ANNUAL REPORT 2013-'14

NCESS Annual Report 2013-'14

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National Centre for Earth Science Studies

Committed to Our Earth Our Future

ANNUAL REPORT 2013-'2014

National Centre for Earth Science Studies
(ESSO, Ministry of Earth Sciences, Govt. of India)
Akkulam, Thiruvananthapuram-695011, India

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From the Director's Desk

This has been one of the most significant years in the history of the Centre, as the process of take-over of the Centre for Earth Science Studies (CESS) by the Ministry of Earth Sciences (MoES), Government of India, initiated in 2012, was accomplished. I feel proud, while recalling significant contributions made by my predecessors towards the growth of the Institute and efforts in this direction, for being personally part of this major achievement. I present this Annual Report for the year 2013-14 of CESS, now the National Centre for Earth Science Studies (NCESS), with immense pleasure and fulfilment of long cherished goal.

The Centre was formally taken over by MoES on 1st January 2014 with the signing of a tripartite MoU by the Secretary, MoES; Principal Secretary, Science and Technology Department, Government of Kerala and the Executive Vice President, Kerala State Council for Science, Technology & Environment in the august presence of Sri. Oommen Chandy, Hon'ble Chief Minister of Kerala, Sri. E. K. Bharat Bhushan, Chief Secretary, Government of Kerala and several other dignitaries. Upon takeover, the Centre was registered as a society with a new name – National Centre for Earth Science Studies (NCESS) and is a constituent of the Earth System Science Organisation (ESSO) of MoES.

I, on behalf of the CESS family, thank the honourable Chief Minister and the Government of Kerala for nurturing this institute and contributing to its growth as a premier earth science institute of the country. The takeover has given CESS an additional impetus to pursue R&D activities that benefit the nation and the scientific community. We are honoured by the confidence bestowed on us by the MoES and the Government of India and are sure that NCESS will live up to the expectations and play vital role in fulfilling the mandate of the MoES. The article "NCESS: Retrospect and Prospect " in this edition of the Annual Report gives an account of vision, mission and the R&D programmes proposed to be taken up by the NCESS.

Our research pursuits are organized along four areas of Earth Sciences, viz. Crustal Processes, Coastal Processes, Atmospheric Processes, and Natural Resources and Environmental Management (NREM). The R&D activities continued unabated in spite of the decreasing number of Scientists consequent on retirement and the increased demand on time of all Scientists due to the rigorous takeover procedures.

The Crustal Processes programme primarily focused on the petrological studies of southern granulite belt, geochemistry and palaeomagnetism of mafic dykes, formation of palaeofluids in petroliferous basins, Quaternary geology and geohazards. Studies on petrology, geochemistry and isotopic work on granulites of Kerala khondalite presented evidence for episodic crustal growth. Palaeomagnetic studies reveal that the palaeoproterozoic mafic dykes in south India belong to discrete, large igneous provinces that are distributed over large areas. The studies of palaeofluids using Micro Laser Raman on the rock samples from the ONGC well RV1 confirmed the occurrence of CO_2 and CH_4 inclusions in the Bassein and Panna Formations off the west coast of India.

Investigations on the palaeo-environmental and palaeoclimatic studies of the Quaternary sediments of SW coast recorded two sea level rise events in the coastal sedimentary archives of SW India – one during the Late Pleistocene and the other during the Early Holocene. Investigation on land degradation due to landslides and land subsidence was another important area of work. A collaborative study of land subsidence with the Revenue Department, Government of Kerala has helped to suggest mitigation measures and to develop appropriate warning system to contain adversities of these hazards. The broad band seismic station at Peechi in central Kerala continued to collect seismic signals and contributed data to the national seismic network through V-Sat connectivity.

Under the programme on coastal processes, the areas of focus were sediment budgeting, sea level rise and impact studies, wave monitoring for INCOIS Ocean State Forecast and preparation of Coastal Zone Management Plans. CESS was able to exercise its expertise on sediment budgeting to prepare sediment budget estimates and recommendations on sustainable

mining volumes for Kerala Minerals and Metals Ltd. for their mining sites on the Chavara coast. During the year, the coverage of ocean state monitoring system has been extended further north by deploying a new wave rider buoy off the Puthiyappa coast in Kozhikode district of Kerala. Sea level rise for Kochi has been estimated in addition to an assessment of the impact of sea level rise and identification of impact zones for the Kerala coast. The estimated sea level rise of 0.5 m for Kochi during 2000-2100 follows the sea level trend for RCP 4.5 which is a moderate emission scenario of the IPCC 5th Assessment Report (2013).

Monitoring of solar Ultraviolet-B radiation and atmospheric minor constituents were continued at Thiruvananthapuram (coast) and Munnar (high altitude) stations as part of the atmospheric processes programme. Studies on clouds, their occurrence, altitudinal distribution and related parameters recorded measurements at three stations, viz. Thiruvananthapuram (coast), Braemore and Agumbe (high altitude). Measurement of atmospheric concentration of carbon dioxide, methane and nitrous oxide were continued for obtaining emission factors of the above gases from major natural and anthropogenic sources in Kerala. The installation of the continuous ambient air quality monitoring station was completed in collaboration with IITM, Pune under the MAPAN Project.

The studies of the NREM group covered water resources evaluation and conservation; terrain analysis; land use and land cover mapping; environmental assessments and ICZM preparation making use of geospatial tools. An important programme taken up by the NREM group was the preparation of Management Action Plan for the eco-restoration of Vembanad (Ramsar) wetland. Integrated Island Management Plans (IIMPs) were prepared for the 10 inhabited islands of the Union Territory of Lakshadweep. In the area of water resources, the studies undertaken pertained to appraisal of drinking water potential of springs, augmenting ground water recharge, etc. Under the theme Terrain Analysis and Land Use Studies, case studies on valley formation and geomorphic processes were taken up. Reports and atlases prepared by the group are useful for macro and micro level planning, researchers, academicians and in societal applications.

NCESS continued to extend consultancy services to Government Departments and public and private sector undertakings on earth science related issues. The Coastal Regulation Zone (CRZ) maps prepared by the Centrefor different parts of the Indian coast have enabled decision makers at various levels to arrive at appropriate management action plans and decisions on development projects envisaged for coastal areas.

NCESS publication record was moderately good with 24 papers in peer reviewed national and international journals, 29 papers/chapters in proceedings/books, 3 monographs/ atlases and 14 project reports. Our academic activities continued to be vibrant with 32 Ph. D. students and 2 Ph. D. awards during the year. Besides, 20 students completed their B.Tech./M. Tech./M. Sc. dissertations, out of whom 9 meritorious students received assistantship, and 18 students underwent internship.

In recording all-round growth of the Institute, most importantly takeover by the MoES, I would like to place on record our appreciation and gratitude to all the members of the CESS family for their hard work and cooperation. CESS community is also indebted to the Expert Committee and various sub-committees constituted by MoES to examine the proposal for the takeover. Special thanks are also due to eight senior scientists, who superannuated this year, for their contribution and support.

I greatly appreciate the unstinted co-operation and support received from the President and members of the NCESS Society, the Chairman and members of the Governing Council of NCESS, the Chairman and members of the Research Council of CESS and the members of the Management Committee of CESS. On behalf of NCESS, I acknowledge with appreciation Dr.K. Somasunder, Scientist G & Advisor, MoES, for officiating as Director and steering the Institute during the transition period from February-March 2014.

Dr. N. P. Kurian
Director, NCESS

NCESS: Retrospect and Prospect

The Government of India vide a Cabinet decision on 19th December 2013, approved the proposal for taking over of the Centre for Earth Science Studies (CESS) by the Ministry of Earth Sciences (MoES). CESS became one of the constituents of the Earth System Science Organisation (ESSO) of the MoES on 1st January 2014 with the signing of a tripartite Memorandum of Understanding by the Secretary, MoES, Government of India; Principal Secretary, Science & Technology, Government of Kerala and Executive Vice-President, KSCSTE.

Background

CESS is one of the leading centres of excellence in the field of Earth System Science in the country, and is functional for the past 36 years. The CESS, as a scientific establishment, was the earliest to embrace the earth system science concept and has carried out extensive R & D work in major components of Geosphere, Hydrosphere and Atmosphere. The approach and accomplishments of CESS, in understanding and addressing the geological evolution of south India, complexities of the coastal processes and natural hazards, natural resources management have all along been consistent with the national R&D priorities in Earth Sciences and thrust areas of the Ministry of Earth Sciences (MoES). However, MoES lacked an organization dealing with specific aspects of solid earth research among its ESSO constituents. Takeover of CESS was to fill the Solid Earth research component of Earth System Science Research and fulfil its commitment to create a framework for understanding the complex interaction among key elements of the Earth system, namely ocean, atmosphere and solid earth, through its national programmes.

Takeover

On takeover by the MoES, CESS was registered as an autonomous centre under the Travancore-Cochin Literary, Scientific & Charitable Societies Act 1955 with a new name National Centre for Earth Science Studies (NCESS). The mission, vision, objectives and thrust areas of the Centre were formulated by an Expert Committee under the Chairmanship of Dr. P S Goel, Prof. M.G.K. Menon DRDO Chair and Former Secretary in the Ministry of Earth Sciences which was constituted by the Ministry to examine the proposal for takeover of CESS. The Expert Committee made a comprehensive assessment of the key scientific programs pursued by the institute and deliberated on a long

term vision as a national centre.

The Road Ahead

The Expert Committee opined that CESS over the years has generated significant quantum of data and enhanced scientific knowledge on the natural processes involved in the continental magmatism, deep continental processes in the Precambrian terrains, the evolution of the passive continental margins and rift tectonics giving rise to the evolution of the north-western Indian Ocean and therefore the focus of the new centre shall be on multidisciplinary studies of the Solid Earth. The committee envisioned to furtherance of knowledge by NCESS with detailed investigations with programmes on deep crustal and surface processes including origin and development of Indian subcontinent. To have a full view of the geo systems, landscapes and changing patterns of geo environment, studies on the crustal evolution, weathering, geochemical processes and mineralization were suggested to be multidisciplinary programs. This approach was also to help resolve the complex processes associated with the mineral resources, natural hazards and environmental management.

Considering the core competence already existing in CESS the Committee formulated the vision, mission, thrust areas and objectives of the NCESS as follows:

Vision:To excel in solid earth research and its applications

Mission

Foster multidisciplinary research in emerging areas of solid earth science, provide services by utilizing this knowledge for earth science applications and generate leadership capabilities in selected areas.

Major Objectives

- To understand the various solid earth dynamic processes with special emphasis on cratonic blocks of India and associated Proterozoic mobile belts with geological history spanning 3000 Ma.
- To understand evolution of Quaternary formations of India and their bearing on climate and sea level changes.
- To study the surface processes including terrain evolution.
- To understand the sedimentary and physicochemical processes of the coastal zone and its subsystems.
- To investigate landslides and coastal erosion and work towards their mitigation and management systems.
- To apply earth science knowledge for geo resources evaluation and environmental conservation
- To undertake earth science applications for societal benefit.
- To effectively integrate with the earth system science programs of the MoES and those of the country.

Thrust Areas

- **Solid Earth Research:** crustal evolution and geodynamics, quaternary evolution processes, sedimentology and depositional processes, weathering and surface processes and coastal dynamics
- **Earth Science Applications:** landslides and coastal erosion mitigation, coastal zone management, resource evaluation and environmental impact assessment

New R & D Programme "Earth System Dynamics & Natural Resources Evaluation"

In tune with the policy and thrust areas formulated by the Expert Committee, a R & D programme was conceived and submitted which has since been approved for implementation in NCESS. The programme has five sub-projects viz. (i) Crustal Processes, (ii) Coastal Processes, (iii) Cloud Microphysics & Lightning, (iv) Natural Resources and Environmental Management and (v) Operation and Maintenance of NCESS. The objectives of the programme are:

(i) Crustal Processes

- To develop knowledge on various processes in space and time within the solid earth through an interdisciplinary research as an important prerequisite to address enigmatic geodynamic problems and understanding the nature and origin of mineral deposits and to formulate future mineral exploration strategies.
- To understand how the India lithosphere became an ensemble of differentially evolved Archaean cratons overlain by mid to late Proterozoic platform basins; tectonic and temporal evolution of cratons, mobile belts and cover sequences; phases of acid/ basic magmatism and development of economically rich mineral deposits.

(ii) Coastal Processes

- Study beach-surf zone morphodynamics by establishing video-imaging facilities coupled with direct field measurements; understand near bed and swash zone sedimentation processes
- Develop prediction models for inundation/coastal flooding/run-up during extreme weather conditions.
- Estimate sediment thickness in the innershelf region and understand their source/sink relationship.
- Study and model the sediment flux and dispersal pathways in estuaries with a view to have a holistic understanding of the coastal sedimentation processes.
- Study coastal aquifers for qualitative measurements of submarine groundwater discharge (SGD) in coastal zone.

(iii) Cloud Microphysics and Lightning

- Establishment of high altitude field stations to monitor lightning frequency, cloud formation, propagation and rain drop size distribution.
- Study the formation and propagation of convective thunderclouds and associated lightning activity.
- Study the functional relation between cloud types, cloud droplet size and rain DSD to understand its diurnal and nocturnal variation.
- Study of orographic rain, connected microphysics and the influence of electrical characteristics of drops in DSD of tropical rain etc.

(iv) Natural Resources and Environmental Management

- Analysis of land system, valley formation and drainage pattern in various river basins.
- Creation of data base for natural resources and environmental management including water pollution studies in river basins.
- Monitoring of landslides, coastal erosion etc., and preparation of management plans for selected hot spots.
- Societal application of earth science in addressing problems of landslides, land subsidence, water harvesting, and environmental management including remote sensing studies.

(v) Operation and Maintenance of National Centre for Earth Science Studies

- To establish system administration and develop and maintain the infrastructural facilities to support all proposed plan activities.

NCESS: Looking Forward

The Centre for Earth Science Studies has developed expertise and earned recognition for its studies on the evolution of the southern Indian peninsular shield. An unlimited scope and an increasing need exist in India for developing and institutionalizing the groups and institutes which have made significant contributions in Earth Sciences. The contributions of CESS in the international scene has drawn considerable attention of scientists to several outstanding problems of crustal genesis including structure and tectonics of the deep continental crust, late Archaean crustal growth, granulite facies metamorphism and fluid action. CESS has made important contributions towards understanding the complexities of coastal processes including the mud banks which is unique for the SW coast of India. In spite of strong committed approach of CESS and that of several universities and institutions in the country, a lot more needs to be done. The study of crustal genesis warrants a concerted and integrated

approach involving terrestrial and planetary geochemistry, geology and geophysics. The study of beach-surf zone morphodynamics which is expected to unravel some of the still unexplained coastal phenomena entails studies employing modern instrumental facilities coupled with numerical modelling. Application of earth sciences in addressing various problems like landslides, land subsidence, water harvesting and environmental management needs concerted efforts of earth scientists of different specialisations. NCESS intends to take forward the vision of MoES in achieving its mandated goals. The laboratories and library at NCESS with augmentation will play a vital role in supporting scientific activities of Earth Sciences research in India. Taking over of CESS is, therefore, a significant step forward in strengthening the solid earth science research in the country and in emulating the integrated manner in which earth science activities are being supported in developed countries of the world.

1.1 Palaeoproterozoic Palaeomagnetism with Special reference to the Mafic Dykes in the Archaean Craton around the Cuddapah Basin

Palaeoproterozoic mafic dykes have become the focus of recent research because of their enormous potential in unraveling global continental reconstructions in the early history of the Earth. The Indian shield comprises one of the five oldest cratons of the world with profuse dyke intrusions in Palaeoproterozoic era.

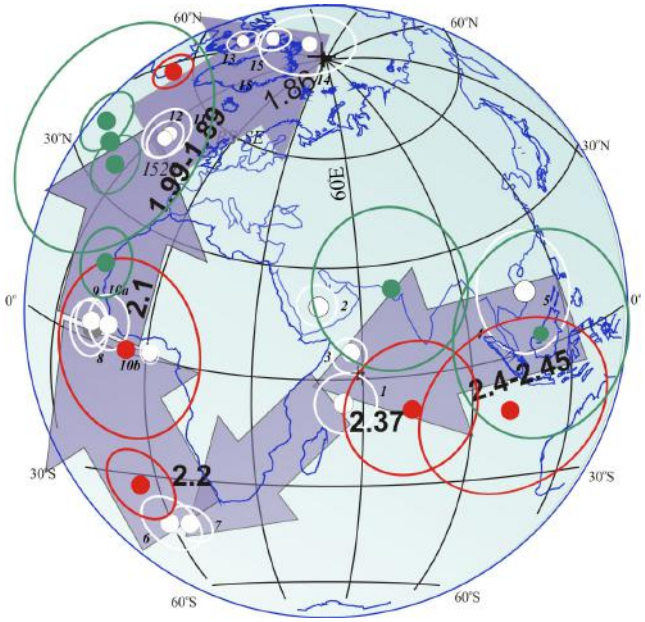


Fig. 1.1.1 Mean palaeomagnetic poles with a95 confidence circles from mafic dykes of the Dharwar (white), Bundelkhand (red) and Bastar (green) Define APW atleast once and in the Palaeoproterozoic APW path indicated by arrows.

Our study comprises of new palaeomagnetic results for Palaeoproterozoic mafic dykes sampled over a large area in the basement along the margins of Cuddapah basin, one of the largest sedimentary basin of the Precambrian age in India. The new data are integrated with all the available earlier results to compute discrete mean palaeomagnetic directions and with the recently reported high precision U-Pb baddeleyite age data to provide a comprehensive account of Palaeoproterozoic igneous activity in India and consolidated palaeomagnetic poles for six distinct ages with robust statistical criteria. We list 205 palaeomagnetic site-mean directions are listed, each site corresponds to a single dyke. The six discrete dyke emplacement events in the south Indian shield are constrained within a timeframe spanning over 600 Ma from 2.45 to 1.85 Ga. Each event is demarcated by a distinct magnetisation with site-mean directions less than 30° from the mean of the subset. The collective palaeomagnetic data permit us to construct a new APW path of the Indian shield for the Palaeoproterozoic eon with enhanced certainty (Fig. 1.1.1). The proposed APW path is in agreement with the palaeomagnetic poles determined for mafic dykes in the Bastar and Bundelkhand cratons (Fig. 1.1.1) and therefore is in conformity with the data across the cratons in the Indian shield.

An attempt has been made to test various global continental reconstruction models, proposed on the basis of geological correlations, using the overall mean poles corresponding to discrete ages from India and other contiguous cratonic elements (Fig. 1.1.2). India along with the Yilgarn craton of Australia was positioned at higher latitudes at 2.45-2.37 Ga in contrast to the position of Laurentia defined by the Superior poles. At 2.22 and 2.18 Ga, India was located around the equator. During this period poles from the Superior Craton suggest a shift to a low-intermediate latitude position for Laurentia; the only pole available for the Slave Craton also indicates a low intermediate latitude position at 2.03 Ga. The Kaapvaal craton indicates a low-intermediate latitude position by 2.15 Ga and further at c. 1.88 Ga. Australia was situated at the equator, like India, at about 1.8 Ga. The India-Australia connection different from the Kaapvaal position does not support the interpretation that the Yilgarn Craton was part of a Zimvaalbara supercraton. Several disagreements between the NeoArchaean and Palaeoproterozoic geology of the Dharwar and Superior cratons are consistent with palaeomagnetically-derived distal positions for these cratons. A close comparison of Palaeoproterozoic poles with the poles determined from the dykes of same age in Bundelkhand and Bastar cratons (Fig.1.1.1) support amalgamation along the Central Indian Tectonic Zone much prior to the envisaged time of 2.1-1.8 Ga. This observation coupled with the position of India and other cratons between 2.2-1.8 Ga do not accord with the configurations proposed for the supercontinent Columbia. The present data appear to be consistent with the essential features of the refined Protopangaea model proposed by John Piper recently and attest the India-Australia proximity in the Ur configurations as originally shown by Rogers in 1996.

