One of the objectives of the study is also to understand the nature of protolith. To accomplish this goal collaboration work was initiated with scientists at the Swedish Museum of Natural History, Sweden. As a result of this effort cathodoluminescence (CL) imaging of zircon crystals and Zircon U-Pb geochronology of selected KKB rocks were performed on a Cameca IMS 1270 ion-probe at the Swedish Museum of Natural History in Stockholm (NORDSIM facility). Results are being processed for publication.

G. R. Ravindra Kumar

Funding: Department of Science & Technology, Govt. of India

1.1.3 Geochemical and palaeomagnetic studies of mafic dykes from Bundelkhand and Baster cratons, Cen tral India: implications for lithospheric evolution and Meso & Palaeoproterozoic continental recon structions

Our earlier studies on mafic dykes in the granulite region of Kerala and Tamil nadu, granite-greenstone region of Karnataka craton and the recently concluded studies on the dykes all around the Cuddapah basin have enlarged the scope of our investigations. A new proposal "Geochemical and Palaeomagnetic studies of mafic dykes from Bundelkhand and Bastar Cratons, Central India: Implication for lithospheric evolution and Meso- PalaeoProterozoic continental Reconstruction" has been approved by the Department of Science and technology; Government of India for a period of three years starting from September 1, 2004. This is a joint collaborative project between the Centre for Earth Science Studies with the Department of Geology, Institute of Earth Sciences, Bundelkhand University. The project is initiated to carry out geochemical and petrogenetic studies and palaeomagnetic investigations on the mafic dyke intrusions from the Bundelkhand and Bastar cratons. The studies have been aimed at understanding the nature of dyke magmatism across the cratons and to test the possible tectonic movements, if any, between them and the south Indian shield, with special reference to central Indian tectonic zone and to improve our understanding of the Meso- and Palaeo-proterozoic continental reconstructions. The work has been initiated in Bundelkhand region. Fieldwork has been carried out to locate and trace the dyke intrusions. More than fifty dykes were located in the Bundelkhand region. All the dykes are NW-SE trending within the gneissic basement. The dykes generally are coarse grained; a few of them are fine-grained dolerites. The dykes generally range 40-50m in width and are extended maximum up to 10 km along strike. Most of the dyke margins are covered by soil and they display development of chilled contacts with steep dips where exposed. All dyke centers and chilled contact zones wherever possible were sampled for geochemical and petrogenetic work. About 200 oriented cores of oneinch diameter have been drilled from 25 sites (dykes) for palaeomagnetic investigations. Petrography of several samples reveals that plagioclase, clinopyroxene and opaques are essential constituents preserving igneous textures without metamorphism or deformation except clouding or turbid appearance of plagioclase and occasional (or minor) bending of lamella twinning. All samples display typical ophitic to subophitic and intergranular igneous textures. Deuteric alterations or uralitisation are generally common. Natural remanant magnetization (NRM) measurements and alternate field (AF) demagnetizations have been performed at progressive steps of 2.5 mT increments until the stable direction is achieved or until the intensities fall down to a very low level (<25 mA). AF demagnetisations of 115 samples from 14 sites (dykes) were completed. It appears that stable characteristic magnetisations are obtained in most of the samples beyond 10-25 mT fields of demagnetisations. However, the NRM directions are largely scattered both within and between the sites as in many Precambrian dykes. Samples are being prepared for major and trace element work. The Indo French Centre for Promoting Advanced Research (IFCPAR) has approved a project paleointensity of the geomagnetic field in India. Efforts are being made for obtaining the necessary clearances by the Indian and French Governments. Analysis of available geochemical and palaeomagnetic data has been carried out in collaboration with Mireille Perrin Laboratoire de Tectonophysique UMR 5568, Montpellier, France. The palaeomagnetism laboratory, set up under this program, has been augmented with new additions of Impulse Magnetiser (ASC Scientific; USA), Frequency de-

pendant Susceptibility meter (SM 100; Czech) and Temperature-Susceptibility System (Bartington Instruments; UK). These equipments have been installed and calibrations have been carried out. A new sample preparation unit has been fabricated for making the core samples for NRM measurements. Thermal demagnetizer which was burnt and damaged considerably due to electrical failures has been rectified using indigenous expertise. Some problems have been rectified with the Pulveriser procured for geochemical sample preparation in an earlier DST project.

Geological map of Bastar craton compiled using DGMs of the GSI giving geocchemical sample locations and palaeomagnetic sites. Detailed AF demagnetization carried out on Baster dykes. Geochemical data of the dykes from Bundelkhand region is synthesized and made some preliminary analysis of the data. Field work carried out in Bundelkhand region and collected around 100 oriented cores for improving the palaeomagnetic record.

T. Radhakrishna

Funding: Department of Science & Technology, Government of India

1.1.4 *Tectonic and hydrologic control on late Pleistocene-Holocene land forms, plaeoforest and non-forest vegetation: Southern Kerala*

Quaternary period spans roughly the last 2 million years of geological time and is of critical importance in earth's history. Quarternary period witnessed the most dramatic changes in climate and the sea level. The effects of these changes coupled with those on account of local and regional tectonics, geomorphology, biota and environment are remarkable. But it is unfortunate that, although Kerala State is endowed with a fairly thick blanket of Quaternary deposit containing many economically viable minerals like heavy mineral sand, limeshell, glass sand, etc., in the coastal lands, detailed studies on Quarternary deposits are scarce and practically little information exist on the tectonic and hydrologic control on the late Pleistocene-Holocene landforms, palaeoforests and non-forest vegetation. In the present study we aim to bridge the gap area in the Quaternary geological understanding of this part of our country.

Study/analysis of borehole sediments collected from South Kerala Sedimentary Basin(SKSB) is in progress. Also, submitted a few samples for C^{14} dating.

D. Padmalal

Funding : Kerala State Council for Science, Technology & Environment, Thiruvananthapuram

Collaborators: Vakkom Moulavi Foundation Trust & Agarkar Research Institute, Pune

1.1.5 *Quaternary evolution of Thiruvananthapuram coast, Kerala*

The study area constitute the coastal plains of Trivandrum district having a shore line length of 78 km extending from Edava kayal in the north to Kollankode in the Kerala-Tamil Nadu border. Geomorphic analysis of the remotely sensed data supplemented with ground truth studies formed the main input to study the geomorphic set up of the area. The major domain of activity that acted along the coastal tracts of Trivandrum to mould the landforms are marine, fluvial, fluvio-marine weathering and aeolian.

The study area exhibit heterogeneity in rock types and diversity in land use as well as landform characteristics. It has two topographic levels separated by three rivers the Vamanapuram, Karamana, and Neyyar rivers. The mineralogy and texture of the sediments vary considerably. Sediment samples collected systematically from different geomorphic domains were sieved and the grain size parameters studied using standard method. The geomorphic map prepared on the basis of the genesis of the landform has enabled the reconstruction of the stratigraphy of the area effectively.

The Quaternary sediments in Trivandrum district are seen prominent only in the middle and the northern segment of the study area. At Kazhakuttom they appear as buried sediments 1.5 km landward from the shore. About four to five successive beach ridges and swales aligned parallel to the present shoreline were identified. At some places these ridges/swales truncate abruptly indicating change in process and the depositional environment. The Quaternary sediments that occur south of Vizhinjam are patchy and they do not have a linear continuity. The underlying stratigraphic sequences of the study area were derived from the resistivity surveys conducted at 2 km interval all along the coast. The environments of deposition

of different sediments were derived from the textural analysis of sediment samples collected from specific geomorphic domains. The dating of sediments was carried out at Wadia Institute of Himalayan Geology, Dehra Dun. The age of sediments collected from nine locations range from 1,800 to 30,000 YBP.

John Paul and D.S.Suresh Babu

1.1.6 GPS constraints on the strain rate across the Andaman and Nicobar Islands

The megathrust earthquake of December 26, 2004 (Mw 9.3), which occurred at the offshore region of northwest of Sumatra, is the largest to have occurred during historic times. We could quantify the co-seismic deformation of this earthquake along the Andaman & Nicobar island arc through GPS campaign mode surveys in August-September 2004 and January-February 2005. In order to understand the post seismic deformation in detail we have established two GPS continuous stations at Car Nicobar and Diglipur. Preliminary results obtained by the analysis of data from continuous stations are presented here along with details of co-seismic deformation.

The associated displacement of the seafloor generated a tsunami that devastated the coasts of Indonesia, Thailand, India, Sri Lanka and Maldives. The earthquake of this magnitude is expected to involve very large displacement, which is also reflected by the large amplitude of tsunami waves. The information on the fault displacement pattern along the rupture zone is important for constraining the nature of surface motion that triggered the massive tsunami. The initial wave form modelling reported a displacement of 16-20m at the source zone, along a shallow dipping thrust fault. The estimates from the far-field GPS data, however, show a relatively low (4m) displacement, near the source that progressively increases northward. The unprecedented rupture length requires near-field data to validate fine-tune the available models. The estimate from the pre and post-earthquake near GPS data and the 2D models of displacement along the Andaman-Nicobar arc is presented here.

CESS had established eight GPS control points along the island arc and campaign mode surveys were conducted from 2002 onwards. These control points were located at Diglipur (North Andaman), Port Blair (South Andaman), Havelock Island, Chatham Island, Hut Bay (Little Andamans), Car Nicobar, Campbell Bay (Great Nicobar) and Barren Island. Post earthquake survey (campaign mode) in January-February 2005 was done at 6 control points (Diglipur, Car Nicobar, Hut Bay, Port Blair, Campbell Bay and Havelock). The Diglipur and Car Nicobar stations are in continuous mode since April 2005 and Havelock stations since February 2006. Table 1.1.6.1 shows the occupation history of these stations. Near field GPS data obtained from our pre and post earthquake campaigns suggest that the coseismic displacement was non uniform along the arc, Car Nicobar having registered the maximum shift of 6.46 m in SW direction (Table 1.1.6.2).

All daily solutions were analyzed using the GIPSY-OASIS software [Zumberge et al., 1997] release GOA4, with solutions run in a network mode. We incorporated data from all CGPS sites in the region that were available to us. Displacements hence obtained provided useful constraints on the slip model.

Pre-earthquake Velocities:

The final pre-earthquake campaign was carried out in August 2004 over a period of about 4 weeks, and was 4-5 months before the main shock. (Fig. 1.1.6.2). The velocities relative to India (Fig.1.1.6.1) show no significant motion of sites in the plate boundary zones bordering the Indian plate.

The sites in the Andaman Islands move purely westward relative to India. Only one site, Port Blair (PBLR), has a velocity significantly different from zero, because the other sites have only to pre-earthquake surveys one year apart. However, the estimated velocities of Diglipur (DGLP) and Car Nicobar (CARN) are consistent with that of PBLR, nearly 10mm/yr. We estimate that Port Blair converges with India at a rate of 5 ± 2 mm/yr oriented almost due west.

Pre-earthquake GPS measurements at Port Blair show slow convergence between the Burma plate and the Indian plate, 5 mm/yr directed almost purely westward. Similar, but less precise, velocities are estimated for Car Nicobar and Diglipur. The uncertainty in this velocity is primarily due to the large uncertainty in the motion of India with respect to the ITRF2000 reference frame. This velocity is a lower bound on the long-term motion of the Burma Plate relative to India, as it includes a component of eastward motion due to elastic strain from the locked shallow plate interface that ruptured in the earthquake.

A dislocation model based on the coseismic displacement geometry suggests that at Port Blair the elastic component is 25% of the total plate convergence rate. An independent measure of the motion of the Burma plate relative to India comes from a plate circuit combining the India-Sunda relative angular velocity (from GPS date), with a Burma-Sunda relative angular velocity (from the traces of assumed transform faults and the spreading rate in the Central Andaman Basin). This estimate predicts that Port Blair should move 14.5 mm/yr relative to India directed toward 246^0, in excellent agreement with the orientation of the coseismic earthquake slip vector there. This model predicts a faster pre-earthquake convergence rate than we observed, although the uncertainties in both the model and observed velocities are large. Better estimates of the relative motions of the Indian and Sunda plates are needed, as well as a systematic re-analysis of earlier data from the Andaman Islands.

We estimated two sets of coseismic displacements directly from the daily time series. Both sets represent absolute site displacements in ITRF2000, rather than displacements relative to a particular reference site. For continuous GPS sites, we estimated displacements by averaging data from roughly one week before and one week after the earthquake. For the campaign sites in the Andaman Islands, we averaged data over the time periods of the last pre-earthquake campaign (September 2004) and the first post-earthquake assuming the velocity of PBLR. This is a small correction and its uncertainty is insignificant relative to other uncertainties in the coseismic displacements. Coseismic displacements are shown in Figure 1.1.6.2, for the near-field and far-field sites respectively, and are listed in Table 1.1.6.1. For each set of displacements we averaged several daily GPS solutions together to get estimates of the pre- and post-earthquake positions. The uncertainty in each set of positions was scaled based on the misfit to the adjustment, assuming that the reduced chi-square statistic should be equal to unity in each case. This resulted in scaling the uncertainties by a factor of ~2.5. The displacement uncertainties were calculated directly from the uncertainties in the pre- and post-earthquake positions; typical values are 1-2 mm horizontal and 2-4 mm vertical. This accounts for daily random errors, but not for systematic errors that may vary slowly over time, such as seasonal variations in position, or other variations that have longer timescales than a week. Because the estimates from the continuous sites are based on the measurements made immediately before and after the earthquake, these systematic effects most likely contribute little. The campaign site occupations are months apart, and seasonal or other systematic variations from linear motion may be significant. As we have field vertical coseismic displacements is critical in resolving tradeoffs between the dip angle, magnitude of amount of slip and width of the rupture plane. A simple model based on 12 planes of uniform slip was evolved, which captures the key features of the slip distribution. Over most of

Table 1.1.6.1 History of occupation of control points in the Andaman-Nicobar region and coseismic offsets. All displacements and uncertainties are given in meters

ID	2002	2003	2004	2005	East	North	Vert	E sig	N sig	V sig
DGLP	——	2	3	2	-3.987	-2.680	0.601	0.004	0.002	0.013
PBLR	4	5	26	12	-2.962	-1.041	-0.841	0.001	0.001	0.002
HVLK	1	——	——	2	-1.322	-1.018	0.072	0.003	0.003	0.008
HBAY	——	——	3	1	-3.577	-2.916	0.342	0.002	0.002	0.010
CHAT	——	3	——	——	——	——	——	——	—	—
BRRN	1	——	——	——	——	——	——	——	—	—
CARN	——	2	2	2	-5.742	-2.973	-1.122	0.004	0.004	0.012
CBAY	——	——	3	2	-4.145	-2.377	-1.386	0.003	0.003	0.011

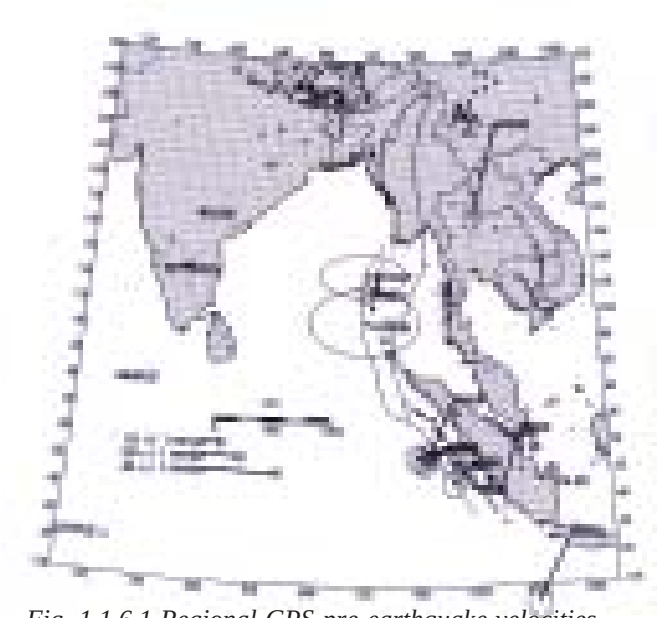


Fig. 1.1.6.1 Regional GPS pre-earthquake velocities

the rupture, the data are satisfied best using a dip angle of 8-12 degrees and a thrust to oblique thrust mechanism. At the northern and southern limits of the rupture, the rupture appears to have been confined to a deeper portion of the plate interface, and did not rupture fully out to the trench. These two segments also require steeper dip angles, consistent with a slab that increases dip with depth. In our model, all slip is confined to the upper 30 km of the plate interface, and extending slip to greater depths causes significantly misfits to the near-field GPS data. We find evidence for significant slip extending to near the trench axis over most of the southern part of the rupture (Sumatra and Nicobar Islands), but in most of the Andaman Islands the rupture did not extend close to the trench. Slip magnitude varies substantially over the rupture, averaging ~16 m for the Sumatra and Nicobar region, and 5-8 m for most of the Andaman section, except for one patch of very high slip offshore of Port Blair. The slip magnitudes for Sumatra and the Nicobar Islands are generally consistent with a millennial recurrence time, although slip in this event in the Andaman Islands is lower than expected for a 1000-year recurrence time. However, this may be explained at least in part by historical earthquakes in the Andaman islands.

We first examine the slip distribution in the Andaman Island because the three slip vectors here are significantly oblique (>25^0) to the trench axis. Because trench-parallel slip has no effect on the vertical deformation field, the vectors at each site are resolved into trench-parallel and trench-normal components. The location of the trench axis obscured increasingly northward by Bay of Bengal sedimentary fill, and we use its inferred location to determine trench-normal distances (Seismotectonic Atlas of India, 2001). Although the strike is approximately linear ($N10^0E$) no simple solution satisfies all three northern sites suggesting that slip, and subduction geometry, changes along strike. Hence we solve for slip at each site separately.

The relocated seismicity for the region does not well constrain the geometry of the subduction zone so we for a series of planar faults buried at 4 km depth and extending to depths from 30-70 km, with dips between 15^0 and 25^0. Adjustments to these parameters yield a range of acceptable fits to the data, although in some cases solutions were non unique. We found that unique solutions could be identified by imposing an east-west tilt constraint near GPS point based on photographic or eyewitness observations of subsidence and uplift reported after the earthquake. From the calculated dip-slip component it is then possible to calculate the total slip at the interface between the two plates near each site by combining it with the trench-parallel component of slip. An example is given for Port Blair, where the observed surface displacement is 3.08 m at azhimuth $N249^0E$, and estimated dip-slip is 7 ± 1m, yielding a total slip of 7.2±1m approximately westward, with a rake of 78.5^0. This procedure was repeated for each of five GPS sites.

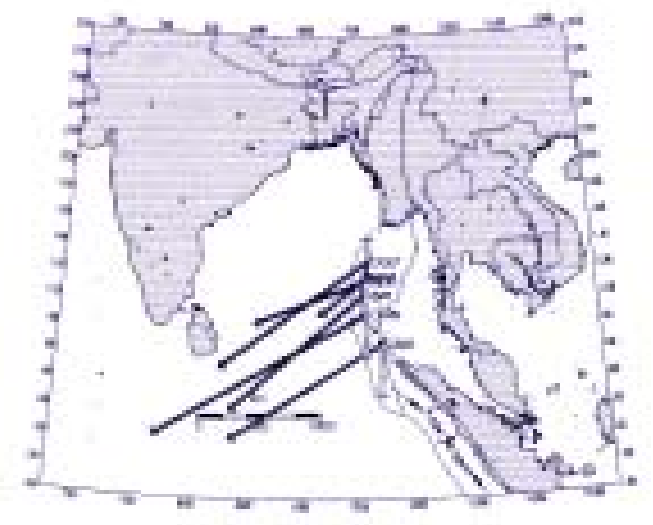


Fig. 1.1.6.2 Far-field GPS co-seismic displacements

Table 1.1.6.2 Slip Model parameters. Slip given in meters, other lengths in km, and latitude and longitude in decimal degrees. Dip, strike and rake are given in degrees. The latitude and longitude specifies the center of the top edge of the rectangular plane, and negative dip angles indicate planes that dip downward from the surface.

Long	Lat	Length	Width	Depth	Dip	Strike	Slip	Rake
95.05	2.75	140	75	9	-16	330.0	-14	96.5
93.60	3.60	120	185	5	-8	340.0	-20.5	132
93.05	4.90	190	155	5	-9	340.0	-16	140
92.70	6.25	125	135	5	-9	336.0	-11.75	88
92.30	7.05	75	123	5	-11	338.0	-17	103
92.05	7.80	100	112	5	-8	345.0	-16.5	112
91.95	9.05	165	112	5	-9	356.0	-13	104
92.10	10.325	120	74.5	7	-11	0.0	-8.25	120
92.15	11.08	45	80	8	-11	0.0	-5.15	117
91.85	11.57	65	65	6	-9	5.0	-20	123
92.10	12.41	130	65	7	-12	8.0	-6.0	125
92.62	13.55	135	80	11	-13	18.0	-9.5	134

Post seismic Deformation

Post-earthquake measurements were begun on January 13, about 3 weeks after the mainshock. Over the next 3 weeks, 5 of the 8 GPS sites were re-surveyed and observations of relative sea level changes, ground shaking effects (such as liquefaction), and investigation of tsunami deposits were made. GPS continuous stations are established at Car Nicobar and Diglipur and Hut Bay. Data from these stations has been processed to understand the post seismic deformation along the arc. Post-seismic deformation could be quantified using the data from the continuous stations.

The pre seismic velocities of the stations Car Nicobar, Diglipur and Port Blair has been estimated based on data collected during the campaign mode surveys in 2002, 2003 and 2004. The Port Blair station shows a slow westward motion of 4.8 mm/yr towards India. This pre seismic velocity has been subtracted from the estimated post-seismic displacements so that they represent true values.

The preliminary analysis of the data from the continuous stations (April to September 2005) shows a continuing southwestward movement for the sites. The Car Nicobar shows a significant displacement of 10 cm in the southwestward direction where as Diglipur shows only 3 cm displacement in the same direction. The uplift of 5.4 cm compared to Diglipur where the magnitude of uplift is 1.4 cm. A better understanding of the post seismic deformation is expected as more data from continuous stations becomes available.

Summary of results

Based on data of last half of 2004, 2003 & 2002 campaigns.

Pre Earthquake Velocity

1. All sites (DGLP, PBLR, CARN) moves towards India (westward)

DGLP - 10mm/yr
CARN - 10mm/yr
PBLR < 10mm/yr

2. Uncertainty in data due to uncertain motion of Indian plate and scatter in time and series. Uncertainity is also in Port Blair due to some reason as above.
3. Port Blair shows rapid uplift, but slow westward motion (2 cm/year).

Post Earthquake Velocity

1. DGLP moved southwestward with <50mm/~35-40mm.
2. PBLR moved southwestward greater than 50mm/~60-70mm.
3.CARC moved Southwestward ~100mm

Uplift (data for May-October, 2005)

1. CARC showed uplift of 50mm
2. DGLP showed uplift of 15-20mm
3. PBLR showed uplift of 40-45mm

C. P. Rajendran

1.1.7 Provenance discrimanation of southwest beach placers based on the varietal studies of ilmenite

This study envisages the unravelling genesis of the deposits on the basis of the chemical and mineralogical changes associated with illmenite with different geological environments on the hinterland to the coastal zone. The project aims at (a) quantative estimation of the contribution of rocks of the Charnockite-Khondalite belt and their mafic intrusives to the percentage of placer deposits, (b) the assessment of role of evolution of the west coast and associated processes like formation of laterites, tertiary sedimentary formations, emplacement of drainage basins and teri sands verses mineral concentrations in Chavara and Manavalakurichi, (c) rationale for the significant mineralogical disparity seen in Chavara and Manvalakurichi placers with respect to garnet and sillimanite, holocene/modern depositional environments of the two deporists in the beach in relation to the mineralogy and chemistry of illmenite.

Fig. 1.1.7.1 Map of the study area showing sampling locations

Rock samples from the hinterland of the study area were collected and analysed for illmenite grains in them and correlate them with the data of illmenite from the placer deposits. While various authors have given credence to rocks of either charnockite or khondalite suits as the main source of placer deposits, a basic provenance has also been suggested by recent studies. In the present study inclusions of native copper are observed in illmenite grains. Similar inclusions have been observed in illmenite from basic dykes of the area. It has to be investigated whether similar features exist in illmenite grains in the Charnockites and Khondalites that form the country rocks of the study area.

Ajith G Nair
Funding: Department of Science & Technology, Govt. of India

Fig. 1.1.7.2 Ilmenite grains of Chavara deposit with native copper inclusions (encircled in red)

1.2 Minerological Studies

1.2.1 *Value-Addition of Selected Placer Minerals (Ilmenite & Zircon) with special reference to the 'Kayamkulam-Thottappally' deposit of Kerala*

This project has two prime objectives namely (a) Grading of ilmenite and zircon concentrates, separated from Kayamkulam-Thottappally deposit and (b) Processing of individual grades of these minerals for value added applications. A total number of 21 surface samples from the beach at an approximate spatial interval of 1 km and 9 subsurface samples from both foreshore and backshore were collected at an interval of half meter from the surface to bottom down to water table, by hand drilling method. The bulk samples were subjected to textural analysis. The fractions from each sample were made free of magnetite using a hand magnet. Magnetite freed fractions were separated using Outokumpu Rare Earth Drum and three grades viz., Premium, Medium and Poor were separated. Specific gravity of the graded ilmenite samples were analysed using pycnometer. The measurements of magnetism in the selected samples were carried out using magnetic susceptibility meter. The three grades of the samples were subjected to X-ray diffraction analysis using X'Pert PRO XRD to find out the different mineralogical phases present. XRF analysis of ilmenite samples and separation of zircon grades from the bulk concentrates are being carried out.

T. N. Prakash
Funding : Council for Scientific & Industrial Research, Govt. of India

1.2.2 *Graphite Mineralization in the Karimukal area, Ernakulam District, Kerala with special emphasis on graphitization process and genesis*

Graphite is a widespread and common accessory mineral in a variety of rocks formed under different geological environments. The multiparametric approach envisaged under this project is the first of its kind to bring into light (1) the conditions of the formation environment of the graphitization process, (2) the quality and grade of graphite from Karimukal and (3) the source characteristics of the graphite of Karimukal.

Extensive fieldwork was conducted in the study area. The field observations indicate the postulated sedimentary origin of the graphite from organic carbon which occurs as chief constituent of graphite gneisses with or without sillimanite and garnet (khondalite) and also as thin lenses and veins at some places. Graphite of this area is of flaky variety.

The degree of crystallization is a very important factor to study the extent of graphitization and quality. High Crystallinity is an effect of closely packed structure due to slow cooling rates. The X-ray Diffractograms (XRD) reveal the highly crystalline

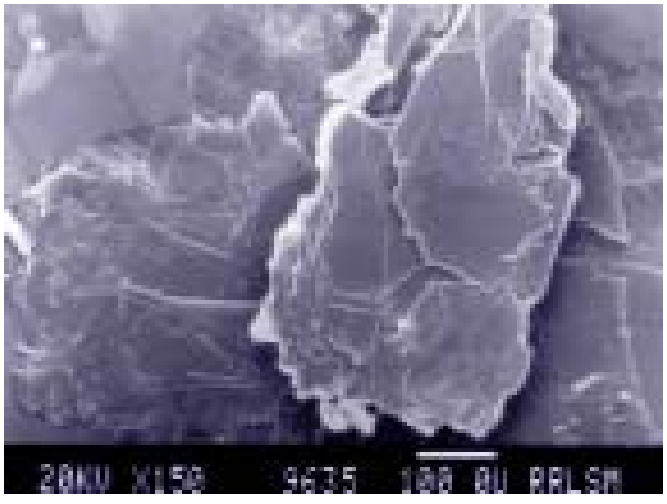


Fig. 1.2.2.1 An SEM photograph of Karimukal graphite

and highly ordered nature of Karimukal graphite, as evidenced by the sharp and well defined peaks at 2• values 26.5^0 and 54.3^0 having interplanar spacing (d_{002}) values $3.36A^0$ and $1.68A^0$ respectively. These results are strictly in concordance with those in the JCPDS file. The Scanning Electron Microscopic (SEM) studies show the arrangement of well formed and platy, individual layers of the flakes in a book type stacking sequence. Perfect triangular markings and micaceous cleavage are very much visible. The unique morphology and textural patterns, revealed by the SEM photo micrographs correlate well with the high degree of crystallinity in the X-Ray Diffractograms. The Thermogravimetric Analyses (TGA) indicate that the decomposition starts at 600^0 C and completely gets decomposed at 1380^0C. The Degree of Graphitization (DG) values is in agreement with the thermal properties of standard flaky graphite. The TGA pattern characterizes its crucible grade quality.

It is to be noted that the carbon stable isotope studies of the graphite samples of Thodupuzha-Muvattupuzha belt proved beyond doubt that they are of sedimentary organic origin. The results for the relative proportion of the lighter carbon isotope falls well within the range of –22.83‰ to 27.6‰. Since Karimukal graphite is a part of Thodupuzha-Muvattupuzha belt, it can be inferred that they are also of sedimentary organic origin. These studies were carried out at the Scottish Universities Research

and Reactor Centre (SURRC), Scotland by the Principal Investigator of the project, during the tenure of her stay there, as Visiting Scientist under the INSA/Royal Society Collaborative Exchange Programme.

The results of the above studies give important clues and factors of the graphitisation process, environment and also the quality of the Karimukal graphite. Crystallization of the graphite has occurred under high temperature and pressure conditions of metamorphism. Since graphite is identified as the end product of metamorphism, the degree of graphitization is an useful indicator of the maximum metamorphic grade attained. The flaky graphite of the study area would be of interest to various agencies involved in conventional exploration and survey, as the study will be helpful in identifying new prospective areas and for evolving better exploration strategies.

Ansom Sebastian

1.3 Atmospheric Processes

1.3.1 Measurement of Cloud Parameters and Cloud Modeling

The project initiated with broad objectives to conduct studies in cloud physics, including measurements and modeling. The project also aimed at building up the facilities and expertise in experimental and modeling studies over a period of five years. Measurements of parameters like cloud height and CCN started initially.

A Vaisala Laser Ceilometer, Model No. CL31 was installed in the premises of Centre for Earth Science Studies (CESS), Akkulam, Thiruvananthapuram (8.29^{0}N, 76.59^{0}E), Kerala, in the first week of July 2006 as part of the cloud physics studies. The cloud base height data is available from the date of installation to the present. Ceilometer CL31 employs a pulsed diode laser LIDAR (Light detection and ranging) technology, where short powerful laser pulses are sent out in vertical direction. The resulting backscatter profile is stored and processed and cloud bases are detected. The time delay between the launch of the pulse and cloud base height (CBH). The Ceilometer is capable of detecting accurate cloud base heights at three vertical levels with a maximum temporal resolution of 2s and a height resolution of 5m. Ceilometer directly detects the presence of cloud, measures cloud base height and determines vertical visibility. We configured the VLC to measure CBH every 2 minuted with 20 m height resolution at the time of installation. Form 7 December 2006

Fig. 1.3.1.1 Ceilometer

onwards, we changed the time and height resolution to 15s and 10m respectively.

From the observation of cloud base height, it was noted that a region between 2 km and 4 km where CBH detections are infrequent. This region could termed cloud free zone; The clouds below the cloud free zone (low clouds) and those above it (middle level clouds) show some kind of diurnal variation in cloud base height. The diurnal variation of middle level clouds are almost similar to the diurnal variation of surface temperature but the diurnal variation of low level clouds are multi modal.

The frequency of occurrence of low clouds is higher than that of middle level clouds. Most of the clouds are present in the layer between 500 m - 1000m. It was noticed that CBH is minimum during southwest monsoon season. Frequency of clouds are high (more than 60%) in southwest monsoon season but in other seasons it was less. The high frequency is found in the morning to noon hours in the southwest monsoon season but

it was in the evening in other two seasons. Maximum occurrence of clouds (more than 90%) is found in the active phase of southwest and post monsoon seasons.

It was found that the zonal wind structure is very similar to the monthly variation of cloud frequency.Outgoing longwave radiation (OLR) shows an inverse relation with the cloud frequency or the formation of the clouds. The OLR values and cloud frequency show a correlation coefficient of -0.53.

Zonal wind at 850 hPa show a linear positive trend with cloud frequency. The intraseasonal variability of the cloud frequency and the zonal wind show similar periodicities (10-20 day periodicity and 35-65 day periodicity).

V. Sasikumar

1.3.2 Characterisation of tropical rainfall in terms of raindrop size distribution and rain rate

Rain drop size distribution (DSD) measurements at different heights were made using a Micro Rain Radar (MMR-2) at Thiruvananthaputam (Lat: 8.3^{0}N, Long: 76.9^{0}E). A typical raindrop size distribution spectrum obtained from the MRR is shown in the Fig1.3.2.1. The variation of DSD with altitude can be noticed here.

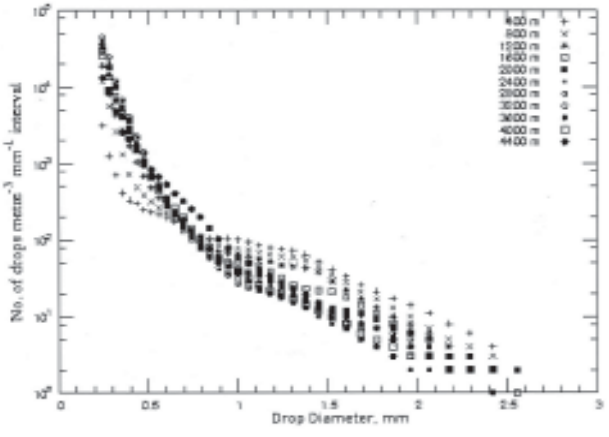


Fig. 1.3.2.1 A typical Drop Size Distribution Spectrum (02:00 to 03:00 hrs, 12-10-05)

Temporal variation in the altitudinal distribution of DSD

The distribution of number of drops in different sizes with altitude during the course of a rain event was studied. The variations during the beginning of the event and at the end of the event are shown in the Fig 1.3.2.2. It can be seen that as rain comes down, the number of smaller drops decreases, and, at the same time, the number of larger drops increases. This clearly shows the predominance of coalescence. In addition, larger drops coming from above collide with smaller drops and coalesce, thus sweeping out the smaller drops as they fall. The rainfall intensity during this period was low (below 5 mm/hr most of the time), and this could be one of the reasons for the relative absence of break up.

Comparison of the (Tropical Rainfall Measuring Mission), MRR and Disdrometer precipitation data

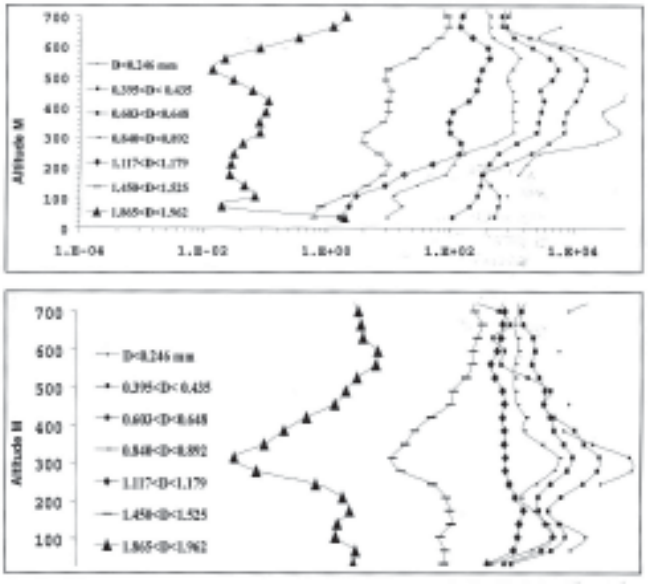


Fig.1.3.2.2 Variation of the number of drops per cubic meter per mm interval with altitude for different drop diameter classes on 12th August at 16:10:01 hrs and 16:12:21 hrs

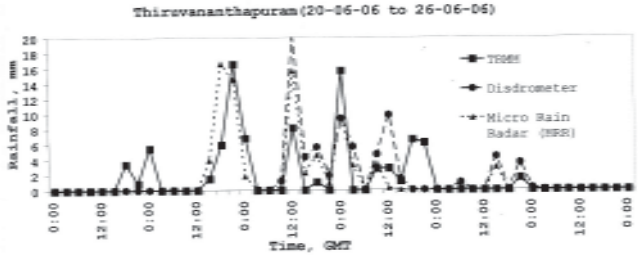


Fig. 1.3.2.3 TRMM, MRR and Disdrometer precipitation data comparison

Active radar observations from the TRMM Precipitation Radar provide satellite-based rainfall estimates. To understand these measurements, it would be needed to compare with ground based measurements. The data from the disdrometer and that from micro rain radar corresponding to a height of 35 metre from the surface are taken here for comparison with the TRMM data. TRMM rain rate is available as 3 hourly data over a 0.25^0 x 0.25^0 grid. The grid that corresponds to Thiruvananthapuram (Lat: 8.375^0N to 8.625^0N, Long: 76.875^0E to 77.125^0E) is chosen for the comparison. The correlation of the three hourly rainfall data between TRMM and disdrometer and TRMM and micro rain radar has been found to be significant. The major conclusions are:

1. For rainfall events detected both by the satellite and ground based sensors, the TRMM rainfall appears to be under estimated, on an average, up to 50%.

2. The number of events detected by single sensor only is high indicating that the rainfall is not uniform even over a small grid size of 0.25 x 0.25 degrees. This also indicates the need to have closely knit network of ground stations for a more meaningful comparison.

S. Sampath
Funding : Space Application Centre, Ahmedabad

1.3.4 Continuous measurement of ambient carbon monoxide in a tropical coastal station

Continuous CO monitoring in the ambient air at Thiruvananthapuram, a coastal site was initiated in 2003. In 2006, CO was measured over Arabian Sea (Fig 1.3.4.1) and Bay of Bengal (Fig1.3.4.2) as a part of the ocean component of the Integrated Campaign for Aerosols, Trace Gases and Radiation Budget coordinated by Space Physics Laboratory (SPL), VSSC, Indian Space Research Organisation from mid-March to mid-May. These measurements in the pre-monsoon season indicate an increasing trend towards evening hours in the mean diurnal CO over both the marine atmospheres. In the maritime air over Bay of Bengal CO concentration was higher than that over Arabian Sea. Very few in situ CO measurements exist over Bay of Bengal and the Arabian Sea for comparison.