Finally, the Palaeoproterozoic mafic dykes in south India may belong to discrete large igneous provinces distributed over large areas and some common events are identified

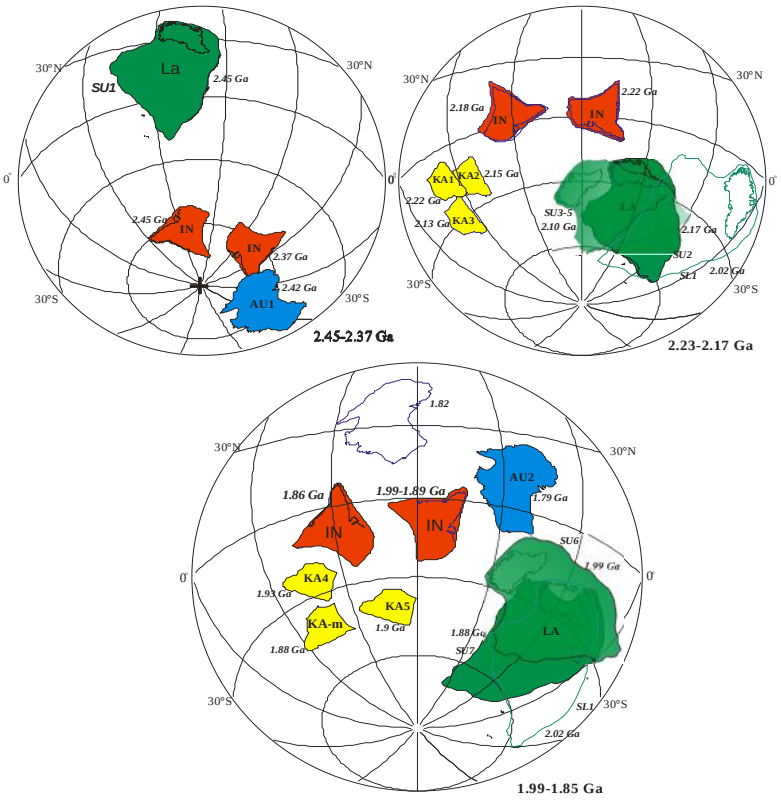


Fig. 1.1.2 Paleomagnetically-based reconstruction in Schmidt projection at 2.45-2.37 Ga (top left), 2.22-2.18 Ga (top right) and 1.99-1.85 Ga (bottom) based on data for the Indian shield and comparable data from other potentially-contiguous cratonic blocks, India (IN): Kaapvaal (KA), Australia (AU); Laurentia (LA).

across the cratons in India. These igneous events are clearly recognized by discrete palaeomagnetic directions falling into discrete high-precision age brackets. The four earlier igneous events corresponding to 2.45, 2.37, 2.22 and 2.21 Ga appear to be short-lived (~5–10 Ma) dyke emplacements. The mafic dyke emplacements during 1.99-1.89 Ga cannot be easily further distinguished by their palaeomagnetic directions and probably relate to a long-lived igneous event. The 1.86 Ga dykes mark the end of Palaeoproterozoic igneous activity in this region; the dykes of this igneous activity are less in number and may relate to waning stages of a large igneous activity linked to a major mantle plume.

The major and trace (including rare earth) element geochemistry of the Bundelkhand dykes have been taken up for detailed evaluation of petrogenetic evolution of Palaeoproterozoic continental magmatism in the Indian shield. The interpretations are in progress.

T. Radhakrishna, G. Balasubramonian & N. R. Krishnendu

Funding: DST, GoI

1.2 Mafic Volcanic Flows/Sills in the Gwalior, Bijawar and Cuddapah Basins

Gwalior, Bijawar and Cuddapah Basins constitute the large Palaeoproterozoic sedimentary basins in India with occurrences of volcanic flows and/or sills in the lower stratigraphic horizons. The igneous activity is generally linked to the dyke magmatism in the adjoining cratons and to the geodynamic development of these marginal basins. A collaborative project between the NCESS and the Bundelkhand University has been initiated with funding from the Department of Science and Technology, Government of India to study petrology, geochemistry and palaeomagnetism coupled with isotope dating of the igneous units occurring within the basins. The project is aimed at integrating and comparing the data with the results produced on mafic dykes in the adjoining Dharwar and Bundelkhand cratons to identify linkages, if any, between them. The results along with our own and other published data will summarize and constrain the Palaeoproterozoic igneous activity in India in terms of Large Igneous Provinces across the Archaean cratons of the world and will test different Palaeoproterozoic supercontinental reconstruction models tracing the position of Indian landmass within the reconstructions.

Fig. 1.2.1 A picture showing drilling for the collection of oriented cores from the Bijawar mafic volcanic flow in the Ken river section near Bhusor village

The project was inititated on July 28, 2013. A joint fieldwork with the project team of the Bundelkhand University was conducted in the Gwalior and Bijawar Basins. The volcanic flows and sills have been traced out at a number of locations. Oriented cores of 2-3 inch long and 1 inch dia

Fig. 1.2.2 A quarry section near Bidja on Morar-Bhed road in Gwalior district. Seen is the volcanic flow section in contact with sedimentary formations of the Upper Morar Formation of the Gwalior Group on the top of the section (the sedimentary section is approximately 15 m)

were drilled from igneous units at six sites in Bijawar Basin and at eight sites in the Gwalior Basin. A total of 7-10 samples were collected from a palaeomagnetic site. Fifteen block samples of 5 kg each were collected for major and trace element analysis and to separate baddeleyite/zircon mineral fractions for U-Pb isotope dating. Section making for petrography, crushing and pulverising for geochemistry, and preparing specimens for palaeomagnetic work are in progress. The project sanctioned Magnetic Barrier Laboratory Separator towards setting up of mineral separation laboratory for isotopic analysis. Procurement of this instrument and setting up of this laboratory have been initiated.

T. Radhakrishna, J. K. Tomson & Ram Chandra
Funding: DST, GOI

1.3 Archeaomagnetism

Archaeo Intensity (AI) data from all over the world is recognised to be very important because these data may help to better constrain the available global geomagnetic field models over the past few millennia and also the core mantle processes. Reliable Archaeo/palaeo intensity and palaeodirection data are scares in the Indian subcontinent. In the last year, we have initiated to employ archaeological artifacts like pottery, bricks and tiles from two different archaeological sites of Marungur (1°27'43"N, 79°24'01"E); Vadaharirajapuram (10°27'140'N, 79°25'08"E) in Tamilnadu for examining the long term behavior of the earth's magnetic field over the subcontinent. Archaeological materials like pottery acquire, under certain conditions, a stable magnetization and hence be used for AI (Archaeo Intensity)research. Accurate estimations are extremely difficult owing to large failure rate with the samples, as the criteria for reliable results are very stringent.

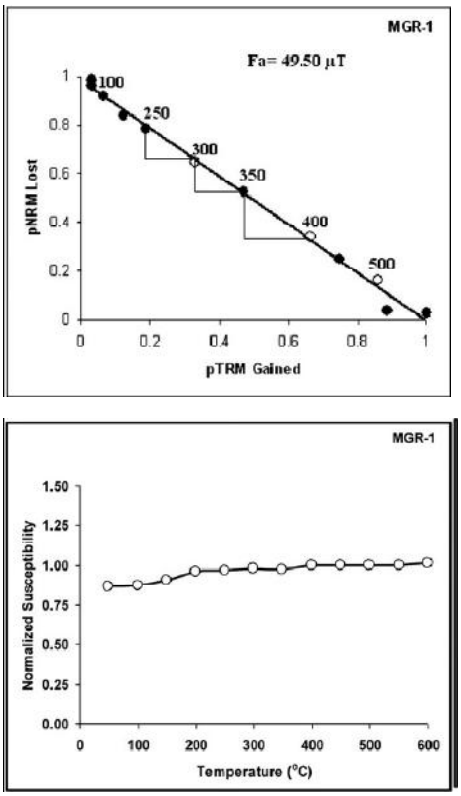


Fig. 1.3.2 Representative Arai plots for samples of Marungur site MGR 1 showing the NRM lost and TRM gain in closed and open ccircles for the pTRM checks (above) and Temperature versus Susceptibility variation plot (below).

The inscriptions suggest that the artifects has an age of 200-300 BC for Marungur and 200-100 BC for the Vadaharirajapuram sites. Samples were screened based on magnetic susceptibility- temperature experiments and Isothermal Remanent Magnetisation (IRM): IRM results were subjected to AI study.

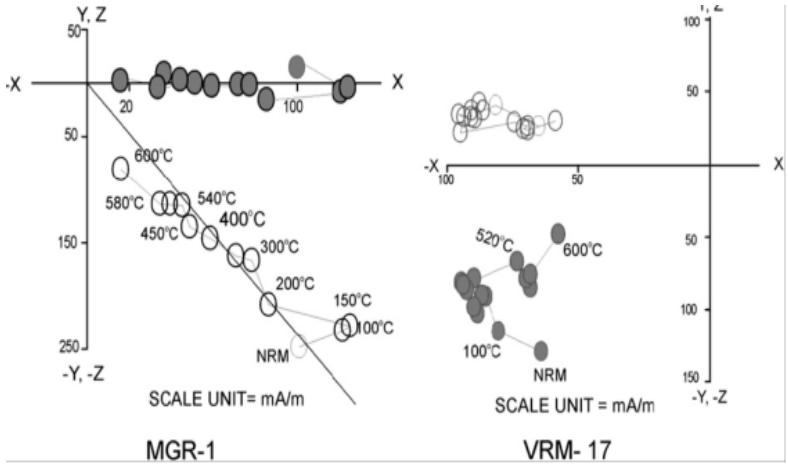


Fig. 1.3.1 Representative Zijderveld plots for successful (MGR-1) and rejected (VRM-17) sites. Open and closed circle correspond to inclination and declination respectively.

Analysis and interpretations have been carried out for the AI values estimated during last year using Zero field/Infield (ZI) method, which is a modified Thellier -Thellier technique. The Zijderveld plots for successful and unsuccessful samples are shown in Fig.1.3.1. Arai plots and Temperature susceptibility curves for satisfactory samples are shown in Fig.1.3.2. The values were corrected for cooling rate effects. Finally, the mean AI values are estimated as 48.22±1.50 μT and 46.08±0.85 μT for the Marungur and Vadaharirajapuram sites respectively. These new AI data from south India are of slightly higher value compared to the that predicted for the same period from the existing global geomagnetic field models. More such studies are essential to improve the palaeosecular variation models based on global database of the earth's magnetic field for the past few millennia.

T. Radhakrishna, R. Venkatachalapathy, R. Mohamed Asanulla & C. Manoharan

1.4 Major and Trace Element Geochemistry and Sr-Nd isotope Study of Charnockites from Southern Granulite Terrain

The Precambrian Southern Granulite Terrain (SGT), southern India is a well-known example of a large exposure of deep-continental crust. There have been suggestions that the SGT comprises a collage of Archean and Neoproterozoic high-grade metamorphic terrains, where the regional tectonic and high-grade metamorphic events culminated at ca.2.52 Ga in the northern granulite blocks and ca.0.55 Ga in the Neoproterozoic Madurai and Trivandrum blocks are well preserved. The Archaean and Neoproterozoic terranes of the SGT are presumed to be separated either by the crustal-scale Cauvery Shear Zone system (CSZ) or the less known Karur-Kambum-Painavu-Trichur shear zone (KKPT). The Neoproterozoic granulite domains comprise mainly the Madurai Block to the north and Trivandrum Block to the south separated by the Achenkovil Shear Zone. A large set of major and trace element geochemistry and whole rock Rb-Sr, Sm-Nd isotopic data have been generated on the charnockite gneisses representing parts of the Archean and Proterozoic domains of the SGT to constrain the chronology and tectonic environments in the SGT. The work was carried out as part of the doctoral programme at the NGRI and more detailed interpretations have been attempted during the period.

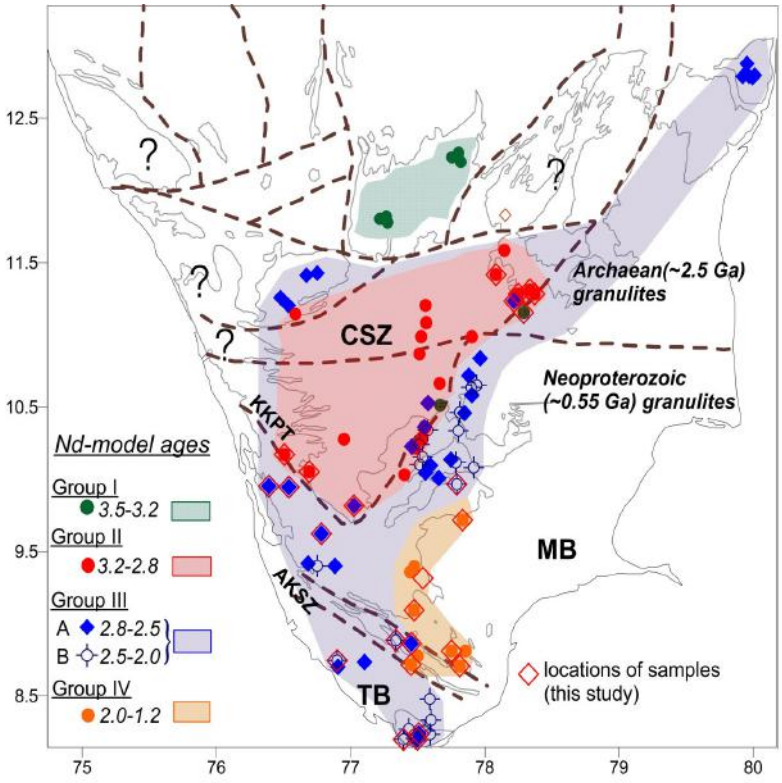


Fig.1.4.1 Nd model age distribution map of the charnockite gneisses of the Southern Granulite Terrain.

Altogether 53 charnockite gneiss samples were analysed for major and trace element chemistry and 27 samples were for Sr-Nd isotopic compositions. The study identifies distinct source compositions and tectonic settings for the formation of the Archaean and Neoproterozoic charnockite gneisses of the SGT. A first ever comprehensive Sm/Nd-model age map for the SGT was prepared utilizing new and published Nd age data (Fig. 1.4.1). The Sm-Nd model age distribution of charnockites identify four distinct Nd-isotopic provinces within the SGT with model ages grouped in the range; ~3.5-3.2 Ga, 3.2-2.8 Ga, 2.8-2.0 Ga and 2.0-1.2 Ga. Charnockites in the Neoproterozoic terrains yield significantly older Meso- to Late- Archean Nd-model ages than the zircon U-Pb emplacement ages. This study delineates a large domain of younger model ages (2.0-1.2 Ga) in the SE part of the Madurai Block. The protoliths of charnockite gneisses in this region form the closest examples of juvenile magmatism. This region connects with the Wanni complex of Sri Lanka. The Neoproterozoic crust of the SGT can be modeled as a subduction-collision setting at an Archean cratonic margin where crustal reworking involving older continental crust predominate juvenile crust formation.

J. K. Tomson, Y. J. Bhaskar Rao T. Vijaya Kumar & A. K. Choudary

1.5 Tracing Source to Sink Link in Placer Deposit Formation of Kerala

This project was taken up with the main objective of examining the source-to-sink relation between heavy minerals in the placer deposits and petrographic diversity of the hinterland rocks of SW India. During the period under report 61 sediment samples were collected from the major rivers and from different beach locations of SW coast of India (Fig. 1.5.1). All the samples were processed for different heavy minerals following the isodynamic, liquid and optical separation methods. Some of the major minerals identified are garnet, zircon, monazite, ilmenite and rutile.

Majority of heavy mineral species have several chemical, structural, colour, morphological, and optical varieties that record signatures of crystallizing conditions in their parent rocks. Detailed petrographic analysis of major rock types in the source region and analysis of grain mounts of beach sediments collected from Pozhiyoorkara to Alleppey were carried out. The study revealed that the source to sink relation can be established by comparing the petrographic analysis of the orthopyroxene, hornblende, ilmenite, garnet, and monazite populations. Since mere physical comparison would not help in tracing the specific source, major focus was on major, trace and REE analysis of selected heavy minerals seperated out from the sediments.

Of all the minerals present in the placer deposits, garnet was found to be the most useful member in provenance studies as it is common accessory mineral accounting to about 10-15% in the hinterland rocks and occur in all the major rock types like khondalite, charnockite, sodic gneiss, potassic gneiss, augen gneiss, granite and pegmatite of source region. The minerals also possesses wide compositional range, strong relation to whole rock composition, and stability as well as ability to withstand geological process. Garnet chemistry, with its composition potential as solid-solution between seven principal end-members is found to be the most ideal mineral in characterising different types of lithologies and comparing the compositional variation with that of beach origin (Fig. 1.5.2). The petrographic study of garnets present in the collected beach and river sediment samples have been completed. Petrographic comparison of garnets in sediments with those in hinterland rocks was also carried out. Thin sections available from our earlier studies on granulites of Kerala region were utilised for this comparative analysis. It is proposed to collect fresh samples,

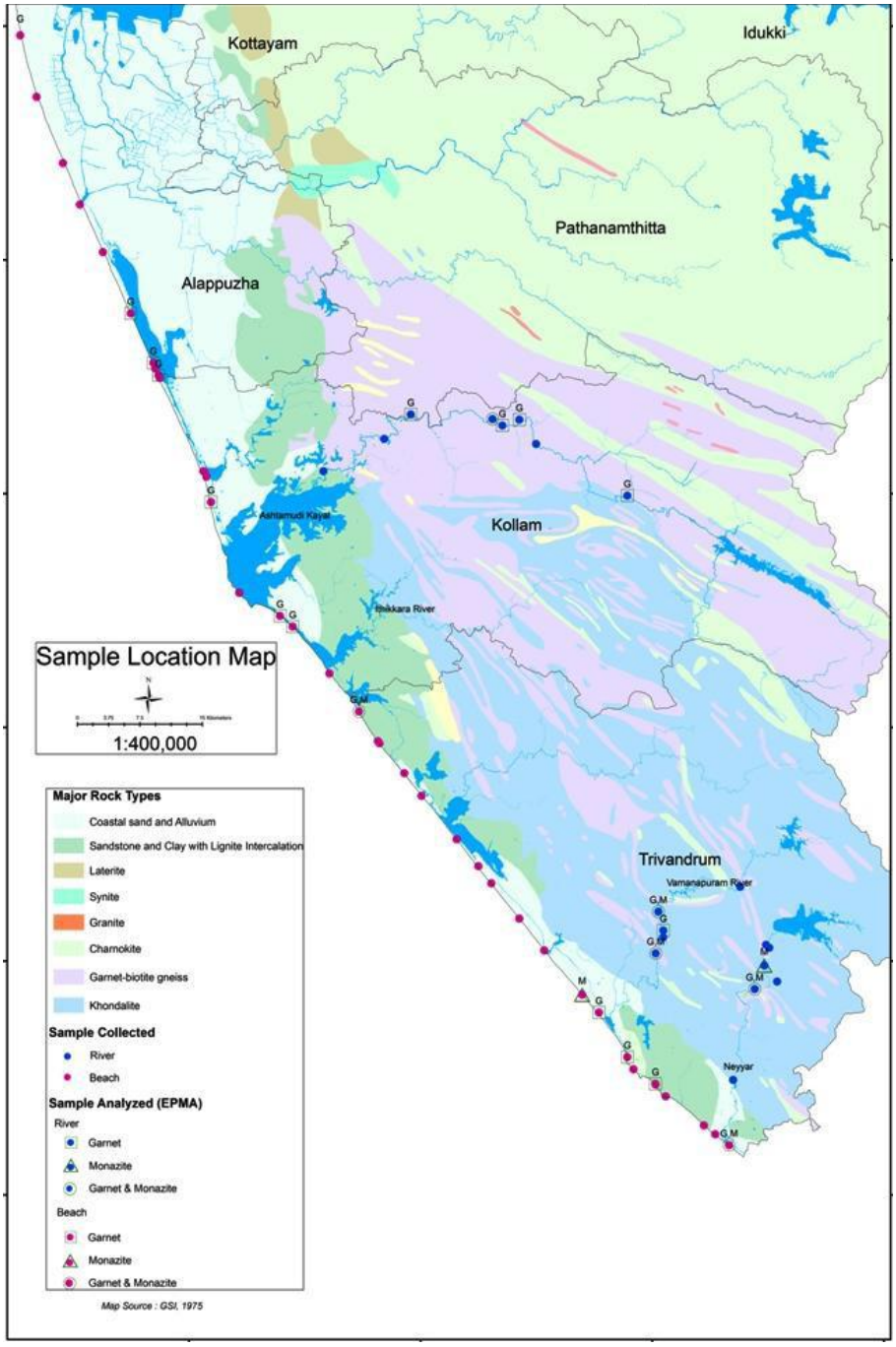


Fig. 1.5.1 Location map showing the general distribution of major rock types of the study area and samples collected for petrographic and EPMA analysis.

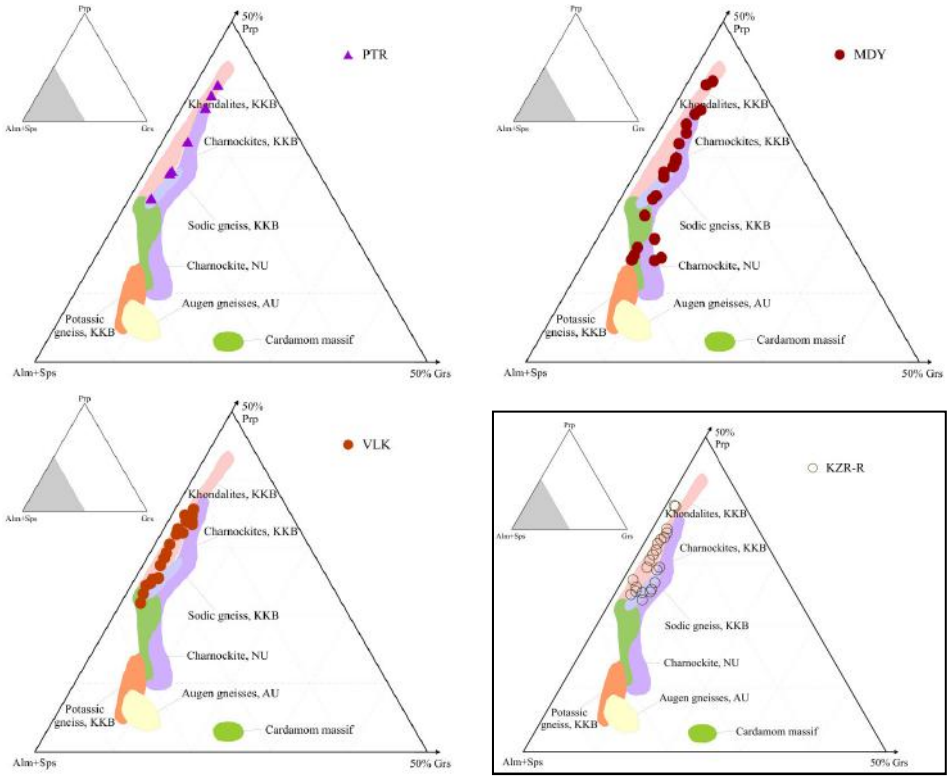


Fig. 1.5.2 Geochemistry of garnets from representative river sediments plotted over source rocks garnet fields. (MDY & PTR: Kallada R, VLK: Karamana R and KZR: Neyyar R)

during the next field season, in hinterland region from where thin sections are not available for petrographic and mineral chemical work. This will enable to establish the relationship between garnets occurring in the hinterland rocks with those in beach and / or river sediments.

Following detailed petrographic study twenty nine polished grain mounts were prepared and analysed at EPMA facility of PPOD, Geological Survey of India, Bangalore. About 900 point analysis of garnet, biotite, feldspars etc., have been obtained. About 45 BSE images of selected grains were taken and sections containing monazite either as grains or inclusions were selected for further work. Rare earth element analysis of polished grain mounts of monazite grains and sections containing monazites as inclusions within garnets for comparison of age and petrochemical charac-teristics with hinterland rocks has also been initiated.

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

1.6 Palaeo Fluids in the Petroliferous Basins of Western Offshore, India

The research project on palaeo fluids in the sedimentary fill of the petroliferous basins of western offshore is primarily aimed at developing and demonstrating the utility of fluid inclusion techniques in buttressing the oil exploration activities in India.

During the second year of this project (i. e., the reporting year), petrography of fluid inclusions was carried out. The size distribution of representative monophase and biphase inclusions are shown in Fig. 1.6.1. The data indicates that the primary as well as the secondary fluid inclusions in the secondary fractures and authigenic portions of mineral grains consequential to digenesis is relatively smaller and are predominantly in the range 5 - 10 μ. In order to determine the entrapped temperature and pressure conditions of the predominant fluids in play, the isochores for Carbondi Oxide (CO_2) and hydrocarbon inclusions in the RV1 well samples were deduced using FLUIDS-1 package by Bakker-2003. In the case of Carbondi Oxide (CO_2) the value ranges from 22.4 to 24.3 °C and 6.06 to 6.43 MPa/mm respectively whereas, trapping temperature of hydrocarbon inclusions range from about 116 ^{0}C - 134 °C and the calculated fluid pressure for hydrocarbon rich inclusions range from 95.71 to 108.86 MPa/mm. Our values of trapping temperature and pressure are almost matching with that of the calculated pore-fluid pressure for Methane (CH_4) -rich inclusions (Fall et. al., 2012).The Carbondi Oxide (CO_2) fluids give a picture of post entrapment conditions during hydrocarbon migration events. The high pressures indicated by the fluid inclusion data are likely to be a consequence of a low-permeability system in which gas was generated faster than the rate at which it was lost from the system, and these high pressures would be normal in charged petroleum conduits. The temperature conditions calculated corroborates with the fluid inclusion data.

One of the significant achievements during the reporting period was the installation of Laser Raman Micro spectrometer (LRM) as National Facility for Fluid Inclusion Research (NFFIR) as part of this project. The LRM is fitted with three lasers of wavelengths 785nm, 405nm and 325nm. The facility is operational since September 2013.

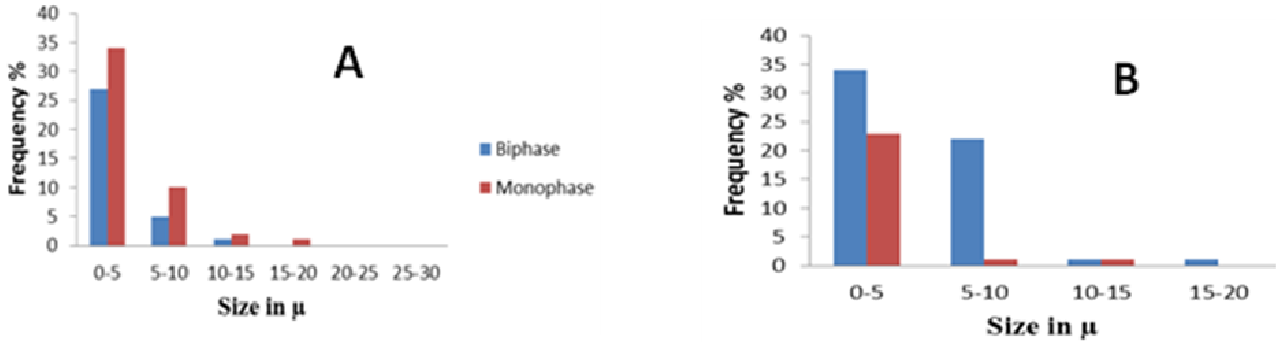


Fig. 1.6.1 Histogram showing size distribution of secondary fluid inclusions (monophase and biphase). A) Monophase and biphase presents in horizon – 3245 – 3250 m, B) Monophase and biphase presents in horizon – 3395-3400 m

The Micro-Laser Raman examinations confirms the existence of aqueous inclusion mixed with CO_2, and the radicals of CH_3 in the Bassen and Panna formation and this is indicative of vertical migration of aqueous and hydrocarbon fluids in RV1 well.

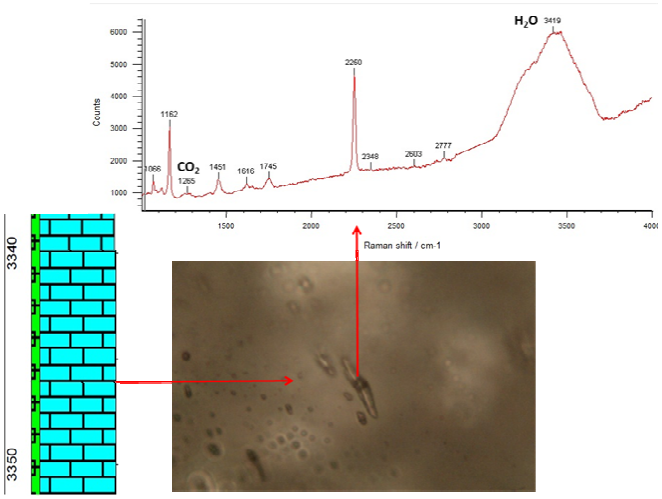


Fig. 1.6.2 The litholog showing the composition (Limestone) of the horizon 3340-3345 m and the Raman spectra of primary fluid inclusion in quartz grains of KK-73 well samples showing peak of aqueous solution and Co_2 rich fluids

A major technical hurdle faced was the recurrence of 2250 cm^{-1} in all the Raman spectra collected. It was later on identified as characteristic of CN bonding, due to cyanoacrylate adhesive used for fluid inclusion wafer preparation.

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

Funding : MoES, GoI

1.7 Graphitization Process in Kollam District, Kerala, India

Graphite is a widespread and common accessory mineral, which occurs in a variety of rocks, formed under different geological settings. The most predominant means of its formation is highgrade metamorphism of organic matter, trapped in sediments. It can also be formed by the decarbonation of carbonate rocks and by magmatic processes. Its source can be identified from the C^{13} values. Graphite once fully crystallized is highly inert and can be used as a marker in determining the grade of metamorphism.

The multi-parametric approach envisaged under this project is the first of its kind to bring into light the various aspects of the graphite mineralization in the study area. Detailed field as well as laboratory- based studies are to be taken-up in order to achieve the following objectives: (i) to identify and classify different types of graphite, associated with different environment based on their physico-chemical characteristics (field associations), (ii) to elucidate the P,T conditions and formation environment of the graphitization process by studying their structural variability

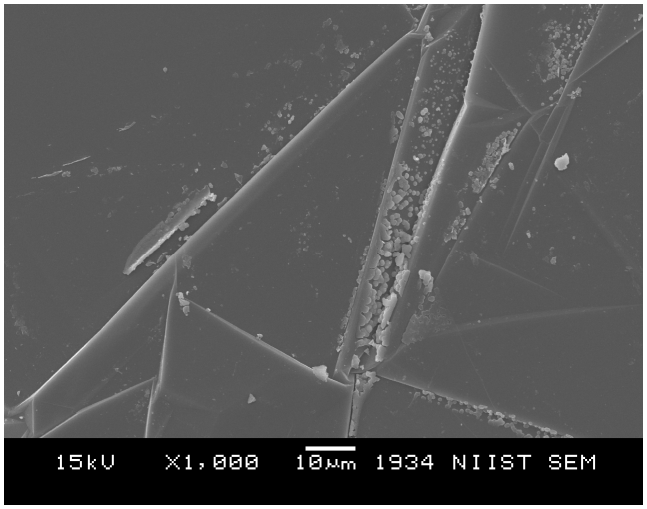


Fig. 1.7.1 Representative SEM photomicrographs of graphite

and morphological features by Scanning Electron Microscopy (SEM) (Fig. 1.7.1), degree of crystallinity by X-Ray Diffraction (XRD) technique and thermal decomposition pattern by Thermo Gravimetric Analysis (TGA), (iii) to find out sourcing of carbon for graphitization using Stable Isotope Studies.

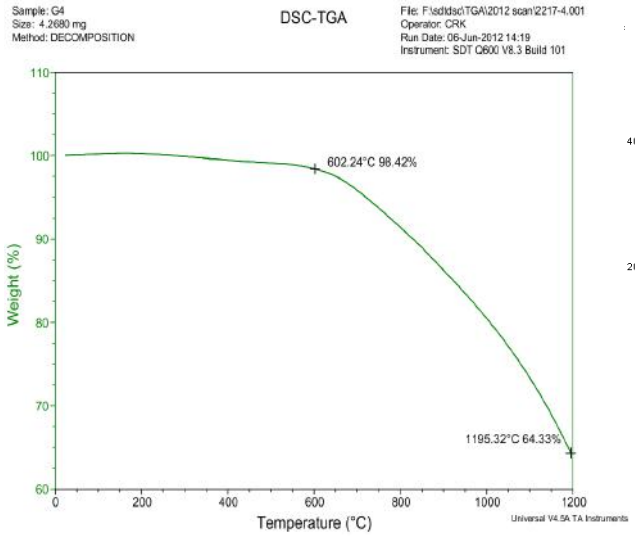


Fig. 1.7.2 Representative Thermograms

Out of the 10 graphite and graphite associated mineral samples collected from various parts of Kollam district, 5 samples were identified, classified, processed, chracterized during the period 2012- 2013. Similar studies were carried out for the samples from the remaining five localities during the period under report. These samples are flaky in nature and are of high grade. In Manjappara graphite occurs in garnetiferous gneiss along with garnet rich layers. Graphite seen as coarse grained patches(Fig. 1.7.2). The foliation is trending 135^0 with steep dips to south, east- west trending graphite bearing vein is seen 2- 3 cm wide within the leucocratic gneiss. Disseminated flakes of graphite are not seen in other rocks. Ottumala- graphite is seen mostly associated with sillimanite bands as fine grained dispersed grains. Occasionally large flakes are also seen in coarse grained quartz feldspar zone. Foliation is wavy trending 120 with a dip of 50 to south. Neighbouring charnockite quarry does not show any indication of presence of graphite. Karalikonam graphite is seen along veins of 2-3 cm width.

The rock contains porphyroblasts of garnet. Graphite is seen as large flakes within the vein. The vein also has porphyroblasts of garnet. Eyyappacha- graphite is associated with clay minerals and laterites. The processing is a very hard, tedious and time consuming task. The samples were crushed to seperate the graphite flakes, which were hand picked and treated with 1:1 HCL and kept on a hot plate at about 100^0 C, to remove iron oxides and carbonates, severeal times till the supernatent solution becomes colourless. This was followed by heating with HF to make them free of silicates. The samples thus treated were washed throughly, dried and powdered in agate mortar. The degree of crystallinity is the yardstick for degree of graphitization.

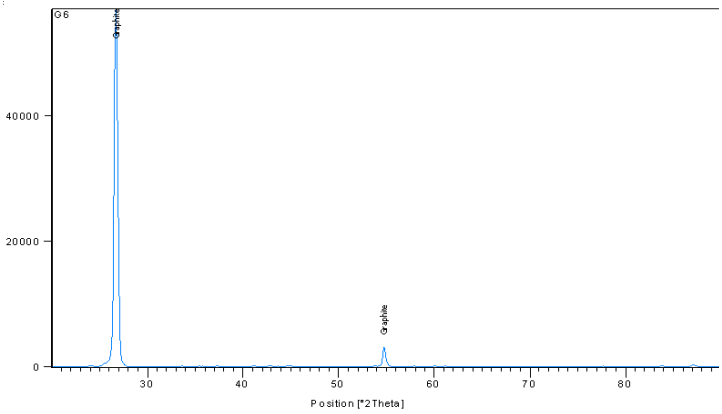


Fig. 1.7.3 Representative X – Ray Diffractogram

The slow cooling rate of graphite results in the sharp peaks exhibited in the XRD. For almost all the samples the data reflect a single trend in the X-ray diffractograms (Fig. 1.7.3). This indicates that the graphitization process in the metamorphic rocks occurs by the same ordering mechanism, as the metamorphic grade is increased. The morphology and texture shown by SEM correlate well with the high degree of crystallinity and slow cooling rate as proved by XRD data. Regarding the Thermogravimetric analysis, the starting decomposition temperature for Manjappara, Arayil, Ottumala, Karalikonam and Eyyappacha are 884.3^0C, 382^0C, 954^0C, 181^0C, 934^0 C respectively and the final decomposition temperature is around 1190^0 C. The stable carbon isotopes ie; C^{12}, C^{13} demarcate the source of carbon from which the graphite was derived. The analyses were carried out by Prof. Tony Fallick, at Scottish Universities Environmental Reseach and Reactor Centre, UK. The standard value of stable carbon isotope is -15.8 $^0/_{00}$. The stable carbon isotope values for Manjappara, Arayil, Ottumala, Karalikonam and Eyyappacha are -6.4$^0/_{00}$, - 22.4$^0/_{00}$, -18.7$^0/_{00}$, -7.9$^0/_{00}$ and -7.4 $^0/_{00}$ respectievely. The graphite from Manjappara having a value of -22.3$^0/_{00}$ can be inferred to have a highly sedimentary origin, whereasthe one from Arayil with a value of -6.4$^0/_{00}$ seems to have a highly remobilized origin. The values -7.4$^0/_{00}$ and -7.9$^0/_{00}$ those from Karalikonam and Eyyappacha show a tendency towards remobilized origin. The samples from Ottumala having a value -18.7$^0/_{00}$ has a relative tendency towards sedimentary origin.