Also, a case study on the impact of a mountain grassland fire on the concentration of aerosol black carbon (BC) and CO near the surface at a remote coastal station was conducted in the collaboration with SPL, VSSC, Thiruvananthapuram. Observations rerveal an increase in concentration of BC (2-fold) and

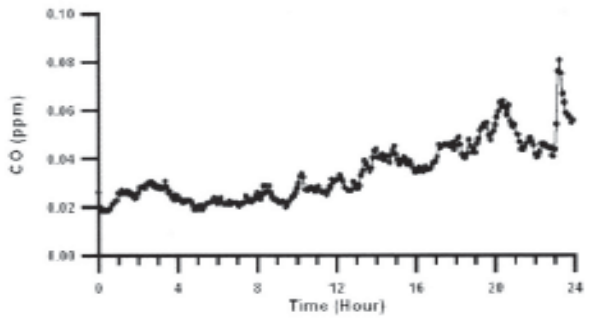


Fig.1.3.4.1 Diurnal CO variation over Arabian Sea

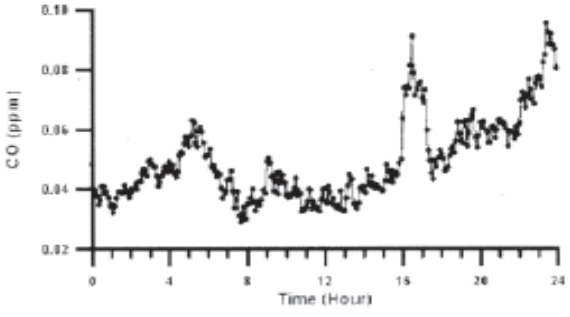


Fig. 1.3.4.2 Diurnal CO variation over Bay of Bengal

CO (1.5 times). The impact persisted for one day after grassland fire that occurred during 15-16, December 2006 in the upland region, Ponmudi.

G. Mohan Kumar
Funding: Indian Space Research Organization, Bangalore

1.4 Coastal Processes

1.4.1 Study of coastal processes and hazards along Kerala coast with particular reference to disaster preparedness

This project was initiated subsequent to the 2004 tsunami, in order to study coastal processes relevant to hazards such as storm surge and tsunami which were not studied till then. The main objectives of this three year focused programme on coastal hazards are:

Establishment of coastal observatories at three locations viz. Thiruvananthapuram, Kochi & Kannur.
Simulation of tsunami and storm surge for the Kerala coast.

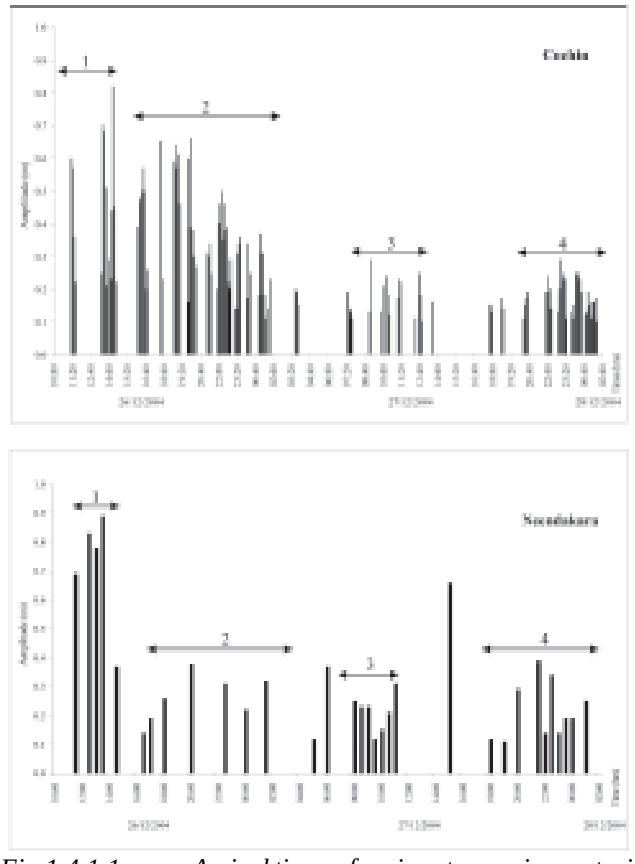


Fig.1.4.1.1 Arrival times of various tsunami wave trains at Cochin (top panel) and Neendakara (bottom panel); 1,2,3,4,are the groups of waves categorised according to the physical process

Study of coastal processes related to these hazards
Study of tides and charting amphidromic points in the Lakshadweep Sea.
Supporting ongoing programmes on coastal zone management, wherever necessary.

During the year under report, the calibration of "Tunami N2" model which was set up in CESS was carried out using post tsunami survey data for the 2004 tsunami. Since fine-scale bathymetric and topographic data were not available and hence were not used as inputs, perfect correlation between the predicted and observed was not achieved. Tsunami amplitude along the Thangasserry-Thrikunnapuzha sector of southern Kerala was simulated using the model for the 2004 tsunami. Further fine-tuning of the model and its use in an operational mode is being pursued under a new project funded by the Ministry of Earth Sciences, Government of India.

A study of the roles of different physical processes in the arrival of the 2004 tsunami along the Kerala coast was carried out making use of post-tsunami field survey data, tide gauge records and eye witness reports. The roles of reflection, energy trapping and secondary undulations were specifically examined. Figure 1.4.1.1 presents the arrival times of various tsunami wave trains (crests) at Neendakara and Cochin derived from the tide gauge data at these locations. It was found that, whereas the direct waves accounted for the water level oscillations during the first part of 26th December (marked as group 1 in the figure), reflected waves from the Lakshadweep-Maldives ridge (which is the relatively shallower region of the Arabian Sea encompassing these island chains) and the east coast of the African continent, could account for the water level oscillations during the late afternoon and evening of 26th December (marked as group 2 in the figure). Water level variations from 27th December onwards (marked as groups 3 & 4 in the figure) were attributed to energy trapping on the continental shelf and secondary undulations. It was surmised that the single solitary type wave (with second highest amplitude after the direct waves) noticed at Neendakara, but not at Cochin was due to a succession of total internal reflections on the west side of the Lakshadweep-Maldives ridge.

N. P. Kurian

1.4.2 Tracking the past disasters and tsunami along the parts of Tamil Nadu coast

This project was initiated during Nov 2006. Objectives of this proposal is primarily to apply the paleoseismologic techniques to look for sedimentological signatures recorded in the Holocene history of fluvial / marine events probably triggered by paleotsunamis or sea surges. Based on literature collection, discussions with experts, and reconnoiter field investigations at Saluvannkuppum and Phomphuhar; Saluvankuppam near Mammallapuram on the east coast was taken up as the primary site to initiate this project.

Excavations at Saluvankuppam near Mamallapuram, an ancient temple complex dating to about 8th century A.D, have exposed possible evidence for a large sea surge, at about 1000 years B.P, an event noted also in the historical records. Preliminary results from carbon dating of two samples from the backshore palimpsest on Mahabalipuram area (Fig. 1.4.2.1 A & B) show correlation with the onshore paleoseismic record for eastern margin of Indian Ocean basin. Chronological events interpreted by the experts of Archeological Survey of India, Chennai circle had temporal correlation with the carbon dating data.

Complementing these efforts are the near source investigations along the Andaman and Nicobar islands. Multiple evidence-age data on elevated coral terraces, subsided mangroves, paleo-seismological data among them, suggest that the predecessor of the 2004 event may be about 1000 years old. Studies were initiated to correlate these data to the sedimentological and archeological evidences being documented for this project. Field investigations covering Pulicat lake, Mammallapuram and Poomphuhar were conducted. The samples are being subjected to TL and carbon dating and other sedimentological analyses. Preliminary results from Mammallapuram area indicated a surge around 970 BP as well (Layer S1 in Fig : A)

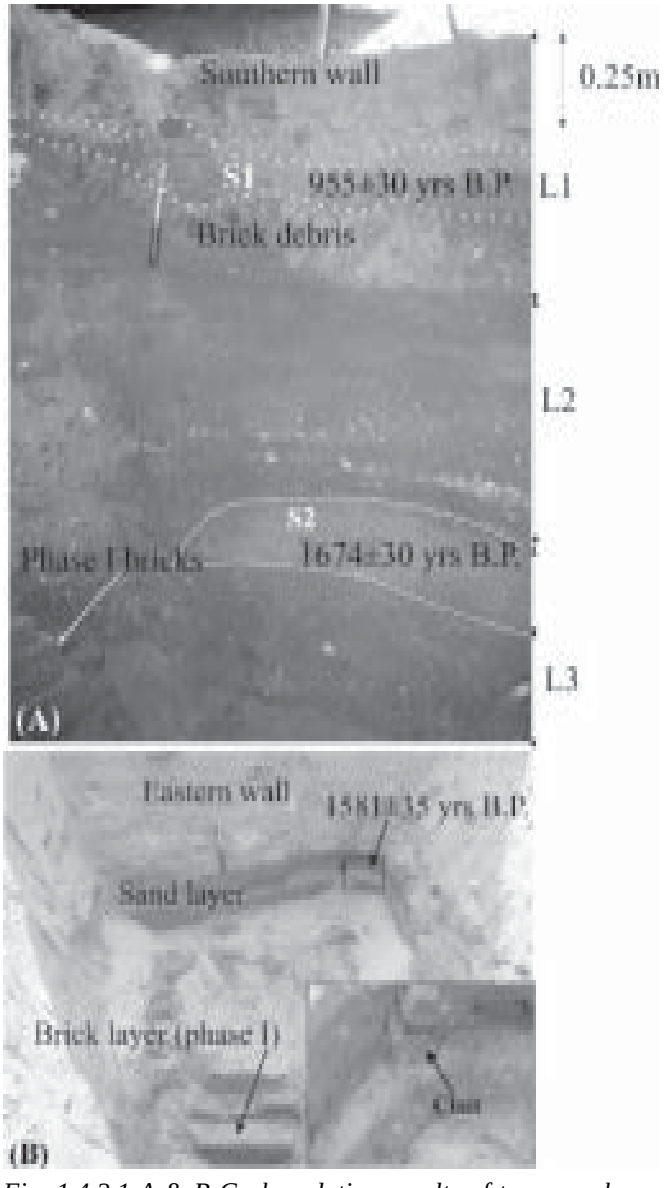


Fig. 1.4.2.1 A & B Carbon dating results of two samples from the backshore palimpsest on Mahabalipuram area

Terry Machado
Funding: Department of Science & Technology, Government of India

1.4.3 Flood height levels for demarcation of vulnerabil ity line

This study is part of a national project for demarcation of vulnerability line for six coastal locations of the country on a pilot scale. The locations identified are Mangalore, Mumbai and Dahej along the west coast and Nellore, Nagapattinam and Paradip along the east coast. For the above project which is being implemented by SAC, CESS and SOI, CESS was expected to provide the flood height levels for the different locations. The parameters that significantly contribute to the flooding on the shore are mainly the wave, tide, sea level, storm surge and tsunami. Out of these, storm surge and tsunami were not considered as per the directions of the Ministry. Finally, the parameters that were considered for calculation of flood height level were wave, The availability of instrumentally recorded/predicted/visually observed data is limited to certain periods, although data for a 100 year period is expected to be used for the calculation of flood height levels. The flood height levels were estimated for the above locations using the available data. Finally, the parameters that were considered for calculation of flood height level were wave, tide and sea level.

Waves: Apart from the data available in CESS, the recorded data on maximum wave height was collected from NIO, Goa and NIOT, Chennai for the six locations. The data pertained to different depths ranging from 2300m to 15m. The highest wave reported at each location was taken and transformed to the breaking zone using the MIKE21 Nearshore Spectral Waves (NSW) model. This model is a wind-wave model which describes the growth, decay and transformation of wind-generated waves and swells in nearshore areas. The model takes into account the effects of refraction and shoaling due to varying depth, local wind generation and energy dissipation due to bottom friction and wave breaking. The model also takes into account the effect of wave-current interaction, if present. The bathymetric data for the model input were taken from hydrographic charts and CMAP. The C-MAP bathymetry was provided by the ICMAM Directorate, Chennai. The average value of the significant breaker height was computed from the maximum breaker wave height by applying the appropriate formula.

Tide: The tide data used for the calculations were taken from the Indian Tide Tables for the period 1979 to 2006. The highest tidal height was noted from the daily heights given in the Tide Table. These data were reduced to Mean Sea Level (MSL) from the datum levels provided in the Tables. The Highest High Water heights above MSL were used in the computations.

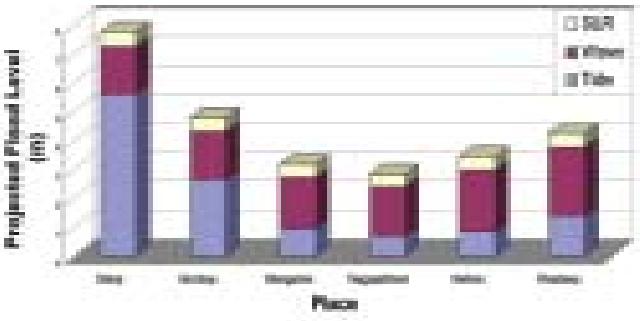


Fig. 1.4.3.1 The estimated flood level at different locations

Sea Level: The past sea level changes and its future projections for a century were noted from the website of Intergovernmental Panel on Climate Change (IPCC Report, 2001). The sea level change in the past 100 years for selected locations along the Indian coast was taken from Unnikrishnan et al. (2006). It was found that the average sea level change was only 10-20 cm in the past 100 years for the Indian coasts. With this value, from the IPCC projections for the period up to 2100, it was seen that on an average 45 cm of sea level rise could be expected in Indian coasts for the period 2000-2100. So this value was considered as the contribution of sea level rise for the computation of flooding.

Wave Run-up on Beaches: The next component of the work was the calculation of wave run-up from the breaker wave height. Literature is scanty for the calculation of wave run-up for the Indian coasts. Towards this, field measurements were made at Valiathura, near Trivandrum, on different dates with differing wave conditions. The pier at Valiathura, facilitated the simultaneous measurements of breaker wave heights and the corresponding run-up heights on the beach. Valiathura is typical of a high energy coast with foreshore slope around 0.1. From the field measurements it was seen that the ratio of run-up height to breaker height was nearly equal to 0.7. This value is the same as the value reported by the Federal Emergency Management Agency (FEMA). Thus the run-up level due to breaking waves was taken as 0.7 times of the breaker wave height.

Flood Level: With these data sets the possible flooding in the century ahead was calculated. The projected flooding levels at the six locations for the next 100 years is given in Fig. 1.4.3.1

T. S. Shahul Hameed, N. P. Kurian & M. Baba

Funding : Ministry of Environment and Forests

2. Natural Hazards

2.1 Landslides

2.1.1 *Field investigations of land disturbances in various parts of Kerala*

Field investigations were carried out at Kuppukada near Pasukadavu, locality of Vadakara taluk, kozhikode district following landslides in the form of debris flow during May-June 2006. Incidences of urulpottal (debris flow), rockfall and were identified for follow-up action. Land subsidence is also noticed in Kuppukada locality at two places. On inspection it was evident that the land subsidences have occurred due to 'piping'- a type of subsurface soil erosion. The subsurface erosion shall result in formation of underground pipes. The underground pipes are formed due to a geological process called 'piping'. This is a funnel shaped depression and the tail end of it usually opens up in a valley cutting or stream channel. During heavy rains water flows through this pipe and discharge on to the stream or valley. In some cases many such pipes may have existed and may be interconnected. At certain localities the roof of the tunnel collapses to form depressions.

Fig. 2.1.1.1 Debris flows at Pasukadavu, Kozhikode Dt.

Fig. 2.1.1.2 'Piping' observed at Pasukadavu, Kozhikode District

G. Sankar

2.2 Earthquakes

2.2.1 *Seismic monitoring in Kerala State and the broadband station at Peechi*

The broadband station at Peechi, install within the campus of the Kerala Forest Research Institute is fully operational. This seimological observatory is part of the national netwrok of broadband seismic stations. During the period under report 16 very minor tremors (see table 2.2.1.1 for details) happened in different parts of Kerala. Moreover, the observatory is capable enough to record major earthquakes occurring in different parts of the world and calculating its epicentre and other details.

Table 2.2.1.1. Details of tremors recorded in Kerala during 2006-07 at the Peechi seismic observatory

Sl. No.	Date	Place Name	Magnitude
1	03/06/2006	Near Ottappalam	1.60
2	17/06/2006	Near Desamangalam	0.80
3	04/07/2006	Ponmudi, Thrissur	0.80
4	21/07/2006	12 km from Peechi	1.10
5	28/07/2006	Kannur	1.30
6	09/08/2006	Kilimannur	2.60
7	18/08/2006	Tannikkudi	2.10
8	20/10/2006	Edamalayar	2.10
9	20/12/2006	Desamangalam	2.80
10	20/12/2006	Desamangalam	1.50
11	21/12/2006	Desamangalam	2.30
12	22/12/2006	Desamangalam	1.60
13	22/12/2006	Desamangalam	1.70
14	23/12/2006	Desamangalam	2.00
15	02/01/2007	Desamangalam	2.70
16	02/02/2007	Pathanamthitta	2.20

Kusala Rajendran

Funding: Department of Science & Technology

2.2.2 *Developing an improved database for seismic hazard assessment*

The main objective of the project is to identify active faults, discriminatory macroseismic and microseismic characteristics, sites of fractures, joints and offsets in order to isolate neotectonically active features. Landsat, thematic mapper of the area has also been analysed and we have identified several faults in the region. Fieldwork composed of quarry mapping to identify sites of fractures, joints and offsets in order to isolate neotectonically active features. Based on our present work, we have been able to identify causative fault of the January 2002 earthquake near Pala, along with its geomorphic signatures. The earthquake appears to have occurred at the intersection of E-W trending and NW-SE trending faults. The 2000/2001 earthquakes appear to have occurred close to the intersection of E-W trending and NW-SE trending faults.

Several shear zones extended into the State of Kerala and the prominent among them are Palghat gap, Idamalayar lineament and Achankovil shear zone. Occasional tremors have been registered along all these structural trends. Apart from routine geological mapping and studies on Precambrian deformation, very little focused attempts have been undertaken to infer the significance of these structures in terms of their seismic potential and such studies are expected to provide essential inputs in design parameters of large dams and other critical facilities such as nuclear power plants that may come up in failure.

Kusala Rajendran

2.3 Lightning

2.3.1 *Investigation on the cause of high lightning in Kerala*

In Kerala, lightning activity kills many people every year. Usually, lightning related deaths are ignored as isolated incidents. But it was estimated that more than 70 people, on an average, lose their life due to lightning, every year. Proper data on loss of property, both direct and indirect, are still unavailable. Even statistics at the state level were not collected by any agency as to the number of deaths and other losses due to this natural hazard, except for some interventions by CESS in the recent past.

Convective cumulonimbus clouds (Cbs) cause most of the lightning discharges in Kerala. Under this project, a field station was established ~ 400 m above sea level , in the Western Ghats at Braemore in Thiruvananthapuram district to detect the formation of Cb clouds and to understand the conditions under which it forms. The field station is equipped with an automatic weather station, a lightning location detector and field mill. Analysis of the data collected during September 2004 to March 2007 revealed that Cb clouds form at the foot hills of the Western Ghats. The analysis also detected conditions conducive to the formation of cumulus clouds which can grow into Cb. On

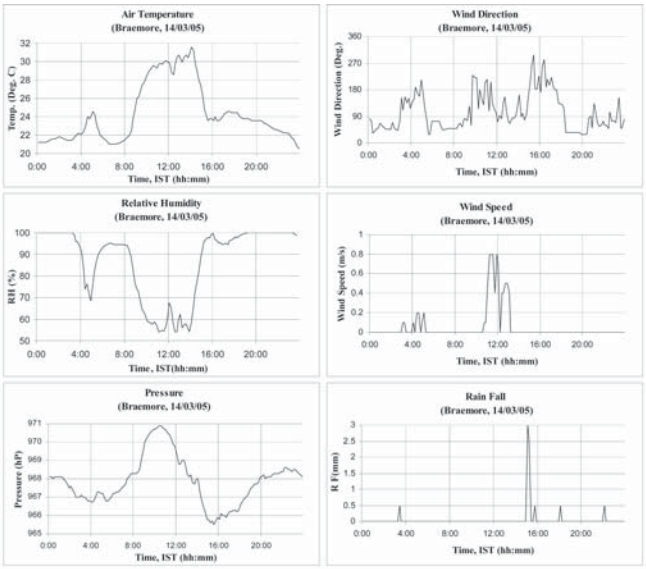


Fig.2.3.1.1 Air temperature, relative humidity, atmospheric pressure, wind speed, wind direction and rainfall measured at Braemore.

many such days lightning was found to occur in Braemore and at a later time in Thiruvananthapuram also. The lightning detector data has indicated the spread of lightning activity along the mountains to the southern direction. This is attributed to the simultaneous formation of Cb along the length of the mountain foot hills.

Preliminary analyses and results

Preliminary analysis indicates that the hypothesis of the Western ghats mountains being instrumental in forming the clouds responsible for causing lightning in Kerala could be true. Given below are the results of a preliminary analyses of the data obtained.

Fig. 2.3.1.1 depicts a set of data collected from Braemore on March 14, 2005. The data shows an increase in pressure at 0457 h, before sun rise, followed by corresponding decrease in relative humidity and increase in temperature. The rain fall graph shows rain to have occurred between 0317 h and 0347 h. This indicates that clouds were present in the location. The changes in temperature (AT), relative humidity (RH) and

pressure could possibly be attributed to atmosphere effect. Thus the data indicates that a pressure change and corresponding effects in other whether elements can be detected.

Another set of data collected on October 9, 2004 showing conditions conducive to formation of cumulus clouds is illustrated in 2.3.1.2. What normally could have been considered as a noise in the pressure data seems to be a clear indication of occurrence of instability leading to formation of cumulus and cumulonimbus (Cb) cloud. In the humidity data an increase can be seen at about 1300 h and 1400 h. Corresponding increase can be seen in air temperature at the

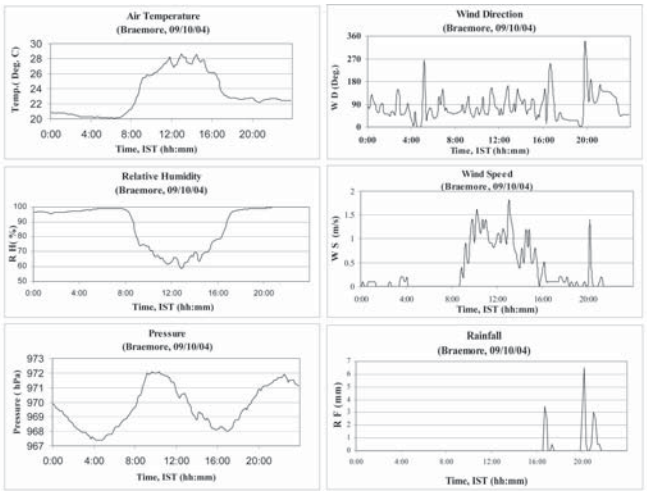


Fig.2.3.1.2 Weather elements recorded at Braemore on a thunder storm day.

same time. The pressure data shows two decreases at the same timings. The decreases in pressure indicate upward movement averaged for a considerable spatial extent and for considerable time. The three sets of data viewed together indicate arrival of humid air at the location and instability indicated by the pressure decrease. Thus the data indicates instability occurring twice during the day. Evening at about 1700 h there were thunder showers at the location.

Events on October 18, 2004 (Fig.2.3.1.3) show the formation of typical convective thunderstorm. A reduction in air temperature at 1026 h and 1226 h and an increase in RH at the same time along with a decrease in pressure is recorded. This variation in humidity is not consequent to temperature decrease due to reduction in insolation because the pressure decreases indicating vertical motion.

Hence variations in data are indicative of humidity increase, consequent temperature reduction and instability which are favourable for formation of cumulus probably maturing into

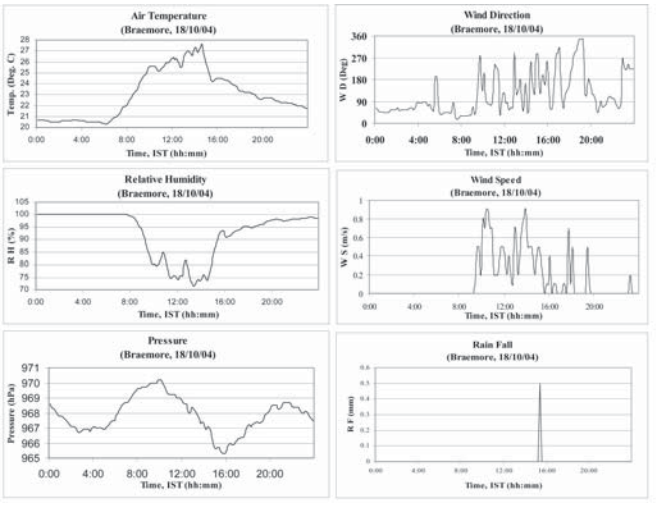


Fig. 2.3.1.3 Weather elements recorded on October 18, 2004, another thunder storm day at Braemore

Cb. It can be seen that in the evening, as is typical of a convective storm day that it has rained at Braemore. At 1730 hours there was thunderstorm and rain at Thiruvananthapuram also, probably caused by the same system. At a typical speed of 30km/h for cloud motion it is not unreasonable to say that the same cloud has reached Thiruvananthapuram after about one and a half hours which is at a distance of about 40 km. The data shown above is only a sample and similar data are available for many days in October 2004 and a few days in March 2005

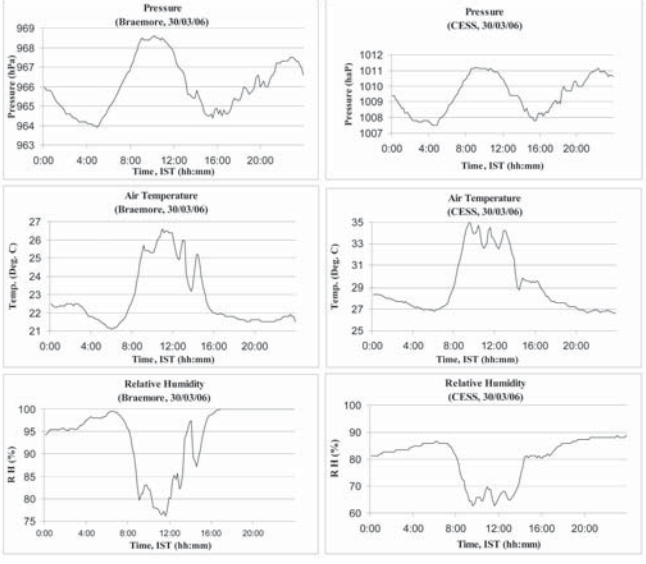


Fig. 2.3.1.4 Comparison of weather elements data from Braemore and CESS collected on March 30. 2006

where the simultaneous variations as mentioned above can be seen. Similar finding of clear variations in humidity, temperature and other related parameters, it seems have not been reported before. Probably because of the occurrence of instability at an earlier time on 18/10/04 thunder showers also occurred at an earlier time than the 9/10/04 rain. Rain and lightning occurred at about 1500 h at Braemore.

Fig. 2.3.1.4 shows a comparison between data from a coastal station (CESS) and data from Braemore on March 30, 2006. The Braemore data shows instabilities and no instability is indicated

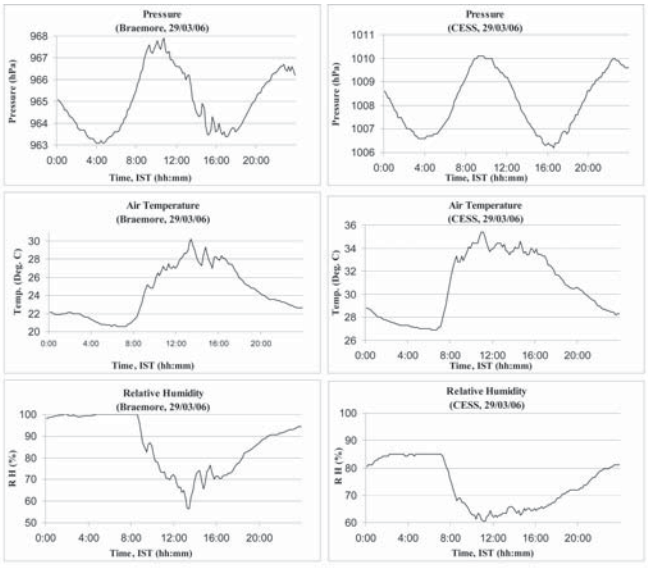


Fig. 2.3.1.5 Comparison of weather elements at Braemore and CESS collected on March 29. 2006

in the data collected at CESS. There was intermittent rain and the changes in atmospheric temparature and relative humidity in the CESS data are due to changes in insolation and rain.

A comparative data from the same set of stations on March 29, 2006 without rain is shown in Fig.2.3.1.5. It can be observed from the figure that the pressure measured at CESS has a smooth diurnal variation indicating the absence of instabilities. The Braemore data, however, shows instabilities several times during the day.

Lightning detector

The lightning detector installed at Braemore can detect lightning without differentiation between cloud to ground and other discharge. The data collected always indicated simultaneous discharges in the evenings at several locations. Lightning activity in the last two seasons were less and was confined to the locations near Western ghats. However one characteristic noticed was that lightning is found initiated in a direction of about 165^0 to north. This is parallel in direction to the Western ghtats itself indicating Cb formation along the western slope of the mountain range. This is also in confirmation to the hypothesis about cumulus and Cb formation.

Field mill data could not be obtained due an incompatibility problem between the data acquisition system of the weather station and the field mill. This is expected to be solved soon.

Braemore was selected because of the possibility of detecting Cbb formation as it falls in one of the areas noted for relatively high lightning activity. But for the same reason the station had to be repaired many times because of damage caused by lightning. Because of this data could not be obtained for some critical periods.

S. Murali Das

2.4 Radioactivity Studies

2.4.1. Natural radioactivity risk assessment in the living environment of the people of SW coast of India

This collaborative project between CESS and Indira Gandhi Centre for Atomic Research, Kalpakkam, Tamilnadu, aimed for the measurement of the levels of natural background gamma radiation and the indoor radon and thoron in the coastal envriroments of the west coast of Kerala and Tamilnadu states. The radiation survey was carried out using a mR- Radiation survey meter to measure a natural background gamma radiation levels. In continuation of the covered structure between Kanyakumari and Malappuram in the previous year, the survey work within a width of 3 km distance of the coastline was also finished between Malappuram and Kasaragode. The mapping of 1700 locations within 77 coastal and hinterland blocks of 10 km x 3 km size covering the entire 620 km of coastal stretch of Kerala and Tamilnadu is underway.

With the specially designed and fabricated 300 Solid State Nuclear Track Detector (SSNTD) based Dosimeter Cups, LR-115 Films, Thoron membrances, filter-paper and other accessories, continued the enhancement work SSNTD Cups for radon/thoron measurements and about 400 Cups (in 2 phases) were deployed inside the dwellings of the study area at the rate of 5 locations in each Block (10 km x 3 km) where maximum gamma radiation levels were seen during the scintillometer survey. About 400 SSNTD Cups were retrieved from the field after a period of 3 months exposure and, the 1200 film samples were collected and sent to the IGCAR Lab for processing and estimating the radon/thoron concentrations.

V. Muralidharan

Funding: Dept. of Atomic Energy , Govt. of India

2.5 Coastal erosion

2.5.1 Shoreline management plan for the west coast of India

The 120 km coastal stretch between Munambam and Kayamkulam in Kerala (2.5.1.1) is unique in many respects. Under the research programme, 'Shoreline Management for the Munambam-Kayamkulam stretch of west coast of India', CESS has undertaken extensive studies to understand the coastal processes leading to erosion/accretion and to identify sediment cells and sub-cells and develop a shoreline management plan for critically eroding sites along this coast. Data on tides, waves, currents and sediment characteristics were collected from four offshore stations viz. Thrikunnapuzha, Mararikulam, Andhakaranazhi and Njarakkal. The wave intensity is generally found to be slightly higher at

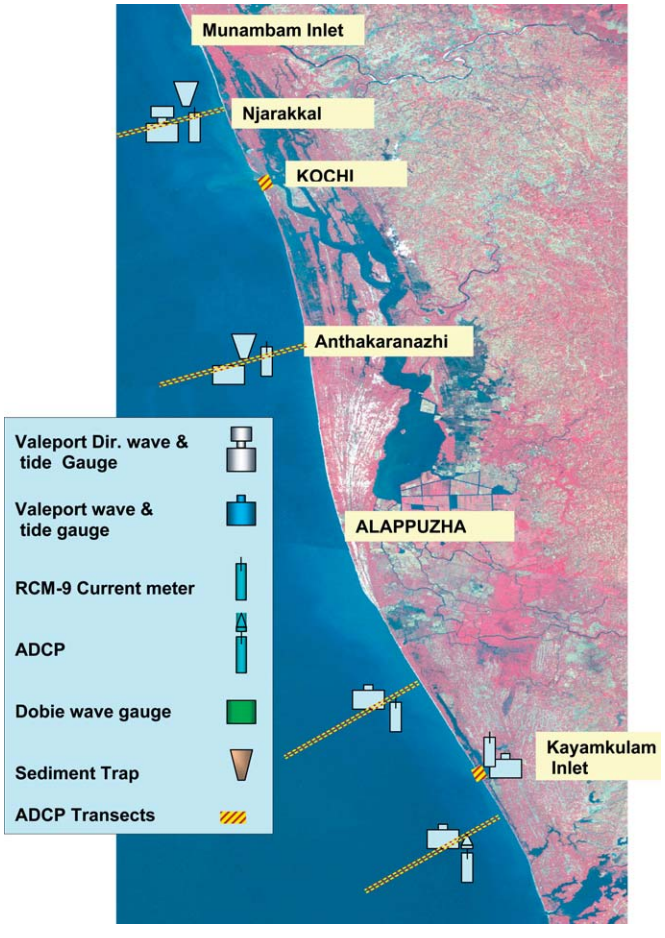


Fig. 2.5.1.1 Study area and the scheme of offshore instrumentation in Nov-Dec 2005

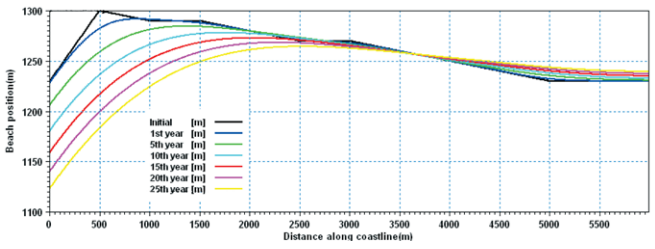


Fig. 2.5.1.2 Shoreline evolution in the present condition

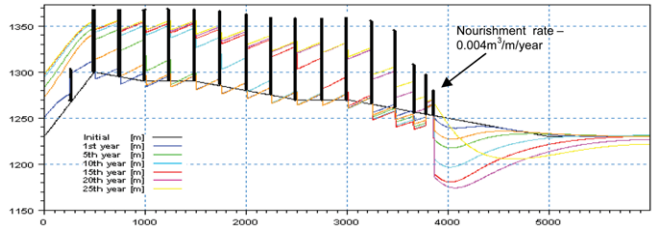


Fig. 2.5.1.3 Shoreline evolution with groin field and point source nourishment

Thrikunnapuzha, which is attributed to the relatively steeper slope of innershelf at this location. The dominance of monsoon forcing, as seen in the case of waves, is not seen in the distribution of innershelf currents. Concomitant with these measurements, the textural and granulometric characteristics of beach and innershelf sediments were determined.

Long-term shoreline change for 15-18 year period of the coast was estimated using satellite imageries referenced to SOI maps. The analysis shows that erosion was prevalent in the southern sector while accretion was dominant in the zone north of Cochin inlet. At Puthuvype, during the 15 year period, a spectacular accretion of about 1.8 km, something unique in Kerala, was observed. Another important aspect evident from the shoreline change study was that a significant part of the coastline appeard stable, which most often was due to well-built seawalls. The southernmost sector from Kayamkulam to Arattupuzha was seen to be a critically eroding coast. Numerical models (MIKE 21 and LITPACK) were set up to simulate shelf circulation, waves, sediment transport and beach evolution. Simulations of waves, currents and sediment transport were conducted for all the three seasons and the salient hydrodynamic and sediment transport characteristics were brought out. Based on field studies and numerical experiments, sediment cells and sub-cells in the coastal sector forming part of the study were identified. A Shoreline Management Plan was proposed for the Kayamkulam-Thottappally coast which encompasses the most critically eroding sector of the coast-

line. This sector is divided into two, Arattupuzha and Trikkunnapuzha, for the purpose of Management Plan preparation. Based on the study, a transitional groin field with beach nourishment is proposed for the Arattupuzha sector. A large quantity of sediment with characteristics similar to the nearshore sediments is available in the southeast corner of Arattupuzha within the Kayamkulam fishing harbour, for nourishment. In addition, sand bypassing from the sector immediately south of the inlet, which is accreting, is also proposed. For the Thrikkunnapuzha sector, which already has a wide beach with accretionary tendency, no intervention is required. It is advisable to leave the coast as such and plan the landuse appropriately so that the impact of pollution from land based activities is controlled and constructions close to the beach are discouraged. Finally, the coastal hydrodynamics, sediment transport processes and shoreline evolution pattern for the Kayamkulam-Arattupuzha coastal stretch were analyzed by numerical model studies. Shoreline evolution modeling using LITPACK indicate that the sector immediately north of the breakwater is getting severely eroded due to the construction of breakwater at Kayamkulam (Fig.2.5.1.2). Based on the numerical model studies, a transitional groin field (Fig. 2.5.1.3) has been proposed for this sector. Simulations show that increase in beach width over a period of 25 years is in the range of 40 to 60m. Beach nourishment is recommended at the downdrift end to prevent erosion of the adjoining area. Further improvement in performance can be attained by artificially filling sand between groins during the initial years. This prevents the downstream erosion on each of the groins (teeth like pattern) seen in the initial years till bypass commences.The extensive data generated by the project has given a fairly good understanding of the hydrodynamic regime of the coastal sector under study and the important outcome of the project is the development of a Shoreline Management Plan for the Kayamkulam–Thottapally sector, together with shore protection measures for the Kayamkulam–Arattupuzha sector. Efforts are being taken to implement the recommendations of the study. This R & D project is supported by the Department of Ocean Development, Government of India.