Ansom Sebastian

1.8 Paleoclimate and Sea Level Records in the Late Quaternary Sedimets of the Coastal Wetlands of Pallikkal and Achankovil River Basins, Kerala

The coastal lowland between Pallikkal and Achankovil rivers in Kerala is boarded on the east by an array of discrete wetlands that are seen incised on the lateritic lower plateau. Interestingly, the western side of these wetlands terminates against the old coastal plain sediments. Available radiocarbon dates of subsurface sediments reveal that these wetlands and the adjoining coastal areas have been evolved during Pleistocene epoch. These basins receive eroded materials from the Tertiary hillocks that bounds the peripheral areas of the Late Quaternary basin. The presence of *Ctenolophonidites costatus*, the typical Tertiary reworked palynomorph in the palynological contents reiterates this view. Study of the borehole core retrieved from Komallur revealed that it is composed of three major lithounits- upper organic rich clay and peat assemblage (2m), middle sand unit (4m) and lower silty clay unit (5m) with broken shells of marine origin. The entire sequence rests over an erosional surface/ conglomeratic basal unit. The deposit represents a typical regressive sequence which ends up with a freshwater swamp facies formed under wet, humid terrestrial environmental condition. The formation of peat having an age of 20600 ± 1030 yBP coincidies with the regressive phase that attained its peak at 18000 yBP. Palynological/ micropalaeontological analysis of the lower greyish green silty clay reveals that the wetlands are evolved due to the land- sea interactions around 40-30ky BP. The medium to fine grained, well sorted quartzose sand lying directly above the greenish grey clay is nothing but the beach/littoral sediments formed under the regressive phase. This was followed by the development of peat and clay apron evolved under continental freshwater environment. Lithological characteristics and body fossils of pelecypodes and gastropods of Pathiyur and Ramapuram borehole cores reiterates the prevalence of Late Pleistocene sea which was in existence till 24450 ± 710y BP at Ramapuram. The basal unit of the Late Pleistocene sediments at Komallur and Pathiyur are made up of hard laterite. However, at Ramapuram the basal unit is represented by white clayey sands. The palynological contents, especially the presence of Cullennia exarillata is an indication of heavy rainfall and wet climate during Late Pleistocene. The study of the borehole cores retrieved from Govindamuttom, Chunakkara, Valummelpunja, Karunagappally and Vettiyar is in progress.

D. Padmalal, K. Maya & S.Vishnu Mohan

1.9 Long term Environmental and Socio- economic Impacts of Landslides: A Study in Selected Parts of Western Ghats Region in Kerala

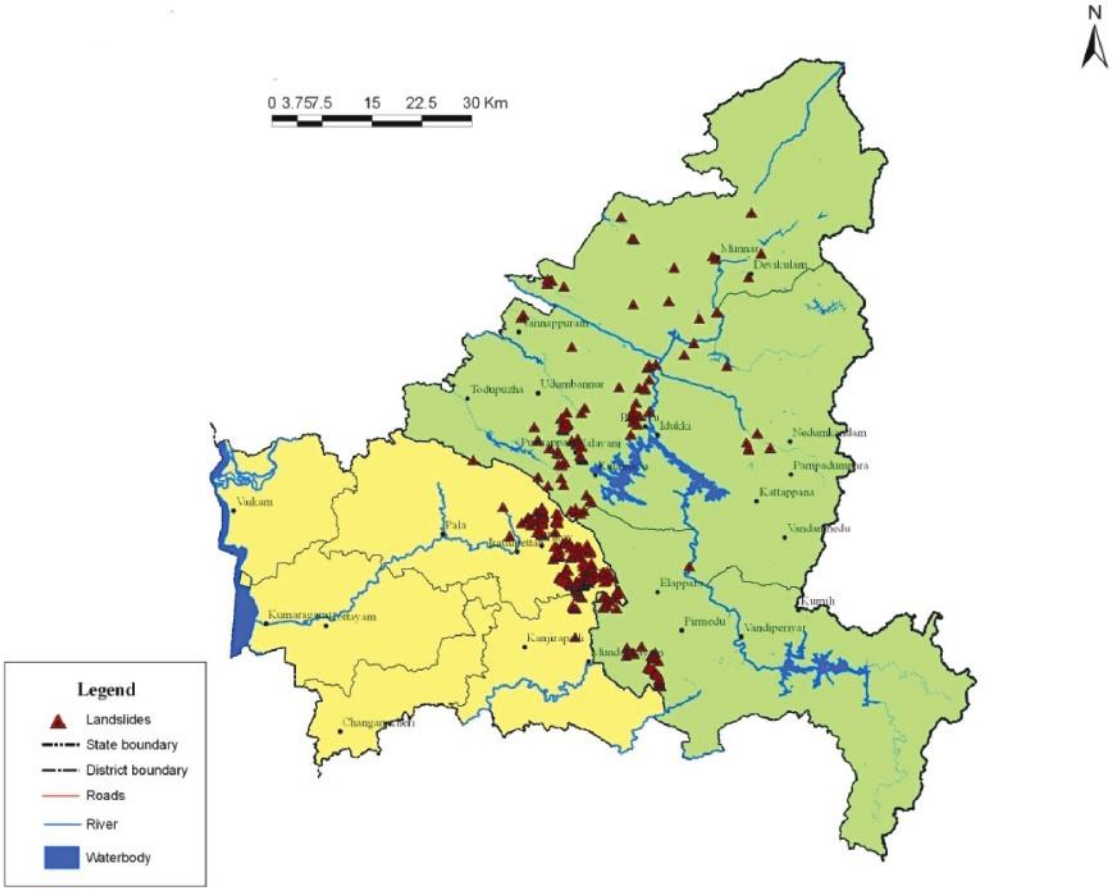


Fig. 1.9.1 Identified landslide incidents within Idukki and Kottayam districts

Fig. 1.9.2 Distribution of landslides in Naliyani-Puchapra basin. Location of surveyed houses are also seen

Fig. 1.9.3 Distant view of the landslide (2013) affected Naliyani area in Idukki district. The area witnessed a previous slide event in 2005.

Landslides are one among the major natural hazards that affect large areas of the Western Ghats region of Kerala and cause extensive damage to life and property such as human dwellings, agricultural lands and roads, resulting in vast economic loss. Due to the increase in expansion of development activities in landslide-potential environments, the risk of casualties and economic losses are also increasing. In many cases landslides generated socio-economic and environmental issues linked to landslides are not addressed properly. Once landslides occur people are temporarily evacuated from the site and after short while they are forced to stay back. Often landslides cause intangible costs such as stress, reduced quality of life, and the destruction of personal possessions with only sentimental value. The indirect impacts include reduced real-estate values in prone areas landslide, loss of productivity of agricultural lands, interruption of transportation systems, living in fear and displacement of people etc. This study proposes to ascertain the impact of landslide hazards both on the environment and socio-economic position of the community.

The present study area falls in the Idukki and Kottayam districts which are identified as major landslide prone areas in Kerala state. These areas, particularly the Idukki district witnessed extensive landslide events during the 2013 south west monsoon season. Through field investigation and secondary data, 299 landslide events were identified in these two districts (Fig. 1.9.1). Based on the estimation of these landslide incidents, a sub- watershed area of the Muvattupuzha River system in the Idukki district covering Naliyani- Puchapra land-slide sites with a geographical area of 32.61 Km^2 was identified to carry out detailed environmental and socio-economic impact study. Along with two major events with toll of three lives, 22 landslide incidents were identified within this area (Fig. 1.9.2).

The impact of the landslide that occurred near Naliyani generated considerable difficulties to the surrounding residents, leading to permanent destruction of available road network (Fig. 1.9.3). Apart from conducting detailed field investigation and terrain analysis, a household questionnaire survey with specifically formulated questions was carried out in the landslide-hit areas of Naliyani-Puchapra landslide sites.

K. Raju

1.10 Land subsidence due to Soil piping

In Kerala land subsidence and land degradation due to soil piping and/or tunnel erosion (Fig.1.10.1) have become a regular phenomenon during the monsoon. Till recently the common belief was that land subsidence due to soil piping was associated with mass movements like landslides. Even though there are many incidences of land subsidence occurring in the Kerala state, most of them often go unreported. Like landslides most of the land subsidence occurs during the monsoons, when the soil is saturated with water. The cavities and pipes that develop below the ground grow with respect to time affecting large extents of land in the form of subsidence thereby making it unsuitable for cultivation or related activities. Infrastructural development in such areas will be dangerous as soil piping can be noticed only when the top soil caves in and huge caves or pot holes develop at these locations. Since piping affected soils will not be able to hold water there is a lowering of ground water level in the area. A programme was initiated by CESS in 2012 to study the land subsidence due to soil piping in collaboration with the Revenue Department, Government of Kerala and financial support from NDMA (National Disaster Management Authority) .

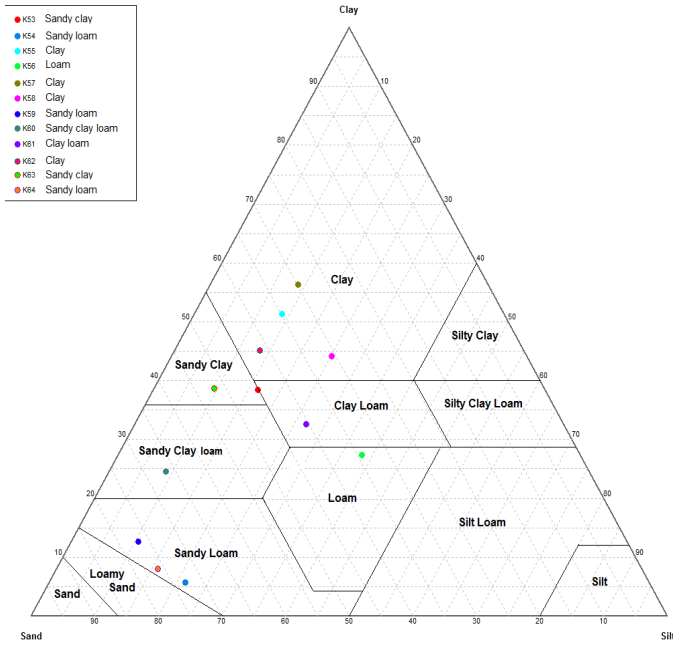


Fig. 1.10.2 Ternary diagram for classification of soil texture (USDA)

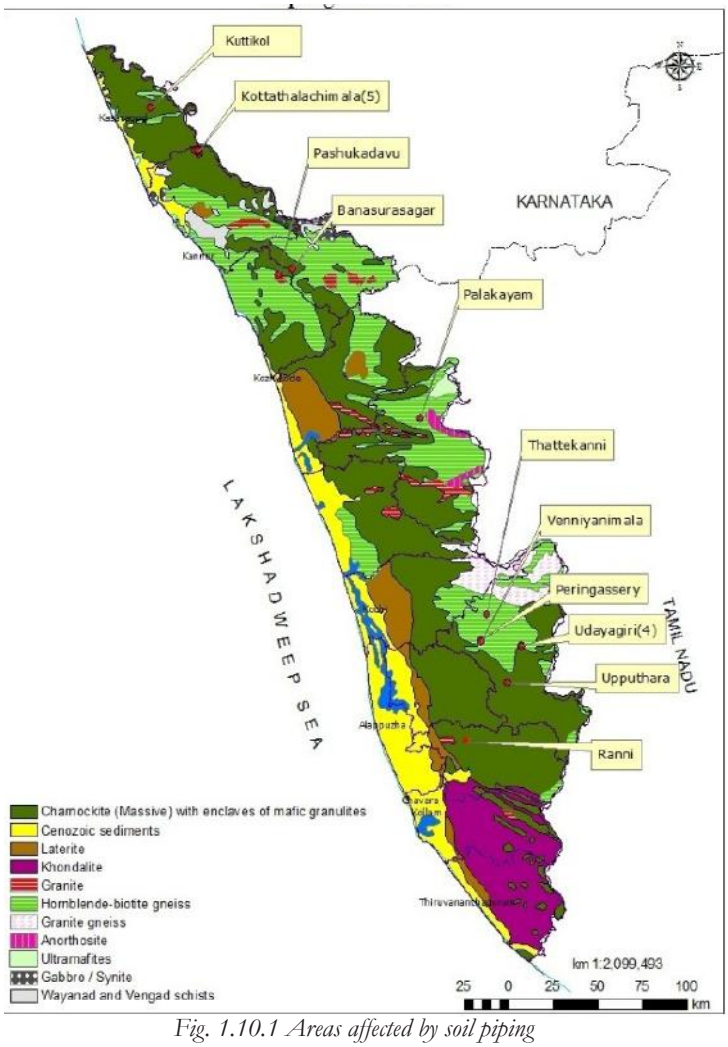


Fig. 1.10.1 Areas affected by soil piping

The recent soil pipping incidences reported at Kuttikol locality in the Kasaragod taluk, Kasaragod district (Fig. 1.10.3) and Upputhara locality in Idukki district created fear and panic among the locals and also destroyed prime agricultural land. During the last decade many land subsidence (piping) incidences were reported in different places from the state. NCESS had investigated such incidences reported by the Revenue Department of Kerala. Subsidence due to piping have been reported from places like Chattivayal (Taliparamba taluk, Kannur district), Palakkayam (Mannarkkad taluk, Palakkad district), Pasukkadavu (Vadakara taluk, Kozhikode district), Padinjareathara and Kunnamangalam Vayal (Vythiri taluk, Wayanad district), Venniyani mala (Todupuzha taluk, Idukki district) etc.

Geochemical analysis of the soil samples collected from Thirumeni at Kannur district and Upputhara, Idukki were analyzed for pH, EC, TDS, XRF, XRD, texture analysis, organic carbon, exchangeable sodium and potassium.

The soil piping occurs mostly in acidic soil. Soil texture is the most important physical property of the soil. Soil texture describes the proportion of sand, silt and clay in the sample. Texture analysis (Fig. 1.10.2) gives difference in sand, silt and clay percentage of soil in the piping and non-piping area. The results show that,

Fig. 1.10.3 Newly identified pipe and piping affected horizontal well Surangam (Tunnel) at Kuttikol in Kasaragod. Inside of the pipe (left), opening of the pipe (middle), Surangam / Tunnel (right)

the percent content of sand is higher in the pipping areas whereas percent content of clay is higher in non- piping area. Decrement of organic matter contributes to enhance the soil piping activity. The XRF study, reveals the presence of some major elements (Na, K) that does not show significant effect. The XRD results show gibbsite and kaolinite are most dominant followed by quartz. Presence of Gibbsite indicates prominenese of leaching which in turn confirms the erosional actvity of the region. The result of exchangeable sodium show that the soil is affected by dispersion.

Geophysical survey using Electrical Resistivity Imaging technique has been carried out to locate and map the alignment of 'Soil Pipes' at Peringassery and Thattekanni in the Idukki district and Kottathalachimala in the Kannur district (Fig. 1.10.4). A multi-function Digital DC Resistivity/IP Meter, WDJD-4, having WDZJ-4 switcher box and 12V rechargeable battery developed by BTSK/ WTS Limited was used.

It features multiple functions, high accuracy, fast speed, high reliability and excellent expandability. The data collected is processed and interpreted using RES2DINV software. A detailed description of the studies are given below.

Four resistivity profiles were laid across suspected soil pipes at Peringassery where the inlet and outlet locations of the pipes were known. Similarly, three resistivity profiles were laid at Thattekanni and two in Kannur. The length of the electrical resistivity profiles were 150m, 120m and 60m for the current electrode spread of 2.5m, 2m and 1m respectively.

Qualitative interpretation of the resistivity section indicates that the technique could delineate the conductive zones where the soil pipes are formed, evident from the profiles laid at Peringassery (Fig. 1.10.5), Idukki and

Fig. 1.10.4 The Electrical resistivity survey conducted at Idukki and Kannur districts.

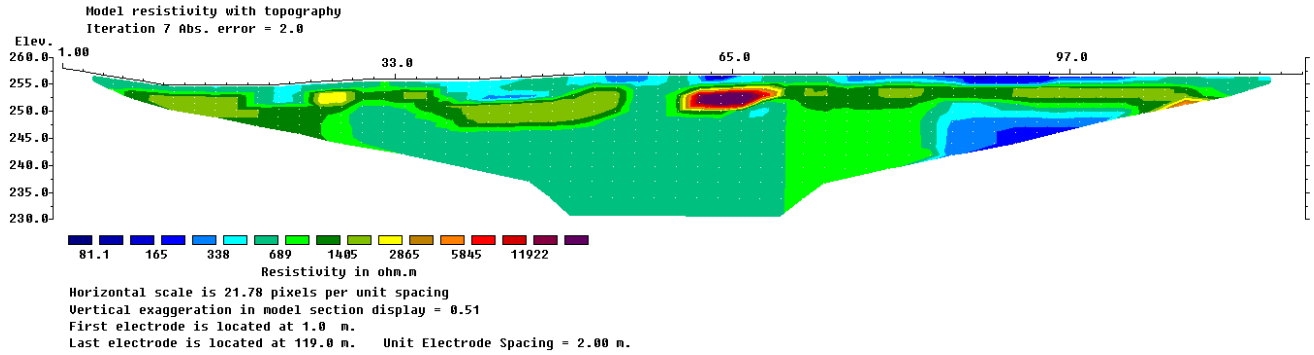


Fig. 1.10.5 Electrical Resistivity Imaging (ERI) section with topography (Peringassery, Idukki)

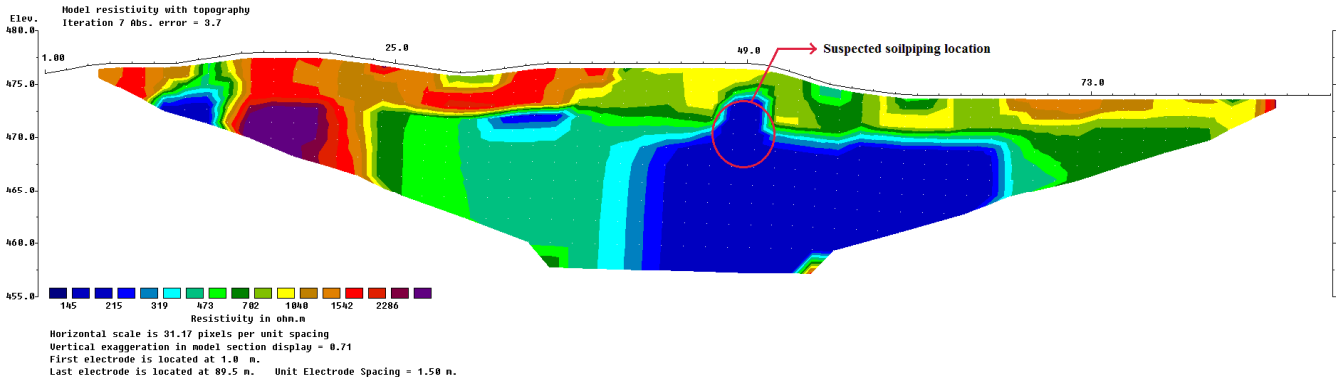


Fig. 1.10.6 ERI Section with topography, unit electrode spacing 1.5m (Kottathalachimala Kannur)

Kottathalachimala, Kannur (Fig. 1.10.6) district. These profiles are close to the inlet of the pipes and the possible orientation of pipes at these locations is known. However, the geometry of the soil pipe is not decipherable from the resistivity section probably due to higher electrode separation in comparison to the diameter of the soil pipe. The data generated by Schlumberger configuration is more accurate than Dipole-Dipole and Wenner array mode and the inference from these will also have to be seen. Therefore, repeating the survey with a lesser electrode separation as well as interpreting the data in different mode will be attempted. Hydrological and meteorological data are being collected from a typical watershed affected by piping. An Automatic Weather Station and a V-notch was installed in Thirumeni locality to have a continuous monitoring of the hydro-meteorological parameters. Mitigation trials are being undertaken at Ranni in the Pathanamthitta taluk.

G. Sankar

Funding: NDMA, GoI

1.11 Building Cracks in Vaniyamkulam II Village, Palakkad district

A study on the occurrence of cracks in dwelling units of the Vaniyamkulam II village in Palakkad district was taken up as per the request of the district collector, Palakad. The site is nearly level laterite capped area with an elevation of about 30-35 m above MSL adjacent to flat bottom valley with paddy fields and the narrow floodplains of the Bharathapuzha river. The area shows a long term lowering of water table in tune with the water level in Bharathapuzha river leading to periodic deepening of domestic wells. In addtition poor inflow from the upper catchment due to poor rainfall during the NE monsoon coupled with the lowering of the water table on account of instream sand mining have resulted in sudden lowering of water level by the end of January, 2014. This leads to subsidence of land and formation of cracks in buildings. Cracks in the residential buildings were first seen as a hairline crack on the walls that latter propogated to the entire length of the building (widened, propagated to the floor of the building) and later also into the ground of the courtyard in a period of four weeks. This often leads to severe damages to the houses. Some of the cracks noticed are older indicating instability of the area.

Fig. 1.11.1 Crack developed on the wall of a house at Vaniyamkulam

Cracks in the wall and floor of residential buildings and formation of ground cracks are mostly attributed to the ground shaking caused by the passage of seismic waves which must be ruled out in the absence of any records or felt report of local seismic events. One of the mechanisms that is relevant to the area is the rapid lowering of water table in tune with the changes in the water level of the Bharathapuzha river. Since the site is located in the flood plain and has shallow foundations condition slight ground subsidence is to be expected when there is rapid lowering in water table. It may be noted that the separation of cracks have been increasing gradually indicating slow imperceptible ground movement similar to soil creep. The presence of older vertical cracks in the houses indicates imperceptible ground subsidence in the area over a long period.

John Mathai

1.12 Ground Cracks in Kadalundi Panchayat, Kozhikode District

Ground cracks were observed in an area of about 0.25 sq. km mostly around eleven dwelling units in kadalundi panchayat, Kozhikode district.. The cracks are discontinuous, oriented mostly in the northeast direction with horizontal separation limited to one or two cm. The extension of the cracks into the building resulted in minor cracks to the floor and walls of houses. The windows and door frames have been visibly separated from the walls but with very minor displacement only. Tilt of the wall in the NW and SE corner by about 5 cm, sub horizontal cracks in the wall, floor exhibiting slight displacement, most of the houses showing recently developed hairline cracks etc., are observed in the area.

It is seen that the ground cracks have developed in an area that has been reclaimed for settlement. The area was originally a marshy land with shallow water table condition. The general elevation of the area is less than 10 m amsl and the drainage is mostly to the northeast. The northern, western and southern flanks are elevated laterite capped mounts. The substrate is mostly a thick bed of organic rich clay resting on laterite basement. Most of the wells reaching up to 5-6 m below ground level are nearly dry. The ground cracks are mostly seen on the periphery of the original marshy land. The land appears to have subsided as is evident from the tilt in the building and slight separation with difference in elevation at the basement of manmade structures with respect to the ground. In the absence of any felt reports or records the event cannot be related to micro-seismicity. However the area has witnessed lowering of water level due to the unprecedented drought like situation faced during the summer of 2013. Some of the wells resting on laterite are dry. Heavy pumping also has been resorted to by those with perennial wells mainly for irrigation. When the water table is lowered to below the clay layer there is a tendency for it to shrink. Clay layer swells when saturated with water and shrinks when it looses water. Hence the probable cause for the ground cracks in this area is shrinkage of under lying clay layer that is seen extensively in the low lying area. The phenomenon can aggravate if the extraction of water from this region is unchecked.

John Mathai

1.13 Ground Subsidence and Damage to Buildings in Perumanna village, Malappuram District

The unusual ground subsidence and damages to dwelling units that occurred in Perumanna Panchayat, Malappuram district was investigated. Ground cracks extending to the basement of buildingsare observed in two plots. The cracks are discontinuous and oriented mostly in east-west direction. The horizontal separation is limited to a few cm only. The cracks later extended into the floor and walls of houses. The floor of the houses appears to be tilted towards southeast. The windows and door frames have been visibly separated from the walls. Sub horizontal cracks are noticed on all the walls and basement. Plaster is scaled off exposing the bricks at many places. The floor tiles have been dislodged with formation of cavities below on account of ground subsidence. The basement appears to have subsided by a few centimeters. Ground cracks are more prominent on the northern and eastern part of the building. An yielding open well in the vicinity developed a crack with a visible displacement at about 5 m depth with an inclination to the south. The crack is seen in the laterite profile below the hard vermicular layer. The events were noticed from 15.04.2013 and continued to aggravate for three days. The

Fig. 1.13.1 Ground subsidence in Perumanna village, Malappuram dist.

damages are limited to two buildings and the ground in their vicinity.

It is seen that the ground cracks have developed in a very small area and limited to two plots with dwelling units. Considering the factors like landform, slope, nature of the overburden, periodic fluctuation in water level, increase in the number of borewells with enhanced depletion in water level and considering the fact that the water evel had increased in few wells down slope prior to the events, it is opined that excess draining of water from the clay substrate has caused shrinkage with slight ground subsidence leading to emergence of cracks in the hard laterite cap rock resulted in damage of dwelling units. This can aggravate under uncontrolled pumping of water from the region during a drought period. Tremors have neither been felt in the area nor reported ruling out it to be a cause.

John Mathai

1.14 Mild Tremors Near Chimoni Dam

Mild earth tremors were reported in the vicinity of Chimoni dam on 23rd and 24th of July, 2013 causing alarm and slight panic in the region. Since the events had taken place in the vicinity of the dam it was felt necessary to assess the nature and extent of damages to the structure of the dam and to allay the fears of the local public. Based on the request from the Irrigation Department and the District Collector, a site study was carried out in the Chimoni dam site. The dam structure including the inspection gallery was inspected for cracks or any other signatures that could be linked with the recent earth tremors.

The Table 1.14.1 shows that the maximum magnitude of earthquake is 2.6 M in the Richter scale. Information was also collected from persons who felt the tremor. Many persons in the area did not even know about the occurrence of the tremors. Few persons expenced it as a loud blast with passing ground vibrations. There were no visible damages to man made structures like houses from the reported area indicating the feeble nature of the shocks. Earthquakes with less than 3 M are classified as minor tremors with no consequences. Ground motion associated with tremors of this type normally do not exceed a velocity of 1 cm/s. The permissible upper limit of particle velocity with quarry blast is 1.5 cm/s. Hence the sequence of tremors that have occurred in the vicinity of the dam structure cannot cause any damage to it. A case of concern can arise only if the magnitude of the earthquake with its epicenter in the vicinity of the dam exceeds 4 M in the Richter scale.

Physical examination of the structure of the dam and inspection galleries was carried out to ascertain whether any fresh cracks were developed due to the recent tremors. Leakage in the form of water spout was observed at 73-74 m level. It was reported that this leakage was noticed during the last 12 years whenever the water level reached 73 m. Cracks were seen on the top cutting the side wall between chainage 130m and 160 m. These are pre-existent cracks often seen between sections of contrasting rheology but unrelated to the present earthquake. In the gallery water was seen spouting out from many points. Notable ones are those seen at chainages of 180 m, 160m and 133m. Vertical cracks on the roof of the gallery with water spouts are noticed between 160m and 180 m. Excessive dampness is seen on the walls near 208 m. Heavy seepage is seen from the body of the dam near 420 m with water gushing out with perceptible noise. Maximum seepage is noticed at 282-285 m. The seepage on the left half is estimated as 6 lps while on the right half it is nearly 15 lps. This difference in seepage noticed the on two halves of the dam needs

Table 1.14.1 pertaining to the Chimoni dam area Records in Peechi Seismic Station

Sl. No.	Date	Time of earthquake	Magnitude	Location
1	18.07.2013	23.49 hrs	2.0	4 km W of dam
2	23.07.2013	16.42 hrs	2.3	6 km SE of dam
3	23.07.2013	18.02 hrs	2.0	6 km SE of dam
4	24.07.2013	19.31 hrs	2.6	7 km SE of dam

further investigation. The combined seepage measured from the rectangular weir gives a lower value. In conclusion it may be stated that the structure of the dam has not been affected by the present earthquake as the cracks, points of seepage and other deformities presently observed are pre-existent. High seepage observed, if it exceeds the design value, needs to be investigated further.

John Mathai

1.15 Monitoring Indian Shield Seismicity with 10 BBS to Understand Seismotectonics of the Region Using VSat Connectivity

The Broadband Seismic (BBS) observatory at Peechi, being operated by NCESS in the campus of the Kerala Forest Research Institute (KFRI) was established in 1999, as part of the programme for strengthening earthquake monitoring in the peninsular India and improving the detection capabilities in the earthquakes in the shield region (Fig. 1.15.1). The station has been recording local, regional and teleseismic events since then. The main objective of the project is continiuos operation and maintanance the BBS station to produce high quality uninterrupted data. The data recorded here is used for the studies of local as well as regional earthquakes. The observatory plays host to a remarkable number of visitors including students and thus serve as a good educational facility to the public. It also serves to provide information on earthquakes to government agencies as well as media and general public. Continuous data recorded here are sent online to NGRI through the Vsat connectivity. A total of 1966 local, regional and global events were recorded during the period 2013 January – 2014 January. There were 53 tremors reported from Kerala, 2 from Karnataka, 4 from Tamilnadu ,1 from Andhra, 29 from Andaman Nicobar region and 38 from other parts of India.

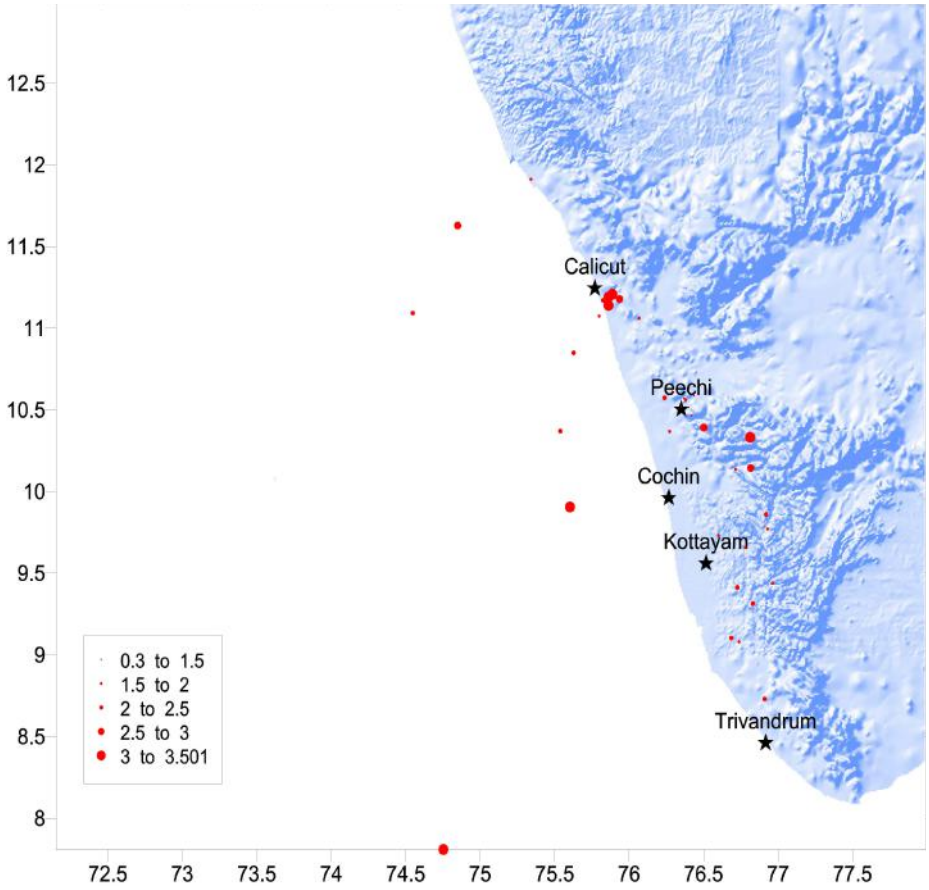


Fig. 1.15.1 Location of tremors recorded from Kerala during 2013 January- 2014 January

The seismic events reported from the nearby states are mainly from Vallakovil, Chettipalayam, Thiruvanna-malai, Ongole and Chitradurga. Koyna, Rajastan, Uttaranchal, India-Bangladesh border, Assam, Kashmir, Arunachal, Uttarakasi and West Bengal arethe other states from which seismic activity was reported.

Continuous archiving of data which includes phase picks, wave form files and catalogue of events recorded in the observatory have been routinely carried out and the details have been sent to the IMD on half-yearly basis. Data up to December 31, 2013 were sent to National Seismic Database Centre of IMD on 04-01-2013. The data is transmitted online to NGRI, Hyderabad through V-Sat connectivity and also shared with other departments like the KSEB, IISC, ISR on their request.

Table 1.15.1 List of tremors recorded at Peechi in 2013 January-2014 January

Sl. No	Date	Latitude	Logitude	Magnitude	Region
1	05/01/2013	11.910	75.340	1.9	Azhikkode, Kannur
2	07/01/2013	10.460	76.420	1.4	Reserve forest Thrissur
3	17/01/2013	10.520	76.350	0.8	1km SE of Peechi Station
4	20/01/2013	9.080	76.738	1.9	Mannady
5	07/02/2013	9.770	76.930	1.5	Near Venjoormedu, Idukki
*6	17/02/2013	9.786	76.912	0.5	Near Kannampadi, Idukki
7	26/02/2013	11.208	75.888	3.0	2 km SW of Vazhayur (Kozhikode)
8	26/02/2013	11.075	75.799	1.9	~5.5 W of Chetipadi (Malappuram) in the sea
9	27/02/2013	11.208	75.888	1.3	Kozhikode
10	28/02/2013	10.587	76.436	1.0	2 km N of Vaniyampara, Thrissur
11	01/03/2013	9.905	75.603	3.4	70 km W of Ernakulam in the Arabian sea
12	24/03/2013	11.093	74.548	2.3	136 km W of Beypore, in the sea
13	25/03/2013	10.467	76.418	1.2	Peechi reserve forest
14	14/04/2013	9.859	76.920	2.0	Near Idukki Dam
15	15/04/2013	10.373	76.268	1.3	4.30 km West of Kodakara (Thrissur)
16	17/04/2013	10.574	76.238	2.0	Thannikudam (Thrissur)
17	17/04/2013	8.730	76.910	2.3	Vamanapuram
18	20/04/2013	9.412	76.728	2.0	Chalappily, Pathanamthitta
19	22/04/2013	9.314	76.830	2.1	Vadasserikkara (Pathanamthitta)
20	23/04/2013	9.314	76.830	2.2	137 km from Peechi
21	24/04/2013	9.314	76.830	2.1	137 km from Peechi
22	03/06/2013	7.808	74.753	3.0	250 km SW of Trivandrum in the sea
23	19/06/2013	9.438	76.963	1.7	Near Koruthudu, Kottayam
24	26/06/2013	9.103	76.686	2.3	Near Pavitraswaram, Kollam
25	03/07/2013	10.849	75.628	2.0	33 km NW of Ponnani (Lakshadweep sea)
26	18/07/2013	10.389	76.492	2.1	4.44 km W of Chimmini Dam (Trissur)
27	20/07/2013	11.060	76.067	1.5	Malappuram
28	23/07/2013	10.395	76.490	2.3	3.39 km S of Chimmini Lake (Thrissur)
29	23/07/2013	10.398	76.492	2.0	3 km S of Chimmini Lake (Thrissur)
30	24/07/2013	10.391	76.503	2.7	4 km S of Chimmini Lake (Thrissur)
31	07/08/2013	10.56	76.376	1.3	Near Kuthiran, Thrissur
32	07/08/2013	11.628	74.849	2.7	81 km Due W of Vadakara in the sea
33	09/08/2013	10.563	76.379	1.8	Near Kuthiran, Thrissur
34	10/08/2013	10.562	76.377	1.5	Near Kuthiran, Thrissur
35	11/08/2013	10.562	76.376	0.9	Near Kuthiran, Thrissur
36	04/09/2013	10.564	76.386	0.9	Near Kuthiran, Thrissur
37	14/09/2013	10.556	76.384	1.2	Near Kuthiran, Thrissur
38	01/10/2013	10.570	76.368	0.3	Near Kuthiran, Thrissur
39	03/10/2013	10.515	76.401	0.3	S Part of Peechi Dam
40	6/10/2013	10.332	76.812	3.0	7.5 km NW of Malakkappara (Forest)

*41	15/10/2013	9.658	76.779	1.5	Irattupetta, Punjar, Thikoy (Idukki)
42	3/11/2013	10.136	76.715	1.6	Near Kuttampuzha(Ernakulam)
43	13/11/2013	10.614	76.289	1.1	5.47 km NE of Thannikudam (Thrissur)
44	08/12/2013	11.192	75.863	3.5	1.5 km N of Ramanattukara (Malappuram)
45	09/12/2013	11.14	75.862	3.1	3.5 km east of Kadalundi (Malappuram)
46	10/12/2013	11.179	75.936	2.6	Andiyoorkunnu (Malappuram)
47	11/12/2013	11.168	75.837	2.3	Feroke (Malappuram)
48	14/12/2013	10.37	75.538	2.0	61 km W of Kazhimpuram Beech (in the Sea)
49	17/12/2013	11.171	75.826	2.1	Karuvanthuruthi (Malappuram)
50	21/12/2013	10.367	76.272	1.7	Muriad, Trichur
51	21/12/2013	10.368	76.271	1.8	Muriad, Trichur
*52	02/01/2014	9.73	76.600	1.5	Elakad (Kottayam)
53	20/01/2014	10.144	76.816	2.5	3.5 km N of Mamalakandam (Idukki)

Sreekumari Kesavan

Funding: MoES, GoI

2.1 Spatio Temporal Shore Changes during the Holocene and Tracing the Evolutionary History of the Ashtamudi Estuary, Southern Kerala

This inter-institutional collaborative project between NCESS and Department of Geology, Anna University, Chennai has been successfully completed and final report was submitted to the Department of Science & Technology, Government of India during the period. The study programme involved the collection of undisturbed sediment cores from coastal plain, estuary and offshore region along two transects viz., southern and northern between Neendakara and Kayamkulam (Fig. 2.1.1). The collected cores were sub-sampled from different litho-units and were analysed for sedimentological, geochemical and foraminiferal characteristics. Here, we are reporting some of the salient results of the study.

The lithological variations of sand, silt and clay contents and their statistical parameters reveal the deposition of sediments in different regimes with dominance of terrigenous origin in southern coastal plain and marine origin in the northern coastal parts. In the Ashtamudi estuary bottom sediment comprises of silty clay to clayey type whereas the offshore region is carpeted with silty clay to relict sand. The hydrodynamic conditions and depositional environment of sediments were explained based on statistical parameters which infer the deposition of coastal plain (open to closed basin), Ashtamudi estuary (partially open to restricted estuary to closed basin) and offshore (open channel). To further strengthen the sedimentological aspects the clay minerals were also identified. Clay mineralogical studies reveal the dominance of kaolinite, gibbsite, illite, chlorite and montmorillonite in the study area. The clay mineral intensities were plotted against the sediment litho-units for the inland core of the Neenadakara and Kayamkulam transect which in turn reveal the difference in peak intensities.This clearly indicates that the sediments have been deposited in different depositional regimes. The radiocarbon dating of peat layer indicates the deposition of sediments from late Pleistocene (40,000 yrs) to present in the area.