N. P. Kurian
Funding: Ministry of Earth Sciences, Govt.of India

2.6 Tsunami

2.6.1 Mapping of inundation area on Tamil Nadu – Kerala border

The objectives of the project was mapping of tsunami inundation, landuse-landcover and geomorphology in 1:8000 scale for the villages in Kanyakumari district affected by tsunami of 26th December 2004. The coastal plain between Colachel and Arokiapuram (lat. 77^0 14' 54'' to 77^0 33' 58''N and long. 08^0 10' 20'' to 08^0 07' 06''E) in the Kanyakumari district coast was investigated during the project period. The Kanyakumari coast displays unique geomorphic and

Fig. 2.6.1.1 Beach inundated in tsunami

sedimentologic signatures left by the 26th December 2004. Some of the salient results of the study are as below:

Dunes have rich amount of loose sand formed by aeolian activity. The coastal dunes are made of dry sands blown to the backshore area. The coastal dunes are noticed in the area of Chothavilai, Periakadu, Pozhikarai, Rajakkamangalam, Tekkurichi and Colachel. A large parabolic dune along with dune complex is observed in Chothavilai beach. It has a length of 5km and the width ranges from 5km to 2km. The height of the dune rose up to 2 to 3m near Periakadu, Rajakkamangalam and Chothavilai. Migration of dune is also noticed between these regions.

Mudflat area is seen in Manakudi, Pallam, Rajakkamangalamm. These mudflats, contains silt, clay and water. They are always associated with sheltered environments like estuaries and embayments.

The most remarkable landforms like mangrove, saltmarshes are also observed in Manakudi estuary. This estuary varied in length and width scored by tidal currents. Flooding of water by high tides control this kind of marshy land in this region.

Beach ridges are also seen in the study area with intervening sandy plains occurring parallel or sub-parallel to the shore formed by periodic wave impounding actions. They are followed in the backshore by sandy plains and are discontinuous in nature.

The Final Report consisting of maps depicting the land ward limits of the tsunami inundation was submitted to the coordinating agency, Integrated Coastal and Marine Area Management (ICMAM) Chennai.

Terry Machado
Funding: The Dept. of Science & Technology, Govt. of India

2.6.2 *Preparation of High Resolution Bathymetry for the Kerala Coast*

The project 'Establishment of National Early Warning System for Tsunami and Storm Surges in the Indian Ocean' of Ministry of Ocean Development requires high resolution bathymetric grid for the Indian Coast. The preparation of bathymetric grid for different sectors of the coastline of the country has been entrusted with different agencies. Centre for Earth Science Studies (CESS) has been allocated the preparation of high resolution bathymetric map for a stretch of Kerala coast from Thottapally in the south to Alleppey in the north. The project was sanctioned in March 2006 and the survey begun by the end of March itself. As per the requirements of the project the survey was to be carried out for a total length of 600 line km at transect intervals of 250m, limited to 20 m depth. The survey covered a total length of approximately 875km in 76 transects.

Bathymetric survey basically involves two synchronized measurements: (a) echo sounding and (b) position fixing. Prior to the start of bathymetric survey, sounding lines were generated parallel to latitudes at 250m line spacing using the Hypack software. WGS 84 was selected as the datum for the survey. The survey started from the southern end ie. Thottapally. The echosounder and GPS were installed in a fishing boat which was used for the survey. On each day the survey started in the morning and ended in the evening. Offset values for the transducer depths were corrected in echo sounder itself. GPS readings and depth soundings were logged to a laptop continuously through the Hypack software throughout the survey. The Hypack software also provided the navigation of the boat along survey lines. Each transect started from around 4m and ended at 20m depth. For applying tidal corrections, two wave and tide gauges, one Valeport and another Dobie, were installed off Alleppey pier at a depth of 7m during the first phase of the survey. The first phase of the survey during

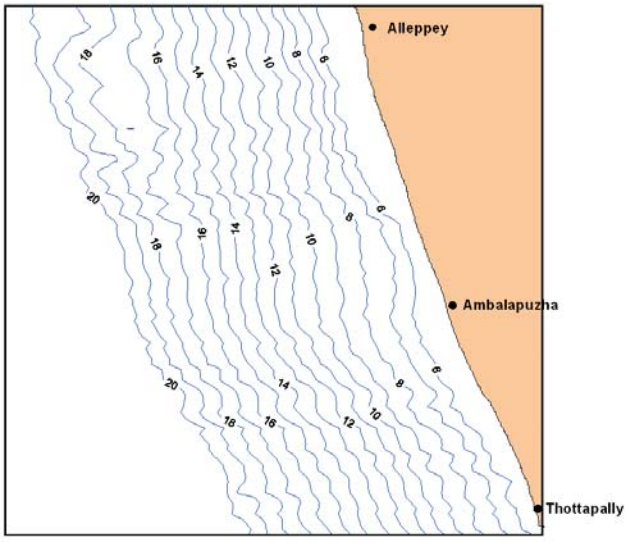


Fig: 2.6.2.1 The bathymetric chart for the project area showing the isobaths

March-May 2006 covered the Thottapally-Ambalapuzha sector. The Ambalapuzha-Alleppey sector was covered during December 2006-January 2007. A total of 76 transects covered the survey area. The transects in the southern side were relatively shorter because of the steeper bathymetry. With the reduction in steepness of the innershelf towards north the length of the transects increased. Thus the lengths of the transects ranged from 10.8 to 12.3 km in the project area.

The collected data were processed using the Hypack software. The X, Y, Z (Easting, Northing, Depth) file created was used for making contours. Using surfer software, the data were converted to grids and from the grid, bathymetric contours were prepared. The bathymetric chart so prepared is presented in Fig. 2. The shoreline presented in the map is taken from Naval Hydrographic Chart No. 221.

On completion of the work, an Interim Report was submitted to INCOIS.

N. P. Kurian
Funding: Indian National Centre for Ocean Information Services, Ministry of Earth Sciences, Govt. of India

3. Natural Resources and Management

3.1 Water Resources

3.1.1 Submarine groundwater discharge across a coastal segment south of Thiruvananthapuram

Coastal areas are natural sites for groundwater release from shallow aquifers because of their down gradient position. Submarine groundwater discharge (SGD) can occur whenever hydraulic head is above sea level and an aquifer extends beyond the shoreline to crop out at the sea floor, or is hydraulically coupled with marine waters through permeable bottom sediments. Number of investigations conducted on the Mediterranean and Atlantic coasts have indicated positive correlation between the submarine groundwater discharge and the beach accretion. Our studies at the Adimalathura-Pulluvila area in the Thiruvananthapuram district of Kerala coastal zone indicated a unique accretion trend, while the neighbouring beaches are consistently eroding. It was found that there exists an apparent relationship between the groundwater level fluctuations and the beach length. Archival data show that the beach at this segment appears to be accreted for about 100m during the last couple of decades. The total annual groundwater discharge computed for this coastal segment was also found to be significant ($2.6\times10^4 m^3$/day).

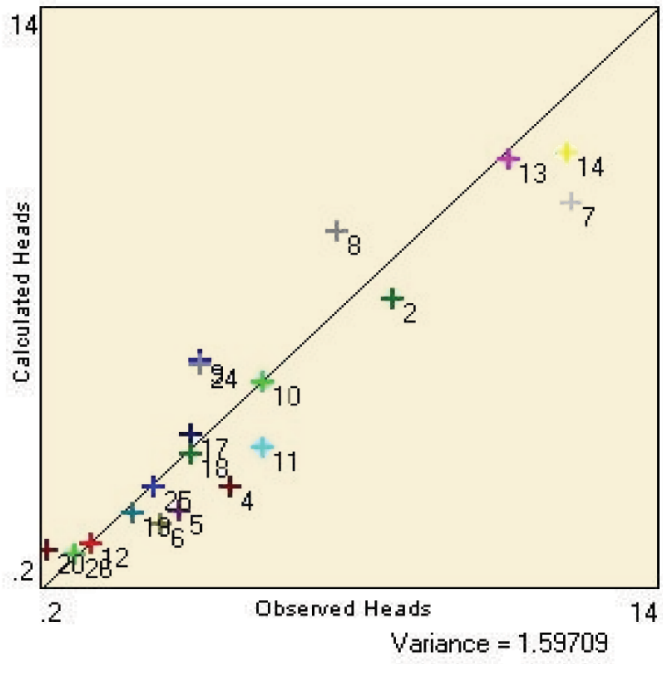


Fig. 3.1.1.1 Comparison between observed and calculated values of water head

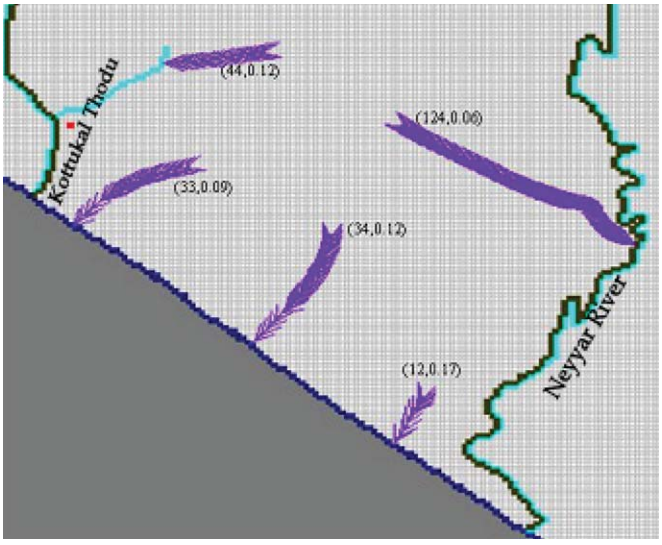


Fig.3.1.1.2 Model calculated residence time (years) velocity of particles (m/s) and direction of particle movement from selected locations of model area. First digit in parantheses represents time required for travel and the second digit velocity of particle.

The SGD of Pulluvila region was studied on the basis of following work elements: a) Remote sensing (image processing of digital data); b) Fieldwork–hydrogeological (piezometer observations, location of springs, water table fluctuations in monitoring wells, recognizing of recharge-discharge areas etc); c) Data collection using CTD meter; d) Resistivity surveys (longitudinal, transverse and seasonal; e) Water quality analysis–spatial, vertical and temporal; f) isotope analyses; and g) Computation of SGD zone using Modflow modeling. This investigation pertains to the unconfined aquifer zone of the area, comprising the Warkalli sediments (Tertiary) and the Coastal sands (Recent).

All the information collected from the field and the laboartory were used for building a steady state groundwater model for the area. The modeling study included steps namely 1) conceptualization of the groundwater system 2) developing the model to derive optimal parameters, 3) calibration studies and 4) simulating the groundwater flow to determine the hydrologic budget. The program PMWIN was used to simulate groundwater flow. For the calculation of the initial hydraulic

heads, two-year data from 26 continuous monitoring wells along four transects as well as 10 spatially different observation wells of study area were used. Before drawing the water table heads, groundwater flow velocity, flow direction and water budget, the generated model was calibrated. The calibration target of <2 m was set as the accepted margin of difference between calibrated and observed heads for each well (Fig. 3.1.1.1).

Simulation of a general head boundary along the northern and southern model boundary of the study region suggests that there are two additional sources of recharge to the aquifer viz., Kottukal Thodu and Neyyar river apart from the rainfall. Groundwater outflow terms of the model included river leakage (3.44×10^4 m^3/day) and submarine discharge from the coastal boundary to the sea ($2.6\times10^4 m^3$/day). The total calibrated groundwater budget was of the order of $7.44\times10^4 m^3$/day. The particle velocity, duration of travel of different particles (residence time) and direction of movement of ground water in the study area are shown in Fig. 3.1.1.2. Based on the sensitivity analyses performed for this investigation it is apparent that the model is sensitive to changes in horizontal hydraulic conductivity and recharge, but least sensitive to river bed vertical hydraulic conductivity.

The synchronised beach profiling with water table monitoring, hydrochemical data from observation wells and inferences from the resistivity surveys strongly support the possibility of truncated extension of coastal unconfined aquifers towards sea, providing SGD from land. Geologically, the Pulluvila region comprises of Tertiary sedimentary layers conformably overlying the Precambrian basement. It is postulated that the configuration of surface topography of crystalline basement coupled with the intense neotectonic disturbances that took place in the area have led to the development of potential submarine groundwater discharge zone, lying between rock abutments at Adimalathura and at Poovar. The accreting shore indirectly supports the probable seaward extension of aquifer sand layers, which are also getting reworked and offers better beach stability.

D. S. Suresh Babu

3.1.2 *Synchronized beach profiling and ground water-table monitoring between Adimalathura & Poovar*

The primary purpose of this project is, to use measurements inferred through seasonal beach profiles and inshore surveys, to obtain evidences for sub-marine ground water discharge on the beach-face and littoral zone of the beaches between Adimalathura and Poovar in Trivandrum District, Kerala. Based on the preliminary analysis of MIR band of IRS 1C, the Pulluvila

Fig. 3.1.2.1 Pulluvila beach in the study site

area located south of Kovalam beach in Thiruvananthapuram district coast (latitude $08^0$18'54.36" and $08^0$20'48.97"N and longitudes $77^0$01'59.83" and $77^0$04'02.83"E) was identified as the zone of potential submarine groundwater discharge. Seasonal fluctuations in four profile locations established in the study area in 2006 had served as a baseline condition for assessing beach morphometric changes in the study area. The monitoring network has been augmented by establishing control wells running across the back shore. A pair of piezometers was installed at two locations each in Pulluvila and at Karimkulam during different seasons for monitoring electrical conductivity, temperature and depth. The elevation of the beach water table was measured by using wells consisting

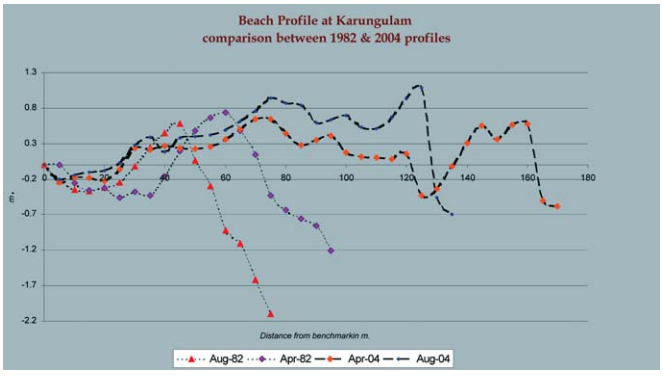


Fig. 3.1.2.2 Comparison of beach profiles measured during 1982 and 2004

of perforated PVC pipe that allows water to flow freely between the sediment and the well.

The data sets were analyzed. From preliminary analysis, it is inferred that, a correlation coefficient of 0.75 for conductivity and temperature probably indicates flushing of freshwater. Similarly, the length of profile is negatively correlated with conductivity; it indicates that the profiles are getting longer (accretion) with the betterment of water quality which could be due to submarine ground water discharge. It could be inferred

that the discharge of freshwater towards sea helps accretion of beach (Fig.3.1.2.11). The beaches in the study area which were monitored during 1982 are less than 100m long whereas profiles recorded during the present investigation are about 180m long. Hence, the beach at Karimkulam appears to be accreted for about 100m during last couple of decades. In the absence of any other study in this area to identify causes for this accretion, it could be looked from the point of SGD. Further investigations are on to detect radon-222 in the nearshore bottom off the study area which could provide convincing evidence for SGD. The advantages of using chemical tracers such as 222-Rn and Ra isotopes include the ability to assess distribution and dispersion of SGD in a coastal ecosystem and its impact on sustainable ground water management.

Terry Machado

3.2 Watershed Development

3.2.1 Watershed characteristics, landuse pattern and water quality parameters of upstream and selected down stream stretches of the Vamanapuram river

Main objectives of the project are to workout interrelationship between watershed characteristics, changing landuse pattern and water quality parameters of pristine catchment and the downstream section of the Vamanapuram river. Generation of primary baseline data to work out management strategies for restoration of water quality is also to be considered. Different thematic maps depicting terrain characteristics, drainage analysis and landuse pattern have been prepared through primary survey and map analysis in 1:50,000 scale. Analysis of physico-chemical parameters of water has been undertaken.

Mahamaya Chattopadhyay
Funding: State Planning Board, Govt. of Kerala

3.3 Terrain Analysis and Landuse Studies

3.3.1 Landscape evaluation in relation to fluvio-estuarine and denudational systems: A case study of Periyar basin, Kerala

Studies on landscape evaluation and its relation to various physical systems have gained importance in recent years. Landscape evolution is linked to fluvio denudational and marine processes. These are well manifested within the bounds of river basins. Main objectives of the project were to undertake morphometric analysis of Periyar river, to prepare maps on land system, to demarcate morphogenetic regions and to assimilate data through GIS analysis. Thematic maps were finalized. Digitization of maps was undertaken. Digital terrain models along with drainage drape were created for Periyar basin and sub-basins.

Mahamaya Chattopadhyay

3.3.2 Landuse/landcover changes and water quality: a case study in the Western Ghats provenances of Central South Kerala rivers

Three sets of water samples (bulk) were collected from rivers. (pre-monsoon, monsoon and post-monsoon). Filtration of TSS, analysis of biogeochemical parameters and phytoplankton analysis were taken up. Preparation and digitisation of landuse maps of Muvattupuzha, Karamana, Neyyar and Kallada river basins were completed.

K. Soman

3.3.3 Impact of landscape alterations on watersheds and ecosystem implications: A case study of Western Ghats provenances of Idukki district Kerala

Biogeochemical analysis of TSS, soil and vegetation completed. Compilation of geology map of the study area completed.

K. Soman
Funding: State Planning Board, Govt. of Kerala

3.4 Environmental Resources

3.4.1 Landuse/Landcover change and its impact: Kakkiar – Agasthyamalai segment

The objectives of this project are: (i) to asses the extent of landuse/landcover change, (ii) to study drivers of landuse/ landcover change and (iii) to assess impact of these changes on biophysical system and societal consequences. This three year project is expected to be completed by the end of 2007. The study area spreading over 5297 km2 in the southern part of the Western Ghats extends from the Kakkiar in the north to Agasthyamalai in the south. It encompasses provenance of seven river basins, namely, the Pamba, Achankovil, Ittikkara, Kallada, Vamanapuram, Karamana and Neyyar. Landuse/ Landcover change analysis based on topographical maps, Landsat image, IRS image and field work indicated that forest cover has reduced from 2914 km2 in 1967 – 68 to 1770 km2 in 1973 and to 1544 km2 in 2004-05. During this 37 years period area under plantation have increased by 737% (Table 3.4.1.1). Landuse change matrix prepared for the period 1973 to 2004/05 brought out that the forest area experienced maximum change. Fig.3.4.1.1 provides existing forest area along with the deforested parts. The forest areas are now fragmented and are mostly restricted to hilly rugged terrain. The upper reaches of the Pamba and Kallda still have good forest cover. The basins showing high level of deforestation are Vamanapuram, Karamana and Achankovil. Study of soil properties under different vegetation covers highlights that distribution of organic carbon is the highest in all depth ranges compared to grassland, rubber and settlement with mixed tree crops. Population growth, construction of roads, expansion of rubber plantations and development activities like impounding of reservoirs are major drivers of landuse change. It is observed that landuse changes are not always due to proximate causes, government policy and market forces do contribute in the process.

Table 3.4.1.1 Landuse changes in the study area during 1967-68 to 2004-05

Landuse	Area under forest (Sq.Km)			Change in forest area (%)		
	(1967-68)	(1973)	(2004-05)	(1967-68 to 1973)	(1973-2004-05)	(1967-68 to 2004-05)
Forest	2914.00	1770.00	1544.00	- 39.25	- 12.80	- 47.60
Grass land	1.00	3.00	5.00	+ 200.00	+ 66.70	+ 400.00
Open shrubs	7.00	26.00	20.00	+271.40	- 23.10	+185.70
Plantation	150.00	1059.00	1255.00	+ 606.00	+18.51	+ 737.00
Teak plantation	36.00	21.00	18.00	- 42.00	- 14.30	- 50.00
Settlement with mixed tree crops	2159.00	2392.00	2411.00	+10.80	+ 0.80	+11.70
Waterbody	30.00	26.00	43.00	- 13.30	+ 65.40	+ 43.30
Total	**5297.00**	**5297.00**	**5297.00**			

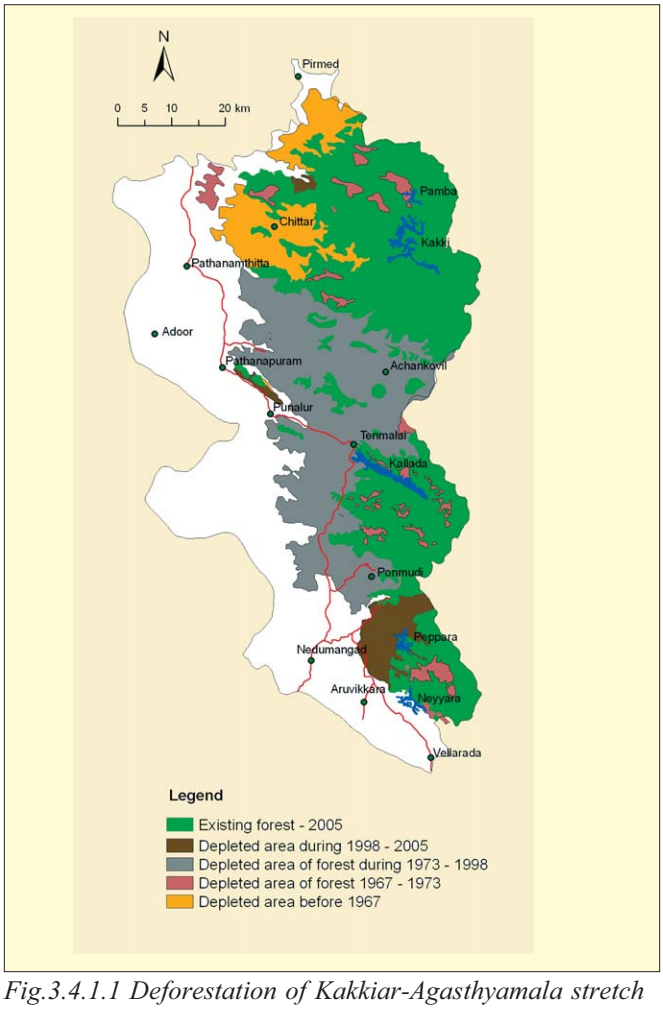


Fig.3.4.1.1 Deforestation of Kakkiar-Agasthyamala stretch

Srikumar Chattopadhyay

3.4.2 Pathiramanal Biodiversity conservation and Bio-park project:An Action Research Program

This project has been taken up at the behest of Muhamma Gram Panchayat. KSCSTE sponsored the project as one year programme. Objective of this project is to conduct a detailed survey of the island covering

Fig 3.4.2.1 A view of Pathiramanal island in the Vembanad Lake

bathymetry, relief, soil, landuse and biodiversity and to prepare an ecotourism plan. The project began with a brain storming workshop at CESS. This island in the

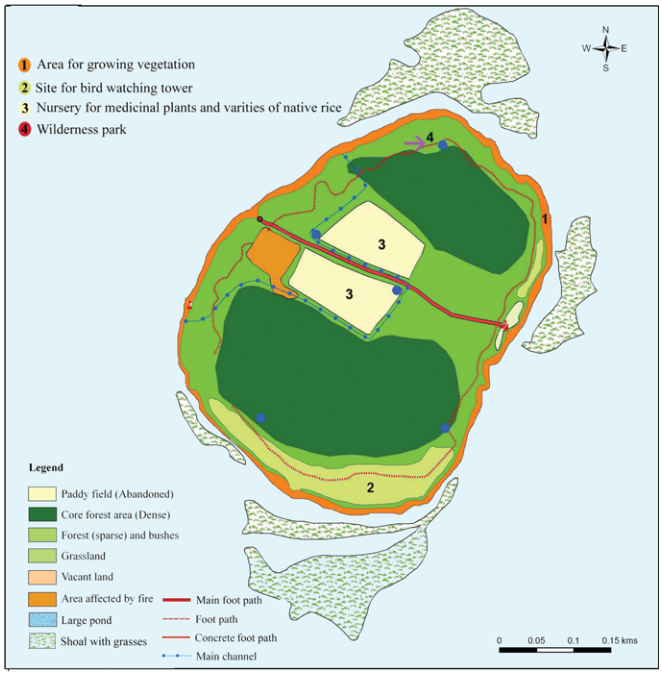


Fig. 3.4.2.2 Proposed activities in the Pathiramanal island

Vembanad lake spreads over an area of 24.1 hectares. It is now uninhabited. Erstwhile paddy fields covering 2.3 ha. area turned into marshy condition. Bathymetric survey of the lake body around this island indicates that shallow water of less than 2m. depth surrounds the island. There is a trough of more than 4m. deep between this island and west shore of the Vembanad lake. This trough gradually merges with a deeper trough of 6 m depth that extends northwards up to the vicinity of the Thanneermukkom bridge. Shoals, with aquatic grasses are seen all around the island (photograph). The ecotourism plan prepared for the island envisaged activities both in the island and mainland. The main objective of this project is to develop this island as a destination ecotourism centering around biodiversity conservation.

Srikumar Chattopadhyay

3.4.3 State of the Environment and Action Plan for Kochi Urban Area

The study envisages a micro environmental analysis of the region comprising an area of 1022 km^2 encompassing Kochi Corporation and surrounding 6 Municipalities and 47 Grama Panchayats. The methodology followed was through the preparation of State of Environment Reporting, action plan formulation for environmental protection and management, and viable projects for landuse and landform of the coastal areas.

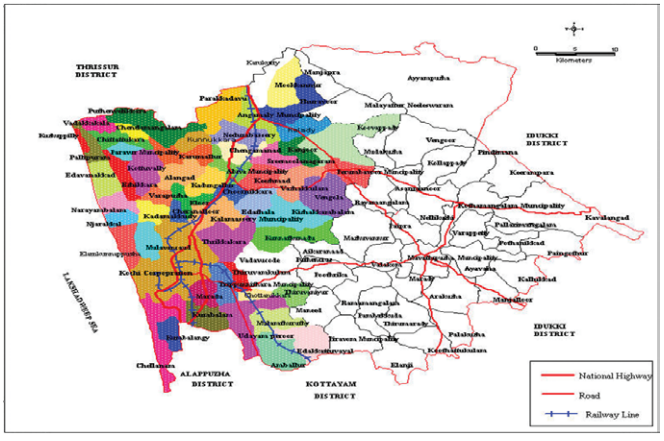


Fig. 3.4.3.1 Study area

The study had brought out the urban sprawl, expanding settlement pattern, increased occupation of runnels, reclamation of natural water bodies, and long-term accretion – erosion trend along beaches. Water quality analysis of surface and ground water from selected spots indicated the status of pollution

vulnerability. Analysis of long-term meteorological data, revealed the significance of general climatic parameters including frequency of climatic shifts, seasonal wind patterns etc. The data on methane flux from 15 spots of Kochi estuary was gathered and analysed. Analysis of noise level in the city area in different zones, and traffic density of biodiversity, especially with respect to Kochi estuary, was also compiled. The major environmental issues identified for the Vypeen islands (comprising of six Grama Panchayats) were occupational pressure and drinking water scarcity.

R. Ajaykumar Varma & C. N. Mohanan

3.4.4 Formulation of model development master plans for selected local bodies in coastal plain areas

A study has been carried out in three coastal Grama Pnachayats to evolve a methodology to prepare local level master plans for selected Grama panchayats. The Grama Panchayats selected for the study are Karumkulam in Trivandrum district, Arattupuzha in Alappuzha district and Muzhuppilangadu in Kannur district. Detailed field investigations have been carried out for environmental appraisal and assessment of resource base making use of resource mapping and linked inventories. The environmental quality assessment has been done using field inventory and secondary data. Incorporating the significances of natural resource system, local environmental constraints, coastal regulation guidelines etc the development potential has been assessed using scenario structuring in this carrying capacity analysis. Based on the supportive capacity estimated from the resource base and assimilative capacity deduced from the environmental quality, the limiting resources of the area have been deduced and environmental management plan proposed considering the Business As Usual Scenario (BAU). The sectoral allocation strategy has been formulated, resource allocation modeling done and perspective plan evolved for all the three study areas. It provides a framework for long term development of the three coastal panchayats which can be incorporated into the annual and five-year plans of the respective local bodies.

Fig. 3.4.4.1 Solid waste management system installed at Kottarakkara panchayat

R. Ajaykumar Varma & C. N. Mohanan

3.4.5 Heavy metal and REE abundance in edible plants of Kollam and Alapuzha district

The project aims to precisely quantify the heavy metal and REE's abundance in the edible plants grown beach placer deposits area of Kollam and Alappuzha districts of Kerala with a view to bring out correlation, if any, between soil and plant heavy metal and REE concentrations. Analysis of 42 plants and 24 soil samples were completed using ICP-MS. Extensive field work was carried out between Kundara and Changanassery and collected 48 plant samples and 28 soil samples (control samples) for geochemical analysis.

G. Balasubramonian

3.4.6 River sand mining and management

Rivers are one of the vital and complex life sustaining systems of nature. But, in the last 2-3 decades, these life support systems are subjected to immense pressures due to human interventions like extraction of river bed resources like sand and gravel contaminant discharges from urban agricultural and industrial sources, etc. The situation si rather alarming in the rivers of Kerala that are generally small (catchment area less than 6200km^2) and with limited river sand resource. Although, efforts are being made for minimizing the detrimental effects, it is not yielding desired results due to various reasons. 'The Kerala Protection of River Banks and Regulation of Removal of Sand Act (2001)' was a major step by the Govt. of Kerala to save rivers. But, lack of adequate knowledge on river system and its ecosystem functioning, is a major hurdle in wise-decision making in areas of river restoration and management. In this context, a study has been undertaken to gather relevant information to prepare district-wise sand mining study reports of Thiruvananthapuram, Kollam, Alappuzha, Thrissur and Kasaragode districts for the use of various stakeholders especially in river conservation and management. A part from district-level reports, a brochure on 'River Sand Mining and Management' and a consolidated report containing the highlights of the district-wise studies are also prepared and communicated to the conserved authorities. The following are the major

recommendations drawn from the study.

- ↓ Controlled bar skimming can be allowed in the rivers of Kerala. The pit escavation method followed in Kerala rivers must be banned.
- ↓ Immediate steps are to be taken to intensity research activities leading to the finding of suitable, low cost and easily available alternatives to river sand. Alternate building technologies with low sand/no sand content to be developed.
- ↓ Import construction grade sand from regions/states having its surplus availability.
- ↓ Create awareness on the finite character of river sand at different levels.
- ↓ Enforce strictly 'The Kerala Protection of River Banks and Regulation of Removal of Sand Act (2001).
- ↓ Continued funding for R & D activities for updating base line knowledge on river processes, restoration and management of rivers.

D. Padmalal & Maya

3.4.7 Lime shell resources of Vembanad Lake with special reference to the future of lime shell based industries of Kerala

Kerala state is endowed with a variety of mineral resources. From economic point of view, the Quaternary sedimentaries are of prime importance as they host many economically viable mineral deposits like lime shells, heavy mineral placers, brick clays, river sand etc. But, it is unfortunate that indiscriminate mining of these mineral resources, on many occasions, causes severe environmental problems in the area. These aspects have to be studied in detail for environment friendly mining and judicious utilization of our valuable mineral resources. With this in mind, an attempt has been made in the present study to assess the environmental impact of mining of lime shell resources of the Vembanad Lake basin for laying down strategies for an environment friendly lime shell mining of the Lake basin.

Lime shell, the purest form of calcium carbonate in nature, is used for the manufacture of a variety of products like white cement, carbides, chemicals, etc. Kerala State is the top producer of lime shells in India and contributes about 50% of the total lime shell production in the country. Two types of shells are being extracted from the Vembanad Lake, white shells (fossilized deposit of Villorita sp.) and black shells (exoskeleton of the living clam Villorita sp.). The black shells constitute the predominant clam species, contributing about 80% of the clam exploited from the shallow areas of the Lake. The white shells are extracted from both the lakebed and also from the adjoining land areas.

Eight co-operative societies are currently engaged in the collection and distribution of black shells. On an average, 30000 tonnes/year of black shells are collected through the respective societies during 1990/91 – 2004/05. A detailed analysis of the black shell collection statistics reveals that harvesting of living clams from the Vembanad Lake is almost in a steady state over the past 2-3 decades. The living clams of the Vembanad Lake are extracted by manual and semi mechanical methods.
It is a fact that the shell mining activities impose irreparable damages to the Lake system. To understand the impact of lime shell mining activities on water quality, a systematic investigation is carried out in specific areas of the Lake including the lime shell mining and non-mining locations. Low to medium increase of pH is observed in water from shell mining areas compared to the samples from non-shell mining areas. Manual mining alters pH a little higher compared to that of mechanical mining. Throughout the year, DO in surface water is higher than bottom water. It is to be noted that the mechanical lime shell mining areas show low DO compared to manual mining areas. The lime shell mining activities have no remarkable impact on sulphate, salinity or hardness distribution of the overlying waters. At the same time, lime shell mining activities can increase the dissolved iron concentration in both surface and bottom waters during pre-monsoon and post-monsoon seasons, while during monsoon such concentration variation is not observed, because of the absence or reduced level of shell mining during this period. The lime shell mining activities can increase TSS contents in the overlying waters to significant levels. The increase is markedly high (21 – 50 times) in pre-monsoon season than the other two seasons.

The process of mining is only a temporary use of land. During mining processes, several environmental problems would also be created in the affected region. Lime shell mining operations in land areas create certain negative impacts such as changes in landuse, landscape and land stability. The shell mining activities adversely affect the estuarine system in a variety of ways. The manual method of mining creates low to medium negative impacts on water quality, while the mechanized mining operation (dredging) causes high negative impact. Dredging creates both long term and short term changes in the water quality, water current, circulation, deflocculation and pollution. Mining operations can cause negative impacts on flora and fauna as well. Lime shell mining does not create any direct change in air and noise on the environment except in areas adjacent to mechanical mining. The transportation and pro-

cessing of the products may cause certain low negative impacts on air and noise. The impact is medium negative on air quality due to processing operations. The lime shell mining activity provides certain positive impacts on the socio - eco-

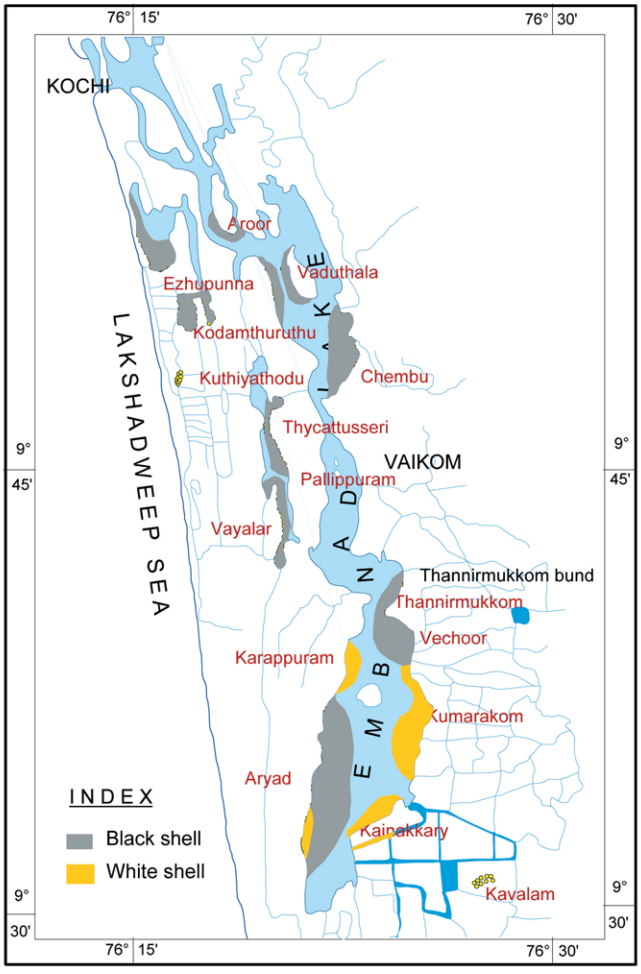


Fig. 3.4.7.1 Map showing major lime shell occurring areas in the Vembanad Lake

nomic conditions of the area. Mining and post mining operations attribute positive impacts in employment opportunities and income generations. There will be a marked decline in the aesthetics of the land areas subjected to shell mining activity. The ugly scars formed due to random mining are aesthetically unacceptable and is really a negative impact.

The following are some of the major recommendations / suggestions drawn from this study.