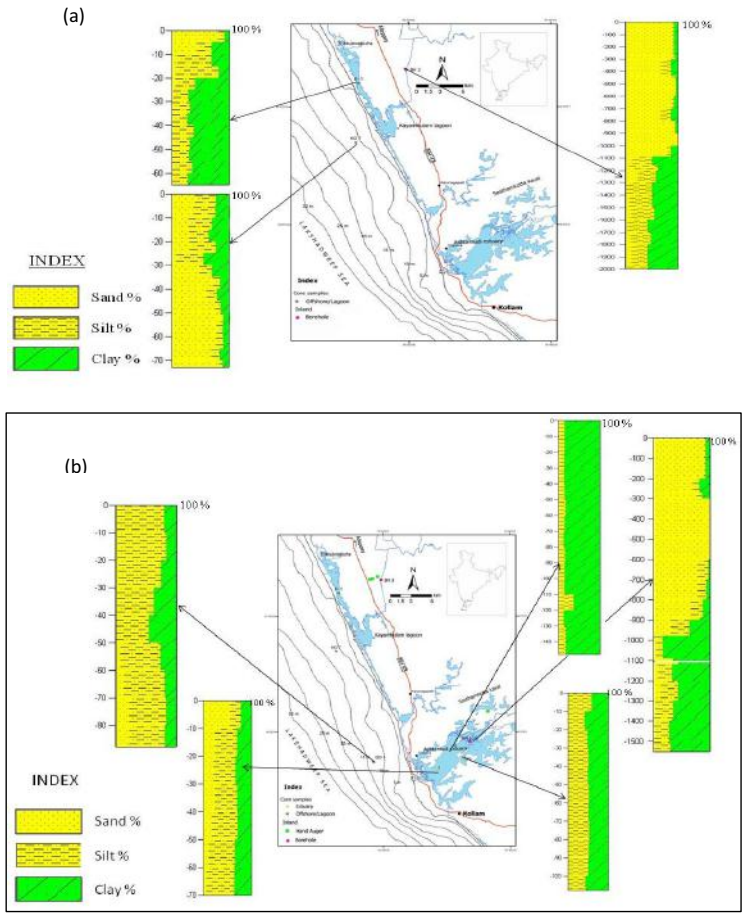


Fig. 2.1.1 Lithological variation of sand silt and clay percentages representing inland, estuary/ lagoon and offshore for (a) Kayamkulam and (b) Neendakara transect

The Microtextural analysis of quartz grains were carried out using Scanning Electron Microscope (SEM) which indicates the sediments of the southern coastal plain are transported and deposited mechanically under the fluvial environment followed by diagenesis under prolonged marine incursion whereas the sediments of the northern coastal plain were transported and deposited under littoral environment suggesting the dominance of mechanical as well as chemical processes. The surface texture features of the offshore sediments suggest that the quartz grains are of littoral origin and represent the relict beach deposits. The SEM analysis and interpretation for the sediment core representing the southern coastal plain is given in Fig. 2.1.2

The major and trace element geochemistry of sediment cores which are considered as function of provenance, degree of weathering, transportation, sorting, diagenesis, tectonic setting and paleoclimate are investigated. Down core variations of major oxides as well as trace elements for both the transects are presented. Moreover the correlation matrixes between the major and selected trace elements were also discussed. The geochemical classification, sediment maturity, palaeo-weathering and provenance of sediment of different environments are illustrated. The

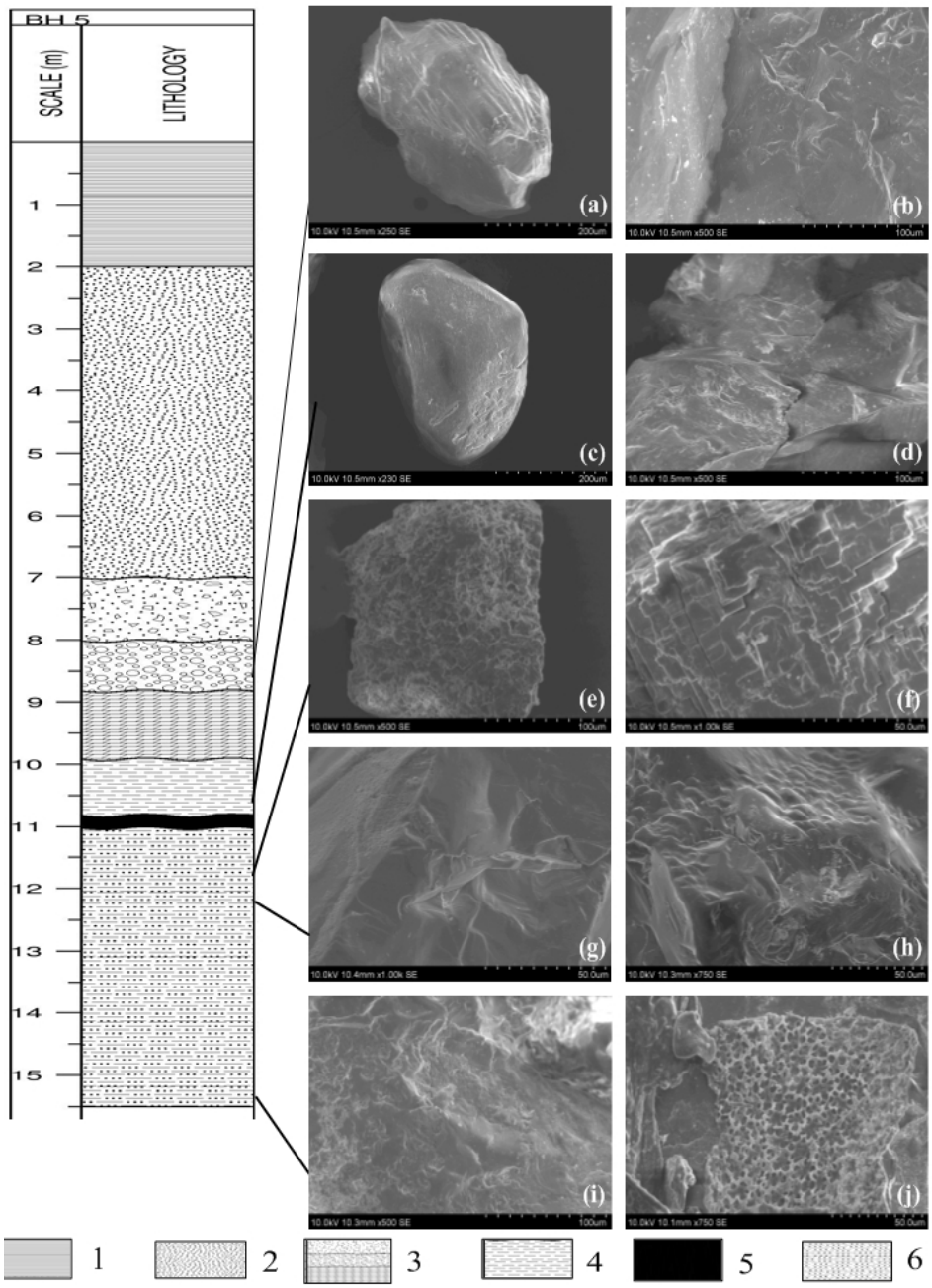


Fig. 2.1.2. Lithology of the borehole core: 1-Soil, 2-Riverline Sand, 3-Sand Slit Clay, 4-Dessicated clay, 5-Peat and 6-Silty Clay; SEM photographs of the sub-surficial quartz grains at various depths: (a) large conchoidal fractire with high relief and angular in outline (b) V-etch pits; showing sub-rounded in outline (c) traces of crescentric grooves with silica plastering (d) showing (e) totally distorted shape with sub-rounded in outline (f) chemically etched fractured plates; showing subrounded in outline with silica pellicle, silica precipitation in conchoidal pattern leading to smoothness (g) pressure solution features (h) diagenesis (i) dissolution etching and (j) Honey Comb structure

relation between K_2O/Al_2O_3 and MgO/Al_2O_3 was used to differentiate between marine and non-marine clays. Majority of the core samples representing the southern transect (Fig. 2.1.3a) falls in the marine dominance except the coastal plain core sediments where top 7 m sediment samples falls under non-marine or freshwater conditions, 7-11 m samples falling along the marginal line of non-marine to marine conditions and from 11 m to down the core falls under marine conditions. The Ashtamudi estuary cores as well as offshore sediments fall totally in the marine environment. In the northern transect (Fig. 2.1.3b) most of the core samples representing the coastal plain, lagoon and offshore sediments falls in the marine condition.

The total foraminifer assemblage and its distribution are studied for the cores. Out of the total 33 core sections, representative core sections were selected for foraminiferal distribution. The lithologged core sections were sub-sampled at 5 cm interval for separation of fossils. The sediment cores from coastal plain (1), estuary (2), bore hole (1) and offshore (1) sections were studied for foraminifera. The generated results are given in Table 2.1.1. The foraminifer's assemblages from the selected sediment cores and surface sediment samples of the Ashtamudi Estuary are as follows:

(i)Foraminifera assemblages of sediment core (C-15): *Ammonia beccarii, Ammonia dentate, Ammonia tepida, Brizalina striatula, Cancris oblangus, Cibicides lobatulus, Elphidium discoidale, Elphidium crispum, Eponide repandus, Globigerina bulloides, Fursenkoina fusiformis, Nonian scaphum, Nonion boueana, Pateorishauverinoides, Rosalina-globularis, Rolshausenia rolshanseni, Pararotalina nipponica.*

(ii)Foraminiferal assemblages of Ashtamudi estuarine samples: The study also attempts to quantitatively analyze the relationship of 29 recent benthic foraminifera in the estuarine sediments with different ecological parameters of the Ashtamudi estuary. The multivariate study has been inspired from the results of the faunal abundance data of the estuary. The estuary has been iterated statistically using Q-mode Cluster analysis to understand the spatial distribution of foraminifera species among the various locations in the arms of the Ashtamudi estuary. Foraminiferal genus *Ammonia* is the dominant taxa

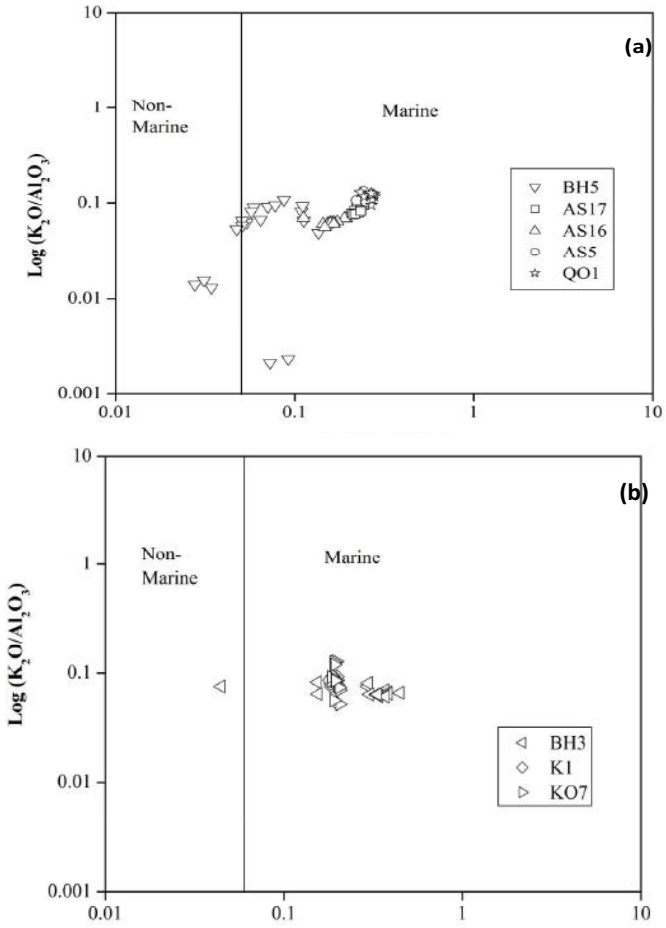


Fig. 2.1.3 MgO/Al_2O_3 diagram (after Roaldset, 1978) to differentiate between marine and non-marine clay for (a) southern and (b) northern transect

in the Ashtamudi estuary and hence, it is not considered for the cluster analysis. Q-mode cluster analysis has identified four distinct biotopes which reveal the distribution pattern of faunal assemblages in the estuarine sediments.

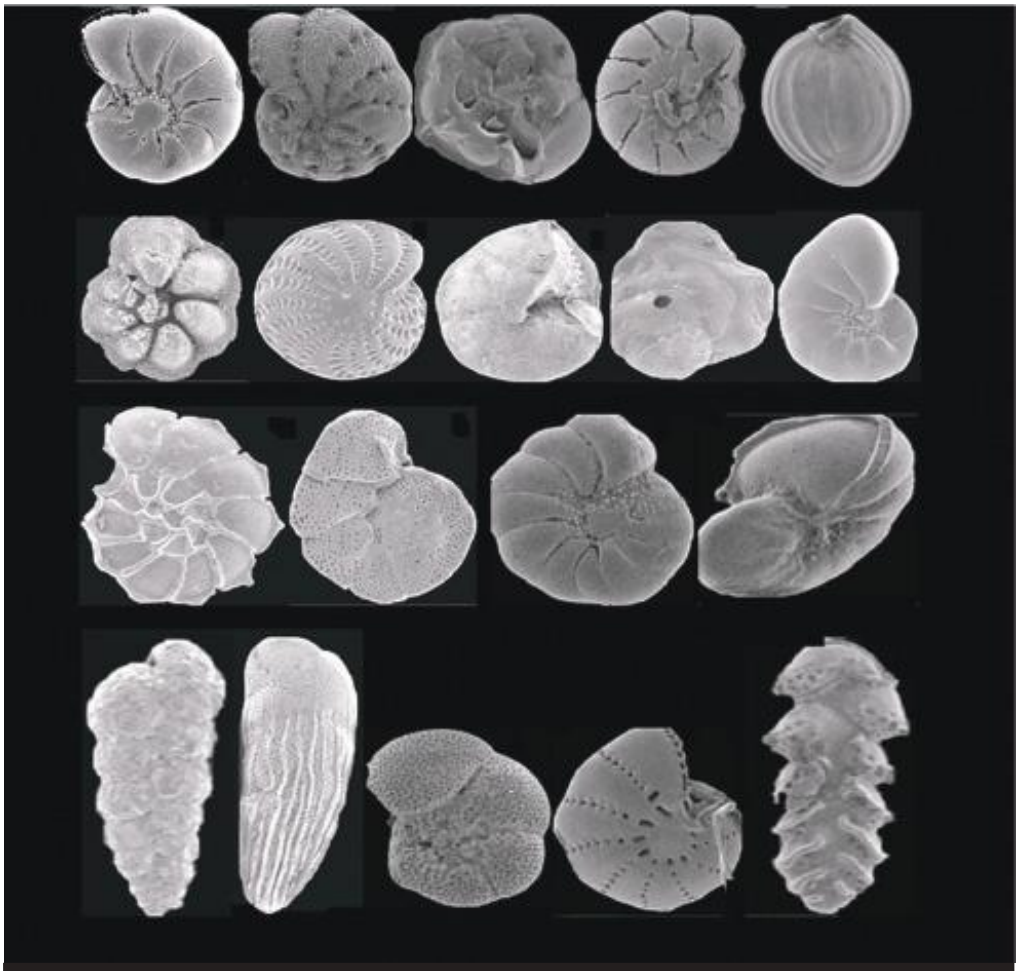
Twenty nine benthic foraminifera species represented by *Ammonia beccarii, Ammonia dentata, Bolivina earlandi, Bulimina marginata, Caribeanella polystoma, Cancris oblongus, Cibicides lobatulus, Dyocibicides sp., Elphidium crispum, Elphidium excavatum, Elphidium discoidale, Elphidium hispidulum, Eponides repandus, Globulina gibba, Loxostomum lobatum, Nonion boueana, Nonion grateloupi, Nonion scaphum, Nonion sp., Pararotalia nipponica, Poroeponides lateralis, Quinqueloculina agglutinans, Quinqueloculina boueana, Quinqueloculina seminula, Rolshausenia rolshauseni, Virgulina riggii, Ammobaculites sp., Textularia agglutinans and three planktics Globigerina bulloides, Globigernoides ruber and Globorotalia ungulata* were identified from 30 fixed stations covering the entire Ashtamudi estuary.

Evolution of estuary

The occurrence of Quaternary formations at various elevations along the Kerala coast and formation of a chain of shore-parallel estuaries/lagoons with rivers debouching into them and separated from the sea by spits/bars provide evidence of a progarding coastline through well preserved palaeo records in the sediment column. In and around the Ashtamudi estuary a thick sequence of Holocene sediments of 20-35 m containing good archives of landform evolution and climate changes have been deciphered by many of the earlier researchers. Further the sediment lithological variations from the above observations and a detailed sedimentological study along with the carbon dating carried out by this work have brought out clear understanding on the evolution of estuary during Quaternary. In the southern coastal plain bordering the Ashtamudi estuary the results of sediment lithology indica-tes several deposition as well as erosion episodes. The top 7 m is carpeted with medium to fine grade fluvial sand of angular to sub angular nature which is considered to be of recent deposition. This is also well documented in the SEM studies. Below 7 to 9 m the sediment colour has changed from reddish brown to

Table 2.1.1 Foraminiferal assemblages of Ashtamudi esturine samples

Ashtamudi entrance	**Central *Kayal***	**Western *Kayal***	**Eastern *Kayal***	**Southern *Kayal***
Ammonia beccarii	*Ammonia beccarii*	*Caribeanella polystoma*		*Ammonia beccarii*
Ammonia dentata	*Bolivina earlandi*	*Elphidium discoidale*		*Ammobaculites sp.,*
Brizalina striatula	*Brizalina striatula*	*Globigerina bulloides*		*Brizalina striatula*
Bulimina marginata	*Cibicides lobatulus*	*Nonion boueana*		*Caribeanella polystoma*
Aribeanella polystoma	*Elphidium discoidale*	*Nonion scaphum*		*Elphidium excavatum*
Dyocibicides sp.,	*Elphidium hispidulum*	*Quinqueloculina agglutinans*		*Elphidium hispidulum*
Eiphidium crispum	*Eponides repandus*	*Brizalina striatula*		*Elphidium sp.,*
Cancris oblongus	*Globigerina bulloides*	*Virgulina riggii*	*Ammonia beccarii*	*Globigerina bulloides*
Elphidium discoidale	*Loxostomum lobatum*			*Nonion boueana*
Globigerina bulloides	*Nonion boueana*			*Nonion scaphum*
Globigerinoides ruber	*Nonion scaphum*			*Quinqueloculina agglutinans*
Nonion boueana	*Nonion grateloupi*			
Nonion scaphum	*Quinqueloculina sp.,*			
Poroeponides lateralis	*Rolshausenia rolshauseni*			
Quinqueloculina seminula	*Textularia agglutinans*			



(1) Nonion Boueana (side view), (2) Elphidium advenum (side view), (3)Rolshausenia rolshauseni (dorsal view), (4) Ammonia beccarii (ventral view), (5) Quinquwloculina boueana (side view) (1) Pararotalia nipponica (ventral view) (2) Elphidium crispum (side view) (3) Eponides repandus (ventral view) (4) Dyocibides sp. (dorsal view) (5) Textularia agglutinans (side view) (6) Noinion grateloupi (side view) (1) Ammonia dentata (dorsal view) 92) Cibicides lobatulus (dorsal view) (3) Brizaliana striatula (side view) (1) Protoelphidium sp., (side view) (2) Loxostomum lobatum (side view) (3) Nonion scaphum (side view) (4) Caribeanella polystoma (dorsal view) (5) Elphidium discoidale (side view)

Fig. 2.1.4 SEM photographs showing Foraminiferal assemblages of Ashtamudi sediment grab samples

yellow of medium to coarse sand with occasional gravel and pelecypods shells indicating a change in the pattern of the shallow marine to lagoon and swamp/marsh environment. It can be concluded that the monsoon strength increased suddenly in two steps, 13-12.5 14C Kyr and 10-9.5 14Ckyr BP (ca.15.3-14.7 and 11.5-10.8 cal kyr BP). Most climatic proxies suggest that the stronger monsoon in the early Holocene was associated with high lake levels; increased flow, floods and scouring. The stronger monsoon during the early Holocene resulted in the formation of incised valley at the entrance of Kallada River. This was followed by the Holocene transgression event submerging the adjacent coastal plain resulting in the formation of coast perpendicular estuary. The Pleistocene-Holocene boundaries were also encountered in the study area. The Holocene sedimentation was replaced by 7 m recent sediment which is directly overlying the late Pleistocene of 40,000 yrs BP.

T. N. Prakash, R. Nagendra & Tiju I. Varghese
Funding: DST, GoI

2. 2 Sediment Budgeting Studies for Mining Sites of Kerala Minerals and Metals Ltd., Chavara

The project sediment budgeting studies for the mining sites of Kerala Minerals and Metals Ltd. (KMML), Chavara was undertaken as per the agreement between the KMML and Centre for Earth Science Studies (CESS). It aims to budget the beachresources at the mining sites of KMML to facilitate sustainable extraction of beach washings. The project was launched in 2011 and completed as per schedule in 2013. The major objectives of the project were to study the hydrodynamic and sediment characteristics in the innershelf off Chavara coast, to carry out numerical model studies to understand the innershelf sediment transport processes of the region and to finally estimate the beach sediment budget for the coast on the basis of which the quantity of mineral sand that can be removed without adversely affecting the beach stability can be recommended.

In order to understand the beach processes and to budget the beach resources, a detailed field investigation programme was designed and various oceanographic and sedimentologic parameters were measured in the offshore and beach adjoining the Ponmana and Anjumanakkal mining sites of KMML (Fig. 2.2.1). The major equipment deployed for the data collection were the MIDAS non-directional & directional wave and tide recorder, Sentinal ADCP with directional wave, Datawell waverider buoy, piston corer, Bathy-500 echosounder, Ceeducer pro, differential/RTKGPS and sediment traps.

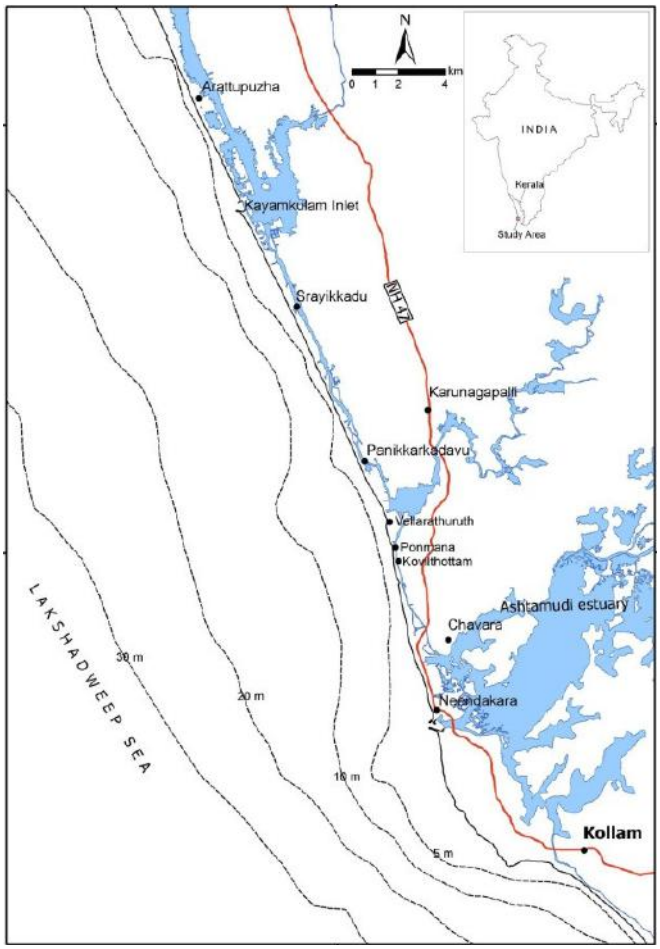


Fig. 2.2.1 Map showing the study area

Beach based field measurement programmes were carried out along the Neendakara-Kayamkulam coast. Close grid beach profiling was carried out along the Ponmana mining sites and coarse grid profiling along the rest of the coast. The MIKE21 modelling system was used for the numerical modelling work and the models employed are the Spectral Wave (SW) for the nearshore wave stimulation & MIKE21 HD model that includes the sand transport module for the hydrodynamics and sediment transport simulation. The computer models employed in the study are the Sand Transport (ST) module of the Flow Modelling

Fig. 2.2.2 Piston corer being operated for collection of sediment cores

(FM) System in the MIKE21 modelling suite.

Extensive wave data collected during the study indicates that the period form June-September that recorded maximum significant wave height of 2.5 m is the roughest. Measurements of currents showed the dominance of southerly/south- westerly flow throughout the year. The wind data collected during the study shows that the highest wind speed is during July wereas the directions are predominantly west/north-west during major part of the year. Analysis of beach profiles and beach volume changes for the different locations selected for the study show a seasonal cycle in the erosion/accretion pattern with erosion during the pre-monsoon and early monsoon period and accretion during the post-monsoon period.

Sedimentological studies have demonstrated that the sediment movement is dynamic both on the beach and in the inner shelf. The capacity of waves and currents to move the sediment across and along the shelf has been clearly demonstrated. The shallow seismic profiling carried out in the inner shelf of Neendakara-Kayamkulam inlet to study the deposition pattern showed that sediment in the 5-10 m depth zone of innershelf has an average thickness of <1 m in the Kovilthottam-Neendakara sector, < 2 m in the Vellanathuruthu sector and < 3 m in the Cheriazhikal sector.Using the numerical models developed/ calibrated for this coast, sediment budget estimates have been carried out. Both the alongshore and cross-shore sediment fluxes were computed based on the

model result to arrive at the sediment budget for the area. Recommendations on sustainable extraction volumes for the different sites during each month were also given.

T. S. Shahul Hameed
Funding: KMML, GoK

2.3 Monitoring of Sea Level Rise and Shoreline Analysis

Global warming and climate change initiated by it is a serious concern today. It puts into stake not only the environment, but the very existence of human race. One of the major concerns is sea level rise, resulting from melting of glaciers and thermal expansion of oceans. According to the last and the recent (5th) Assessment of IPCC report, global sea level continues to be rising. A small change of sea level can lead to extensive flooding of coastal areas which are densely populated. This makes sea level change, a serious of concern. For the 20th century, the average rate of sea level rise was 1.7 ± 0.5 mm/year. The global climate projections by IPCC (2013) give model-based estimates of sea level rise by the end of this century as 0.73 m, in the range 0.53–0.97 m, for the highest emissions of greenhouse gases RCP8.5. There is strong evidence that global sea level gradually rose in the 20th century and is currently rising at an increased rate.

Sea Level Rise (SLR) is of great concern for a micro-tidal region like Kerala with a coastline of about 590 km and large expanse of backwaters and estuaries with extensive low-lying areas such as filtration ponds. This necessitates the need to monitor sea level rise along the coast of Kerala and study its impacts on the shoreline. Accordingly the project has been initiated with objectives of establishing tide measuring stations and collecting tide data; establishing GPS Stations to monitor micro level vertical changes; deriving realistic estimates of SLR from tide gauge & GPS data; impact analysis of different SLR scenarios for Kerala coast; analysis of shoreline changes for enhanced erosion due to SLR; analysis of flood plain shrinkage in Vembanadu and its effect on increased SLR. Tide gauge data available at the PSMSL website was used to determine trends for Kochi and Mangalore. The present study showed a trend of 1.76 mm/yr for Kochi during 1939-2003 whereas 1.88 mm/year for the period 1939-2007, after applying GIA corrections. That is, during the period 2003-2007 the rate of sea level rise has increased by 0.12 mm/year, on the average, at Kochi.The trend analysis and linear extrapolation of sea level data of Kochi done up to the year 2100 showed that the sea level will increase by 0.25 m only in the present century, if no greenhouse gas emission is considered. IPCC 5th Assessment report of 2013 includes 4 climate scenarios based on emission levels of greenhouse gases. These emission scenarios in the increasing order of severity are RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5. The model-basedestimates of sea level rise by the end of this Century are given as 0.43, 0.52, 0.54 and 0.73, for the four cases of emissions. The sea level rise at Kochi is plotted together with the prediction of IPCC 5th Report in Fig. 2.3.1. The sea level rise by the year 2100 at Kochi was estimated to be around 0.5 m higher than the level during the year 2000. This is likely to hold good at Kochi even in the present scenario also.

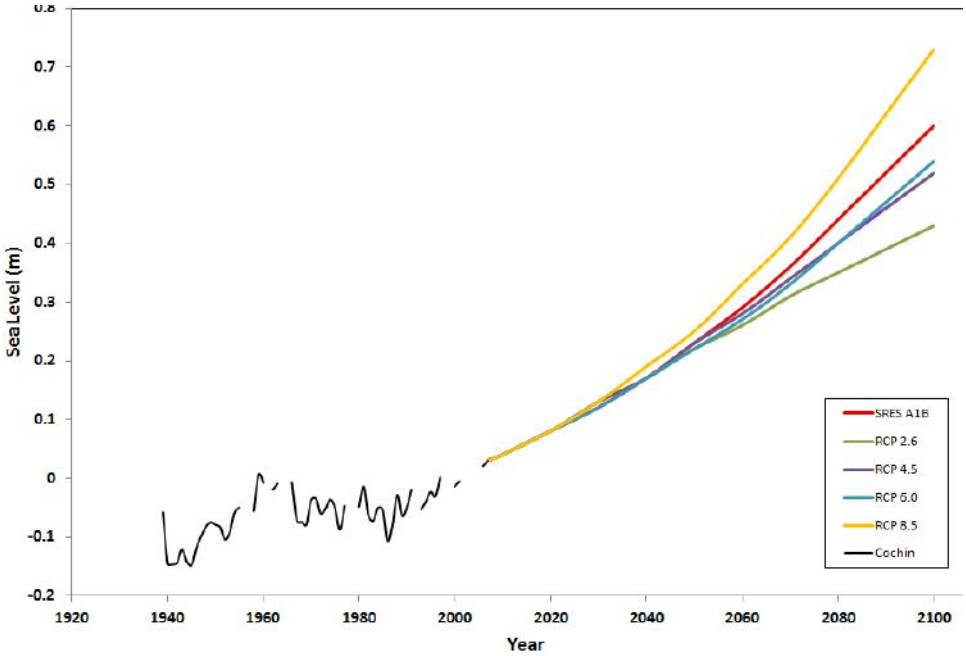


Fig. 2.3.1 Sea level of Kochi (black) with average future predictions with different emission scenarios of IPCC 5th Assessment Report, 2013.

T. S Shahul Hameed
Funding: KSCSTE, GoK

2.4 Eatablishment and Maintenance of Wave Gauge Stations in the Coastal Waters of the SW Coast of India

The project - establishment of wave gauge stations along the coastal waters of Kerala is a MoES sponsored project carried out by the NCESS in collaboration with the

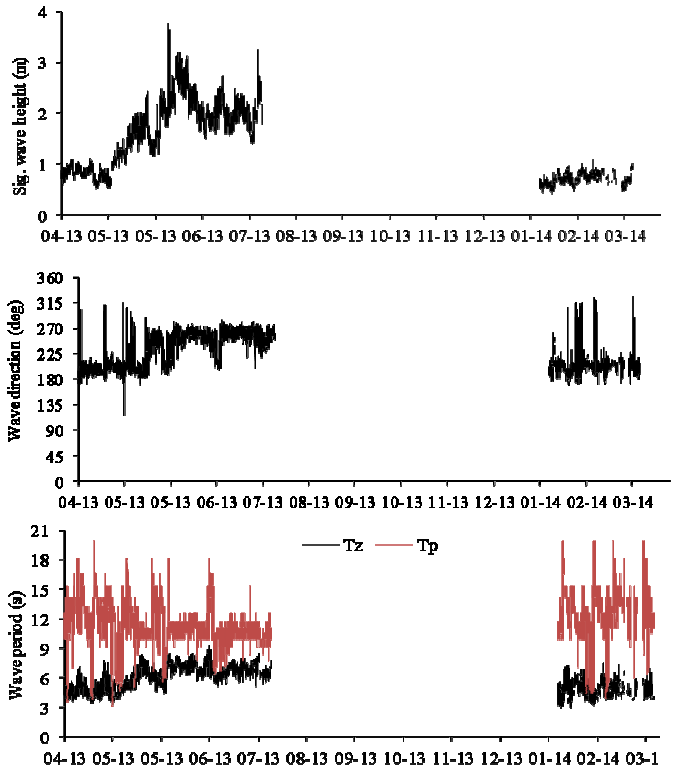


Fig. 2.4.1 Measured wave data from the WRB deployed off Kollam (a) Significant wave height (b) Predominant wave direction and (c) Wave periods (zero crossing and peak)

INCOIS, Hyderabad. The main objective of this project that was initiated during July 2010 are to establish and maintain wave gauges at selected locations along the Kerala coast for the collection of site specific real time wave data for the validation of the daily Ocean State Forecast (OSF) given by INCOIS. As part of this programme the first Wave Rider Buoy (WRB) was deployed off the Valiathura coast in Trivandrum during May 2011 and this was later shifted to Kollam in May 2012. The second station was established in North Kerala by deploying another WRB off Puthiyappa in Kozhikode on 26th April, 2013. At both the locations land based shore stations have been set up for the reception of HF data from the WRB and for further transmission of data at regular intervals to the INCOIS server at Hyderabad.

The OSF web-based service provided by INCOIS for north Kerala was inaugurated in a public function organised in connection with the deployment of wave rider buoy off Kozhikode on 26th April 2013. The mobile phone based OSF - SMS facility (text as well as voice message in Malayalam) for the coastal community of Kozhikode was also formally launched in the same function.

The methods currently being adopted for the dissemination of the site specific OSF to the coastal community of Kerala include providing site specific OSF (period) through emails to the user and also through news bulletin of the All India Radio (AIR). At present the AIR broadcasts site specific OSF for the five important coastal locations of Kerala viz. Trivandrum, Kollam Aleppey, Cochin and Kozhikode through separate new bulletin twice a day (morning and evening).

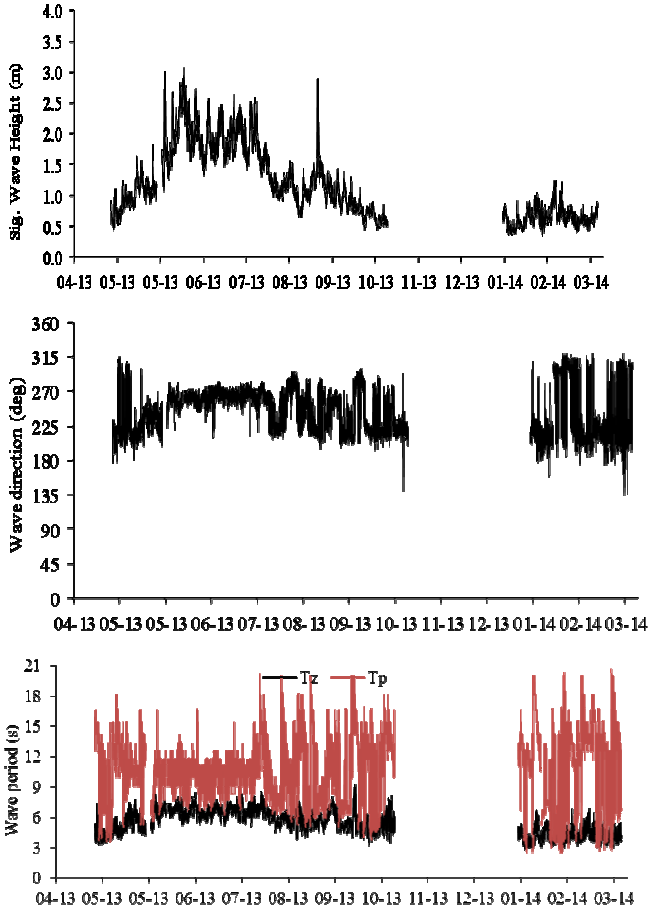


Fig. 2.4.2 Measured wave data from the WRB deployed off Kozhikode: (a) Significant wave height (b) Predominant wave direction and (c) Wave periods (zero crossing and peak)

The real time wave data from the WRBs (Fig. 2.4.1, Fig. 2.4.2) are also being used for the validation of the site specific daily forecast provided by INCOIS. The statistical error estimates are also computed at regular intervals by comparing the forecast data with the measured values so thattimely corrective measures can be taken by INCOIS to improve the quality of forecast. In addition to this the feedback during extreme events from the users particularly the fishermen are collected, compiled and sent to INCOIS.

L. Sheela Nair

Funding: MoES, GoI

2.5 Study of Impact of Sea Level Rise along the Kerala coast

Sea Level Rise (SLR), as a consequence of global warming and climate change, is of great concern for a micro-tidal region like Kerala, with vast expanse of backwaters, estuaries and extensive low-lying areas such as filtration ponds. A realistic assessment of the impact of SLR and the identification of impact zones are very crucial for evolving adaption measures and planning mitigation of impacts. Economic and financial implications due to damages to ecosystems and infrastructure need to be assessed to integrate development requirements with environmental issues of sea level rise.

The impact of SLR depends mainly on the coastal morphology and vulnerability to SLR due to exposure to seas, estuaries and backwaters. Morphological hotspots to SLR are determined based on the varying levels of resistance offered by morphological forms to the impacts due to sea level rise. Morphological units along the Kerala coast have been identified from toposheets, high resolution imageries – like the Google, IKONOS and Quickbird. Visual interpretation was validated with field investigations using GPS. Image processing and GIS techniques have been used for the analysis of data and the presentation of results.

The morphological units identified are coastal plains, sandy beaches, barrier beaches, pocket beaches, spits, cliffs, headlands, seawalls, breakwaters, tidal inlets, estuaries, backwater islands and filtration ponds. Among these the major hot spots of SLR are low lying backwater islands and adjoining filtration ponds, since they are prone to inundation from all the sides. Sandy beaches, especially barrier beaches and spits are the next set of hot spots. Separate management plan is required for each of the different sets of morphological units in order to deal with sea level rise. The topography has been collected for the coastline as secondary data. Preparation of contour maps, using GIS software, is underway on the basis of which shoreline changes and the impacts of different scenarios of SLR will be assessed.