Estimate the white shell resource of the coastal lands of Kerala without much delay. Also work out the maximum sustainable yield of the black shells in the back water systems of the State.
The lime based major industries of the State like TCL has to evolve strategies to use alternate sources of lime for the manufacture of their products as the shell deposits within the Vembanad Lake are declining fast due to overexploitation.
Use the human resources of the area at the maximum level in lime shell mining and processing sectors.
Dredging may be limited to areas, which are not accessible to manual mining.
Use the lime shells for the indigenous lime based industries like TCL, lime kilns etc.
Prohibit mining of juvenile clams. Fishing should be banned during spawning period (October-January) of these bivalves.
Use the lime shell of the State only for value added products.
All the proposals for future development projects should be evaluated in terms of the potential consequences to the ecosystem and effects on the resource base.

K. Maya

3.5 Environmental Pollution

3.5.1 Methane emission flux from wetlands in Kerala

The anthropogenic connection to global warming through the increase of greenhouse gases in the atmosphere has been well accepted now, and is currently the hottest international issue. The greenhouse gases in the atmosphere allow the short wavelength solar radiation to reach Earth's surface and warm it, but does not allow the longer wavelength heat waves from its surface to leave Earth and prevent its cooling. This results in the effective warming up of Earth's surface. Major greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), etc.

Methane is the second most important greenhouse gas after carbon dioxide, and is expected to contribute nearly 18% of the total global warming during the present half-century. The atmospheric concentration of this gas is known to have been increasing steadily from about 1.4 ppmv at the beginning of the industrial revolution to its present value of 1.9 ppmv. Methane has a number of natural and anthropogenic sources. Wetlands are the largest natural source of methane, contributing about 22 % of global methane from all sources put together. Both Northern as well as the tropical wetlands are considered to be important sources of methane. Kerala has substantial extent of wetlands, which include estuaries, lakes, and rice paddy fields. The

high density of population in the coastal regions of Kerala put excessive pressure on the estuarine ecosystem.

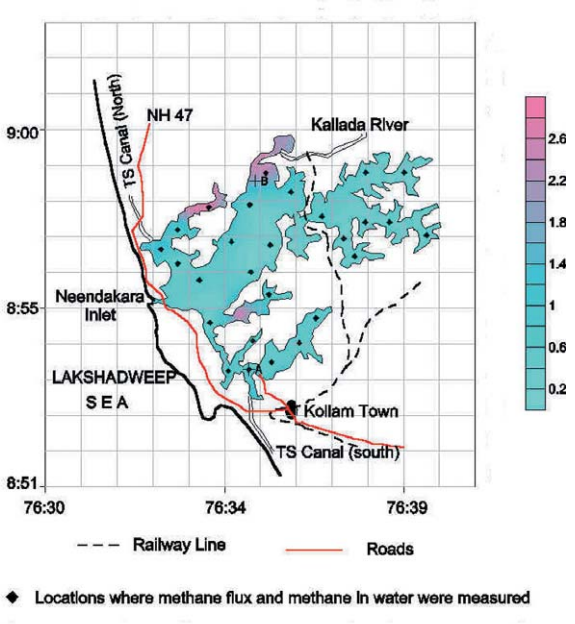


Fig. 3.5.1.1 Distribution of dissolved methane in the surface layers of Ashtamudi estuary

Methane flux measurements from some of the major estuaries in Kerala were carried out by CESS. Water to air fluxes of methane as well as dissolved methane in the estuarine water was measured. Fig. 3.5.1.1 shows the distribution of dissolved methane in the surface layers of the Ashtamudi estuary in Kollam district. The average water to air flux from this estuary was 0.57 mg/m2/hr, based on measurements at 27 locations in the estuary. This corresponds to a loading of 270 tonnes methane to the atmosphere annually from this estuary alone. The amount of methane reaching the coastal ocean as dissolved in the water discharged from the estuary was estimated to be 42 tonnes.

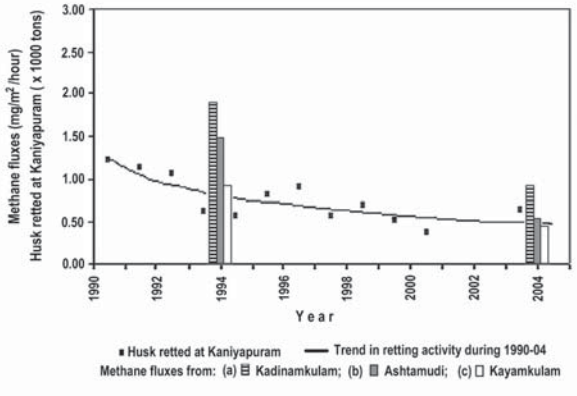


Fig. 3.5.1.2 Methane fluxes from husk retted areas.

Aquatic plants growing in the water bodies are known to enhance methane fluxes to atmosphere by providing an easier conduit for the methane produced in the sediments to the atmosphere, bye-passing the oxidation zone in the sediment. The contribution from a few common aquatic plants in the region was investigated.

E. J. Zachariah

3.5.2 Nutrient flux studies in the Ashtamudi estuary

The term nutrients in the aquatic environment refers to the dissolved inorganic forms of nitrogen, phosphorous and silicon, which is utilized by photosynthetic organisms, in the formation of organic matter. Nitrogen and phosphorous are bio-limiting elements, since concentration of these elements limits biological growth. Thus, nutrients in estuaries play a definite role in controlling the productivity of the system. The nutrients supply from fresh water inputs in important in sustaining their high rate of primary production, but today estuaries receive some of the highest inputs of nutrients because of the local influence from land drainage and pollution from high urbanization in the banks of estuaries, which in turn reduces the water quality creating eutrophication.
The Ashtamudi is the second largest estuarine system; one of the Ramsar sites (Ramsar no-1204) of Kerala having water surface area of 57 Sq.km.and is connected to the Arabian Sea at Neendakara.

The present work envisages study of the nutrient chemistry of the Ashtamudi estuary. The objectives of the present study are to study the water quality in the Ashtamudi estuary, to quantify the nutrients in Ashtamudi estuary, to study the dispersal and pathways of nutrients in the Ashtamudi estuary, to monitor effects of pollution in the estuary and to assess the productivity status of the estuary.

Nutrient flux in the Ashtamudi Estuary and the boundary layers of the estuary has been estimated in the study period of one year, comprising five surveys. Major input of nutrients into the estuary is through Kallada River and TS Canal during the monsoon period. Nitrate con-

tent in the estuary was marked with drastic variation, showing heavy consumption during monsoon periods. Increased utilization of phosphates was also noticed during monsoon, but in the case of nitrates, it was observed that the input has exceeded consumption. Land derived nutrient inputs to the estuary was found to be maximum during monsoon months.

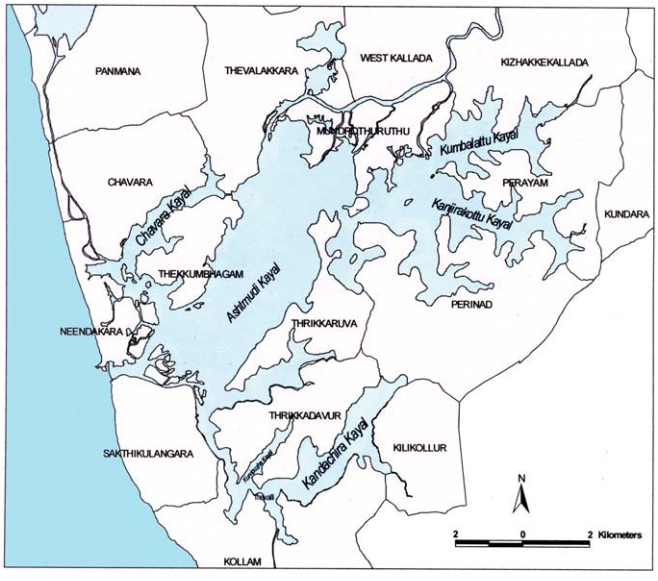


Fig. 3.5.2.1 Ashtamudi estuary

M. N. Muraleedharan. Nair

3.6 Carrying Capacity Studies

3.6.1 Tourism carrying capacity study of Varkala, Kerala

Varkala, a coastal town in the Thiruvananthapuram district is a fast developing tourism destination, which is increasingly attracting many Indian and foreign tourists. The main tourist attraction of Varkala is the beaches backed by laterite cliffs, which attracts many local and foreign tourists. Tourism activity is also coming up on the banks of Nadayara kayal, a back water north of Varkala coast.

A carrying capacity study would assess the supportive and assimilative capacity of Varkala tourism area and would set limits for tourism developments in the area. It would also bring out the hotspot of pollution and other unsustainable aspects of the present tourism development. Based on the study suitable guidelines for sustainable development of tourism would be suggested. During the period under report a resort survey was carried out to assess the total number of rooms occupancy during different months, number of people employed, etc. The survey was also conducted among the residents of Varkala tousim area to assess their perceptions about the impact of tourim on the social and economic sphere. Six hundred and thirty households where surveyed engaging six students of Master of Toursim Administration course from the Mar Ivanios College, Thiruvananthapuram. In addition to this a survey of Small Business Establishments (SBE) was also conducted to evaluate the economic benefits, if any, from the toursim activity in the region.

G. K. Suchindan

3.7 Coastal Zone Management

3.7.1 Conservation and nourishment of beaches of selected tourism locations of Kerala

The most important and vital requirement for coastal tourism is the availability of aesthetically undisturbed beaches and coasts. The aesthetics of a coast is provided by the presence of geomorphologic features such as cliffs/headlands, beaches and pocket beaches supported by vegetative landuse. Many of the beaches and earth cliffs of Kerala are prone to erosion. The lost beach has to be regained as a recreational facility and also to reduce the threat of coastal erosion and cliff slumping. Tourism Department, Government of Kerala has sponsored this project on 'Conservation and nourishment of beaches of selected tourism locations'.

Kovalam coast has 2 major headlands – the Light House headland and the Kovalam headland with a smaller headland north of Kovalam headland. Seasonal erosion coinciding with monsoon is dominant south of Kovalam headland while the coast north of Kovalm has eroded to a tune of 20 to 50 m during the last 15 years. The cliff line and the shoreline at Varkala have retreated over a period of time. The long term trends show retreating cliff line and shoreline. Over the last 16 years the cliff line has retreated by about 15-20 m. The fair season shoreline also shows a retreating trend.

Considering the nature of seasonal erosion, wave climate and availability of sand in the nearshore, artificial surf reefs have been recommended for coast conservation and beach rebuilding at Kocalam and Varkala. Artificial reef is environment

friendly and generates a fishery habitat around the reefs. It could also support by generating breakers suitable for surfing.

K. V. Thomas
Funding: Tourism Department, Govt. of Kerala

3.7.2 Coastal Engineering Strategy for Shore Protection for Kerala -A Pilot Project

Various designs of seawall have been attempted along different stretches of the coast covering about 75% of Kerala's coastline of about 570 km. The maintenance cost of these seawalls is enormously high since they get damaged very often. One of the major concerns of the Government of Kerala in dealing with the issue of coastal erosion is the protection of the eroding "protected shorelines". This pilot project is for the design of a coastal protection measure along Panathura coast in Thiruvananthapuram, as part of developing an appropriate coastal protection strategy for Kerala coast. Kovalam-Panathura coast has been highly eroding and present shoreline is maintained by seawalls, though these collapse frequently.

After considering the environmental and technical feasibility of various options such as seawalls (conventional or using gabions), strengthening of existing seawalls (by pitching toes and using gabions) and groins (conventional, Transitional or Transitional - T), the Transitional - T groins have been recommended for Panathura coast. The Govt. of Kerala approved the implementation of 2 Transitional – T groins as a pilot programme as suggested by the Expert Advisory Committee for Kerala Coastal Protection Programme. The State Irrigation Department has initiated actions to take up the construction of 2 transitional T-groins in consultation with IITM, ICMAM and CESS.

K. V. Thomas
Funding: Ministry of Earth Sciences & KSCSTE
Collaborator: Kerala State Irrigation Department and Indian Institute of Technology Madras (IITM).

3.8 Pollution Studies

3.8.1 Monitoring of water and sediment quality in the Cochin harbour region

The project aims at periodic evaluation of the state of pollution of the Kochi harbor region by collecting and analyzing surface and bottom water samples and sediment samples from seven locations . The water samples are analysed for productivity and nutrients and the sediment samples for trace elements like lead, mercury and cadmium. The water and sediment quality of the Cochin Harbour Region were monitored. The results of physico-chemical parameters, comparison of previous three

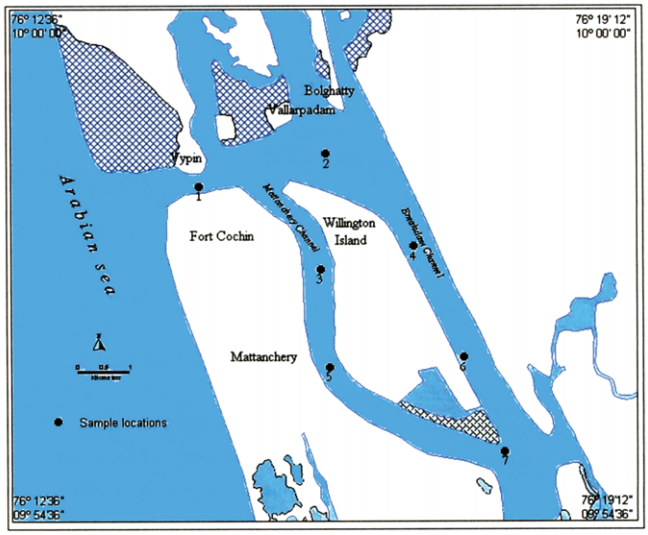


Fig. 3.8.1.1 Sampling locations of Kochi harbour region

years data of the same study period, correlation matrix of the data using SPSS 11.0 ™ were also incorporated. The fluctuation in temperature, pH, salinity, DO is significant and high turbidity and TSS which may be due to the presence of heavy rain. The strong negative correlation of salinity with nutrients reveals that these two factors are inversely proportional and seawater is less nutrient rich than fresh water. The correlation coefficient of nutrients revealed the fact that strong correlation exists in between them. The negative correlation of salinity and pH with nutrients point out that seawater has fewer nutrients than fresh water. Negative correlation can also be observed from nutrients to trace metals. It all lead to the fact that fresh water with industrial and anthropogenic input on the bar mouth is the major source of nutrients and trace metals to the environment.

P. P. Ouseph
Funding: Cochin Port Trust

3.8.2 Coastal Ocean Monitoring and Prediction System (COMAPS)

The marine and coastal areas harbour a variety of specialized ecosystems like mangroves, coral reefs, islands, salt lakes, sand/mud flats, which provide unique habitats for a myriad of flora and fauna. Due to manifold usages of Seas and Oceans for harvesting resources, shipping and dumping of wastes, the

areas constantly face various environmental stresses and threats, which ultimately affect the biotic factors of the system. Due to the rapid increase in global population and industrialization, the major source of marine pollution is from municipal and urban runoff and among them; industrialization contributes for 56 % of the pollution load. The industrial waste discharge is estimated to be 0.79 x 109 cu. m as of 1994 (Subramanian, 1999), while microbial pollution is largely confined to nearshore waters, released/dumped chemicals are found even in the offshore waters.

Salient findings of COMAPS along Kerala and Karnataka coast

- Veli, Cochin and Mangalore which have shown severe changes in physico-chemical, biological and microbiological parameters which are indicators of marine pollution.
- High acidity, Oxygen depletion, very low photosynthetic activity and consequent reduction in fauna was observed from the nearshore off Veli, which shows the effect of acidic effluents from the Titanium factory.
- The offshore region of the northern part of west coast is enriched with more DO than the southern part possibly due to the low reception of organic wastes. In general, the shelf waters were found to be well aerated. No live benthos observed at the TTP effluent discharge point.
- High domestic sewage input from Akkulam Kayal on the northern side and from Punthura towards the south end of the TTP effluent discharge point. Contaminations from the factory effluents at Veli transect have a decisive role in the biological productivity of the nearshore waters of these regions.
- Generally, nitrate nitrogen in the nearshore waters of the southwest coast has, over the years, increased to a great extent, possibly due to the increased sewage dumping, though industrial effluents attributes to its increase at certain transects like Chitrapura. The high phosphate content noticed occasionally in the offshore regions of Neendakara during pre-monsoon and Cochin during post-monsoon may be caused by upwelling.
- High total oil content was observed at Neendakara. This is due to the heavy trafficking of fishing boats harboring at one point near the harbor mouth and High municipal sewage pollution is also observed.
- The concentration of heavy metals is found to be high at Cochin region probably due to the discharge of effluents from Eloor industrial area. High municipal sewage discharge observed from the Cochin Corporation.
- Very high municipal sewage discharge observed at Calicut, Cannanore and Mangalore. Industries are the main contribution to pollution in Mangalore. Compared to all other stations, Paravur, Kayamkulam, Alleppey, Cochin, Mangalore to Karwar found to be highly productive regions.
- In spite of the slight drop in the primary productivity values, in general, along the Kerala coast from pre-monsoon to post-monsoon season, the density of phyto and zooplankton communities are comparatively more during post-monsoon season. This could be the after effect of increase in primary nutrients in seawater during the monsoon period.
- The COMAPS project has identified high risk, low risk and no risk regions in monitoring pollution. Veli, Cochin and Mangalore are included in the high-risk region. At Cochin, there are lot of industries which

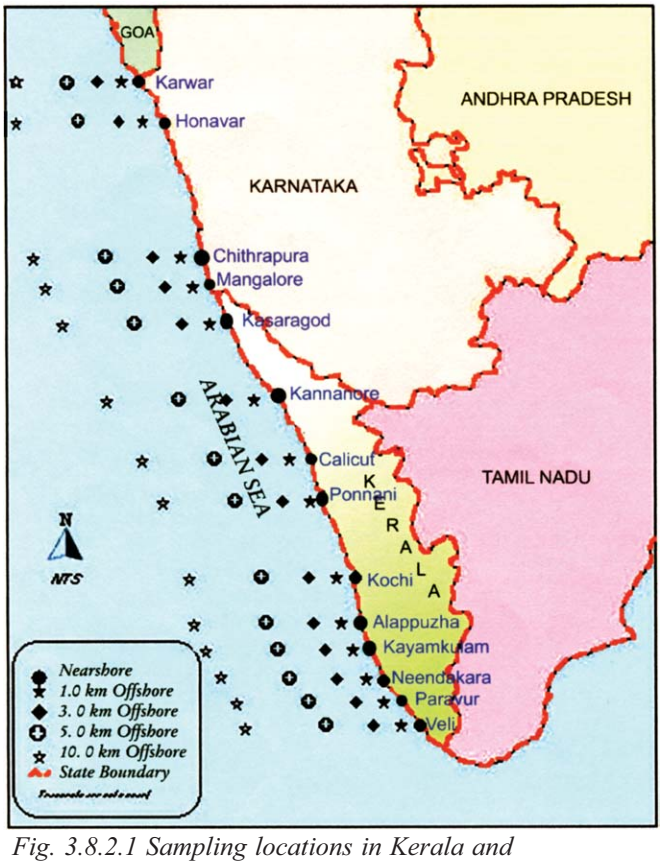


Fig. 3.8.2.1 Sampling locations in Kerala and Karnataka

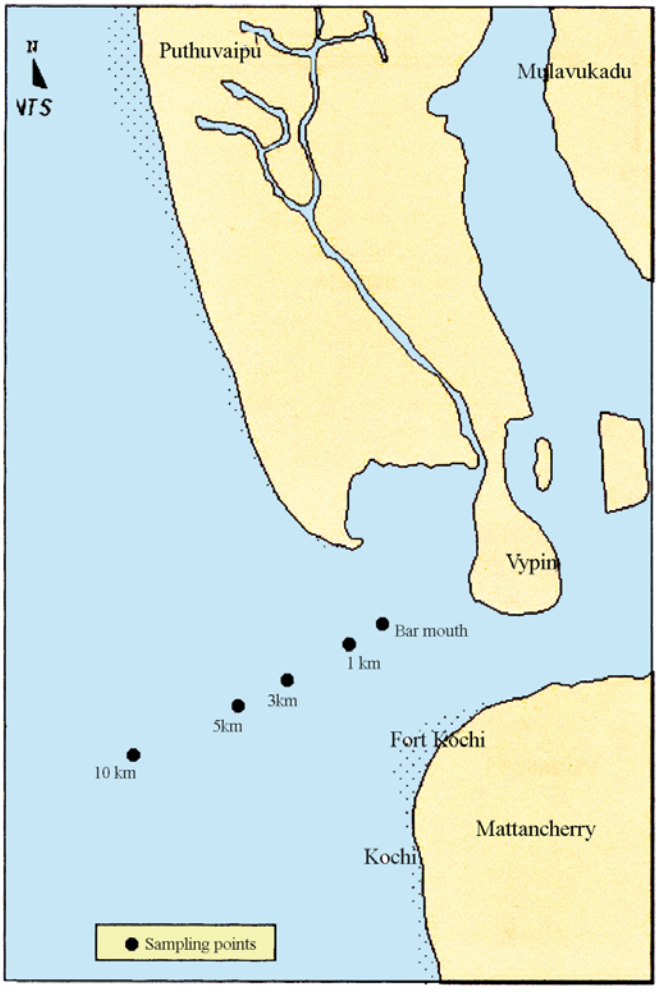


Fig. 3.8.2.2 Sampling points in the Kochi hotspot region

discharge untreated effluents directly to the sea, rivers and estuaries and thus severely affecting the marine and fresh water ecosystem of this region.

- At Veli also there is a similar situation due to the discharge of acidic effluent from a neighboring industry. In order to prevent this effluent discharge, it is recommended to set up separate effluent treatment plants according to the terrain of the particular area.
- Setting up of effective sewage treatment plants will also be very useful in safeguarding the environmental quality of these areas. Neendakara, Calicut, Cannanore, Chitrapura, Honavar and Karwar are included in the Low risk region and Alleppey, Kayamkulam and Paravur are included in the no risk region. The maximum pollution is up to 5 km across the coast.
- At Kavaratti, most of the areas are clean except the near shore. The closed side of the lagoon is almost polluted due to the huge discharge of domestic and anthropogenic wastes. The trace metal concentrations in the Kavaratti region found to be within the accepted standards.
- Semi-diurnal studies in the lagoon region at Kavaratti reveals the fact that water quality fluctuated widely from morning to evening. High counts of TC and SFLO observed indicate the intensity of degradation occurring in the lagoonal environment.
- This may be due to the discharge of domestic refuse and the fish wastes along the banks of the lagoon. Setting up of effective sewage treatment

P. P. Ouseph
Funding: Ministry of Earth Sciences, Govt. of India

3.8.3 Geochemical investigations on anthropogenic mercury and other heavy metals in Vembanad lake sediments

The geo chemical investigation of sediments from the hydrosphere has recently become a major subject of interest in research on aquatic systems, as they reflect the current quality of the system and provide information on the impact of man (Singh *et.al*, 1997).

Total mercury and other heavy metals like Pb, Cd, Cu and Zn in sediment, water and biological samples of Vembanadu Lake and rivers debouching to the lake were estimated for a period of two years. Seasonal variation in water chemistry was also studied for premonsoon and monsoon seasons.

The statistical analysis of water quality parameters shown that Principal Components (PCs) governing the backwater system was Chloride, Salinity, Calcium hardness and total hardness, Biological Oxygen Demand (BOD), and pH. BOD as a principal component due to urban sewage and industrial effluents along with decreased dilution rate has significant effect on the backwater system. The values obtained for physico-chemical parameters such as salinity, chloride, total dissolved solids (TDS), conductivity, turbidity, pH and hardness were underline this fact. The lake samples are more alkaline and saline than any adjoining river stretches except the Chitrapuzha which was shown estuarine characteristics in the premonsoon season where the input of fresh water is very low. Seasonal variations are also dominant in the case of Dissolved Oxygen (DO),

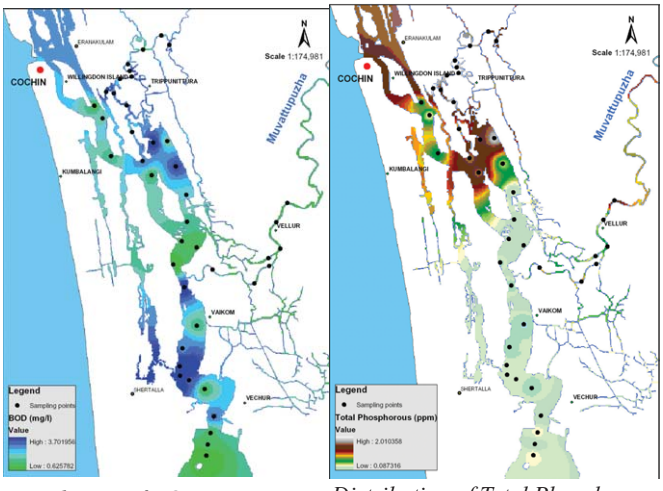
(BOD) and Chemical Oxygen Demand (COD). Nutrient concentration was high in the premonsoon and maximum values shown by Chitrapuzha indicate high amount of sewage and organic waste disposal might be entered in to this stream.

The chemical analysis of heavy metals such as Pb, Cd, Cu Zn, and Hg in water and sediment samples were conducted. Maximum concentration of THg in Lake water varied from 10ng/l (monsoon) to 20ng/l (nonmonsoon). The THg in Periyar river water samples varied from 50 – 130ng/l. High mercury concentration was observed only at certain stations in Periyar river and Cochin estuary area. This might be due to the effluent discharge from different industries located on the banks of the river.

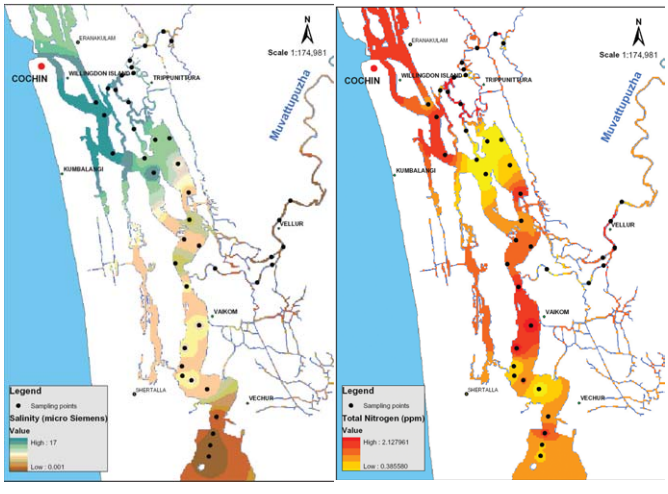
The maximum values for Pb was noticed in water samples during non monsoon months (2.1 – 2.6 ng/l). The mean concentration of Cd was obtained for non monsoon samples and it is varied from 0.38 to 0.39ng/l and the low mean value is in monsoon season (0.28ng/l). The Cu content in Lake water varied from 0.004-78.4ng/l and is high during non monsoon seasons. The Cochin estuary and Periyar river samples contains more Cu than the other samples. The Periyar river showed a minimum Cu concentration of 6.3ng/l and a maximum of 78.4ng/l.

Total mercury in Vembanad Lake sediments were varied from 0.002 to 0.13 σg/g with a mean value of 0.03 σg/g. Higher values in Lake sediments (0.13 σg/g) were obtained during premonsoon. During all the seasons the mean sediment THg concentration was showed very little changes and higher values were obtained for the sediments of Periyar River (0.12-12.20 σg/g).The mean concentration of mercury in Periyar river sediment was 2.65 σg/g.

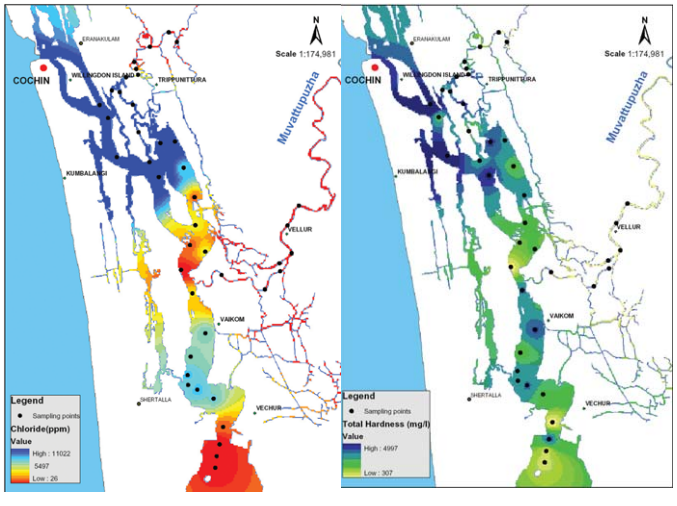
The Lake sediment samples were showed a maximum concentration of 75.8 σg/g for Pb. The minimum and mean concentration obtained for the same is 3 σg/g and 33.84 respectively. The maximum Cd concentration was high for Periyar sediments (11.4 σg/g) and low for Muvattupuzha (2.1 σg/g) with a mean concentration of 3.83 σg/g and 0.87 σg/g respectively. Lake samples were shown a mean concentration of 1.36 σg/g. Cu concentration in lake sediments varied from 6.8-125.8 σg/g and the mean value was 41.44 σg/g. High concentration for Zn (1528 σg/g) was obtained for Periyar river sediments during the premonsoon season. Zn in Lake samples varied from 16-401σg/g. The premonsoon sediments were shown higher concentrations for Zn in Lake(401 σg/g), Chitrapuzha (398 σg/g), Muvattupuzha (142 σg/g), Cochin estuary (520 σg/g) and Periyar river (1528 σg/g).Concentration of heavy metals and mercury



Distribution of BOD *Distribution of Total Phospherous*



Distribution of Salinity *Distribution of Total Nitrogen*



Distribution of Total Chloride *Distribution of Total Hardness*

is positivelycorrelated with the organic matter in the sediments. Pb, Cd, Cu and Zn also showed high values in different environmental matrices.

THg in core samples from Periyar river samples were shown a decrease in concentration towards the bottom. At the first site THg varied from 1.01ppm to 0.8ppm. But in the second site low concentrations were obtained (0.25 – 0.15ppm). Site 3 and 4 shown high concentrations than others and varied from 3.1-2.6ppm and 5.0-3.94ppm respectively. Variation in THg concentration in the core samples indicates anthropogenic input of mercury from factory effluents and other atmospheric fall out.

Total mercury and other heavy metals were determined for several fish samples of various types available from the study area. Various parts of fish samples (gills, flesh and alimentary canal with liver) were analysed for total mercury. THg was observed mainly in fishes such as Arius arius, Etroplus suratensis etc., which are bottom feeders and omnivoric. In Arius arius maximum concentration was obtained in alimentary canal (7.5ppm) where in Etroplus it is in gills (3ppm). THg concentration in mugil cephallus is minimum in flesh (0.5ppm) and maximum in gills (1.5ppm). Macrobrachium rosenbergii shown a maximum concentration of 1.69ppm. The bottom feeding fishes showed high concentration of total mercury.

Since heavy metals are non-degradable and are toxic metal pollutants are being continuously concentrated in the estuarine sediments with unpleasant consequences for the future requires special attention.

Present study mainly focuses on the heavy metal pollution, particularly, mercury in the Vembanadu lake ecosystem. Mercury, which is one of the major toxic heavy metal, requires special consideration because it can undergo methylation in the aquatic environment by both biotic (micro organisms) and abiotic processes. Mercury also bio accumulate and bio magnify in the food chain.

P. K. Omana

3.8.4 Nutrient flux studies in the Ashtamudi estuary

The term nutrients in the aquatic environment refer to the dissolved inorganic forms of nitrogen, phosphorous and silicon, which is utilized by photosynthetic organisms, in the formation of organic matter. Nitrogen and phosphorous are bio-limiting elements, since concentration of these elements

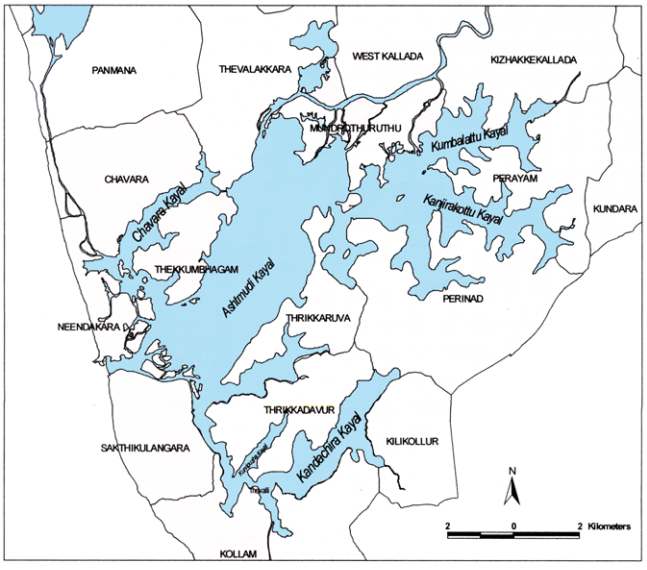


Fig. 3.8.4.1 Ashtamudi estuary - the study area

limits biological growth. Thus, nutrients in estuaries play a definite role in controlling the productivity of the system. The nutrients supply from fresh water inputs in important in sustaining their high rate of primary production, but today estuaries receive some of the highest inputs of nutrients because of the local influence from land drainage and pollution from high urbanization in the banks of estuaries, which in turn reduces the water quality and creating eutrophication.

Fig. 3.8.4.2 Field measurements in progress

The Ashtamudi is the second largest estuarine system; one of the Ramsar sites (Ramsar no-1204) of Kerala having water surface area of 57 Sq.km. is connected to the Arabian Sea at

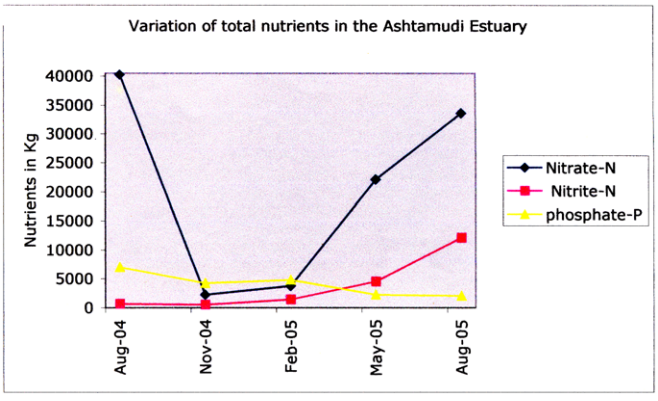


Fig. 3.8.4.3 Variations in total nutrients in the Ashtamudi estuary

Neendakara. The major fresh water input to the estuary is through the Kallada River, which is 121 km long and is formed by the confluence of three tributaries viz., Kulathupuzha, Chendurni and Kalthuruthy that originate in the high lands of the Western Ghats. The Ashtamudi estuary receives pollutants of various types through domestic and municipal sewage, effluents from the industrial area, waste disposal from the port and fishing harbor activities, husk retting and processing, salt water washings from aquaculture ponds, and leachates through TS canal.

The present work envisages study of the nutrient chemistry of the Ashtamudi estuary by studying the water quality, DO quantifying the nutrients and the dispersal and pathways of nutrients. The study also aims to monitor the effects of pollution and to assess the productivity status of the estuary.

Extensive field operations were conducted. A Vandorn water sampler was used for the collection of surface, mid-depth and bottom waters. Water current and direction were recorded at every 15 minutes interval using mooring type current meters. Tide measurement was taken in every 15 minutes interval from tide staffs fixed at each location. Temperature, pH, salinity and measurements were carried out ***insitu*** using portable water quality analyzer. Chlorophyll-a was estimated by filtering 500ml of the water sample through 0.45µm porosity membrane filter paper and extracting it with aq.acetone solution.

Nutrient flux is calculated for the day of sampling with using nutrient data from the analysis and water discharge data obtained from the current meters. Average cross-sectional area is also calculated from the depth of diurnal monitoring stations. The nutrient flux for every hour are calculated and is summed to 24 hours giving the net flux for a day, using Excel spreadsheet application and programming.

Nutrient flux in the Ashtamudi Estuary and the boundary layers of the estuary has been estimated in a study period of one year comprising of five surveys. Major input of nutrients into the estuary is through Kallada River and TS Canal during the monsoon period. Nitrate content in the estuary was marked with drastic variation, showing heavy consumption during monsoon periods. Increased utilization of phosphates also was noticed during monsoon, but in the case of nitrates, it was observed that input has exceeded consumption. Land derived Nutrient inputs to the estuary was found to be maximum during monsoon months.

M. N. Muraleedharan Nair

3.9 Biophotonic applications

The laser-induced fluorescence and diffuse reflectance spectroscopy (LIFRS) system developed in the Biophotonics laboratory of CESS was used for detection of early stages of oral cancer and dental enamel erosion that lead to caries formation.

3.9.1 *Early discrimination of oral cancer using laser induced autofluorescence spectral ratio reference standard*

Oral cavity cancer represents a significant health problem owing to its high rate of incidence. Measurements were carried out to diagnose different grades of oral cancer at the outpatient clinic of the Regional Cancer Centre (RCC), Thiruvananthapuram, after obtaining clearance from the Ethics Committee of RCC. The study subjects included 35 healthy volunteers with no clinically observable lesions or inflammatory conditions in their oral cavity and 44 patients under varying stages of cancer affecting different anatomical sites of the oral cavity.

In order to develop a site-specific database, fluorescence measurements were taken from 14 different anatomical sites of the oral cavity in healthy volunteers. Excluding the vermillion border of lip, the dorsal and the lateral sides of tongue, the LIAF spectra from 11 sites showed similar spectral characteristics with a broad autofluorescence peak at 500 nm. Flourescence intensity ratios from 20 patients were used for the development of a spectral ratio reference standard (SRRS); while the remaining data from 17 patients were used for the blind test to validate the reference standard developed.

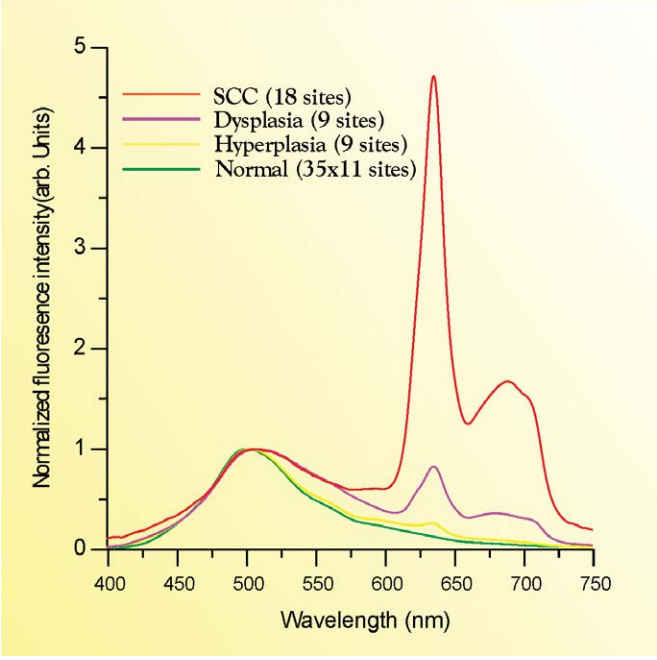


Fig. 3.9.1.1 LIAF emission from different types of oral mucosa from 40 sites of 20 patients and the mean spectra from 11 sites in 35 healthy volunteers, normalized to autofluorescence emission at 500nm

The 500 nm emission observed in the LIAF spectra is due to emission from endogenous fluorophores, like NADH, FAD, collagen, elastin and amino acids. In SCC and dysplastic tissues, this peak appears broadened and red-shifted by about 20 nm and two additional peaks due to protoporphyrin IX (PpIX) emission are observed around 635 and 705 nm. In addition to these peaks, we noticed a prominent peak around 685 nm in malignant tissues due to the accumulation of endogenous flurophore corproporphyrin III, which is a precursor of PpIX in the heme synthesis, in cancerous cells (Fig. 3.9.1.1).

The mean fluorescence intensity ratios, F500/F635, F500/F705 and F500/F685, show a decreasing trend with increasing malignancy, with the lowest values for SCC and highest for normal. The F500/F685 ratio shows a maximum variation of 45% between normal and hyperplastic tissues and 68% between hyperplastic and dysplastic tissues, whereas between dysplastic and SCC tissues, the F500/F705 ratio varies by 75%. Fig. 3.9.1.2 (a-c) shows the SRRS for F500/F635, F500/F705 and F500/F685 ratios. Sensitivity and specificity of discrimination are assessed based on the cut-off discrimination lines drawn between the normal and hyperplastic, hyperplastic and dysplastic, dysplastic and SCC at values that correspond to the average ratio values of the respective groups. For the F500/ F635 ratio, by selecting cutoff at the mean of normal and hyperplastic values (7.08), a sensitivity and specificity of 89% and 97% respec-

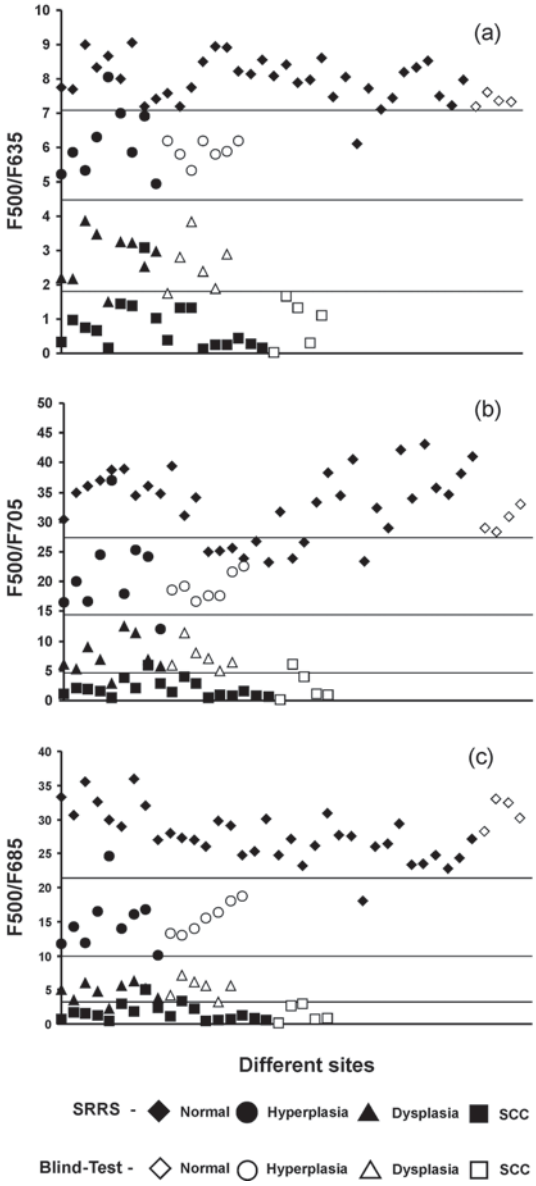


Fig 3.9.1.2(a-c) Spectral ratio reference standard (SRRS) developed from 35 healthy population and 40 sites in 20 patients for fluorescence intensity ratios (a) F500/F635 (b) F500/F705 and (c) F500/F685. The solid symbols represent SRRS while the hollow symbols relate to the blind test results at 21 sites in 17 patients.

tively, was obtained to discriminate normal from hyperplastic mucosa. In the same plot, the cut-off drawn at 1.79 discriminates premalignant dysplastic tissues from malignant SCC with a sensitivity and specificity of 95% and 86%, respectively. Further, an overall sensitivity and specificity of 89% was achieved for distinguishing normal from hyperplasia, whereas a sensitivity and specificity of 100% and 96% respectively, was obtained to distinguish dysplasia from hyperplasia.

For validation, the spectral ratios from 21 sites of 17 patients were inserted in the SRRS developed (Fig.3.9.1.2 a-c) and the results were correlated with histopathological findings. It is seen that SRRS discriminates normal mucosa from hyperplastic, and hyperplastic from dysplastic mucosa, with 100% sensitivity and specificity. An overall sensitivity of 93% and specificity of 94% was achieved in discriminating 5 SCC lesions from 6 dysplastic tissues.

The SRRS scatter plots developed gives improved sensitivity and specificity as compared to earlier reports and matches well with the gold standard. Therefore, the methodology developed has the potential to be used for early discrimination of oral dysplasias and hyperplasias, and in cancer grading.

3.9.2 Investigation of dental erosion

Dental erosion has become an increasing predicament in dentistry and diagnosis in its formational phase is a challenging task. Early detection and quantification of caries lesions helps to monitor changes in tooth status over a period of time. Nitrogen laser-induced fluorescence (LIF) and tungsten halogen lamp excited diffuse reflectance spectra were recorded on a miniature fiber-optic spectrometer from in vitro premolar tooth during various stages of artificial erosion with 36% phosphoric acid.

Both the LIF and diffuse reflectance spectral intensity increases gradually during tooth erosion. The LIF spectra from demineralized tooth within 1 min., has the same shape as that of the spectra from sound enamel; but, it slowly get transformed to that of dentin in 5 mins. We also observed that the spectral intensity of the 440 nm band increases with the extent of demineralization. This could be related to the appearance of dentin fluorescing compounds that are associated with the penetration of the demineralizing substances to the dentin layer of the tooth or due to disappearance of prism structure of the hydroxyapatite in enamel with increased demineralization. With curve fitting using Gaussian spectral functions, broad bands seen in cut–section tooth slices at 440 and 490 nm were resolved into four peaks centered at 409.1, 438.1, 492.4 and 523.1 nm in sound enamel and at 412.0, 440.1, 487.8 and 523.4 nm in sound dentin.

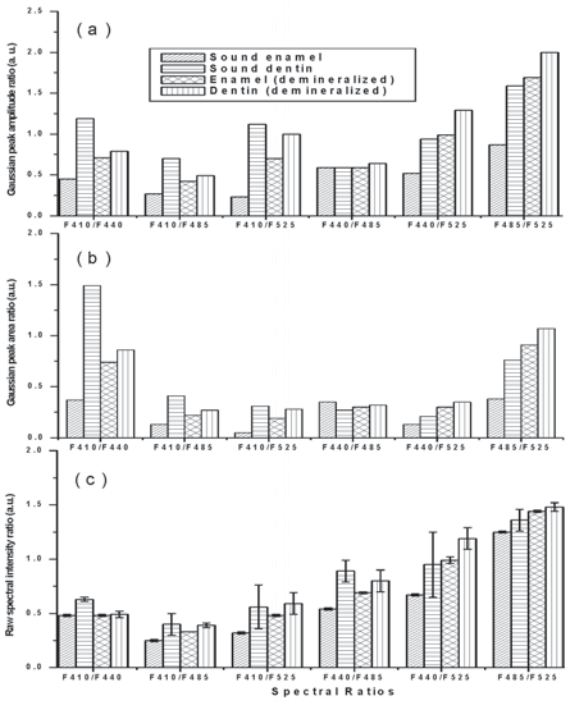


Fig 3.9.2.1 Fluorescence ratios derived from a) curve-fitted spectral amplitude, b) curve-fitted spectral area and c) raw LIF spectral data of sound enamel and dentin slices and those of demineralized samples.

The fluorescence ratios (F410/F440, F410/F485, F410/F525, F440/F485, F440/F525 and F485/F525) calculated from Gaussian spectral curve areas and amplitudes derived by curve fitting show pronounced variation with respect to the raw spectral LIF ratios (Fig.3.9.2.1). The transformation from the enamel layer to the dentin layer can be visualized from the sudden increase/decrease in ratios. In all these ratios, marked deviations were seen in 5 min. of dental erosion. Significant differences in the Gaussian amplitude and area ratios (F410/F440, F410/F525 and F485/F525) were observed during the process of demineralization.

On the basis of the results obtained, the UV laser based technique appears to have the potential for in vivo monitoring of demineralization changes in tooth. The fluorescence spectral ratio F410/F525, derived from curve-fitted Gaussian peak amplitudes and curve areas were found to be more sensitive to erosion as compared to the diffuse reflectance ratio R500/R700 and the raw LIF spectral ratio F440/F490. Changes in the LIF spectral shape and constituent peak position could be due to changes in the intrinsic fluorophores and this could help in accurate

differentiation between carious tooth and early tooth demineralization.

N. Subhash
Funding: Department of Science & Technology, Govt. of India, New Delhi.

3.10 Sand Characterisation

3.10.1 Resource evaluation and inventory of manufactured sand from Kerala State

During the course of the project, extensive fieldwork has been carried out to make primary inventory on quarries of Thiruvananthapuram district. The natural sand and rock sand samples were tested for their engineering properties to identify the suitable ones for concreting purposes. Sieve analysis, specific gravity tests and pipette analysis have been done on all the natural sand samples. Sieve analysis, fineness modulus values and surface area indices of rock sand samples were determined. Geologically, Khondolite is mined at 91 quarries, Charnockite is mined at 12 quarries and at 4 quarries both the varieties are being mined. While 67 quarries fall under excellent quality in terms of homogeneity, in grain texture, massive nature etc, 35 quarries are moderate and 5 quarries were found to be poor. Most the quarries with crushing units have aggregates of ½", ¾" and dust (not rock sand) as products. The dust has been supplied as sand for plastering purposes and concreting purposes. These quarries usually use jaw crusher for crushing the aggregates into smaller size fractions. The crushing unit at Poabs Granites uniquely uses a Vertical shaft Impactor for getting rock sand with texture and gradation similar to natural sand. Out of the 107 quarries, 47 are big with exposure height having 24 – 27m.

Five thematic maps were prepared using 1:25, 000 SOI topographic sheets for creating a detailed digital data base of the quarries in the district, under GIS platform using ArcView. Surveying of important quarries for volume estimation was completed. All the field and laboratory data were compiled and developed an information system for quarries (QIS).

D. S. Suresh Babu
Funding: Department of Science & Technology, Govt. of India

3.11 GIS Applications in Natural Resources Management

3.11.1 *High resolution remote sensing data and information technology for local level planning*

The project was intended to generate and implement the locale specific, integrated land and water resources development plans for the area on a pilot basis in order to develop and standardise methodologies. These were based on techniques of geoinformatics, especially remote sensing and other collateral sources on landuse/land-cover, soils, groundwater prospects, and slope combined with the local socio-economic scenario. PRINCE was designed essentially to provide information systems support to the Tirurangadi Block based on the data thus generated.

Objective of the programme is to develop methodologies for accurate mapping of the resources at parcel level to generate

Fig. 3.11.1.1 A screen shot of the 'PRINCE'

land/water scenario, socio-economic database etc, which would converge in to a query shell based information system

Thematic maps of Kollengode and Vadavannur panchayats have been finalized and subjected to Integrity checking of the layers. Asset mapping for Kollengode and Vadavannur panchayaths based on the asset document provided by the Panchayats completed. NRIS codification process for the different thematic attributes comleted. Slope and aspect generated for the area has been vectorized and field validation of assets carried out. Final project report incorporating the

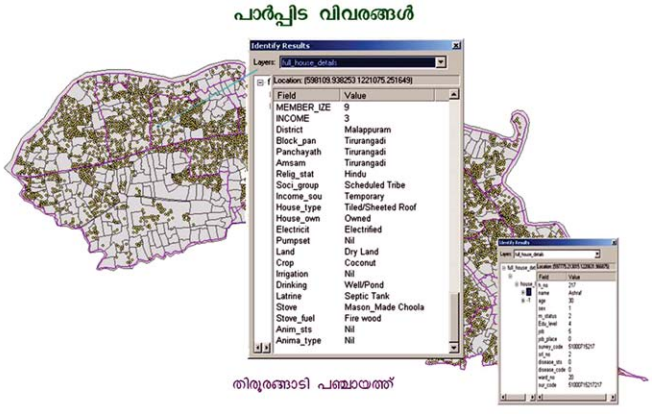


Fig.3.11.1.2 A screen shot of information system of Tirurangadi panchayat in malayalam

cadastre-level data base of the Tirurangadi Block and Kollengode and Vadavannur panchayats completed.

K. K. Ramachandran
Funding: Indian Space Research Organization

3.11.2 Generation of natural resources and environmen tal database for local level planning

Realizing the need to provide the natural resources and environmental data for local level planning, 1SRO at the specific request of Kerala State Planning Board has embarking upon a prestigious program to create Natu-ral Resources and Environmental database (NREDB) on 1:12,500 scale, which could be used for local level plan-ning purposes. The project is being executed by CESS and KSREC. As part of the above program, the resource monitoring of the entire State of Kerala has been generated.

Main focus of the programme is to prepare and disseminate spatio-temporal information on land and water resources for sustainable development of natural resources through the state of the art techniques of remote sensing and GIS. The project envisages use of remote sensing technology and geographical information system (GIS) for the generation of reliable and timely information on natural resources. The present study is aimed at preparing different thematic layers on natural resources using satellite images, other collateral data and field observations. Ultimately, this would lead to drawing up of location-wise resource based perspective plan for sustainable development. Digital and visual interpretation of LISS IV satellite data is being used for the thematic layer generation. Digitization of spatial contour information of all the districts completed and district-level merging of contour and QC under progress. Delineation of Landform of Thrissur, Alappuzha, Ernakulam, Kannur, Pathanamthitta and Kasargod districts completed and Pathananthitta and Kasargod districts are ongoing. Hydrologic data collection in the Alappuzha, Ernakulam, Thrissur Kozhikkod, Kannur, Kasargod and part of Idukki Districts completed. Ground water prospect map of Malappuram, Palakkad and Kollam Districts Thiruvananthapuram and completed. Lineaments of Kasargod, Kannur, Kozhikkod, Thrissur, Ernakulan, Pathanamthitta, Kottayam, Kollam and Thiruvananthapuram Districts extracted from the imagery. Merging and QC of Spatial slope information completed. The QC of the digital database of the thematic layers prepared is being carried out. Landslide hazard zonation of 6 districts completed. Relative relief and relief maps of 14 districts of Kerala completed.

The shape file data of 6 districts has been integrated as coverage in RRSSC frame. Analysis of non-spatial data in progress. Mosaicing of district-wise images in progress. Analysis and reproduction of socio & economic data is in progress. Grid wise intersection of thematic layers and individual theme ranking for hazard zonation in progress. Frame work of the Geo-environmental Resource Atlas prepared. The QC of the digital data base of the thematic layers prepared is being carried out

M. Samsuddin
Funding: Indian Space Research Organization & State Planning Board, Govt. of Kerala
Collaborator: Kerala State Remote Sensing and Environment Centre

3.11.3 Bio-Geographical Information System (BGIS) for Thrissur District

The BGIS is a comprehensive information system capable of viewing and querying GIS map layers and biodiversity information. It is a powerful tool for the preparation of species database, atlases, derivative maps for identification of biological hotspots and preparation of habitat-wise conservation plans. It is useful for managing and monitoring spatial relationships of species distribution pattern, for identification of biological hotspots, for prioritizing developmental needs. It would also help in environmental impact analysis (EIA), estimate species loss when implementing developmental projects, construction of reservoirs and roads as well as to suggest/find out alternative sites with least damage to biodiversity. It is also helpful to find out species on the

verge of extinction and identify possible threats to their habitats, and to explore the existence of RET species in hitherto unnoticed locations. The facility to search for newer habitats with similar ecological amplitude for species in need of rescue/ rehabilitation and eco-restoration based on query is an added attraction.

Since it integrates spatio-temporal inputs on land, water, and climate, it could also be useful for evolving suitable management strategies for the sustainable development of a region. The study also highlights the need for a full-fledged BGIS for the State to further the cause of biodiversity related studies, conservation planning and monitoring of our rich heritage, using GIS, RS and IT tools against conventional taxonomic studies, which is laborious and time consuming.

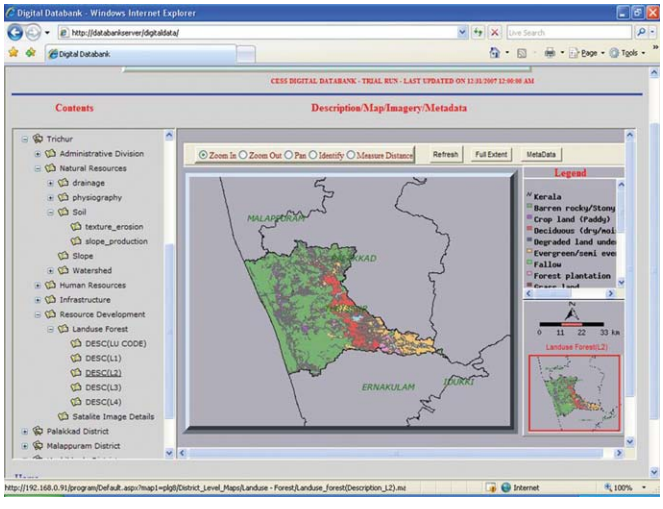


Fig. 3.11.3.1 Bio Geographical Information System for Trissur district, Kerala

A Bio-Geographical Information System (BGIS) for Thrissur district, sponsored by Kerala State Biodiversity Board, has been developed by Centre for Earth Science Studies (CESS) in collaboration with Kerala Forest Research Institute, Tropical Botanical Garden and Research Institute, Kerala Agricultural University etc. Preparation of thematic maps in GIS, design of bio-resources database, data entry software, information system and system integration were the major work components of CESS. Customized software was designed and developed using MapObjects and Visual Basic for viewing thematic maps, retrieving geographical and environmental data and biodiversity information. Environmental data entry software package has been developed and installed at KFRI and other collaborating institutions.

V. N. Neelakandan

3.11.4 *Preparation of city base maps for the five Municipal Corporations of Kerala*

Urbanisation places enormous burden on organizations responsible for planning and management of urban regions. There is an ever-increasing demand for land, shelter, employment and infrastructure in the urban areas. Effective policies, plans and implementation procedures must be designed and implemented to match these requirements. This in turn necessitates accurate spatial information in cadastral scale.

The study area is confined to the 5 Municipal Corporations of Kerala Viz., Thiruvananthapuram (142 km2), Kollam (58 km2), (Kochi (88 km2), Thrissur (101 km2), and Kozhikkod (84 km2), covering a total area of about 400 km2. The proposed work has different components such as remote sensing, ground truthing, GPS and GIS. The project essentially focuses on deriving spatial information on various themes of importance to the urban domain in cadastral scale (1:4000). QuickBird satellite data of 0.6 metre resolution is used for database generation. Digital and visual interpretation of high-resolution remote sensing data was employed for preparing various thematic layers using image interpretation techniques. The thematic and the derivative maps generated were vectorized and brought into a GIS platform for integration with other related supplementary data for querying, retrieval and decision-making.

GPS survey for establishing Principal Reference Points (PRP) at Kollam, Kochi, Kozhikode and Trichur and Thiruvananthapuram corporations were carried out and post processing of data completed. GCP survey in Kollam, Kochi and Kozhikode completed.

QuickBird images obtained for the three Municipal corporations of Kollam, Kochi and Kozhikode have been georeferenced using the DGPS data. Mosaic of the cadastry of the town blocks of the three corporations has been prepared and rectified with reference to the QuickBird images. The cadastry has been vectorized and quality checking and geodatabase conversion completed. Digital thematic layers such as road network, drainage, landuse and major buildings and individual households as visible from imagery were generated MSS and PAN fused image of the QuickBird satellite data and the database has been integrated.

Intensive field work was carried for asset verification, assigning of attribute, locating of additional landmark assets on the initial maps prepared from image, verification of transport network

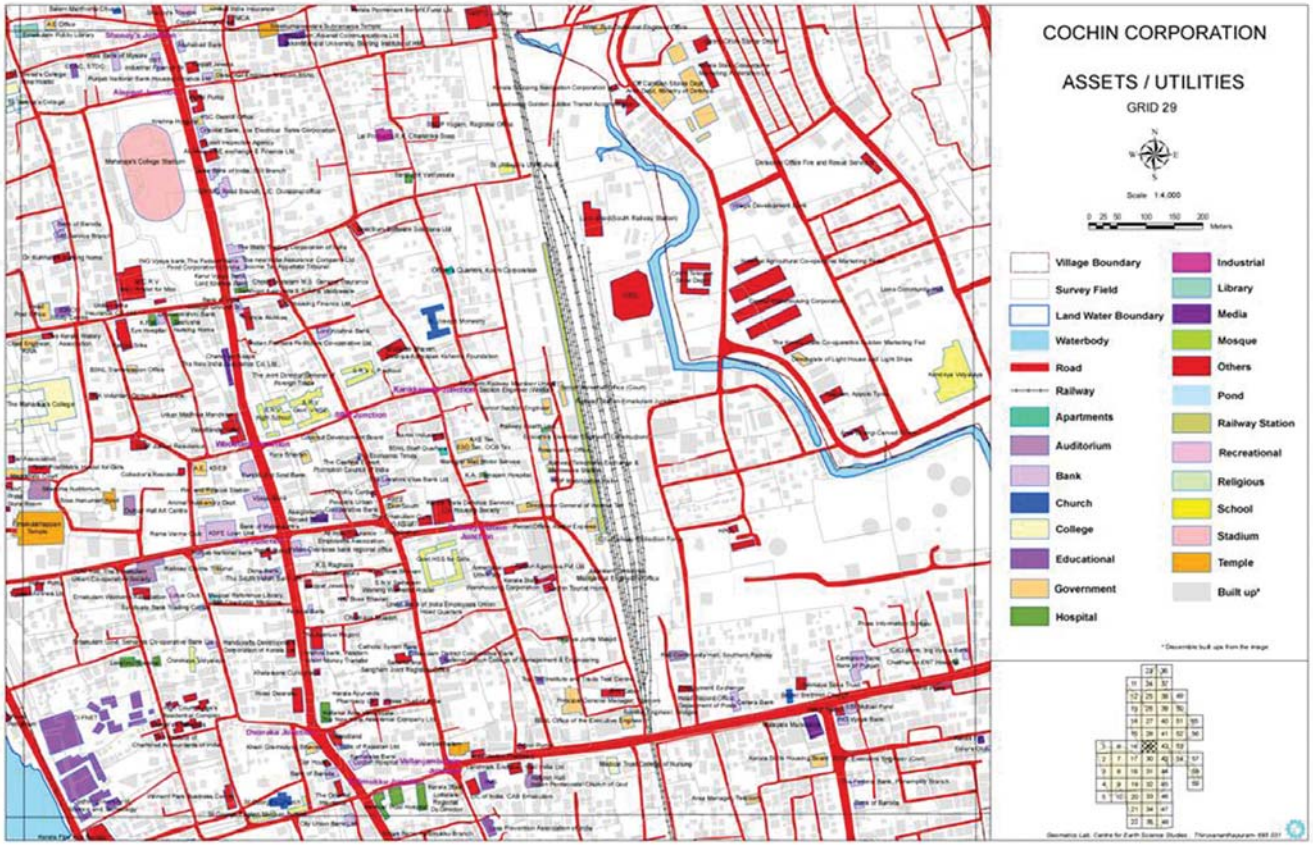


Fig. 3.11.4.1 A portion of the High Resolution map of of Kochi showing assets and utilities

and tracing the missing roads on the field, validation of landuse derived from the QuickBird image. Maps on all themes of the three corporations printed in 1:4000 were reproduced in A2 format as well as in A4 format. launching the new version.

M. Samsuddin
Funding: Kerala State Urban Development Programme

3.11.5 Spatial and non-spatial database for health surveillance in the Vengannur Grama Panchayat

This is a collaborative programme for building a Participatory GIS for Vengannur Grama Panchayat of Athiyannor Block as a part of ASA (Athiyannur Sree Chitra Action Programme) programme. Health Information System (HIS) is essentially a capacity development at community level for a healthy Participatory Geographical Information system building. Main objective of the programme is to generate comprehensive spatial data base (resource and health relates data) at micro level. HIS is envisaged to integrate spatial and non-spatial data in a customized environment using .Net and Map Objects of ESRI with facilities to integrate, analyze, query and extraction of user required information according to the will and wish of the user.

Convened a meeting of health workers at CHC Vizhinjam and demonstrated the utility of spatial data. The first round of correction of building numbers have been completed in consultation with the ward members of the Vengannur panchayat which has been has been finally linked to the spatial datasets.

The customized Health Information System developed as part of this programme is being modified by taking into consideration the user input. Ward-level entry of socio-health and demographical data entry in Oracle database has been completed and linked with the spatial data of the local body.

The system is useful for health officials and decision makers to

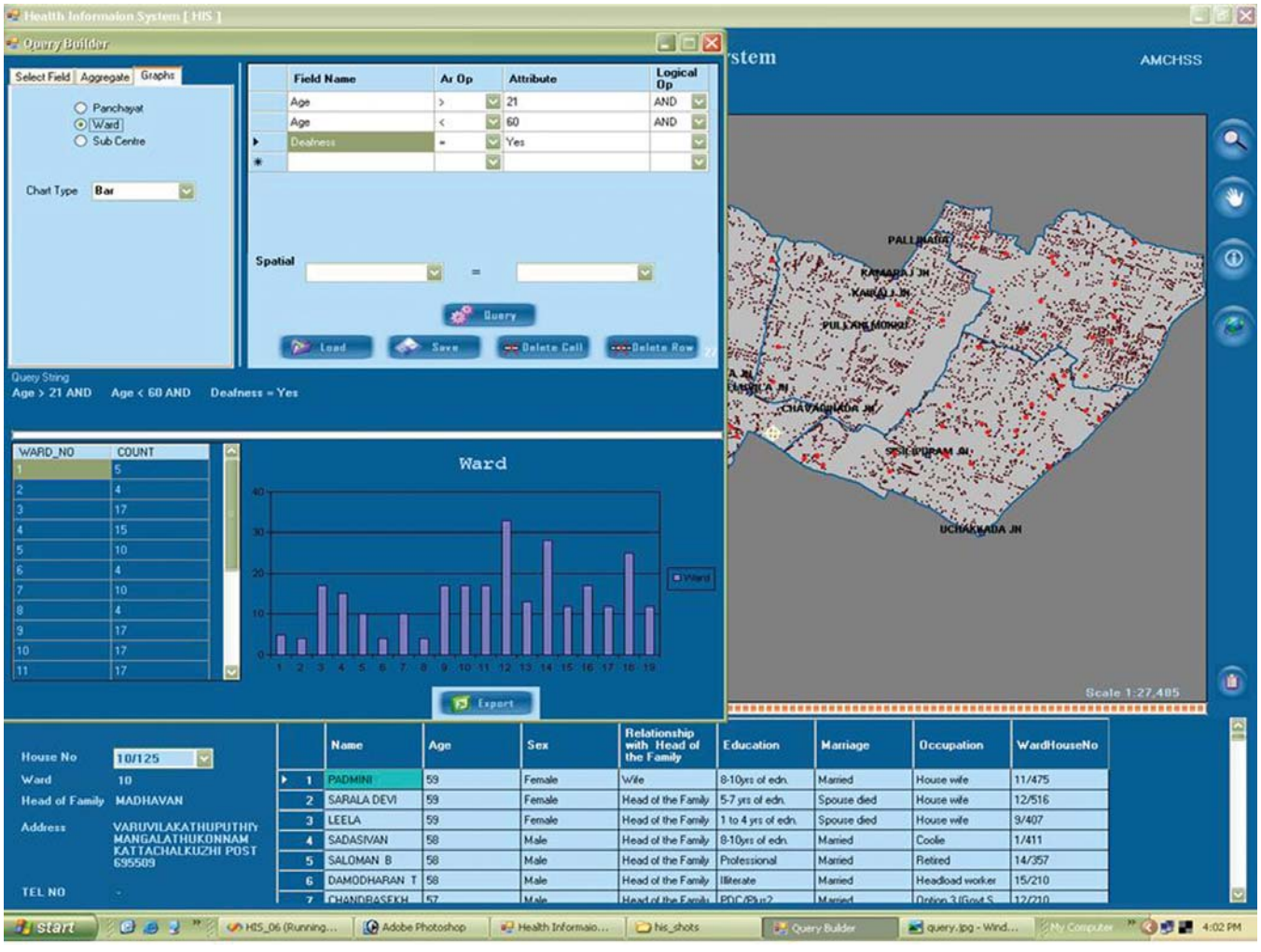


Fig.3.11.6.1 A screen shot of Health Information System

implement health related projects and to expedite health services to the local people during disease out break and for health surveillance.

B. K. Jayaprasad
Collaborator: Achuthamenon Centre for Health Science Studies, Thiruvananthapuram

3.11.6 Creation of a digital data bank at CESS

Objective of the project is to create state-of-the-art facilities for efficient management and retrieval of desired data and to develop a digital data bank of spatial and non-spatial data in conformity with NSDI framework.

Map themes on geology (based on1:500,000 scale GSI map) for the entire Kerala State and those of Trivandrum, Kollam, Kottayam, Alappuzha, Ernakulam, Kannur and Kasargod districts (based on 1:250,000 scale GSI maps) and thematic layers of Wynad District generated as part of the PLG-8 project and 1:50,000 scale digital soil map of Thrissur District have been incorporated into the databank.

A dedicated Network Attached Storage system (NAS) having an array of SCSI hard disks (1 TB) with RAID configuration has been procured and made operational for enhancing the storage and backup facilities of the dedicated spatial database server. The NAS Gateway server provides data access to various server/clients on network using NFS/CIFS protocol. The solution is scalable with number of servers and storage requirements.

As part of efforts to make the data bank contents web enabled, the metadata browser developed earlier has been modified. The modified version makes use of ASP.NET, HTML, UMN Mapserver and CSharp software. The Mapserver is open source software. It consists of the Webserver, database server and other scripting languages that are used to request the data to the server. The NSDI Metadata utility software is used for generating metadata information.

The prototype web application developed is being tested in the CESS intranet. It has facilities to zoom in and out, pan, identify, measure distance, view metadata etc. The system is under trial run.

V. N. Neelakandan

3.11.7 District spatial information system for Kasaragod district of Kerala

patial information is vital for planning with ready reference material. Information may be scattered at many sources. If all those valuable spatial data are brought to a single space, planning process will become simpler. The present project, is an attempt in this direction to create a spatial information for Kasaragode district in digital as well as in the hard copy format. Spatial data derived from survey of India topographic maps on 1:50, 000 scale, Geological Survey of India, Central Survey Department, Central Groundwater Department, Kerala State Landuse Board, Kerala State Soil Conservation Department, statistical data from the Directorate of Economics and Statistics, Census of India data, IRS LISS III digital data etc. were used in the creation of the digital database. Eighty five thematic maps including land use/land cover, land capability, Digital Elevation Model (DEM), slope, aspect and drought prone areas were prepared and published as an atlas in both digital and hard copy formats.

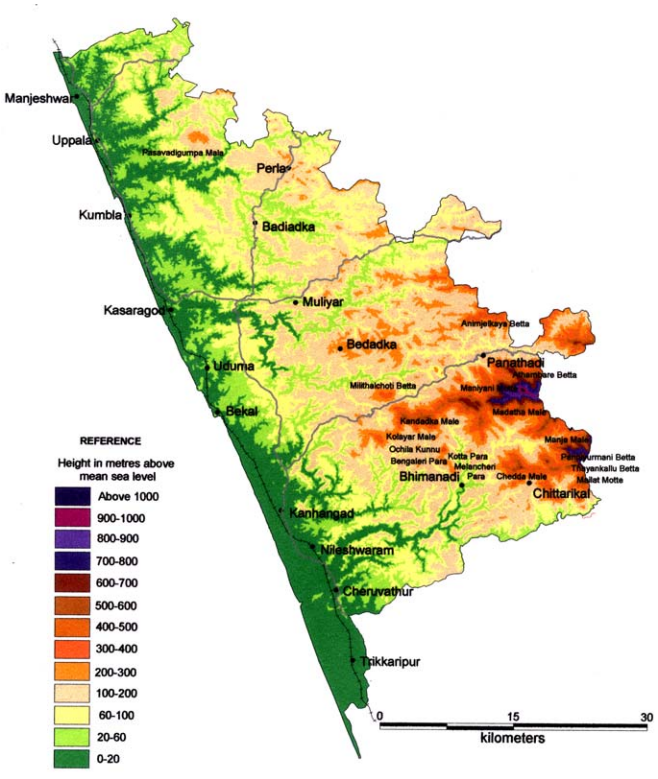


Fig.3.11.7.1 The elevation map of Kasaragod district

Ahalya Sukumar

3.11.8 Resource atlas of Thiruvanathapuram district, Kerala

Resource atlas is a collection of multi-coloured thematic maps showing distribution of / utilization of resources. It is a prerequisite for integrated planning. It would include themes like natural resources, human resources, resource development, infrastructure and regional development. These maps will be ready reference for the administrators and planners. The maps are prepared in digital format using Geographic Information System (GIS). During the period under report the following maps were prepared on the distribution of workers: workers under household industries, male workers under household industries, female workers under household industries, total other workers, male other workers, female other workers, total marginal workers, male marginal workers, female marginal workers, marginal cultivators, male marginal cultivators, female marginal cultivators, marginal agricultural labourers, female agricultural labourers, marginal workers in household industries, marginal , male workers in household industries, marginal female workers in household industries, marginal other workers, marginal male other workers and marginal female other workers.

Digital thematic maps were also prepared on land use/land cover, wet and dry areas, decadal variation of total population from 1991 to 2001, decadal variation of Male population from 1991 to 2001, decadal variation of female population from 1991 to 2001, decadal variation of total scheduled caste population from 1991 to 2001, decadal variation of total main workers from 1991 to 2001, decadal variation of male main workers from 1991 to 2001, decadal variation of female main workers from 1991 to 2001, decadal variation of total cultivators from 1991 to 2001,

decadal variation of male cultivators from 1991 to 2001, decadal variation of female cultivators from 1991 to 2001, decadal variation of total agricultural labourers from 1991 to 2001, decadal variation of male agricultural labourers from 1991 to 2001, decadal variation of female agricultural labourers from 1991 to 2001, decadal variation of total household workers from 1991 to 2001, decadal variation of male household workers from 1991 to 2001, decadal variation of female household workers from 1991 to 2001, decadal variation of total other workers from 1991 to 2001, decadal variation of male other workers from 1991 to 2001 and decadal variation of female other workers from 1991 to 2001. In addition Digital Elevation Model, slope, aspect maps were also completed.

B. Sukumar

4. Consultancy Programmes

4.1 Environmental Studies

4.1.1 Feasibility study for hard rock quarrying operations at Keezhayikonam, Nellanad, Venjaramoodu, Thiruvananthapuram

A detailed study has been carried out with respect to the feasibility of quarrying operations in Survey Nos.65/3 and 65/13 of Nellanadu Village of Thiruvananthapuram Taluk. The environmental implications of metal crushing operations in the area and the feasibility of quarrying has been assessed based on the evaluation of various environmental attributes and the magnitude of quarrying and crushing operations. The study has considered various environmental attributes, especially with respect to land stability and societal concerns. Accordingly, the recommendations contain operation of the quarry with strict conditions.

R. Ajaykumar Varma
Funding: Nellanad Grama Panchayat, Venjaramoodu

4.1.2 Environmental appraisal of a granite crusher unit at Vellavoor, Manimala, Kottayam District

Based on a writ petition, the Hon'ble High Court of Kerala has directed the Centre for Earth Science Studies (CESS) to conduct a study and report to the court regarding the impact of a crusher unit owned by M/s. Promoters Charitable Society at Vellavoor, near Manimala. The study focussed on four environmental issues: ground vibrations caused by the crusher and its impact on upcoming water storage structures 700 m away from the crusher, chances of the water tank receiving air pollutants; noise level impacts on the local population; and possibility of increase in land based activities in the region.

C. N. Mohanan
Funding: M/s Promotors Charitable Society, Manimala

4.1.3 Environmental implications of Local Self Governance – Developing Manual on Environmental Impact Assessment, Environmental Management Planning and Environmental Clearance and Audit

Review of Enactment, Rules, Regulations, Statues and Guidelines of Environmental Protection/Conservation. The Local Self Governments (LSGs) in Kerala have a major role in the environmental up keep of the State. The introduction of Kerala Panchayat Raj Act, 1994 and Kerala Municipalities Act, 1994 enable the LSGs to have vast powers to enforce environmental management requirements and take up appropriate initiatives for environmental protection and conservation. In addition, the Government of India enacted a number of comprehensive laws, rules and regulations and issued guidelines and circulars pertaining to environmental upkeep which also cast various duties and responsibilities on LSGs. The important aspects of these enactments, both Central and State have been reviewed under this project to highlight the role of LSG's in enforcing the provisions of the enactments. The study area included six local bodies covering different agro climatic zones of Kerala, such as Vizhinjam and Koilandy representing coastal low lands, Manjeri and Kottarakkara in the midlands, Nedumudi in the Kuttanad – Vembanad wetland region and Vadakarapathi in the Palghat gap region of the Western Ghats. The study indicates that the level of compliance, in general is poor to moderate. The review highlights that lack of awareness, inadequate technical support, lack of political will etc are the major reasons for the low level of compliance. Considering these, the study recommended an intensive and broad based Information, Education and Communication (IEC) campaign. In order to facilitate this, an Integrated Environmental Cell/Mission is favoured in place of fragmented and single target missions. There is also necessity and possibilities of tapping national and international funds for facilitating capacity building and implementing environmental management projects through the LSGs.

State of Environment report and Action Plan

Credible environmental information is necessary to strengthen decentralize system of planning and move towards sustainable developments. The State of the Environment (SoE) report of the region provides objectives and comprehensive information on environmental conditions and trends including their significance. The SoE report is prepared for four Grama Panchayats and two Municipalities lying in different physiographical zones in the State. One of the methodologies, accepted widely is by analyzing the environmental issues in a driving force-pressure-state-impact-response (DPSIR) format. However, applicability of this format for preparing SoE report of Local Bodies is not tested at the local level. Therefore, model SoE reports are prepared using DPSIR format for Vizhinjam Grama Panchayat and Koilandy Municipalities in the coastal zone, Kottarakka Grama Panchayat and Manjeri Municipality in the midland terrain, Nedumudi in Kuttanad region and

Vadakarapathy in Palghat gap. This is to examine the viability of the methodology and develop model SoE reports. The methodology included a general environmental appraisal of the local region, identification of key environmental issues, analyses of these issues using DPSIR format and suggest action plans. In order to prioritize the action plans and monitor the effectiveness of its implementation, key environmental implications are suggested for future monitoring.

Biodiversity Register of Selected Grama Panchayats and Municipalities.

The Convention on Biological Diversity emphasizes decentralization in the management of bio-resources to the lowest possible level of governance taking stock of all streams of knowledge. The National Biodiversity Act, 2002 adopts this approach and promotes preparation of Biodiversity Register and Management Committee for conservation of Biodiversity at grass root level. However, a full fledged methodology has not been evolved neither in documentation nor in management of bioresources. An attempt has been made here to document all forms of life in an area, as far as possible, taking a local body (grama panchayat/municipality) as the basic management unit. The Environmental study and Biodiversity Register documentation show that rural communities, have a fairly broad based understanding of the local bioresources which they put to diverse purposes mainly in agriculture and medicine, but lack the necessary concerns for its long term conservation and sustainable use. Therefore, the biodiversity register prepared for each of the local bodies serves as a knowledge base of the bioresources and its status in that particular area, analyses the present uses and conservation practices and emphasizes the need for biodiversity friendly process of eco development in the region. This is the first time that a biodiversity register is prepared along with state of environment report of the region for prioritizing conservation of nature and natural resources at micro level.

R. Ajaykumar Varma
Funding: Decentralized Support Programme, Govt. of Kerala

4.2 Coastal Regulation Zone

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

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

CRZ mapping has been undertaken for different departments and public undertakings in the State such as Kerala Coastal Zone Management Authority, Harbour Engineering Department, Local Self Government (Urban Development) Department, Calicut Development Authority, Kozhikode Corporation, Irrigation Department, Port Department, Tourism Department, Kitco, Goshree Island Development Authority and Bakel Resort Development Corporation. It has also been carried out for Cochin Port Trust, National Highway Authority, Indian Rare Earths Ltd and Coast Guard. In addition to this a major CRZ mapping programme is being carried out for the Govt of Maharashtra. This is also done for private concerns such as Kerala Rare Earths and Minerals Ltd, Reliance, Essar Oils, Tata Power, Taj Hotels, Hotel & Allied Trades Pvt. Ltd, Joy's Beach Resort, etc.

Technical support was provided to Kerala State Council for Science Technology and Environment and Kerala Coastal Zone Management Authority on numerous issues connected with Coastal Regulation Zone such as court cases, expert opinion on violations and CRZ clearances, etc.

K. V. Thomas

4.3 Environmental Impact Assessment

4.3.3 EIA of the proposed Airport at Minicoy Island, Lakshadweep

A small Airport with a runway dimension of 1200 m x 30 m is proposed at the northern most portion of Minicoy Island. The site is suggested based on suitability analysis and after examining two other alternate sites. The baseline status of the

island environment is good but fragile. The atmospheric visibility is good throughout the year. The uprooting of coconut trees from the site will incur a loss of about Rs. 4 lakh per annum and the removal of strand vegetation affects land stability. The entire stretch of the project falls in the No Development Zone (NDZ) of Coastal Regulation Zone IV (CRZ IV). The location experiences high waves at times and the proposed site gets inundated occasionally.

The environmental impact due to various ongoing activities in the island is marginal, but minimally adverse. The consequences are mainly on the water and biological environments due to the undesirable practices in tourism and waste disposal. There will be four to five fold increases in the impact level during the construction phase especially on water, socioeconomic and biological environments due to the civil works, transportation and labour camp. However, during the operation phase, the impacts, though adverse, will be marginal. Specific environmental management measures are proposed to be undertaken by which the adverse impact will subside appreciably even during the construction phase. The Minicoy site is in the CRZ and is the only site where acquisition is minimal and favoured by the local inhabitant. The site is also vulnerable to high waves and requires engineering protection, which is prima facie feasible. The environmental impact due to the proposed project here has only marginal adverse during the construction phase and the same will be slightly beneficial during the operational phase. Rapid environmental impact assessment study has been simultaneously taken up for Androtт Island of Lakshadweep also.

R. Ajaykumar Varma
Funding: Lakshadweep Administration

4.3.1 *Rapid Environmental Impact Assessment study of the proposed Breakwater stage III at Androtт island in Lakshadweep*

The existing harbour facilities at Androtт include a RCC jetty, wharf, breakwater of 530 m and associated navigational facilities enable the berthing of small vessels with draught up to 4 m only. The proposed scheme is to enhance the berthing facilities by constructing an additional 700 m of breakwater for developing Androtт harbour as an all weather port for vessels up to 7 m draught. The Rapid Environmental Impact Assessment (EIA) of the proposed Breakwater Stage III at Androtт Island, Lakshadweep was carried out using standard methods and procedures. The CWPRS, Pune provided the design of the proposed breakwater based on wave tranquility studies and sediment transport modeling. The NIO, Goa provided information on the specific impacts of the breakwater on corals. The EIA study found that the environmental impact in the existing phase is minimally beneficial. During the construction phase, the overall impact will be mainly adverse due to the destruction of live corals and other reef organisms along the alignment of the breakwater. Based on the past experience, prospects for natural regeneration of the reef area is possible. Therefore, during the operation phase, the overall impact will be minimally beneficial, though the adverse impacts on marine ecosystem will continue to remain marginally. An Environmental Management Plan was suggested for both construction and operational phases of the project to reduce the adverse impacts considerably and enhance the beneficial impacts during the operational phase.

R. Ajaykumar Varma
Funding: Lakshadweep Harbour Works

4.3.2 *Rapid EIA of Mill Development Programme of Hindustan Newsprint Limited, Vellore*

A Rapid Environmental Impact Assessment (EIA) of the 100 tones/day De-Inking Plant (DIP) of Hindustan Newsprint Limited (HNL), Kottayam has been carried out by monitoring the baseline environmental status of an area with 7 km radius of HNL as impact Zone and evaluating the beneficial and adverse impacts on pertinent environmental attributes. The activities during the existing phase of HNL, construction phase of DIP and operational phases of HNL after integrating the DIP to the main paper mill have been considered for the study which found that the overall impact was minimally adverse, mainly due to problems in air, water and health environments. Considering the reuse of paper waste, waste minimization, reduced use of natural resources and environmentally sound recycling effected consequent to DIP, the impact minimizes considerably. The marginal adverse impact that persists even after adopting the de-inking process has been incidental due to the occasional release of foul odour, unacceptable colour of treated effluents and improper management of wastes. It has been inferred that adoption of appropriate EMP with care while and after integrating DIP Plant with HNL Mill stream can overcome the adverse impacts significantly. It will also lead to a scenario with minimally beneficial impact in the industrial environment.A Rapid Environmental Impact Assessment (EIA) of the 100 tones/day De-Inking Plant (DIP) of Hindustan Newsprint Limited (HNL), Kottayam has been carried out by monitoring the baseline environmental status of an area with 7 km radius of HNL as impact Zone and evaluating the beneficial and adverse impacts on pertinent environmental attributes. The

activities during the existing phase of HNL, construction phase of DIP and operational phases of HNL after integrating the DIP to the main paper mill have been considered for the study which found that the overall impact was minimally adverse, mainly due to problems in air, water and health environments. Considering the reuse of paper waste, waste minimization, reduced use of natural resources and environmentally sound recycling effected consequent to DIP, the impact minimizes considerably. The marginal adverse impact that persists even after adopting the de-inking process has been incidental due to the occasional release of foul odour, unacceptable colour of treated effluents and improper management of wastes. It has been inferred that adoption of appropriate EMP with care while and after integrating DIP Plant with HNL Mill stream can overcome the adverse impacts significantly. It will also lead to a scenario with minimally beneficial impact in the industrial environment.

R. Ajaykumar Varma
Funding: M/s Jaakko Poyri Consulting, Finland

5. List of Projects

5.1 Grant-in-aid Projects

Sl. No.	Project Title	Funding Agency	Principal Investigator	Division	Co-Investigators	Project Period	Total Outlay Rs. in lakhs	Fund received during the year Rs. in lakhs
1.	GPS campaign for crustal movements in and around Palghat gap shear zone, southern peninsular India	Dept. of Science & Technology, Govt. of India	Shri. K. R. Unnikrishnan	Geosciences	Dr. C. M. Harish Dr. C. P. Rajendran Dr. Kusala Rajendran	2001-2006	7.44	Nil
2.	Investigation of the causes behind electrical conductivity variations	Dept. of Science & Technology, Govt. of India	Dr. S. Murali Das	Atmospheric Sciences	Dr. S. Sampath	1999-2006	9.98	Nil
3.	Continuous measurement of atmospheric carbon monoxide at Thiruvananthapuram, a tropical site	Indian Space Research Organisation	Dr. G. Mohan Kumar	Atmospheric Sciences	Dr. S. Sampath	2002-2006	11.73	2.49
4.	Coastal Ocean Monitoring and Prediction System (COMAPS) along Kerala and Lakshadweep coast	Dept. of Ocean Development Govt. of India	Dr. P. P. Ouseph	Chemical Sciences		2003-2007	163.00	11.49
5.	Monitoring of Water and sediment quality in the Cochin Harbour Region	Cochin Port Trust	Dr. P. P. Ouseph	Chemical Sciences	Dr. K. Narendra Babu Dr. P. K. Omana	2001-2006	20.00	Nil
6.	Establishing 10 new seismological observatories in the shield area at Peechi, Thrissur	Dept. of Science & Technology, Govt. of India	Dr. Kusala Rajendran	Geosciences	Dr. C. P. Rajendran Dr. C. M. Harish Sri. K. R. Unnikrishnan	2002-2006	11.05	Nil
7.	Assimilative capacity of urban air and noise environments of Thiruvananthapuram	Science, Technology & Environment, Govt. of Kerala	Shri. V. Muralidharan	Atmospheric Sciences	Sri. V. N. Neelakantan Sri. V. Shravan Kumar	2001-2006	2.58	Nil

Sl. No.	Project Title	Funding Agency	Principal Investigator	Division	Co-Investigators	Project Period	Total Outlay Rs. in lakhs	Fund received during the year Rs. in lakhs
8.	GIS based seismic hazard microzonation of Kochi city using ground shaking site effects data .	Science, Technology & Environment, Govt. of Kerala	Dr. H. N. Singh	Geosciences		2003-2005	9.85	1.72
9.	Coastal engineering strategy for shore protection for Kerala - a pilot project.	DOD/KSCSTE	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian, Dr. T. N. Prakash, Dr. T. S. Shahul Hameed, L. Sheela Nair	2003-2007	81.47	17.15
10.	Watershed studies in selected districts of Kerala with special emphasis on tribal settlements .	Planninng Commission, Govt. of India & Scheduled Tribe Development Dept., Govt. of Kerala	Dr. V. Nandakumar	Geosciences	Dr. P. Rajendran, Sri. V. M. Abdul Hakkim, Dr. D. S. Chandrakaran, Dr. K. Narendra Babu, Sri. S. Sidharthan, Dr. K. Raju, Dr. B. K. Jayaprasad	1999-2005	100.05	Nil
11.	Formulation of model development plan for local bodies in coastal plain areas.	Science, Technology & Environment, Govt. of Kerala	Dr. R. Ajaykumar Varma	Environmental Sciences	Dr. C. N. Mohanan	2001-2005	4.00	Nil
12.	Malignancy detection using laser induced fluorescence emission (MADELIFE).	Dept. of Science & Technology, Govt. of India	Dr. N. Subhash	Atmospheric Sciences	Dr. Jayaprakash Madhavan, Dr. Anitha Mathews	2002-2005	18.00	Nil
13.	Terrestrial inputs (Nutrient loads) and estuarine productivity - A case study in south Kerala .	Science, Technology & Environment, Govt. of Kerala	Dr. K. Soman	Resources Analysis	Dr. Srikumar Chattopadhyay, Dr, P. P. Ouseph	2002-2004	2.40	Nil
14.	Integrated coastal and marine area management (ICMAM) west coast (Munambam to Kanyakumari stretch in Kerala).	Dept. of Ocean Development, Govt. of India	Dr. N. P. Kurian	Marine Sciences	Dr. K. V. Thomas, Dr. K. K. Ramachandran, Dr. T. S. Shahul Hameed, L. Sheela Nair	2002-2007	83.00	4.98
15.	Preparation of integrated coastal zone management plan for Lakshadweep islands	Ministry of Environment & Forests, Govt. of India	Dr. T. N. Prakash	Marine Sciences	Dr. K. V. Thomas, Dr. Terry Machado, Dr. P. V. S. S. K. Vinayak, Sri. John Paul	2002-2006	75.00	Nil

Sl. No.	Project Title	Funding Agency	Principal Investigator	Division	Co-Investigators	Project Period	Total Outlay Rs. in lakhs	Fund received during the year Rs. in lakhs
16.	Digitisation coastal zone management plan (CZMP) maps of west coast of India	Ministry of Environment & Forests, Govt. of India	Dr. Terry Machado	Marine Sciences	Dr. K. V. Thomas Sri. John Paul	2002-2006	16.75	Nil
17.	Development and application of shoreline change model for shoreline management.	Dept. of Science & Technology, Govt. of India	Dr. T. S. Shahul Hameed	Marine Sciences	Dr. N. P. Kurian, Dr. K. V. Thomas, Dr. M. Samsuddin, Sri. R Mahadevan	2002-2006	29.00	Nil
18.	Integration of natural resource potential (NRP) and socio economic development (SED) for microlevel planning of Kottayam, Kerala .	Dept. of Science & Technology, Govt. of India	Dr. Srikumar Chattopadhyay	Resources Analysis	Dr. Mahamaya Chattopadhyay	2002-2006	13.05	0.05
19.	Remote sensing data analysis and GIS application .	Indian Space Research Organisation	Dr. M. Baba (Coordinator) Dr. M. Samsuddin (PI)	Geomatics Lab	Dr. K. K. Ramachandran, Sri. V. N. Neelakandan, Dr. C. M. Harish, Sri. S. Sidharthan	2003-2005	57.00	---
20.	Evaluation for appropriate technology based utilisation of laterite horizons in Neyyar watershed in western ghat region as water harvesting structure .	Western Ghats Cell Planning Board	Dr.Narayanaswamy	Geosciences	Dr. Terry Machado	2003-2005	3.92	Nil
21.	Stream characteristics and water quality parameters of a forested watershed in upper Kallar, Thiruvananthapuram.	Western Ghats Cell Planning Board	Dr. Mahamaya Chattopadhyay	Resources Analysis	---	2002-2005	3.15	Nil
22.	Ecozone based carrying capacity assessment of a high range watershed for sustainable development planning .	Western Ghats Cell Planning Board	Dr. R. Ajaykumar Varma	Environmental Sciences	Dr. C. N. Mohanan Dr. M. N. M. Nair	2002-2006	7.15	Nil

Sl. No.	Project Title	Funding Agency	Principal Investigator	Division	Co-Investigators	Project Period	Total Outlay Rs. in lakhs	Fund received during the year Rs. in lakhs
23.	Application of high resolution remote sensing data and information technology for local level planning .	Space Application Centre (ISRO)	Dr..K.K.Ramachandran	Geomatics Lab	Dr. M. Samsuddin, Sri. John Mathai,Dr. Terry Machado, Sri. V. N. Neelakantan, Sri. S. Sidharthan, Dr. P. V. S. S. K. Vinayak, Sri. K. R. Unnikrishnan	2002-2006	22.85	Nil
24.	Evaluation of agrotypologies in Kerala	Science, Technology & Environment Dept.	Dr. P. V. S. S. K. Vinayak	Camp Office, Kochi	Dr. V. Sasikumar, Dr. S. Sampath	2003-2007	3.36	Nil
25.	Setting up of Laborarory at Kakkanad for testing the purity of Gold	Legal Metrology Dept., Govt. of Kerala	Dr. M. N. Muralidharan Nair	Chemical Sciences	Dr. P. P. Ouseph	2002-2006	32.00	Nil
26.	Characterisation of Indian placers	Central Mining Research Institute	Dr. Narayanaswamy	Geosciences	Dr. D. S. Suresh Babu	2003-2007	18.85	Nil
27.	Environmental impact assessment of inland placer mineral mining	Central Mining Research Institute	Dr. R. Ajaykumar Varma	Environmental Sciences	Dr. C. N. Mohanan, Sri. K. Raju, Sri. G. K. Suchindan	2003-2007	83.41	13.55
28.	Integrated coastal zone management plan preparation for the selected placer mining sites in the country	Central Mining Research Institute	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian Dr. T. N. Prakash Dr. T. S. Shahul Hameed & Dr. Terry Machado	2003-2006	16.80	Nil
29.	Natural radio activity risk assessment in the living environment of the people of South west coast of India	Dept. of Atomic Energy	Sri. V. Muralidharan	Atmospheric Sciences	K. Vijaya Kumar & K. J. Mathew	2003-2006	9.30	2.70

Sl. No.	Project Title	Funding Agency	Principal Investigator	Division	Co-Investigators	Project Period	Total Outlay Rs. in lakhs	Fund received during the year Rs. in lakhs
30.	Tectonic evaluation of Panvel flexure using Palaeo-seismologic techniques	Dept. of Atomic Energy	Dr. Kusala Rajendran	Geosciences	Dr. C. P. Rajendran	2003-2006	11.50	Nil
31.	Coastal Processes	Dept. of space Govt. of India	Dr. A. S. K. Nair	Marine Sciences	---	2003-2008	11.50	Nil
32.	Characterisation of tropical rainfall in terms of raindrop size distribution and rain rate	Department of space Govt. of India	Dr. S. Sampath	Atmospheric Sciences	Dr. V. Sasikumar Dr. P. V. S. S. K. Vinayak	2003-2006	19.44	Nil
33.	A study on the role of active tectonics in the development of ancient indigenous cultures around gult of Cambay, north west India	National Institute of Ocean Technology, Chennai	Dr. C. P. Rajendran	Geosciences	Dr. Kusala Rajendran	2003-2006	4.00	Nil
34.	Crop based studies on soil climate relationship Western Ghat region of Palakkad district and adjoining areas	Western Ghat Cell, Planning Board	Dr. Terry Machado	Marine Sciences	Dr. Narayanaswamy	2004-2006	2.50	Nil
35.	Landuse/landcover changes and water quality: A case study in the Western Ghat provenance of Central-south Kerala rivers	Western Ghat Cell, Planning Board	Dr. K. Soman	Resource Analysis	---	2004-2006	4.38	Nil
36.	Generation of Natural Resources and Environmental Database for local Level Planning in Kerala	State Planning Board (ISRO)	Dr. M. Samsuddin	Geomatics Laboratory	Dr. K. K. Ramachandran, Sri. John Mathai, Mr. V. N. Neelakantan, Sri. B. K. Jayaprasad	2004-2008	67.70	Nil
37.	Water quality analysis for setting up of five drinking water plants in Kerala for Kerala Water Authority	Tokyo Engineering Consultancy company, Japan	Dr. P. P. Ouseph	Chemical Sciences	Dr. P. K. Omana	2004-2007	---	Nil

Sl. No.	Project Title	Funding Agency	Principal Investigator	Division	Co-Investigators	Project Period	Total Outlay Rs. in lakhs	Fund received during the year Rs. in lakhs
38.	Developing spatial and temporal constraints on earthquakes Gujarat using palaeoseismological techniques	Department of Science & Technology, Government of India	Dr. C. P. Rajendran	Geosciences	Dr. Kusala Rajendran	2004-2007	13.40	2.00
39.	Resource evaluation and inventory of manufactured sand from Trivandrum district, Kerala.	Department of Science & Technology, Govt. of India	Dr. D. S. Suresh Babu	Geosciences	Sri. B. K. Jayaprasad	2005-2007	1.88	2.00
40.	JALAM	KRWSA	Sri. John Mathai	Geosciences	Sri. K. R. Unnikrishnan	2003-2005	10.30	Nil
41.	Post Earthquake GPS/ Earthquake survey in Andaman & Nicobar islands	Department of Science & Technology, Government of India	Dr. C. P. Rajendran	Geosciences		2005-2006	1.40	Nil
42.	Computation of annual ground water discharge through the Western coastal zone of Tamil Nadu	Department of Science & Technology, Government of India	Ms. Asha Rani	Geosciences		2005-2008	5.04	1.68
43.	Mapping of Inundation area on Tamil Nadu - Kerala border	Department of Science & Technology, Government of India	Dr. Terry Machado	Marine Sciences	Dr. T. N. Prakash Dr. N. P. Kurian, Dr. S. Chattopadhyay, Dr. A. S. K. Nair, Sri. C. K. Sasidharan	2005-2006	4.60	Nil
44.	Impact of Tsunami on the Kerala coast and an initiative for development of a management plan for the region	Department of Science & Technology, Government of India	Dr. M. Baba		Dr. D. S. Suresh Babu, Dr. R. Ajaykumar Varma, Dr. C. N. Mohanan	2005-2006	11.50	Nil
45.	Numerical simulation - acquifers	Department of Science & Technology, Government of India	Dr. D. S. Suresh Babu	Geosciences		2005-2006	6.50	Nil

Sl. No.	Project Title	Funding Agency	Principal Investigator	Division	Co-Investigators	Project Period	Total Outlay Rs. in lakhs	Fund received during the year Rs. in lakhs
46.	Chemical loading into reservoirs: Investigations from selected watersheds of Periyar basin in Western Ghats, Kerala	Ministry of Environment & Forest, Govt. of India	Dr. M. N. M. Nair	Chemical Sciences	Dr. R. Ajaykumar Varma, Dr. C. N. Mohanan, Dr. D. S. Suresh Babu	2005-2008	10.30	Nil
47.	Preparation of city base maps for 5 Municipal Corporations of Kerala	Kerala State Urban Development Programme	Dr. M. Samsuddin	Geomatics Laboratory	Dr. K. K. Ramachandran, Sri. B. K. Jayaprasad, Sri. John Mathai, Sri. V. N. Neelakantan, Dr.C.M.Harish	2006-2007	54.96	19.03
48.	A model system for management and disposal of Sewage in the Lakshadweep Island, India	Union Territory of Lakshadweep	Dr. M. N. M. Nair	Chemical Sciences		2005-2007	42.65	11.12
49.	Environmental monitoring of water sediment quality parameters in Cochin harbour	Cochin Port Trust	Dr. P. P. Ouseph	Chemical Sciences		2006-2007	3.99	3.38
50.	CSIR senior research fellowship to Shri.J.Rupananda Mallia	Council for Scientific & Industrial Research	Dr. N. Subash	Atmospheric Sciences		2006-2007	1.46	1.45
51.	Demarcation of vulnerability	Ministry of Environment, Govt. of India	Dr. T. S. S. Hameed	Marine Sciences		2007	6.32	1.89
52.	Upgradation and operation of broadband/seismological observatories in the peninsular sheild of India.	Department of Science & Technology, Govt. of India	Dr. Kusala Rajendran	Geosciences		2006-2009	13.40	0.31
53.	Subsurface flux of coastal waters and management of coastal acquifer	Department of Science & Technology, Govt. of India	Dr. D. S. Suresh Babu	Geosciences		2006-2009	10.12	4.23

Sl. No.	Project Title	Funding Agency	Principal Investigator	Division	Co-Investigators	Project Period	Total Outlay Rs. in lakhs	Fund received during the year Rs. in lakhs
54.	Tracking the past Disasters & Tsunami along the part of Tamil Nadu coast	Department of Science & Technology, Govt. of India	Dr. Terry Machado	Marine Sciences		2006-2009	16.33	6.00
55.	Metasedimentary rocks of the Kerala khondalite belt southern India: Petrology and geodynamics of their formation	Department of Science & Technology, Govt. of India	Dr. G. R. Ravindra Kumar	Geosciences		2006-2009	17.85	10.90
56.	Palaeointensity and India & Re-union/Marion plume activity in India Project	Project 32072 (IFPR)	Dr. T. Radhakrishna	Geosciences		2006-2009	22.45	2.97
57.	Assessment of environmental impact of sand mining in the rivers of Pamba & Manimala, southwest coast of India	Kerala State Council for Science, Technology and Environment	Ms. S. Sheeba			2006-2008	0.30	0.15
58.	Pathiramanal Biodiversity	Kerala State Council for Science, Technology and Environment	Dr. Srikumar Chattopadhyay	Resource Analysis		2006-2007	4.67	4.67
59.	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 and Environment	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian, D. Raju, S. Mohanan, M. Ramesh Kumar	2006-2007	6.98	6.98
60.	Tectonic & Hydrologic control on late Pleistocene Holocene landforms, palaeoforest and non-forest vegetation: Southern Kerala	Kerala State Council for Science, Technology and Environment	Dr. D. Padmalal	Environmental Sciences		2006-2008	0.20	0.02

Sl. No.	Project Title	Funding Agency	Principal Investigator	Division	Co-Investigators	Project Period	Total Outlay Rs. in lakhs	Fund received during the year Rs. in lakhs
61.	Understanding the seismo-tectonics of the Andaman Nicobar Subduction zone in Relation to other subduction zone	Kerala State Council for Science, Technology and Environment	Smt. Anu. R	Geosciences		2006-2008	0.30	0.01
62.	Late Quaternary environmental changes in the coastal plains of Southern Kerala, South West India	Council of Scientific & Industrial Research	Dr. D. Padmalal	Environmental Sciences	Inter Institutional project. AGI, Pune, VMFT & CESS, TVPM	2005-2008	0.308	0.308
63.	SOE REP, preparation-phase II	Council of Scientific & Industrial Research	Director			2006-2007	0.00	0.85
64.	Tsunami and storm surges inundation modelling and mapping for the coasts of Kerala, Karnataka and Lakshadweep	Ministry of Earth Sciences, Govt. of India	Dr. N. P. Kurian	Marine Sciences	Dr. T. N. Prakash, Dr. K. V. Thomas, Sri. B. K. Jayaprasad, Dr. T. S. Shahul Hameed	2006-2007	27.80	27.80
65.	Coastal zone studies	Space Application Centre, Ahmedabad	Dr. M. Samsuddin	Geomatics Laboratory		2006-2007		
66.	Watershed characteristics, landuse pattern and water quality parameters of upstream and selected downstream stretches of the Vamanapuram river	Western Ghats Cell, Kerala State Planning Board	Dr. Mahamaya Chattopadhyay	Resources Analysis		2006-2008	2.05	Nil

5.2 Consultancy Projects

Sl. No.	Project Title	Funding Agency	Principal Investigator	Division	Co-Investigators	Project Period	Total Outlay Rs. in lakhs	Fund received during the year Rs. in lakhs
1.	Technical Study on Sand availability of various rivers of Kerala	Local Bodies, Govt. of Kerala	Dr. D. Padmalal	Environmental Sciences	Dr. K. Maya	2002-2006	Nil	Nil
2.	Studies on coastal erosion and sediment movement in selected islands of UT of Lakshadweep, androtт, Kalpeni & Minicoy	UT of Lakshadweep, Govt. of India	Dr. T. N. Prakash	Marine Sciences	Shri. G. K. Suchindan, Dr. K. V. Thomas, Dr. T. S. Shahul Hameed	2002-2005	14.75	Nil
3.	Comprehensive EIA of Mankulam Hydro Electric Project at Mankulam Village in Idukki District	Kerala State Electricity Board	Dr. R. Ajaykumar Varma	Environmental Sciences	Dr. C. N. Mohanan, Dr. M. N. M. Nair, Dr. S. Muralidas, Shri. V. Muralidharan, Dr. D. S. Suresh Babu, Shri. T. K. K. C. Nair	2002-2005	12.44	4.74
4.	Comprehensive EIA of H.E project (60 MW) - Pallivasal Extension Scheme	Kerala State Electricity Board	Dr. R. Ajaykumar Varma	Environmental Sciences	Dr. C. N. Mohanan, Dr. M. N. M. Nair, Dr. S. Muralidas, Shri. V. Muralidharan, Dr. D. S. Suresh Babu, Shri. T. K. K. C. Nair	2002-2005	6.77	3.79
5.	Rapid Environmental Impact Assessment study of the proposed Break water stage III at Androth island in Lakshadweep	Lakshadweep Harbour Works	Dr. R. Ajaykumar Varma	Environmental Sciences	Dr. C. N. Mohanan, Dr. N. P. Kurian, Dr. K. V. Thomas, Dr. S. Muralidas, Dr. T. N. Prakash, Dr. T.S.S. Hameed	2003-2006	Nil	Nil
6.	Hydrodynamic and Littoral Environmental data collection at Androth during the Nemonsoon and Fair weather season	Lakshadweep Harbour Works	Dr. N. P. Kurian	Marine Sciences	Dr. T. N. Prakash, Sri. M. Ramesh Kumar, Sri. D. Raju	2003-2005	10.08	Nil
7.	Rapid Environmental Impact Assessment (REIA) and preparation of Environmental Management Plan (EMP) Akkulam	Dept. of Tourism, Govt. of Kerala	Dr. C. N. Mohanan	Environmental Sciences	Dr. M. N. Muralidharan Nair, Dr. S. Muralidas, Dr. K. Narendra Babu, Dr. Ajaykumar Varma	2004-2005	Nil	Nil

Sl. No.	Project Title	Funding Agency	Principal Investigator	Division	Co-Investigators	Project Period	Total Outlay Rs. in lakhs	Fund received during the year Rs. in lakhs
8.	Rapid EIA of Mill Development Programme of Hindustan Newsprint Limited, Vellore	M/s Jaakko Poyri Consulting, Finland	Dr. R. Ajaykumar Varma	Environmental Sciences	Dr. C. N. Mohanan, Dr. S. Muralidas, Dr. M. N. M. Nair	2004-2006	Nil	Nil
9.	Study and preparation of Reports of Dam Break Analysis, Disaster Management Plan and Catchment Area Treatment Plan - Puyankutty Hydro Electric Project	KSEB, Govt. of Kerala	Dr. Ajaykumar Varma	Environmental Sciences	Dr. C. N. Mohanan, Dr. D. S. Suresh Babu	2002-2006	Nil	Nil
10.	CRZ work for the state of Maharashtra	Govt. of Maharashtra	Dr. K. V. Thomas	Marine Sciences	Dr. M. Samsuddin, Dr. K. K. Ramachandran, Sri. S. Sidharthan, Dr. T. N. Prakash, Dr. Terry Machado, V. Vasudevan, Dr. T. S. Shahul Hameed, Sri. John Paul, Sri. Ramesh Kumarr.		137.5	Nil
11.	Coastal erosion studies in Selected Islands of Lakshadweep	Nil	Dr. T. N. Prakash	Marine Sciences	Sri. S. Mohanan, Sri. D. Raju, Dr. C. N. Mohanan, Dr. M. N. M. Nair.		14.75	Nil
12.	CRZ work for the State of Maharashtra - 2nd Phase	Nil	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian, Sri. D. Raju		124.00	Nil
13.	Environmental implications of Decentralized Governance	Nil	Dr. R. Ajaykumar Varma	Environmental Sciences	Dr. C. N. Mohanan, Sri. John Mathai, Dr. K. V. Thomas		Nil	18.66
14.	Rapid Environmental impact assessment study for the proposed Air strips at Andrott and Minicoy Islands in Lakshadweep	Nil	Dr. R. Ajaykumar Varma	Environmental Sciences	Dr. C. N. Mohanan, Dr. S. Muralidas, Sri. K. R. Unnikrishnan, Dr. K. V. Thomas, Dr. P. V. S. S. K. Vinayak		Nil	Nil

Sl. No.	Project Title	Funding Agency	Principal Investigator	Division	Co-Investigators	Project Period	Total Outlay Rs. in lakhs	Fund received during the year Rs. in lakhs
15..	Demarcation of HTL, Rewas Port Devt. For M/s Reliance Gas Pipeline Ltd. Mumbai	Nil	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2006-	2.1	2.06
16..	CRZ status report for resort site at Cherthala for - JOY's The Beach Resorts Pvt. Ltd.	Nil	Dr. K. V. Thomas	Marine Sciences	--do--	2006-	1.20	1.20
17.	Demarcation of HTL/LTL and CRZ for cable land'ing station at Thiruvananthapuram for Reliance	Nil	Dr. K. V. Thomas	Marine Sciences	--do--	2006-	0.87	0.87
18.	CRZ status report for resort development for Integrated Eco.Resorts, Thiruvananthapuram	Nil	Dr. K. V. Thomas	Marine Sciences	--do--	2006-	1.20	1.20
19.	HTL/LTL Delineation for M/s IMC. Limited, at JNPT, Mumbai	Nil	Dr. K. V. Thomas	Marine Sciences	--do--	2006-	2.85	2.85
20.	Demarcation of HTL/LTL at Bakel, Kasargod and Asramam, Kollam for Hotel & Allied Trades Pvt. Ltd. Kochi	Nil	Dr. K. V. Thomas	Marine Sciences	--do--	2006-	2.02	2.02
21.	CRZ status report for HTL delineation and verification, Cuffe Parade, Mumbai	Nil	Dr. K. V. Thomas	Marine Sciences	--do--	2006-	3.75	3.75
22.	CRZ status report for Air Travel Enterprises - Bakel Kasaragod	Nil	Dr. K. V. Thomas	Marine Sciences	--do--	2006-	1.50	1.50
23.	CRZ status report for Grand Hotel 'Palaces' Resorts a project at Kasaragod	Nil	Dr. K. V. Thomas	Marine Sciences	--do--	2006-	1.50	1.50

Sl. No.	Project Title	Funding Agency	Principal Investigator	Division	Co-Investigators	Project Period	Total Outlay Rs. in lakhs	Fund received during the year Rs. in lakhs
24.	Verification and Demarcation of existing foot bridge and approach road of TMC CRZ	Nil	Dr. K. V. Thomas	Marine Sciences	Dr. N. P. Kurian	2006	0.44	0.44
25.	CRZ status report for the rail connectivity scheme from Vallarpadam to Edappally in Ernakulam District	Nil	Dr. K. V. Thomas	Marine Sciences	--do--	2006	2.92	2.92
26.	HTL & LTL delineation along Korali, Murud, Maharashtra for M/s Bradford Resorts Pvt. Ltd., Mumbai	Nil	Dr. K. V. Thomas	Marine Sciences	--do--	2006	2.85	2.85
27.	HTL and LTL delineation for port at Dhamankul Bay Jaigargh, Maharashtra for JSW Infrastructure & Logistics Ltd., Mumbai	Nil	Dr. K. V. Thomas	Marine Sciences	--do--	2006	4.50	4.50
28.	CRZ status report for resort development at Mararikulam for M/s East Venice Property Developers Pvt. Ltd. Alappuzha	Nil	Dr. K. V. Thomas	Marine Sciences	--do--	2006	1.35	1.35
29.	CRZ status report for resort project at Talikulam, Thrissur, for M/s M Far Hotels Ltd., Cochin	Nil	Dr. K. V. Thomas	Marine Sciences	--do--	2006	1.65	1.65
30.	Demarcation of HTL & LTL for Azhimala Beach Resort Pvt. Ltd., Trivandrum	Nil	Dr. K. V. Thomas	Marine Sciences	--do--	2006	0.24	0.24
31.	CRZ status report demarcating the HTL/ LTL and CRZ for resort development at Perumbalam, Kochi for P.R. Holiday Homes (P) Ltd., Thiruvananthapuram	Nil	Dr. K. V. Thomas	Marine Sciences	--do--	2006	1.35	1.35

5.3 Plan Projects

Project Code	Title	Principal Investigator	Division	Co-Investigator	Project Period	Total Outlay (Rs.lakhs)	Expenditure during the year (Rs. lakhs)
PLAN 201	District spatial data information system for Kasaragod and Kannur districts of Kerala	Ms. Ahalya Sukumar	Resource Analysis	Sri. B. Sukumar, Sri. V. Shravan Kumar	2003-2005	3.20	0.22
PLAN 202	Geochemical investigations on anthropogenic mercury and other heavy metals in the Vembanad lake sediments	Dr. P. K. Omana	Chemical Sciences	Dr. P. P. Ouseph	2003-2005	6.20	10.05
PLAN 203	Occurrences and mining of limeshell resources of Vembanad lake with special reference to the future of lime shell based industries of Kerala	Dr. K. Maya	Environmental Sciences	Dr. K. Narendra Babu, Dr. D. Padmalal	2003-2005	0.00	0.00
PLAN 204	Developing an improved database for seismic hazard assessment in Kerala	Dr. C. P. Rajendran	Geosciences	Dr. Kusala Rajendran	2003-2008	3.10	0.72
PLAN 205	Landuse-landcover change, its impact on biophysical system and environmental consequences: case studies in two sensitive zones of Northern Kerala (Kakkiar-Agasthyamalai hill tract)	Dr. Srikumar Chattopadhyay	Resource Analysis	---	2004-2006	1.60	1.20
PLAN 206	Heavy metal and REE abundances in edible plants of heavy mineral areas of Kollam and Alappuzha districts	Sri. G. Balasubramonian	Training & Extension	Sri. V. Vasudevan, Dr. C. N. Mohanan	2003-2006	2.34	0.98
PLAN 207	Computation of Submarine Groundwater Discharge (SGD) from Neyyar-Karamana watersheds	Dr. D. S. Suresh Babu	Geosciences	---	2003-2006	0.00	0.63
PLAN 208	Investigation on the cause of high lightning incidences	Dr. S. Muralidas	Atmospheric Sciences	Dr. S. Sampath, Dr. G. Mohan Kumar	2003-2006	1.07	0.89
PLAN 209	Seismic monitoring in Kerala State and the maintenance of the broad band station at Peechi	Dr. Kusala Rajendran	Geosciences	Dr. C. P. Rajendran, Dr. K. R. Unnikrishnan, Ms. Sreekumari Kesavan, Sri. K. K. Varghese (CESS) & Jose Kallarackal (KFRI)	2003-2008	7.50	0.00

Project Code	Title	Principal Investigator	Division	Co-Investigator	Project Period	Total Outlay (Rs.lakhs)	Expenditure during the year (Rs. lakhs)
PLAN 210	Landscape evaluation in relation to fluvio-estuarine and denudational systems: a case study of Periyar basin, Kerala	Dr. Mahamaya Chattopadhyay	Resource Analysis	---	2003-2006	0.85	1.08
PLAN 211	Creation of Digital Data Bank at CESS	Sri. V. N. Neelakandan	Geomatics Laboratory	Dr. C. M. Harish, Dr. M. Samsuddin, Dr. K. K. Ramachandran, Sri. B. K. Jayaprasad	2003-2006	3.0	2.82
PLAN 212	Methane emission flux from wetlands in Kerala	Dr. E. J. Zachariah	Atmospheric Sciences	---	2003-2006	0.85	1.07
PLAN 213	Coastal Field Research Facility and Coastal Ocean Monitoring	Dr. K. V. Thomas	Marine Sciences	Dr. T. S. Shahul Hameed, Sri. M. Ramesh Kumar	2003-2007	3.38	1.51
PLAN 214	Landslide Hazard Zonation and Mitigation in the Western Ghats of Kerala with people's participation	Sri. G. Sankar	Geosciences	Sri. John Mathai, Sri. S. Sidharthan	2003-2006	1.84	1.04
PLAN 215	Evolution of supercrustal rocks and associated gneisses of Wayanad schist belt, Kerala	Dr. G. R. Ravindrakumar	Geosciences	---	2003-2006	0.00	0.00
PLAN 216	GPS constraints on strain rate across the Andaman-Nicobar Islands: kinematics of subduction zone tectonics & platemargin deformation	Dr. C. P. Rajendran	Geosciences	Sri. K. R. Unnikrishnan, Dr. C. M. Harish, Dr. Kusala Rajendran	2003-2005	35.60	3.69
PLAN 217	Bio Geographical Information System (BGIS) for Trivandrum district	Sri. V. N. Neelakandan	Geomatics Laboratory	Dr. C. N. Mohanan, Sri. B. Sukumar	2003-2005	0.00	0.00

Project Code	Title	Principal Investigator	Division	Co-Investigator	Project Period	Total Outlay (Rs.lakhs)	Expenditure during the year (Rs. lakhs)
PLAN 218	Graphite mineralization in the Karimukal area, Ernakulam District, Kerala with special emphasis on graphitisation process and genesis	Dr. Ansom Sebastian	Training & Extension	---	2004-2006	0.00	0.09
PLAN 219	Studies on agro-ecological regions of Palakkad District, Kerala	Dr. E. Saravanan	Training & Extension	Sri. V. Shravankumar	2004-2006	3.55	0.24
PLAN 220	Nutrient flux studies in the Ashtamudi Estuary	Dr. M. N. M. Nair	Chemical Sciences	Dr. T. S. Shahul Hameed	2004-2007	1.75	0.57
PLAN 221	Tourism carrying capacity study, Varkala, Kerala	Sri. G. K. Suchindan	Training & Extension	Dr. C. N. Mohanan, Dr. M. N. M. Nair, Sri. C. K. Sasidharan, Sri. K. Raju	2004-2006	1.32	1.10
PLAN 222	Synchronized beach profiling and ground water table monitoring between Adimalathura and Poovar	Dr. Terry Machado	Marine Sciences	---	2004-2006	0.00	0.07
PLAN 223	Laser induced flourescence in cancer diagnosis	Dr. N. Subhash	Atmospheric Sciences	---	2004-2007	0.08	0.68
PLAN 224	Resource atlas of Thiruvananthapuram district of Kerala	Sri. B. Sukumar	Resource Analysis	Ms. Ahalya Sukumar, Sri. V. Shravankumar	2004-2006	1.00	0.49
PLAN 225	Quarternary evolution of Trivandrum coast	Sri. John Paul	Geosciences	Dr. D. S. Suresh Babu	2004-2006	1.01	1.21

5.4 Institutional R & D Projects

Project Code	Title	Co-ordinator	Division	Project Period	Allotment for the year (Rs. lakhs)	Expenditure during the year (Rs.lakhs)
PLAN 230	Study of coastal processes and hazards along Kerala coast with particular reference to disaster preparedness	Director		2006-2008	14.66	36.47
PLAN 231	Natural Resource Data Management at the local level	Dr. M. Samsuddin	Geomatics Laboratory	2006-2008	49.49	16.70
PLAN 232	State of the Environment and Action Plan for Kochi urban area	Dr. R. Ajaykumar Varma	Environmental Sciences	2006-2008	35.02	21.00
PLAN 233	Development of Integrated Coastal Zone Management Plans (ICZMP)	Dr. K. V. Thomas	Marine Sciences	2006-2008	28.70	5.08
PLAN 234	Measurement of cloud parameters and cloud modelling	Dr. V. Sasikumar	Atmospheric Sciences	2006-2010	41.18	13.99
PLAN 235	Tsunami related studies	Dr. N P. Kurian	Marine Sciences	2006-2007	0.00	0.37
PLAN 236	River sand mining and management	Dr. D. Padmalal	Environmental Sciences	2006-2007	13.07	0.00
PLAN 239	Preparation of district level natural hazard zonation maps for Kerala	Sri. John Mathai	Geosciences	2006-2007	7.15	1.60
PLAN 240	Study of coastal processes and hazards along the Kerala coast with particular reference to disaster preparedness	Dr. N. P. Kurian	Marine Sciences	2006-2007	40.40	2.64

5.5 R & D Infrastructure Projects

Project Code	Title	Co-ordinator	Division	Allotment during the year (Rs. lakhs)	Expenditure during the year (Rs. lakhs)
PLAN 101	Sophisticated analytical facility & studies on geodynamics	Head, G S D	Geosciences	20.70	9.11
PLAN 102	Upgradation of palaeomagnetic laboratory	Head, G S D	Geosciences	7.30	1.60
PLAN 103	Strengthening of ecological laboratory	Head, E S D	Environmental Sciences	5.00	1.05
PLAN 104	Upgradation of electronic laboratory and Air Quality Monitoring laboratory	Head, A S D	Atmospheric Sciences	18.71	6.84
PLAN 105	Upgradation of chemical laboratory	Head, C S D	Chemical Sciences	12.25	8.91
PLAN 106	Upgradation of Library facilities	Head, T E D/ Librarian	Library	24.45	10.48
PLAN 107	Publication of monographs/memoirs/annual report/newsletter	Director		5.70	0.47
PLAN 108	Upgradation of training/extension/exhibition/ LAN and other technical facilities	Head, T E D	Training & Extension	6.70	2.77
PLAN 110	Seminar/Symposium/Workshop	Director		2.00	1.18
PLAN 111	Marine laboratory infrastructure development	Head, Marine Sciences Division	Marine Sciences	38.30	28.24
PLAN 112	Geomatics laboratory infrastructure development	Scientist-in-Charge, Geomatics Laboratory	Geomatics Laboratory	19.62	12.51
PLAN 114	Placer mineral testing laboratory	Head, G S D	Geosciences	41.97	24.12

5.6 Building Infrastructure Projects

Project Code	Title	Co-ordinator	Allotment during the year (Rs. lakhs)	Expenditure during the year (Rs. lakhs)
PLAN 109	Construction of compound wall	Registrar	49.33	20.01
PLAN 119	Recreation facilities	Secretary, Recreation Club	1.00	0.00
PLAN 120	Upgrading centralized air conditioning and facilities of CESS buildings	Deputy Registrar, Stores	2.80	0.95
PLAN 122	Construction of parking shelters	Registrar	10.00	8.18
PLAN 123	Upgrade/repair and maintenance of toilets	Deputy Registrar, Stores	1.00	1.75
PLAN 124	Upgrading EPABX system	Registrar	8.50	9.58
PLAN 126	Garden development and landscaping	Dr. C. N. Mohanan	6.00	0.01
PLAN 128	Upgrading electrical installations and facilities	Deputy Registrar, Stores	4.00	0.00

6. Academic Activities

6.1 Awards and Distinctions

Dr. G. R. Ravindra Kumar, Scientist, CESS was awarded the prestigious Prof. M. R. Srinivasa Rao Award for the year 2006 by the Geological Society of India, Bangalore for his outstanding contributions in the field of Petrology. The award was presented by Dr. H. K. Gupta, Vice President of the Geological Society of India during Annual Convention held at Wadia Institute of Himalayan Geology, Dehradun on 24 November 2006.

While presenting the award to Dr. Ravindra Kumar, Geological Society noted that his studies "brought to light the great natural laboratory for lower crustal rocks available in Kerala and paved the way for more detailed studies in this region". Further the citation stated that "his efforts and publications, from a region which presents protracted history of granulite evolution from early Proterozoic tolate Proterozoic, have been of extreme importance in pinning on improving our understanding of the evolution of granulite belt and in placing constraints on the dispersal of Gondwana.

6.2 Ph. D Awarded

Dr. K. B. Bijumon has been awarded Ph. D by the Cochin University of Science and Technology for his thesis titled 'Integrated Water Quality Assessment of Andrott Island, Lakshadweep' prepared under the guidance of Dr. P. P. Ouseph, Head CSD.

6.3 Ph. D Students

Student	Topic	Research Guide	University
Abhilash P. P.	Charecterisation of marine pollution along the southern coast of Kerala using macrobenthic assemblayes	Dr. P. P. Ouseph	Cochin
Anil Earnest	Constraining the active tectonic deformation of the Andaman-Nicobar Arc in the background of December 26, 2004 the great Sumatra-Andaman earthquake	Dr. C. P. Rajendran	Cochin
Anjali R.	Study of ambient atmospheric carbon monoxide in the tropics	Dr. G. Mohan Kumar	Kerala
George Thomas	The development of urban heat island in a tropical coastal city	Dr. E. J. Zachariah	Kerala
Harikumar R.	Study on tropical rainfall with special reference to rain drop size distribution & integral rain parametres	Dr. S. Sampath	Cochin
Jayanthi J. L.	Laser Induced Fluorescence imaging for cancer diagnosis	Dr. N. Subhash	Kerala
Prasanth M.	Physico-chemical characteristics and speciations of heavy metals in the selected upland reservoirs of Periyar river basin	Dr. M. N. M. Nair	Cochin
Rupananda M.	Photo diagnosis of oral malignancy using LIF & DRS	Dr. N. Subhash	Cochin
Shainy S. T.	Spectroscopic investigation of tooth caries & demineralization	Dr. N. Subhash	Cochin
Shamji V. R.	Shoreline change modelling	Dr. N. P. Kurian	Cochin
Sinosh P. K.	Studies on pesticide residues in the Periyar river basin	Dr. M. N. M Nair	Cochin
Sreebha S.	Environmental impacts of sand mining: A case study in the river catchments of Vembanad lake	Dr. D. Padmalal	Cochin
Sreeja R.	Origin, occurrence and mining of limeshell reources of Vembanad lake, Kerala	Dr. D. Padmalal	Cochin
Sudhanand V. S.	Studies on pathogenic enteric bacteria and their seasonal distribution with special reference to public health along selected estuaries of southern Kerala coast	Dr. P. P. Ouseph	Kerala
Udayakumar P.	Distribution of heavy metals in marine environment and its bioaccumulation along the central and northern coast of Kerala	Dr. P. P. Ouseph	Cochin
Vishnu R.	Electrical charecteristics of lightning & thunder storms	Dr. G. Mohan Kumar	Kerala

6.4 Studentship for Post Graduate Students

The Centre for Earth Science Studies, as part of its efforts to improve research aptitude among students in different areas of earth sciences, has introduced to support post graduate students. The programme was initiated during the academic year 2005-06. The studentship was extended to selected M.Sc/M.Tech students nominated by the Departments of Universities and Government / aided colleges in the disciplines of Geology / Geography / Chemistry / Physics / Environmental Sciences / Computer Applications / Geophysics / Oceanography / Atmospheric Sciences / Mathematics for doing their dissertation / internship in CESS as part of the course. The monthly studentship is Rs. 2000/- for a period of 3 to 6 months.

Details of students who received the assistantship during 2006

Student	*Affiliation*	*University*	*Topic of dissertation*	*Supervisor*
Anju V. R.	Department of Geology	Kerala	'Petrological studies of gneiss – charnockite–khondalite association in and around Thiruvananthapuram, Kerala'	Dr. G. R. Ravindra Kumar.
Leelitty Thomas	School of Planning	CEPT, Ahmedabad	Environmental impact assessment of inland placer mineral mining, Manavalakurichi	Dr. R. Ajaykumar Varma
Sasikala S.	Environmental Sciences	Bharathiar	State of the Environment of Manavalakurichi, a placer mineral mining area with emphasis on air quality and socio-economic status	Dr. C. N. Mohanan
Safarunisa	MES College	Calicut	'Long term and short term stability of Ponnani coast, Kerala'	Dr. K. K. Ramachandran

6.5 M.Sc / B.Tech / M.Tech Dissertations

Student	*Affiliation*	*University*	*Topic of dissertation*	*Supervisor*
Anjusha K.	School of pure and applied physics, Kottayam	Mahatma Gandhi	Rain drop size distribution	Dr. V. Sasikumar
Deepa Sekhar Divya K. Pillai	Catholicate College, Pathanamthitta	Mahatma Gandhi	Methane emission from Akkulam lake, Trivandrum-Diurnal pattern	Dr. E. J. Zachariah
Shahna Beegom Seena Fathim J. S	Milad-E-Sherief Memorial College, Kayamkulam	Kerala	Comparison of rain drop size distribution at the surface and different heights	Dr. V. Sasikumar
Princy S. S. Vibitha B. V. Anitha B.	S.A.S.S.N.D.P Yogam College, Pathanamthitta	Mahatma Gandhi	Laser-induced autoflourescence spectral ratio reference standard in oral cancer detection	Dr. N. Subhash
Snitha R. S.	Mahatma Gandhi College, Trivandrum	Kerala	Study of the concentration of condensation particles in different geographical locations	Dr. V. Sasikumar
Sreepriya K. J.	Mahatma Gandhi College, Trivandrum	Kerala	Diurnal variation of cloud base height during southwest monsoon and post-monsoon	Dr. V. Sasikumar
Malini K. V. Ganga B. G.	University College, Trivanadrum	Kerala	Study of rain drop size distribution at different heights	Dr. V. Sasikumar

Renji S. Sapna J.	University College, Trivanadrum	Kerala	Investigation of invitro tooth demineralization and remineralization by optical techniques	Dr. N. Subhash
Sasi T. S. Faisal A.	M E S Ponani College, Malappuram	Calicut	Landslide hazard zonation of upper catchment of Mahi river, Kozhikode District, Kerala	Shri. John Mathai
Irfana	M E S Ponani College, Malappuram	Calicut	Short-term stability of Ponnani coast, Malappuram District	Dr. K. K. Ramachandran
Annie John Anju K. A.	J J College of Arts and Scinece, Pudukottai	Bharathidasan	Diurnal variation of phytoplankton at Vallarpadam, Cochin, Kerala	Dr. P. P. Ouseph
Deepthi R. Nair	Department of Future Studies	Kerala	Identification of flood prone areas in the Karamana river basin- A GIS approach	Sri. B. K. Jayaprasad
Renu V. Kavitha G. Mubeena J. M. Rakhasree O. S.	College of Engineering, Trivandrum	Kerala	Study of beach characteristics in the coastal tracts of Trivandrum District	--do--
Varun K. R	P. S. N. A. College of Engineering & Technology	M. S	Run off estimation using GIS and remote sensing in Neyyar catchment-Kerala	--do--
Arun K. R	--do--	--do--	Landslide vulnerability analysis using GIS and remote sensing in	--do--
Divya Raj	--do--	--do--	Neyyar catchment - Kerala Landslide information system for the Neyyar catchment area- Kerala	--do--
Abhilash U R	Centre for Remote Sensing	Bharathidasan	Wayanad Information System	--do--
Anand Balanujan	T. K. M. College of Civil Engineering	Kerala	Impacts of urbanisation on aquifers Kollam town	Dr. K. V. Thomas
Aswathy C.M	S.N.College, Chengannur	Kerala	Variation of wellwater chemistry with well depth- Acase study in Vembayam panchayat, Trivandrum	Dr. K. Narendra Babu
Bijimol R. L	--do--	--do--	Iron ore concentration in deep well waters of a midland area: A study of Manickal panchayat, Trivandrum	--do--
Chithra V.R	--do--	--do--	Impact of urbanization on the water quality of shallow wells: A case study in Sreekariam panchayat, Trivandrum	--do--
Lekshmi S. Dharan	--do--	--do--	Hydrochemistry of Pamba river waterand its distributory, the Varattur: Acomparative study of river water quality with the nearby wells	--do--
Praseeda K.	M E S Ponnani College, Malappuram	Calicut	Studies on sedimentological charecteristics of different sedimentary environments along the Ponnani coast, Malappuram, north Kerala	Dr. T. N. Prakash

Reja K.V	M E S Ponani College, Malappuram	Calicut	Studies on minerology of different sedimentary environment along the Ponnani coast	Dr. M. N. M. Nair
Aswathy R	S.N.College, Kollam	Kerala	Water quality assessment of two upland reservoirs in Periyar river basin	--do--
Divya Chandran V	S.N.College, Kollam	Kerala	Sediment quality assessment of two upland reservoirs in Periyar river basin	--do--
Sunil Culas	S.N.College, Kollam	Kerala	Phosphorus speication studies in the Ashtamudi estuary	Shri. John Mathai
Faisal A	College of Engineering, Trivandrum	Kerala	Landslide hazard xonation of upper catchment of Mahi river, Kozhikode District, Kerala	Dr. G. Mohan Kumar
Kamal P Mani	School of Pure and Applied Physics	Mahatma Gandhi	Green house gases in the Earth's atmosphere	--do--
Ashly G S	St. Joseph's College	Kerala	Global distribution of total ozone in the northern hemisphere	--do--
Sany Mathew	St. Joseph's College	Mahatma Gandhi	Global distribution of total ozone in the three zones of Southern Hemisphere	--do--
Rahul Krishnan P Kishore P	S A S S N D P Yogam College	Mahatma Gandhi	Atmospheric carbon monoxide measurements at Trivandrum & at a few other sites	Dr. K.Narendra Babu
Soumya L.	S. N. College, Chengannur	Kerala	Enrichment of nitrogen and phosphate in well water of an agriculturally important region: A case study of Tholicode panchayat, Trivandrum	--do--
Shyma George	All Saints' College Trivandrum	Kerala	Impact of chemical factory on well water quality: A case study in Veli region, Trivandrum	--do--
Prabeena B. Dev	--do--	--do--	Well water quality of a rural region: A case study of Karavaram Panchayat, Trivandrum	--do--

6.6 Participation in Training Programmes

Sri.S.Sidharthan has successfully completed onlinecourse on Disaster Risk Management frame work conducted by World Bank Institute, Washington in partnership with National Institute of Disaster Management New Delhi during October-Nov 2006. He has been rated as one of the 10 most outstanding participants in the course.

Sri. S.Sidharthan has successfully completed web based certification course on National Disaster Risk Management, Training of Trainers conducted by the World Bank Institute, Washington during March-April 2007.

6.7 Lectures in courses/training programmes/ seminars

Ajaykumar Varma, R. delivered a talk on 'Watershed based development and its linkage with National Rural Employment Guarantee Act as Town Hall, Kalpetta, Wayanad' organized by the Local Self Government Department, Government of Kerala on July 9, 2006.

Ajaykumar Varma, R. delivered a talk on 'Environmental issues and Urban Development' in the two day conference Chamber of Municipal Chairmen at Alappuzha on August 21, 2006.

Ajaykumar Varma, R. delivered a lecture on 'Social Participation in Solid Management' at a training programme on 'Participatory approach for sustainable development' conducted by the Extension Training Centre, Kottarakkara on December 12, 2006.

Ajaykumar Varma, R. attended a one day workshop organized by Kerala Union of Working Journalists at KILA, Thrissur and delivered a talk on 'Water policy of Kerala' on December 3, 2006.

Ajaykumar Varma, R. delivered a lecture on carrying capacity based development planning for coastal areas with special reference to Thinnakkara Island as part of Four day Training Programme for the members of CZMA sponsored by MoEF, Government of India held at CESS during 20-23, February 2007.

Chattopadhyay, S. delivered a lecture on 'Sustainable Development – Role of Educational Institution' at Govt. College of Teacher Education, Trivandrum, as a part of National Conference on Environmental Education, on March 17, 2007.

Chattopadhyay, S. delivered a lecture on 'Preparedness for disaster management' at SIRD Kottarakara on March 3, 2007.

Chattopadhyay, S. delivered a lecture on 'Ecological Security as a base for social security: Context Kerala' for students participating in the international course on 'Institutionalizing social security' organized by ISS, The Netherland and CDS, Trivandrum on March 5, 2007.

Chattopadhyay, S. conducted a one day training programme for the Watershed Development Team of Lallam Block. delivered a lecture 'Geomophology for Coastal Zone Management' at the training workshop organized by CESS on February 20, 2007.

Neelakantan, V. N. delivered a lecture on 'Bioinformatics an adjunct to Taxonomy and Biodiversity Management' to the participants of the workshop in Taxonomy held at Department of Botany, Univeristy of Kerala on August 24 , 2006.

Nair, A. S. K. attended the seminar on 'Fire Protection Force and Society' held during the Silver Jubilee Celebration of the Kerala Fire Service Association and delivered a talk on 'Science and Technology inputs to Fire and Rescue Services Department of the Government of Kerala' on October 26, 2006.

Nair, A. S. K. has been guest faculty in the vacation training programme on bio-resources and delivered a lecture on coastal eco system management on May 8, 2006.

Nair, A. S. K. gave a lecture on 'Disaster Scenario in Kerala Earthquakes – Do's and Don'ts for the short-term training course on Disaster management organized by the Extension Training Centre, Kottarakkara on November 28, 2006..

Nair, A. S. K. delivered a lecture on 'Hydrology of wetlands' at a training workshop organized by the Department of Geology, University of Kerala, on February 2, 2007.

Nair, A. S. K. delivered a lecture on remote sensing and GIS applications to environmental engineering in the short-term course on 'Advanced technological interventions for environmental sustainability' organized by the Department of Civil Engineering, Rajiv Gandhi Institute for Technology, Kottayam, March 23, 2007.

Soman, K. attended a seminar on 'R&D needs for Regional Development' and made a presentation on 'R&D needs in natural

resources & environmental management' organized by Indian Institute of Chemical Engineers, Trivandrum Regional Centre and Regional Research Laboratory on December 8, 2006.

6.8 Visits abroad

Balasubramonian, G. visited Centre for Tropical Marine Ecology (ZMT), Bremen (Germany) for six weeks from 24 September 2006 for performing biogeochemical analysis.

Rajendran, C. P. visited Singapore in connection with third annual meeting of Asia Oceania Geosciences Society (AOGS) during 10 to 14 July 2006 and chaired a session on 13 July 2006.

Rajendran, C. P. attended the Association of Asia Oceania Geosciences Conference on 'Restoration program from giant earthquakes and tsunamis' held on 10-14 July 2006 in Singapore and presented a paper on 'The style of crustal deformation and seismic history associated with the 2004 Indian Ocean earth quakes: a perspective from the Andaman-Nicobar Islands' and Chaired the session on Recent Earth quakes and tsunamis in Asia and Oceania.

Rajendran, C. P. and Kusala Rajendran attended the Chapman conference on 'Active Tectonics and Seismic potential of Alaska' in Girdwood, Alaska, USA during 11-14 May 2006 and presented papers on: (1) 'The style of crustal deformational characteristics and occurrence pattern of the 26 December 2004 Indian Ocean Earth quake' (2) 'Do the historic ruptures along the Andaman – Sumatra and Makran subductions /Zone signal future great Earth quakes'.

Soman, K. attended the scientific meeting related to coastal marine ecosystem and their relation to management of coastal zones organized under the auspices ACEMON network at Phuket (Thailand) during 24-28th September, 2006 and made a presentation on 'Drainage basins and their role in managing coastal aquatic system of Kerala'.

Soman, K. attended the meeting related to coastal marine ecosystem and their relation to management of coastal zones organized under the auspices of ACEMON network at Phuket (Thailand) during 24-28 September 2006 and made a presentation on 'Drainage basins and their role in managing coastal aquatic system of Kerala'.

Suresh Babu, D. S. visited Russian Academy of Sciences (Geological Institute and the Institute of Geology of ORE Deposits, Petrography, Mineralogy and Geochemistry RAS), Moscow, Russia for 4 weeks from 15 August, 2006 for research work.

6.9 CESS wins ESRI National Quiz Competition

The team from the Geomatics Laboratory of CESS has won ESRI technical quiz on GIS, conducted during the ESRI Users' Meet held on 18 January 2007. The team led by Sri. B.K.Jayaprasad won the competition pushing back formidable teams from the National Informatics Centre (NIC), New Delhi and the Regional Remote Sensing Centre (RRSC), Delhi.

6.10 Membership in Committees

Ajaykumar Varma, R.

Member, 'Plan Committee on Irrigation, Water and Waste Water' constituted by the Planning Board, Trivandrum.

Co-chairman, 'Working Group for irrigation sector' constituted by the State Planning Board, Trivandrum.

Convener, 'Core Committee formed for organizing a workshop on Draft State Water Policy'.

Member, 'Technical Committee of the Solid Waste Management projects' under ADB assisted KSUDP.

Technical member, 'Kerala sustainable urban development project' by the Local Self Government Department.

Member, Board of Studies, Environmental Sciences, Kerala University.

Member, Working Group on Sanitation, Kerala State Planning Board.

Member, Project Management Committee on Environment and Earth System Sciences of KSCSTE.

Baba, M

Member, 'Committee of Experts to assist the Cabinet Sub-Committee constituted for preliminary discussion with the Government of Tamil Nadu on the Mullaperiyar issue', constituted by the Government of Kerala.

Member, 'University Level Advisory Board of the Rajiv Gandhi Chair for Contemporary studies' constituted by the Cochin University of Science & Technology.

Member, Standing Committee on Ocean Resources & Meteorology (SC-OM), constituted by the Department of Space, ISRO, Government of India

Member, 'Kerala Protection of River Banks and regulation of removal of sand rules – High level committee for river management fund 'constituted by the Government of Kerala'.

Member, Expert committee for infrastructural development and miscellaneous projects, Ministry of Environment & Forests, Government of India.

Member, National Coastal Zone Management Authority, Ministry of Environment and Forests, Government of India.

Member, Technical Expert Committee on flood control and coastal erosion prevention, Government of Karnataka.

Member, Steering Committee for MOEF projects on Snow / Glacier Studies and Coastal / Mangroves / Coral Reef Studies.

Member, Reconstituted Kerala and Lakshadweep Coastal Zone Management Authority, MOEF, Government of India.

Member, Reconstituted Governing Council of Attappady Hills Area Development Society, Government of Kerala.

Member, Kerala Dam Safety Authority, constituted by the Government of Kerala.

Chattopadhyay, S.

Member, 'Advisory Committee to finalise the methodology and design of Urban Atlas' prepared by the Information Kerala Mission

Member, 'Working Group on Urban Infrastructure, Plan Committee on Transport Infrastructure' constituted by the State Planning Board, Government of Kerala.

Member, 'Plan Committee on Fisheries, Environment & Ecosystem' constituted by the Sate Planning Board, Government of Kerala.

Special Invitee, 'Mission Group of Flag Ship Programme on Rural Energy' constituted by the State Planning Board, Government of Kerala.

John Mathai

Member, 'Committee of Experts to assist the Cabinet Sub-Committee constituted for preliminary discussion with the Government of Tamil Nadu on the Mullaperiyar issue', constituted by the Government of Kerala.

Muralidharan, V.

Executive Committee member, Indian Meteorological Society, Trivandrum chapter.

Member, District Level Technical Advisory Committee on Agriculture, Soil Conservation, Rainwater Harvesting, Water Recharging, Drinking Water and Sanitation, Energy & Tribal Sub Plan of the District Planning Committee.

Member, Executive Committee of the Indian Society of Remote Sensing, Trivandrum chapter.

Nair, A. S. K.

Member of the block level technical advisory committee of the Thiruvananthapuram rural block.

Member of the working group on State of Environment Kerala – Wetlands by the Kerala State Council for Science, Technology & Environment.

Member Plan Committee on Irrigation, Water and Waste Water, Science & Technology and Water Supply & Sanitation of Kerala State Planning Board.

Padmalal, D.

National Working Group Member IGCP-495: Quaternary land-ocean interactions-driving mechanisms and coastal responses.

Rajendran, C. P.

Council member, Geological Society of India

Radhakrishna, T.

Member of Expert Committee, for IRPHA project entitled 'Setting up of palaeomagnetic Laboratory in Mizoram University, Aizawl, Mizoram', of the DST.

Ravindra Kumar, G. R.

Member, CSIR Network Project Monitoring Committee, 2005-07.

Samsuddin, M.

Member of the expert 'Committee for evaluation of the proposals on the development of GIS database of vested forests in Palakkad District'.

Saravanan, E.

Executive Committee member, Indian National Cartographic Association, Hyderabad.

Shravankumar, V.

Executive Committee member, Indian National Cartographic Association, Hyderabad.

Sidharthan, S.

Member of the Working Group II on Urban Earthquake Vulnerability Reduction Program of Thiruvananthapuram Development Authority.

Soman, K.

Member of the 'Plan Committee on Fisheries, Environment and Eco-system' constituted by the Sate Planning Board, Government of Kerala.

Chairman, Working Group on 'Coastal marine and wetland eco-system' under the Plan Committee-Fisheries, Environment and Ecosystem, December 2006.

Subhash, N.

Member of the 'Technical Advisory Board of Aries Institute of Marine Technology, Cochin', which gives training to engineers for various branches in the marine field.

Sudeep, P.

Chairman, National Institute of Personnel Management (NIPM), Thiruvananthapuram Chapter, 2006-08.

Thomas, K. V.

Member of the Expert Committee to study the Prevention of sea erosion at Poonthura by Water Resources Department, Govt. of Kerala

Member f the State Level Committee to provide support in the preparation of Integrated Coastal Area Development Project by Fisheries and Port Department, Govt. of Kerala

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

7. Library and Publications

7.1 Library

The library of the Centre for Earth Science Studies is a special one. The collection of the library includes Books, Journals, Back volumes, CDs, VCDs, Proceedings, Standards, CD ROM database, Maps & Atlases, Theses, Project Reports, Reference Books, Annual Reports etc. Acquisition policy of the library is in tune with the ongoing programs of the Centre. In addition, the library acts as a resource pool to meet anticipatory demands of users. The collection consists of both print as well as contemporary digital resources by blending the normal and IT oriented information systems. In addition to the scientific community of CESS, the Library is open to Scientists and Researchers of other Institutions and Universities for reference.

During the year under report 37 books were added to the collection. The library subscribes to 23 National Journals and 15

International journals. In addition, journals are being received as gratis also. The library has a CD ROM bibliographic database – GEOBASE – with access to abstracts of articles from 1994-2005, published by Elsevier. Few VCD films on environment related topics are also available in the library.

The library is using the software SOUL, which is an integrated multi-user library management system that supports all in-house operations of the library. The software has different modules like Acquisition, Catalogue, Circulation, Serial Control, Online Public Access Catalogue (OPAC) and Administration. Bibliographic records of books available in the library can now be accessed through this OPAC module. One personal computer has been provided for users to search the OPAC. Search can be done by using different access points like title, author, accession number, subject, ISBN, publisher, class number etc. The search can be refined by using other parameters also. The database of books is being updated on day-to-day basis with details of recently acquired books.

As part of the infrastructure development programme two personal computers have been provided in the library for internet browsing, searching GEOBASE and other electronic contents. Library services like Selective Dissemination of Information (SDI), Current Awareness Services (CAS), Bibliography Service, Literature Search, Reference Service, Library Membership, Reprint Service, Press Clipping Service and Document Delivery Services are extended to CESS scientists.

7.2 Publication in Journals, Proceedings and Books

7.2.1 In Journals

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Chattopadhyay, S., Saji Kumar and Mahamaya Chattopadhyay. 'Landscape Evolution in Parts of Vamanapuram Drainage Basin, Kerala – A Hypsometric Approach'. Jr. Geological Society of India, 68, pp 841-856, 2006.

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Maya, K., Narendrababu, K., Padmalal, D. and Seralathan. 'Hydrochemistry and dissolved nutrient flux of two small catchment rivers of the South Western India', Chemistry and Ecology, 23 (1), pp 13-27, 2007.

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Nair, K. M., Padmalal, D. and Kumaran, K. P. N. 'Quarternary geology of South Kerala Sedimentary Basin - an outline'. Jr. Geological Society of India, 67, pp 165-179, 2007.

Neelakandan, V. N., Mohanan, C. N. and Sukumar, B. 'Development of Biogeographical Information System for conservations and monitoring of biodiversity'. Current Science, 90(3), pp 444-450, 2006.

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7.2.2 In Proceedings

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Ajaykumar Varma, R. 'Solid waste management – Issues and initiatives of Kerala'. Proc. of National Seminar on Environment Management and Waste Disposal – Emerging Trends. NSS College, Pandalam, pp 24-30, 2006.

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7.2.3 In Books

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Prakash, T. N., Chattopadhyay, S. and Nair, A. S. K . ' Impact of Tsunami on the Kerala coast and Rehabilitation Plan for the Worst Affected Stretch at Alappad', In: 26th Dec, 2004 Tsunami – Causes, Effects, Remedial Measures Pre and Post Tsunami Disaster Management – A Geoscientific Perspective. Editor-in-Chief: Rajamanickam, G. V. Editors: Subramaniyan, B. R., Baba, M., Ramesh, R., Lelango. and Prithviraj., M. Published by New Academic Publishers, New Delhi, pp 139-149, 2006.

Srikumar Chattopadhyay. 'Integrated coastal zone management – a conceptual frame work', In: Urban and regional development in India", (Eds. B. Thakur & Others) Concept Publication Co., New Delhi, pp 658-675, 2006.

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7.3 Project Reports

Ansom Sebastian. 'Graphite Mineralisation in the Karimukal area, Ernakulam district, Kerala with special emphasis on graphitization process and genesis' Submitted to Director, Centre for Earth Science Studies.

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Ajaykumar Varma, R. et al. 'Biodiversity Register of selected Grama Panchayaths and Municipalities' Submitted to Decentralisation Support Programme Mission, Govt. of Kerala.

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8. Conference, Seminar, Workshop

8.1 Prof. C. Karunakaran Endowment Lecture 2006

Understanding the Earth is riddled with complexities. According to Prof. S.K. Tandon earth records are 'snapshots' and linking them in the 'string of time' requires not only inter and multidisciplinary approaches, but tran disciplinary thinking. Prof. S. K. Tandon, the renowned Geologist, presently Pro Vice Chancellor of the Delhi University was giving the seventh Prof. C. Karunakaran endowment lecture in CESS on December 23, 2006.

The evolution of both life and matter cannot be understood through knowledge sets that are limited by disciplinary boundaries. Most of us are trained in any one of the following related set of disciplines-Geophysics, Geology, Geography, Geochemistry, Oceanography, Meteorology and Atmospheric Science.

Prof. S. K. Tandon recieves a memento from Dr. P. K.Thampi, former Head, Geosciences Division, CESS during the Endowment Lecture. Dr. M. Baba, Director, CESS is also seen.

Although there is growing recognition that new knowledge often lies at the intersection of disciplines, it is difficult to adopt problem solving approaches using the knowledge skills and methods of both related disciplines and seemingly unrelated disciplines. Prof. C. Karunakaran was one of the few geologists in this country who had the courage and conviction to recast 'traditional geosciences' into a Earth Science mode - a strongly inter disciplinary mode in which the three main components of the Earth - the lithosphere, hydrosphere and atmosphere are investigated in a holistic framework. That his thinking stood shaped in this way as early as the seventies is remarkable. He was ahead of his time by two to three decades; sadly his visionary thinking has very few followers in he earth sciences community in India. I feel privileged to count myself amongst those who follow the path shown by him, and be counted amongst those who firmly believe that problem - solving in the area of Environmental Sciences requires inter-multi and trans-disciplinary approaches.

We live in a world that is loaded with debatable issues; indeed in a world of loaded debate about climate change and the consequences of climate change. One of the most serious societal concerns of our times is how freshwater resources will be impacted upon by climate change. This will require a comprehensive understanding of modem surface and sub-surface water systems. We will have to move to paradigms in Earth Systems Sciences that will support 'Global sustainability'. This brings me to the subject of today's discussion - 'Large River Systems'. They have to be studied from several aspects Geology, Hydrology, Geochemistry, Hydrogeochemistry, Vegetational Systems, Anthropogenic influences and Management. These aspects of large river systems require approaches that help our understanding regarding positive and negative feedbacks between different sub systems (for example Vegetation and Hydrology; Pollution and Vegetation; Pollution and Hydrology), and the 'dynamics' of feedbacks in a scenario of climate change.

It is well known that the Earth's climate has changed with time, and will continue to change, to some extent, in a predictable way. Through geologic time, the Earth has witnessed several transitions from greenhouse state to icehouse state. The beginnings of the current icehouse earth go back to 30 million years. The icehouse earth witnesses glacial interglacial cycles that are strongly linked to the periodicities associated with the parameters of the Earth's orbital motion. There is overwhelming evidence to support the conclusion that for 500,000 years, major climatic changes have followed variations in obliquity and precession.

Unprecedented increments in temperature over the next century are predicted from the temperature trends of the previous century. The impacts of these changes on various elements of

A view of the audience attended the Prof. C. Karunakaran Endowment Lecture 2006

geomorphic systems and ecosystems need to be modeled. This modeling ultimately will have to be focused on the Earth's fresh-water resources. It is in this context that the world's large river systems assume a special significance. Understanding of large river systems will require new knowledge regarding their geologic and tectonic evolution, hydrological characteristics, sediment transport characteristics, morphological complexity, geochronologically constrained integrated facies models and thought experiments and simulation models of responses of large river systems to changing climatic states. These studies will have to factor in assessments of the sensitivity of river systems to century and millennial scale changes in different climatic regions of India.

Against this background, our investigations of the responses of the Ganges dispersal system to Late Quaternary climatic shifts suggest that variations in monsoonal strength dominated Ganges river and interfluve behavior over the past ~100 ka. Also, other workers have suggested a strong response refiected in sediment delivery to the G-B deltaic region in the Early to Mid-Holocene because of the marked strengthening of monsoonal precipitation.

Prof. S. K. Tandon plants a sapling in the CESS campus

Large river systems of the monsoon belts will require further focused efforts on the following issues:

• an improved understanding of sources and sustenance mechanisms of large rivers in a tectonics-climate coupled system;
• variations in annual sediment flux driven by climate through geological time and its implications for sequence models;
• improved understanding of the system wide response of large river systems to climate change and the links to component scale response of the system;
• propagation and transfer of the climatic response from one component to another;
• newer models of propagation of base level driven changes and an improved understanding of the interplay between the upstream propagation of basic level changes and down stream;
• propagation of the source area related changes of large river systems.

The endowment lecture series was instituted in 2000 in memory of Prof. C. Karunakaran, the founder Director of CESS. Prof. S. K. Tandon paid rich tributes to Prof. C. Karunakaran and said that his visionary thinking had enabled the establishment of CESS by the Government of Kerala in 1978. Dr. M. Baba, Director of CESS welcomed Prof. Tandon and the gathering of scientists and professional from institutions of Trivandrum. Dr. P.K. Thampi, former Advisor CESS remembered his association with Prof C. Karunakaran and the latters contributions to the field of Earth Sciences. Dr. C.P. Rajendran, Scientist CESS introduced Prof. S.K Tandon. Sri G.K. Suchindan, Head, TED,CESS gave the vote of thanks.

8.2 Integrated Coastal Zone Management Training Course for Coastal Zone Management Authorities

A view of the Training programme on Integrated Coastal Zone Management (ICZM) conducted at CESS

CESS conducted a short-term training course during 20-24 February 2007, on Integrated Coastal Zone Management (ICZM) for the members of the Coastal Zone Management Authorities belonging to Gujarat, Maharashtra, Goa, Daman, Diu, Karnataka, Kerala and Lakshadweep islands. Sixteen participants were given intensive training in this course, which was approved by the Ministry of Environment and Forests, Government of India. CESS is the nodal institution in Kerala dealing with Coastal Zone Management (CZM) issues, including training and capacity building of officials and local communities. During the workshop the following lectures were delivered:

The participants undergoing field training

Dr.Srikumar Chattopadhyay on 'Geomorphology for coastal zone management', Dr.R.Ajaykumar Varma on 'Carrying capacity based development planning for coastal areas with special reference to Thinnakkara Island', Dr.M.Baba on 'ICZM and CRZ on a National/State level perspective', Dr.C.N.Mohanan on 'Coastal ecosystems', Dr. N.P.Kurian on 'Shoreline changes', Dr. K.K.Ramachandran on 'Mapping principles & GPS', Sri. B.K. Jayaprasad on 'Application of GIS in CZM', Dr.Samsuddin on 'Remote Sensing Applications', and Dr.K.V.Thomas on 'CRZ Notification & demarcation of HTL and implementation mechanisms in CRZ'.

8.3 Training cum field workshop on 'Geo-information for Landslide Hazard and Risk Assessment'

Delegates of the Geo-information Workshop

CESS along with the Institute of Land Management (ILM) have hosted a Training cum Field Workshop on 'Geo-information for Landslide Hazard and Risk Assessment' during Jan. 15-27, 2007. The programme was organized by the United Nations University-International Institute for Geo-information Science and Earth Observation (UNU-ITC) School for Disaster Geo-information Management, Enschede, the Netherlands and Geological Survey of India Training Institute (GSI TI), Hyderabad. Prof. Dr. V.G. Jetten, Dr. C.J. Van Westen and Dr. Santiago Begueria from UNU-ITC, Mr. G. Sankar and John Mathai from CESS and Dr. P. K. Thampi (retired scientist from CESS) along with scientists from GSI conducted the lectures and gave hands on training to the participants of the workshop. The target group for the workshop was Geologists, Physical Geographers and Environmental scientists working on landslides from various

Participants of the Workhop during field visit

research institutions in India. 20 participants drawn from organizations such as NHPC, GSI, CESS, Universities such as Kerala Agricultural University, MG University, Jiwaji University, and colleges such as Chirst College, Irinjalakuda, Thyagaraja College of Engg., Madurai, participated. The field session was conducted in the Munnar area where a number of landslide incidents have occured during the monsoon season of 2005. The participants also visited the famous Idukki arch dam during this trip. The course enabled the participants to understand the process of landslides in a holistic manner and the skills acquired would be useful to reduce revenue losses to various state governments in the long run.

A visit to the Southern Regional Head Quarters of the Geological Survey of India

8.4 Workshop on Pathiramanal Biodiversity Conservation and Biopark Project

The Pathiramanal Biodiversity Conservation and Biopark Project, sponsored by the KSCSTE, was initiated in the month of April 2006. A brain storming workshop was held to discuss various issues related to this project on17 August 2006 at CESS. Professional having expertise in the fields of Biodiversity, Fishery, Environment, Geology, Tourism, Economics and Rural Management, from various organisation in the State were invited. Representatives from Kanjikuzhy Block Panchayat and Muhamma Gram Panchayats also participated in the workshop. The discussion began with a brief presentation made by the CESS project team highlighting objectives of this project and

Hon'ble Minister for Finance Dr. Thomas Isaac inaugurates the workshop on Pathiramanal biodiveristy conservation and biopark project

presenting results of the preliminary survey. During deliberations it was stressed that conservation and enhancement of biodiversity will be the focus of this project. Development of ecotourism and all other ancillary activities will be around this main theme. As a part of diagnostic survey it was proposed to conduct bathymetric survey, land use mapping, plant biodiversity survey, identification of core forest area, computation of tourist visitation, soil analysis and preparation of a plant biodiversity information system. Planting of trees enhancement of vegetation cover in the island and also in the shoals around the island have been envisaged as a first step of intervention. It was suggested that outcome of this project will be a detailed action plan for biodiversity conservation and ecotourism development. This project is identified as one year programme of CESS.

8.5 User Interaction Workshop: Integration of Natural Resource Potential (NRP) and Socio-Economic Development (SED) for Micro Level Planning in Kottayam District

This three years project, sponsored by the DST, Government of India was undertaken to generate panchayat level information on natural resources and levels of socio-economic development and to understand interrelationships between NRP and SED. It is expected that results emerged from this study will help preparation of micro level planning of Kottayam district. The user interaction workshop held on 18 February 2006 at Kottayam was intended to receive feed back from the panchayats and to use that information for finalising the report. The second objective was to initiate a discussion for evolving a broad guideline for district plan through detailed interaction among the participants. A brief write up was circulated before hand among the potential participants from Gram Panchayats, Block Panchayats, District Panchayat and different Government, Semi-Government and Non Government organisations.The programme of the workshop was accomplished through one inaugural session and three technical sessions. There were 145 participants from all levels of the district. Director, CESS welcomed the gathering and Sri. Thomas Kunnappally, the President, Kottayam District Panchayat inaugurated this one day workshop. Technical session began with presentation of the study report. Group discussion followed general identification of core forest area, computation of tourist visitation, soil analysis and preparation of a plant biodiversity information system. Planting of trees enhancement of vegetation cover in the island and also in the shoals around the island have been envisaged as a first step of intervention. It was suggested that presentation. Each group coordinated by a resource person and discussed all the issues relevant to their panchayat / block. The study findings were scrutinised by the group members with the help of a check list of problems emerged from data analysis related to the project. There were presentations from the groups during feed back session. Participants opined that 80% to 90% of the problems identified through the study were valid. They also got an understanding about the relationship between NRP and SED and expressed their desire to use the report for preparation of development plans of their panchayat / block with Dr. Srikumar Chattopadhyay as Principal Investigator.

Sri. Thomas Kunnappally, President, Kottayam, District Panchayat inaugurating the workshop

Group discussion of participants during the workshop

8.6 Invited/Keynote Lectures

Ajaykumar Varma, R. gave a keynote address on 'Environment of Kerala and Desertification' in a workshop organized by the Darsanam Samskrika Vedi and KSCSTE in connection with 'World Environment Day' at Kozhikode on June 24, 2006.

Ajaykumar Varma, R. delivered a talk on 'Watershed based development and its linkage with National Rural Employment Guarantee Act at Town Hall, Kalpetta, Wayanad' organized by the Local Self Government Department, Government of Kerala on July 9 , 2006.

Ajaykumar Varma, R. delivered a talk on 'Environmental issues and Urban Development' in the two day conference Chamber of Municipal Chairmen at Alapuzha on August 21, 2006.

Ajaykumar Varma, M. delivered a lecture on 'Social Participation in Solid Management' at a training programme on 'Participatory approach for sustainable development'

conducted by the Extension Training Centre, Kottarakara on December 12, 2006.

Baba, M. delivered the Engineers' Day lecture on 'Role of Engineers in Natural Disaster Mitigation and Management' in the Engineers' Day Celebrations organised by the Institution of Engineers at Thiruvananthapuram on September 15, 2006.

Baba, M. inaugurated the session hosted by Department of Geology in connection with 'Spectrum-2006' academic conference and delivered the Key Note Address on 'Relevance of Earth Sciences' at the Sree Narayana College, Thiruvananthapuram on October 31, 2006.

Baba, M. delivered the keynote address on 'Agriculture and Environment' at the Valedictory function of the Golden Jubilee Year Celebrations of Mitraniketan, Vellanad, Thiruvananthapuram on August 17, 2006.

Baba, M. delivered the lead paper on 'Indian experiences in Coastal Zone Management' in the Seminar on 'Conservation and Management of Natural Resources for Environmental Protection of the Coastal Zone of Kerala' at KFRI, Peechi on August 28, 2006.

Baba, M. presented the lead paper on 'Coastal Zone Management' in the workshop on Integrated Caostal zone management held at Thiruvananthapuram on May 20, 2006.

Baba, M. delivered the inaugural address at the ISRS Workshop on 'Geoinformatics for Local Level Planning' held in the Institute of Engineers Hall, Thiruvanan-thapuram on November 17, 2006.

Baba, M. delivered the Prof. T.C. Madhava Panicker Endowment-cum-Valedictory Lecture in the National Seminar on 'Geoscience for Disaster Management' at the Department of Geology, Government College, Kasaragod, on March 24, 2007.

Chattopadhyay, S. delivered a special lecture on 'On the way to sustainability: Kerala's initiatives' during Indian Geography Congress organised by the Department of Geography, Madgadh University, Bodh-Gaya on November 10-12, 2006.

Kurian, N. P. delivered a talk on 'Coastal erosion problems and remedies' in the workshop on Disaster Management organized by Department of Land Revenue on August 29, 2006.

Kurian, N. P. gave an invited talk on 'Coastal process of South West coast of India' in the National workshop on Emerging Trends in Ocean Science & Technology on March 16, 2007.

Neelakandan, V. N. delivered a lecture on 'Bioinformatics an adjunct to Taxonomy and Biodiversity Management' to the participants of the workshop in Taxonomy held at Department of Botany, University of Kerala on August 24, 2006.

Ravindra Kumar, G. R. gave an invited talk on 'Overview on Kerala charnockites' in the annual convention of the Geological Society of India held at the Wadia Institute of Himalayan Geology, Dehradun during November 22-24 , 2006.

Soman, K. delivered a lecture on 'Natural Disasters' to the participants of the 'Thalir Vacation Camp' organized by State Institute of Children's literature on May 3, 2006.

8.7 Conference/Symposium/Seminar/ Workshop presentations

Ajaykumar Varma, R. attended a one day workshop organized by Kerala Union of Working Journalists at KILA, Thrissur and delivered a talk on 'Water policy of Kerala' on December, 3 2006.

Chattopadhyay, S. and Chattopadhyay, M. delivered lectures as resource persons in DST sponsored training programme on 'Modelling in Resource Management and Environment through Geomatics' at Jaipur during December, 2006.

Kurian, N. P. attended NDMA workshop on storm surge, flood and drought during February 1-2, 2007 and made a presentation on CESS activities in the field.

Nair, A. S. K. attended a National workshop on 'Geoinformation Management for micro-planning and Governance in India at Institute of Rural Management, Anand, Gujarat during 27-28 April 2006 and made a presentation on Geo-ICT enabled microplanning and governance: Kerala experience.

Nair, A. S. K. attended one day symposium on 'Need for better natural resources management for Kerala on July 28, 2006 at the Science and Technology museum, Thiruvananthapuram and presented a paper on 'Management of Wetlands for Sustainable Developments'.

Nair, A. S. K. attended the one day workshop on 'Science and Technology in out for the perspective development of Kerala organized by Kerala State Remote Sensing and Environment Centre at Government guest house, Thiruvananthapuram on September 1, 2006.

Nair, A. S. K. attended the International conference on b-GIS@India organized by Department of Geology, University of Kerala, Thiruvananthapuram on December 7-8, 2006.

Nair, A. S. K. attended the IInd Kerala Environment Congress 2006 organized by the Centre for Environment and Development during 15-16 December 2006 at Kozhikode and acted as a member of the presidium for one technical session.

Nair, A.S.K. presented a paper on 'Management of Wetlands for Sustainable Development' in the symposium on 'Need for Better Natural Resources Management for Kerala' organized by Kerala State Land Use Board on July 28, 2006.

Nair, A.S.K. attended the seminar on 'Fire Protection Force and Society' held during the Silver Jubilee Celebration of the Kerala Fire Service Association and delivered a talk on 'Science and Technology inputs to Fire and Rescue Services Department of the Government of Kerala' on October 26, 2006.

Nair, A. S. K. attended a seminar organized by Kerala State Land Use Commissioner, Government of Kerala and presented a paper on 'Resource Mapping for Development at Panchayat Level' on December 26, 2006.

Prakash, T. N. participated in the 'National Meet on Indian Tsunami' and presented the paper 'Results of Post-Tsunami field surveys along the Kerala coast', held at Anna University, Chennai on June 6, 2006.

Sasikumar, V. participated in a National Seminar on 'Effective Utilisation of EDUSAT' organized by the Education Department of Kerala during 3 – 4 August 2006 and presented a paper on 'Free Educational Content for EDUSERVE'.

Soman, K. attended a seminar on 'R&D needs for Regional Development' and made a presentation on 'R&D needs in natural resources & environmental management' organized by Indian Institute of Chemical Engineers, Trivandrum Regional Centre and Regional Research Laboratory on 8 December 2006.

9. Extension

9.1 CESS News - the official newsletter

CESS News, the quarterly official news letter of the Centre was published uninterrupted during the period under report. The copies of the newsletter were circulated among institutions and individuals in the mailing list. Copies were also distributed to the public and students through the CESS exhibition stalls at various venues. The electronic version of the newsletter is available for download in the CESS website. The soft copies are also sent via electronic mail to individuals all over the world who have subscribed through internet. The back volumes of the newsletter are also sent to individuals on request.

9.2 CESS Website

The website of the Centre with its URL: http://www.cessind.org is operational since 1999. The site gives almost all details about the Centre and its activities. It is also offering pages on current activities and latest publications etc. Visitors of the website could subscribe to the electronic version of the CESS News, the quarterly newsletter, other bulletins and brochures. The site records an average of 90 thousand hits per month.

9.3 Exhibition

During the period under report CESS participated in many exhibitions conducted at different parts of the State. CESS stall at the exhibition conducted at Erattupetta in connection with the Awareness programme on Disaster Management was very popular among the people living in the landslide prone regions of the Western Ghats. Other major exhibitions in which CESS set up an exhibition stall are 'Swasrya Bharat 2006' at Kochi, the Golden Jubilee Celebrations of Mitraniketan, the Trichur Pooram exhibition, the 'Suvarnavarsham' exhibition organized by Kochi City Police at Marine Drive, the exhibition organized as part of the 19th Kerala Science Congress at Kannur, the exhibition organized by the Revenue Department of the Government of Kerala in connection with the one day seminar cum exhibition on 'Natural Disasters and their Mitigation Measures' at KKTM College, Kodungallur and the Seventh All India Photographic Competition and Exhibition in connection with the World Environment Day Celebration. Dr. K. Raju and Sri. R. Sivarajan Pillai lead the team that manned the exhibition stalls set up by CESS.

9.4 Earth Day and Technology Day

CESS observed the Earth day and Technology day on 11 May 2006 with various awareness programmes. About two hundred students from nearby higher secondary schools and the public visited the Centre and participated in the programmes arranged in the campus. Laboratories were open to the students and public. Mr. Satish Babu, President INAAP technologies, Technopark, while delivering lecture on 'Information technology - for young practitioners' said that 'ITC have revolutionalised the way we think, work, educate and do business'. He also said that 'the pervasive computing is accessible, affordable and present everywhere'. Another lecture by Dr. Nandakumar, Scientist, GSD, stressed that 'Soil is the life and it is our responsibility to conserve it, protect it and nurture it'. A quiz competition was held for high school students from Thiruvananthapuram city and neighbouring regions on

Winners of quiz competition receive prizes from Dr. M. Baba, Director CESS.

the theme 'Earth Environment and Technology'. Kumari Neeraja Ramakrishnan from VSSC Centre School won the first prize, Master Shyam Venkat from Sainik School,

Students in CESS campus during the Earth Day and Technology Day celebration

Thiruvananthapuram and Master Sunil Thomas from St. Thomas School Thiruvananthapuram, won the second and third prizes respectively. The winners of the quiz competition were given trophies and cash awards.

9.5 Radio talks

Dr. R. Ajaykumar Varma gave a talk on 'Stockholm Convention on Persistant Organic Pollution' in AIR, Trivandrum on 3 May, 2006.

Dr. A.S.K. Nair delivered a talk in Malayalam on 'Land resources conservation and soil conservations' in AIR, Thiruvananthapuram on 6 November 2006.

A talk by Dr. Kurian on Tsunami warning system was broadcasted in the All India Radio on 7th February 2007.

9.6 National Science Day

National Science Day, 2007 was observed in CESS on 28th February. Talks were conducted for Post Graduate students in Geology and Geography on Geomatics, Applications of GIS and Coastal hazards. Students and teachers interacted with scientists in Remote Sensing and Geographical Information Systems during their visit to the laboratories.

9.7 Booklet on Earthquake for the public

A Malayalam booklet on earthquakes entitled *Bhoochalanam-Ariyenda Karyangal* authored by Dr. C.P. Rajendran, Dr.

The Science Quiz Trophy being given away by Dr. E.P. Yesodharan, the Executive Vice-President of the KSCSTE during the Science Day 2007 celebrations in the presence of Dr. M. Baba, Director, CESS

Kusala Rajendran and S. Sidharthan was published by CESS for the general public of Kerala State. This short publication is aimed to clear the doubts of the common man on various aspects of tremors. The booklet was officially released by the Hon'ble Minister for Revenue Sri. K.P. Rajendran at a function organised at Wadakkanchery in Trissur district on January 7, 2007. Copies of this publication can be obtained free from the Director, Centre for Earth Science Studies, Akkulam, Thiruvananthapuram, on request.

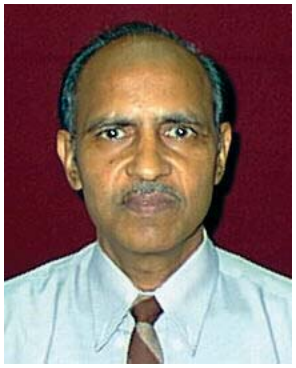
9.8 Other actvities

Soman, K. delivered a lecture on 'Natural Disasters' to the participants of the 'Thalir Vacation Camp' organized by State Institute of Children's literature on 3 May 2006.

Ajaykumar Varma, R. delivered a talk on 'Watershed based development and its linkage with National Rural Employment Guarantee Act as Town Hall, Kalpetta, Wayanad' organized by the Local Self Government Department, Government of Kerala on 9th July 2006.

10. Visitors to CESS

10.1 Distinguished visitors



Dr. P. S. Goel, Secretary, Ministry of Earth Sciences, Government of India, visited CESS on 5 June 2006. He addressed the scientists and visited the laboratories of CESS and stated that "CESS is an excellent lab covering all aspects of earth sciences and a very unique laboratory. Done well and can play a very important role in national context".

A two member team from the Centre for Tropical Marine Ecology (ZMT), Germany visited CESS as part of the collaboration project on "biogeochemical studies of small mountainous rivers of Kerala, India" and visited selected study area sites.

Professor Dr. Victor Jetten of ITC Netherlands visited CESS and held discussions with scientists on practical methods of disaster management.

A delegation of Vietnamese technocrats and bureaucrats from mining/small scale industry visited CESS and held wide ranging discussions on the clay mining, its environmental impacts, clay based industries and utilization of laterites in the building industry.

Dr. P. K. Sinha, Deputy Director General, Geological Survey of India, Hyderabad.

As part of Kerala study tour 2006, a team of 8 American citizens visited CESS for a discussion on 'the state of environment in Kerala: the changing trend and Kerala's attempt to attain sustainable development' with Dr. Srikumar Chattopadhyay on 28 November 2006.

Dr. T. S. Murty, the internationally acclaimed tsunami and storm surge expert, was in CESS during 16 July to 6 August 2006 and 8 November to 7 December 2006 in connection with the Coastal Hazards project for which he is an Advisor.

10.2 Other Visitors

Geology students of Bangalore University visited the Centre on 25.4.2006.

The IVth year students and staff members of Govt.College of Engineering, Krishnagiri, Tamil Nadu visited CESS on 31 August 2006 as part of their industrial visit.

Thirty five students and five teachers visited our campus on 23rd September 2006 as part of the 'Yuvasangamam programme' sponsored by the 'Kerala Sasthra Sahithya Parishath'.

Eighty students from Lady Doak College, Madurai visited CESS on 29.11.2006.

Fifty students and staffs from A.R.V.S.M.H.S.S Vallikunnam, Puthenchantha and attended talk by our scientists on 23.12.2006.

Fifty students and staffs from R.V.S.M. Higher Secondary School, Vallikunnam, Puthenchantha visited CESS on 10th November 2006.

Seventy five students and four staff members from Infant Jesus Convent ICSE School on 20th January 2007.

Thirty students and two staff members from Kuvempu University, school of earth & environmental science, Karnataka on 25.01.2007.

A ten member team from the Department of Agronomy Kerala. Agricultural University visited CESS on 20th December 2006.

11. Committees

11.1 Statutory Committees

11.1.1 Research Council

Dr. S. K. Acharya Director General Geological Survey of India (Retd) Kolkatta	Chairman
Prof. S. K. Tandon Pro-Vice-Chancellor University of Delhi New Delhi	Member
Dr. Prithvish Nag Director, National Atlas & Thematic Mapping Organisation Kolkatta	Member
Dr. Shailesh Nayak Director Indian National Centre for Ocean Information Services Hyderabad	Member
Sri. K. K. Krishnanunni Director General Geological Survey of India (Retd) Palakkad	Member
Dr. P. V. Joseph Visiting Professor Cochin University of Science & Technology Kochi	Member
Dr. M. Baba Director Centre for Earth Science Studies Thiruvananthapuram	Member & Ex-Officio Convener

11.1.2 Management Committee

To be constituted

11.2 Internal Committees

11.2.1 Heads of Divisions

Dr. M. Baba Director	Chairman
Dr. S. Sampath Atmospheric Sciences Division	Member
Sri. G. K. Suchindan Training & Extension Division	Member
Dr. N. P. Kurian Marine Sciences Division	Member
Dr. K. Soman Resouces Analysis Division	Member
Dr. P. P. Ouseph Chemical Sciences Division	Member
Dr. T. Radhakrishna Geosciences Division	Member
Dr. M. Samsuddin SIC, Geomatics Laboratory	Member
Dr. R. Ajaykumar Varma Environmental Sciences Division	Member
Sri. P. Sudeep Registrar	Member
Sri. C. K. Sasidharan SIC, Technical Cell	Convenor

11.2.2 Editorial

Dr. N. Subhash	Chairman
Dr. V. Sasikumar	Member
Sri. Abdunnasar	Member
Sri. C. K. Sasidharan	Member
Sri. S. Sidharthan	Convenor

11.2.3 Purchase

Dr. S. Sampath	Chairman
Sri. P. Sudeep	Member
Sri. John Mathai	Member

11.2.4 Library Management

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

11.2.5 Library Stock Verification

Sri. V. N. Neelakantan	Chairman
Dr. Narayanaswamy	Member
Smt. Ahalya Sukumar	Member

11.2.6 Canteen

Dr. N. Subhash	Chairman
Sri. V. Muralidharan	Member
Sri. S. Devadas	Member
Ms. Ahalya Sukumar	Member
Sri. A. Gopinathan	Convenor

11.2.7 Toposheet Verification

Dr. E. J. Zachariah	Chairman
Dr. Narayanaswamy	Member
Ms. C. Sakunthala	Member

11.2.8 Plan Project Evaluation & Monitoring

Dr. S. Sampath	Chairman
Dr. S. Chattopadhyay	Member
Dr. R. Ajay Kumar Varma	Member
Sri. John Mathai	Member
Dr. K. V. Thomas	Member
Dr. K. Narendra Babu	Member
Dr. M. Samsuddin	Member
Sri. G. Balasubramonian	Member
Sri. C. K.Sasidharan	Convenor

11.2.9 Stock Verification (CESS)

Dr. E. J. Zachariah	Chairman
Dr. Narayanaswamy	Member
Sri. B. Sukumar	Member
Dr. P. K. Omana	Member
Sri. John Paul	Member
Sri. Ramesh Kumar	Member
Sri. K. J. Mathew	Member
Sri. M. Ismail	Member
Sri. K. Surendran	Member
Smt. P. Prabhavathy	Member
Smt. S. Lyla Beevi	Member
Sri. K. Ravikumar	Convenor

12. Staff Details

12.1 Director's Office

Dr. M. Baba	Director
Sri. N. Rajasekharan Nair	P. A to Director
Sri. C. K. Sasidharan	Scientist-C & SIC, TC
Sri. S. Sidharthan	Scientist-C
Sri. V. Krishnan	Typist (Gr. II)
Sri. N. Unni	Helper (Gr II)
Sri. V. Chandran Nair	Helper (Gr. II)
Sri. G. Krishnan Nair	Driver (Gr. II)

12.2 Atmospheric Sciences Division

Dr. S. Sampath	Scientist-F & Head
Dr. N. Subhash	Scientist-F
Dr. E. J. Zachariah	Scientist-F
Dr. V. Sasikumar	Scientist-E2
Dr. S. Muralidas	Scientist-E2
Sri. K. Vijayakumar	Scientist-E1
Sri. K. J. Mathew	Scientist-E1
Sri. Mohammed Ismail	Technical Officer (G2,Gr.3)
Sri. T. K. Krishnachandran Nair	Technical Officer (G2,Gr.3)
Ms. P. Prabhavathy	Stenographer (Gr 2)
Sri. A. Kunhiraman	Helper (Gr. II)

12.3 Chemical Sciences Division

Dr. P. P. Ouseph	Scientist-F & Head
Dr. M. N. Muraleedharan Nair	Scientist-E2
Dr. K. Narendra Babu	Scientist-E2
Dr. P. K. Omana	Scientist-E2
Sri. R. Sarachandran	Technical Officer (G2,Gr.3)
Sri. K. Surendran	Stenographer (Gr. II)

12.4 Environmental Sciences Division

Dr. R. Ajaykumar Varma	Scientist-E2 & Head
Dr. C. N. Mohanan	Scientist-E1
Dr. D. Padmalal	Scientist-C
Dr. K. Maya	Scientist-C
Ms. K. Prasanna	Typist (Gr. I)

12.5 Geomatics Laboratory

Dr. M. Samsuddin	Scientist-F & S I C
Dr. K. K. Ramachandran	Scientist-E2
Dr. V. N. Neelakantan	Scientist-E2
Dr. C. M. Harish	Scientist-E2
Sri. B. K. Jayaprasad	Scientist-B

12.6 Geosciences Division

Dr. T. Radhakrishna	Scientist-F & Head
Sri. John Mathai	Scientist-F
Dr. C. P. Rajendran	Scientist-E2
Dr. Narayanaswamy	Scientist-E2
Dr. Kusala Rajendran	Scientist-E2
Sri. G. Sankar	Scientist-E2
Sri. G. R. Ravindrakumar	Scientist-E2
Dr. V. Nandakumar	Scientist-C
Dr. D. S. Suresh Babu	Scientist-C
Sri. S. S. Salaj	Technical Officer
Sri. R. Karunakaran Nair	Helper (Gr. II)

12.7 Marine Sciences Division

Dr. N. P. Kurian	Scientist-F & Head
Dr. K. V. Thomas	Scientist-E2
Dr. A. S. K. Nair	Scientist-E2
Dr. T. N. Prakash	Scientist-E2
Dr. T. S. Shahul Hameed	Scientist-E2
Dr. X. Terry Machado	Scientist-E2
Sri. V. Vasudevan	Scientist-E1
Ms. L. Sheela Nair	Scientist-E1
Sri. John Paul	Scientist-C
Sri. S. Mohanan	Technical Officer (G2,Gr3)
Sri. A. Vijayakumaran Nair	Technical Officer (G2,Gr.3)
Sri. M. Ajith Kumar	Technical Officer (G2,Gr.3)
Sri. M. Ramesh Kumar	Technical Officer (G2,Gr.3)
Ms. K. G. Omana Amma	Typist (Gr. II)

12.7.1 Coastal Laboratory, Valiathura

Sri. Louis Williams	Helper (Gr. II)

12.8 Resource Analysis Division

Dr. K. Soman	Scientist-F & Head
Sri. B. Sukumar	Scientist-E2
Dr. Srikumar Chattopadhyay	Scientist-E2
Sri. Shravan Kumar	Scientist-E1
Ms. Ahalya Sukumar	Scientist-E1
Dr. Mahamaya Chattopadhyay	Scientist-C
Ms. C. Sakunthala	Technical Officer (G2,Gr.3)
Ms. A. Balkeez	Typist (Gr. I)
Sri. P. C. Sasikumar	Helper (Gr. I)

12.9 Training & Extension Division

Sri. G. K. Suchindan	Scientist-F & Head
Sri. G. Balasubramonian	Scientist-E2
Dr. E. Saravanan	Scientist-E1
Dr. Ansom Sebastian	Scientist-E1
Dr. K. Raju	Scientist-B
Sri. S. Devadas	Tech. Officer (Photography)
Sri. R. Sivaraja Pillai	Tech. Asst. (Drafsman)
Ms. Najumunniza	Tech. Asst. (Drafsman)
Ms. S. Lyla Beevi	Typist (Gr. II)

12.10 Library

Sri. A. Abdunnasar	Scientist-B (Librarian)
Ms. Preetha Sathyan	Proffessional Assistant
Ms. P. Girija	Office Assistant (Gr. I)
Sri. P. M. Gopakumar	Helper (Gr. II)

12.11 Camp Office, Kochi

Dr. P. V. S. S. K. Vinayak	Scientist-E2 & S I C
Sri. K. R. Unnikrishnan	Scientist-E2
Ms. Sreekumari Kesavan	Scientist-B
Sri. K. K. Varghese	Tech. Asst. (Gr. V)
Sri. D. Raju	Tech. Asst. (Draftsman)
Sri. N. R. Prakasan	Tech. Asst. (Gr. IV)
Sri. K. P. Bhaskaran	Stenographer (Gr. I)
Ms. M. K. Radha	Typist (Gr. I)
Ms. O. S. Sarojini	Helper (Gr. II)
Sri. Asokan Andy	Helper (Gr. II)

12.12 Administration

Sri. P. Sudeep	Registrar
Sri. R. Renganathaswamy	Internal Audit Officer
Sri. M. P. Sivakrishnan	Deputy Registrar (Accts)
Sri. K. Ravikumar	Deputy Registrat (Stores)
Ms. S. Kalpana Devi	Asst. Registrar (Purchase)
Sri. K. Sreedharan	Asst. Registrar (Admn.)
Sri. P. Gopakumar	Asst. Controller, Finance
Sri. A. Gopinathan	Section Officer
Sri. M. A. K. Haroon Rasheed	Section Officer
Ms. K. V. Padmaja Kumari	Section Officer
Sri. N. Sukumara Pillai	Engg. Supervisor (Grd. I)
Sri. P. Ramachandran Nair	Driver (Gr. I)
Sri. S. Krishnakumar	Office Asst. (Gr. II)
Sri. R. Haridas	Office Asst. (Gr. II)
Ms. K. Viswabharathy	Office Asst. (Gr. II)
Sri. C. M. Yousuf	Office Asst. (Gr. II)
Ms. G. Sarojini Amma	Office Asst. (Gr. II)
Sri. M. Madhu Madhavan	Office Asst. (Gr. IV)
Ms. R. Jaya	Office Asst. (Gr. IV)
Ms. G. Lavanya	Office Asst. (Gr. IV)
Sri. T. D. Besherdeen	Stenographer (Gr. I)
Sri. C. N. Gopalakrishnan Nair	Stenographer (Gr. II)
Ms. N. J. Saramma	Typist (Gr. I)
Ms. C. Thulasi	Typist (Gr II)
Ms. K. Nirmala	Clerical Asst. (Gr. II)
Sri. N. Jayapal	Clerical Assistant
Sri. K. R. Satheesan	Clerical Assistant
Sri. G. Chandukutty	Clerical Assistant
Sri. M. Parameswaran Nair	Skilled Assistant
Sri. G. Balakrishnan	Skilled Assistant
Sri. K. P. Thulaseedharan	Skilled Assistant
Sri. C. Surendran	Skilled Assistant
Sri. K. Gopi	Skilled Assistant
Sri. R. Karthikeyan Nair	Helper (Gr. I)
Ms. S. Vimala Kumari	Helper (Gr. I)
Sri. R. Sudhakaran	Helper (Gr. I)
Sri. P. Devan	Helper (Gr. I)
Sri. B. Rajendran Nair	Helper (Gr. II)
Sri. P. Saseendran Nair	Helper (Gr. II)
Sri. P. Rajendra Babu	Helper (Last Grade)

CENTRE FOR EARTH SCIENCE STUDIES

(An Institution of Kerala State Council for Science, Technology and Environment)

Balance Sheet as at 31st March 2007 (without excluding inter-unit balances of CESS and External Projects)

Liabilities	SCH	31.03.2007	31.03.2006	Assets	SCH	31.03.2007	31.03.2006
		Rs. Ps.	Rs. Ps.			Rs. Ps.	Rs. Ps.
General Fund	I	34389435.07	20853195.07	Fixed Assets	VI	47323754.00	33787514.00
Current Liabilities and Provisions	II	17858208.00	20438842.00	Current Assets	VII	16666390.85	18308091.35
				Loans & Advances	VIII	13873496.00	14819951.00
Unspent balance of Grant from GOK		25615997.78	25623519.28	External Projects:			
				Current Assets	IX	22996874.21	22626172.21
				Loans & Advances	X	1197096.00	3855121.00
Unspent balances of External Projects	III	24193970.21	26481293.21	Consultancy Projects:			
				Current Assets	XI	29413702.00	23259441.00
				Loans & Advances	XII	15634550.00	15105008.00
Advance received for Consultancy Projects pending adjustment	IV	45048252.00	38364449.00				
Corpus Fund	V	14383015.50	11026678.00	Corpus Fund:			
				Balance with SBT		806998.50	5350661.00
				Term Deposits		13576017.00	3976017.00
				Fund Transfer			1700000.00
Total		**161488878.56**	**142787976.56**	**Total**		**161488878.56**	**142787976.56**

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

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

AUDITORS' REPORT
As per our report of even date attached

Thiruvananthapuram
Date: 15.12.2007

For S. Suresh Babu & Associates
Chartered Accountants
Sd/-
S. Suresh Babu, B.Sc., FCA
Membership No. 202893