T. S. Shahul Hameed

Funding: DoECC, GoK

2.6 Coastal Zone Management Plan of Mira Bhayandar Muncipal Corporation in 1:25000 scale

The damages to the coastal zone and the impact of coastal hazards to communities and properties, to a certain extent, can be controlled by regulating high impact activities in the coastal zone. It was with this objective the Coastal Regulation Zone (CRZ) Notifications (MoEF, 2011; 1991) were introduced in the country. The preparation of the Coastal Zone Management Plan (CZMP) for Mira Bhayandar Municipal Corporation (MBMC) has been undertaken as part of the CZMP preparation for the coastal zone of Thane and Sindhudurg districts in Maharashtra.

The CRZ provides a spatial planning framework for Coastal Zone Management Plans that offer setbacks around sensitive eco-zones restricting development and other activities close to it. The Coastal Zone Management Plans are prepared in two scales: (i) CZMP consisting of CRZ maps in 1:25000 scale with the Survey of India toposheets as base maps, (ii) CZMP consisting of CRZ maps in 1:4000 scale with cadastral maps as base maps

The CZM/ CRZ maps in 1:25000 scale with the Survey of India toposheets as base maps are required for policy decisions. The local level CRZ/ CZMP are prepared in 1:4000 with cadastral base maps are based on the approved CZMP. Local level data in cadastral scale was generated initially which is being used for preparing the 1:25000 CZMP on toposheet base maps. The same is used for local level CRZ/CZMP maps.

High Tide Line (HTL)

A functional High Tide Line (HTL) is defined in the CRZ notification with the sole objective of protecting a given stretch of coastal strip from environmental degradation. The HTL is defined 'for the purpose of the notification' as *"the line on the land up to which the highest waterline reaches during the spring tide"* which is different from the well known and widely accepted definition of High Tide Level. The above definition of HTL takes into consideration not only the level of inundation due to maximum tide (spring tide) but also the wave set up (having a seasonal periodicity). The sea level thus formed due to the combined effect of spring tide and wave set up gives the line of maximum reach of water on the land. Morphological signatures like berm crest, cliff, headland, line of permanent vegetation, etc. are used as indicators of the reach of sea water into the land for identifying the HTL.

The 100, 200 and 500 m setback lines are drawn landward of the HTL. Once the HTL is well defined and demarcated, the above three setback lines could be drawn without any ambiguity following planimetric methods.

The distance up to which CRZ is applicable upstream of estuaries, creeks, backwaters and lagoons depends on the extent of tidal influence. Salinity concentration give a measure of the distance up to which tidal influence is there:

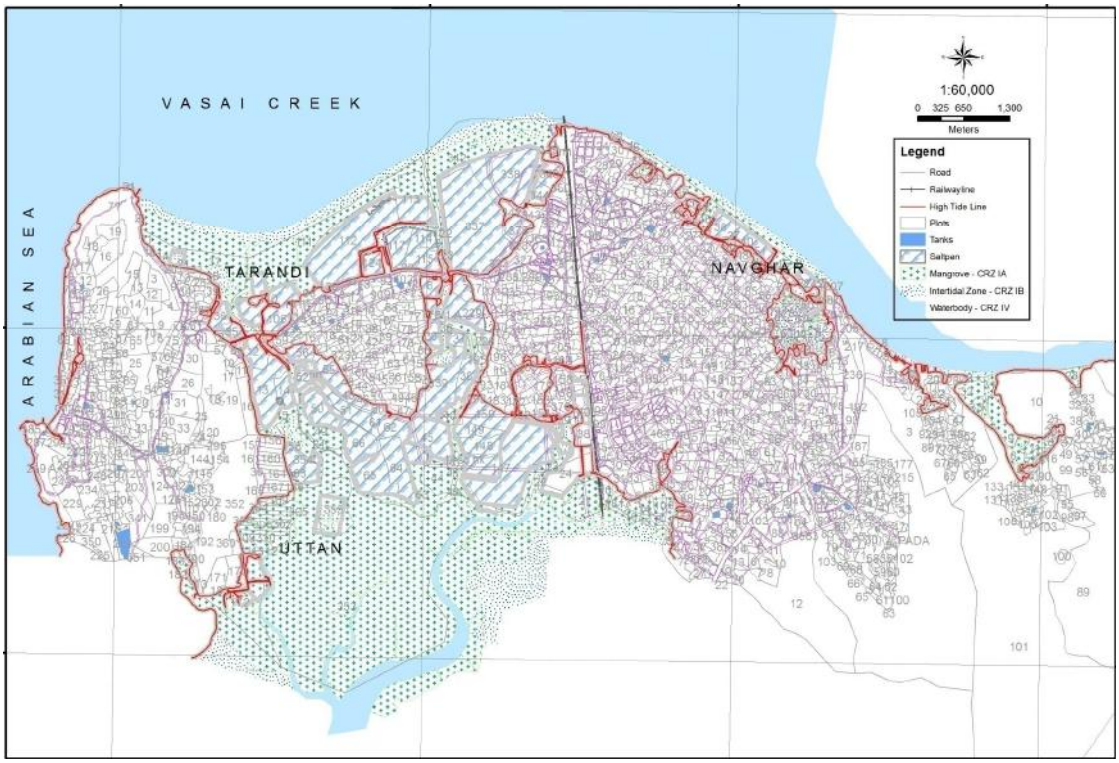


Fig. 2.6.1 HTL and coastal ecosystems in Mira Bhayanadar

if it is 5 ppt or more the water body is considered to be influenced by tidal action. Salinity measurements are carried out to determine the limit. Tidal barrages and bunds constructed are also taken as the limit of tidal influence.

CZMP/ CRZ map of Mira Bhayandar in 1:25000 scale

The MBMC area is shown in two 1:25000 toposheets: Sheet No. 47 A15 SW and Sheet No. 47 A15 SE. Field data was generated in 1:4000 scale from the 18 villages viz. MBMC such as Chowk, Tarandi, Raimrdhe, Murdhe, Uttan, Morva, Dongri, Bhayandar, Khari, Ghoddev, Ghodbundar, Versave, Chene, Kashi, Mira, Mahajanwadi, Penkarpada and Pali. In addition to field investigations including GPS/ DGPS mapping, data sources such as topographic sheets, hydrographic charts and satellite images have been used. The High Water Line (HWL) from the toposheets has been appropriately modified with the HTL obtained from field observations and the satellite imageries for preparing the CZMP as per CRZ 2011.

The CRZ of Mira Bhayandar consists of CRZ I, CRZ II, CRZ III and CRZ IV (Fig. 2.6.1 and Table 2.6.1). The CRZ IA includes those ecologically sensitive and the geomorphological features which play a role in maintaining the integrity of the coast such as mangroves, corals, sand dunes, etc. Acanthus Iliforus, Avicenia Officinalis, Exocarria Agallocha are the dominant variety of mangroves in the MBMC. The CRZ IB is the area between the Low Tide Line and the High Tide Line. The CRZ II is those developed areas (with more than 50% built up area) in legally designated urban areas. Mira Bhayandar being a Municipal area, the CRZ in Mira Bhayandar which have more than 50% built up area, is CRZ II. The CRZ III is undeveloped areas in the CRZ of Mira Bhayandar Municipal area. The CRZ IV is the nearshore waters, the inland water bodies and the bed.

Table 2.6.1 CRZ details of Mira-Bhayandar Muncipal Council

HTL Length (km)	Mangroves (CRZ IA) within Sy plot (km^2)	Mangroves (CRZ IA) within Sy plot and outside (immediately adjoining) (km^2)	ITZ (CRZ IB) within Sy plot (km^2)	ITZ (CRZ IB) within Sy plot and outside (immediately adjoining) (km^2)	Saltpan (km^2)	Mangrove buffer zone (CRZ I) (km^2)	CRZ II (km^2)
114.23	**14.33**	**18.82**	**5.96**	**8.10**	**9.28**	**20.89**	**8.32**

The MBMC has HTL for a length of 114.23 km. The total CRZ area is 65.41 km^2 which includes those areas outside the revenue boundaries in the intertidal zone. Mangrove area (CRZ IA) is 18.82 km^2 with a mangrove buffer zone of 20.89 km^2. The inter-tidal zone (which includes seasonal beach on the sea coast and mudflats on the banks of creek/ river) is spread over 8.10 km^2 while saltpan area is 9.28 km^2.

K. V. Thomas

Funding: Govt. of Maharashtra

2.7 Shoreline Monitoring and Mapping of the West coast of India

The west coast of India consisting of the coasts of west coast of Tamil Nadu (Kanyakumari-Thiruvananthapuram stretch), Kerala, Karnataka, Goa, Maharashtra and Gujarat (including that of Daman and Due) has a length of about 3384 km. The west coast has diverse coastal morphology on which shoreline changes are dependent. Anthropogenic interventions such as harbour breakwaters, coastal protection structures have destabilised the natural

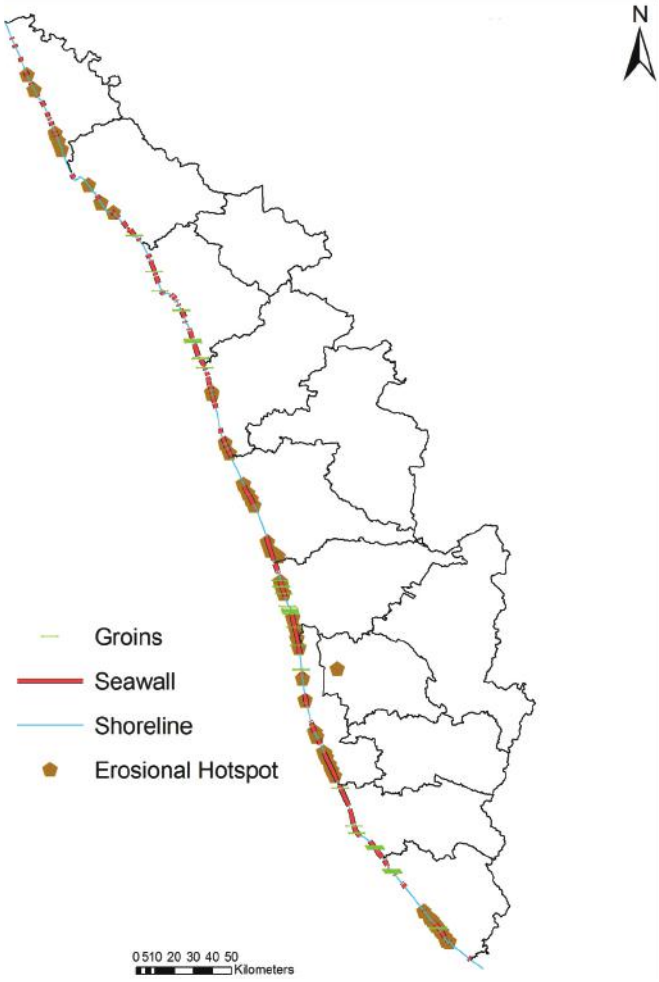


Fig. 2.7.1 Erosion hotspots & coastal protection structures during monsoon 2013

morphological set up of the west coast resulting in erosion and accretion. It is reported by the Central Water Commission that more than 1180 km along the west coast is eroding. Comparison of Multi-temporal shoreline positions would help identify erosion hot spots. Many of the coastal management schemes, including coastal protection measures, are not performing as expected probably because of the inaccuracies in the information on shoreline position, orientation, rate of coastal erosion, sediment transport and morphological modifications. Accurate shoreline position and orientation are key to get 'near realistic' output for numerical model studies to compute sediment transport. Monitoring of shoreline changes could give a better insight into the sediment transport pattern that causes erosion and accretion within sediment cells.

Except for a few sporadic attempts, the coastlines around India have not been systamatically mapped utilizing advanced techniques of GPS, remote sensing and GIS. Shoreline mapping available along certain coastal sectors vary in methodological approaches, source data, scale, content, accuracy, datum and projection. Updating coastline maps and monitoring rates of coastal change are most important for planning mitigation measures for a country like India which has a lengthy coastline. Existing shoreline datasets tend to be too coarse in scale. Registration differences of the existing datasets when used with currently available high resolution data products create serious incompatibility with ground dimensions. The resultant deficiency in positional accuracy is a concern for precision applications. Multi-temporal vector shorelines have the potential for easy and frequent updation with the latest high resolution remote sensing data.

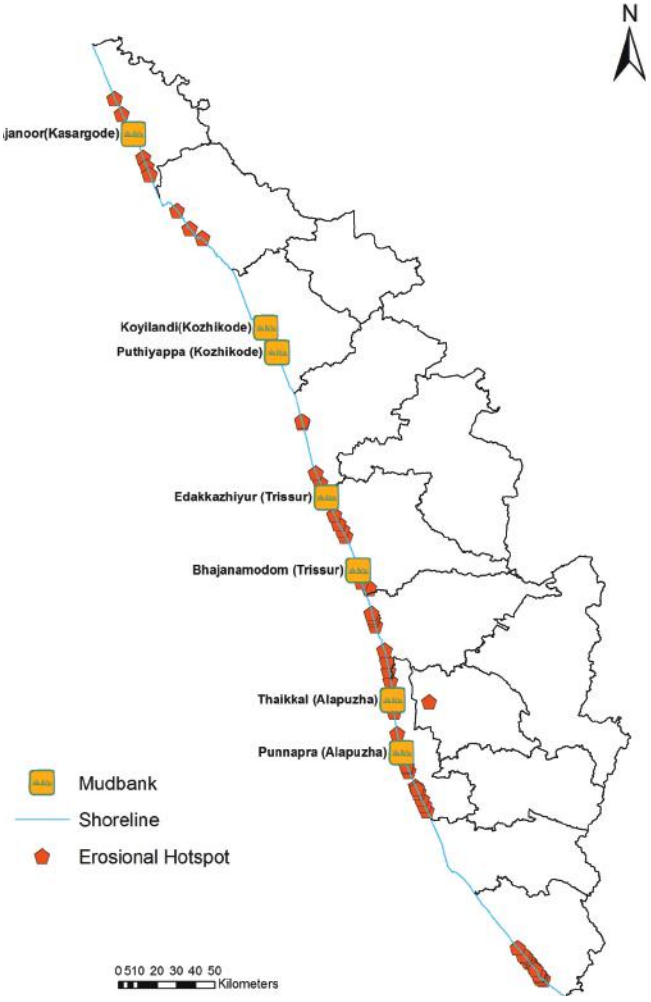


Fig. 2.7.2 Erosion hotspots & occurrences of mudbanks during monsoon 2013

Time series replication of the coast gives temporal, morphological changes in the shoreline. Extraction of precision vector shorelines from multi-dated data products is the primary objective of the study. This depends on reliable multi-date geospatial data and appropriate techniques for co-registration enabling planimetric integrity across data sources. The techniques to be used consist of

heterogeneous data source, such as, topographic sheets, aerial photographs, satellite images and GPS mapping. The GIS technologies are used to represent coastline information to a defined datum and coordinate system. A hybrid approach deriving information from geo-coded imageries and field mapping is used for rectifying the data products and extracting shoreline and morphologies from the imageries and the maps. Sufficient ground truth data will be used to validate and support the information derived from the remote sensing data. Any gaps in the information will be supplemented by GPS shoreline mapping establishing sufficient number of ground control points. The shoreline changes will be computed and rate of erosion will be derived using appropriate tools for 4 or 5 year periods comparing the shorelines in 2003, 2006, 2010, 2013 and 2015 using IRS P6 and Cartosat 1 imagery. The information will be used to identify erosion hotspots for yearly monitoring and analysis will be carried out. Shoreline changes will be linked to morphological modifications wherever artificial morphological interventions are made. In the process various sediment cells are proposed to be identified. The output will be in the form of shoreline change maps in 1:25,000 scale with morphological features.

Mudbanks are one of the major morphological features that influence erosion hotspots along the Kerala coast. The erosion hotspots, coastal protection structures and mudbank occurrences have been identified through field mapping during monsoon 2013 (Fig. 2.7.1 & 2.7.2).

K. V. Thomas

Funding: MoES through ICMAM P. D., Chennai

2.8 Quaternary Evolution Studies in Kochi region

Quaternary evolution studies were carried out along the Kochi metro rail route extending from Tripunithura to Aluva covering a linear distance of about 30 km within the Cochin Corpation limits of Ernakulam district (Fig. 2.8.1). We have carried out Quaternary evolution studies earlier for the entire Ernakulam district. However the metro rail project gave us an opportunity to examine at close intervals the sub-surface Quaternary deposits that lie buried upto a depth of about 50 mts below the ground level all along the metro rail route. Along the rail route we have carried out studies using proxies such as clay minerals, organic carbon, peat and decayed wood to understand the palaeo-climate and sedimentation environment of the primordial past.

The repeated occurrences of the peat beds at depths 30, 42 and at 55 metres below the ground level clearly mark the complexity in the depositional environment during the

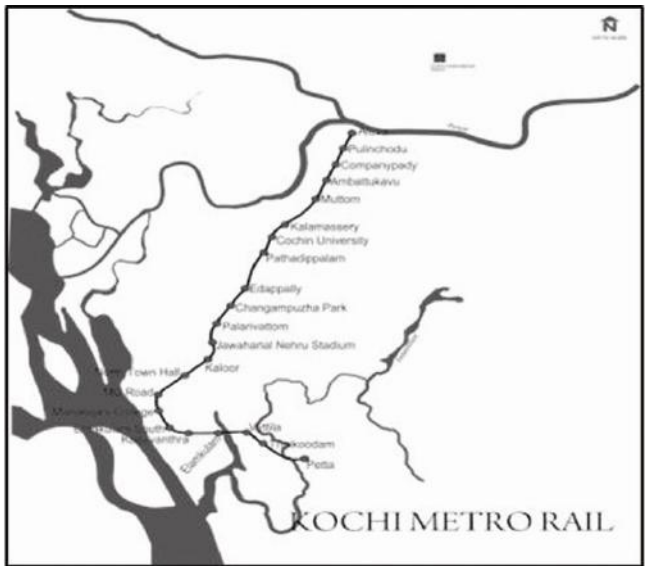


Fig 2.8.1 Kochi Metro rail route

The Kochi metro rail project envisages constructing rail corridor erected on pillars in the centre of the existing road connecting two townships. The close spacing of the pillars at intervals of 250 mts allows us to monitor minor changes in the sedimentation patterns along the linear stretch upto 50 mts depth. Examination of sub- surface sediments from various depths collected from drilling boreholes at different locations (Fig. 2.8.2) has enabled to draw conclusions on the origin and distribution of the sub-surface sediments.

Fig 2.8.2 Drilling of bore holes by CMRL in progress

Quaternary period. Presence of Kaolinite, Bauxite, Chlorite, Illite, and Montmorlite clays in the sediments at various depths indicate a swing or shift from freshwater to swampy and to shallow water marine sedimentation condition. The presence of freshwater or saline intrusion

is reflected in the sediments by way of different clays minerals. The oxidization and ferroginization of the clays at various depths and locations reveal the palaeo-environmental set up of the basin.These clay minerals assemblage has a direct relationship with the bedrock and soils of the drainage basins of the adjacent rivers.The results of the textural, chemical, XRD, C^{14} and XRF analysis of surface and sub-surface sediments indicate that the study area has undergone fluctuation in climatic changes, oscillations in sea levels, submergence and emergence during the Quaternary period. The Quaternary sediments of Ernakulam district provide early Holocene to upper Pleistocene age. The younger Holocene beds deposited at shallow depths are rich in shell deposits, while the older peat deposits occurring at depths ranging from 40 to 60 mts are devoid of shell fragments. The project work is in its final phase and the final project report depicting an evolution model for the study area is under preparation.

P. John Paul & D. S. Suresh Babu

3.1 Solar Ultraviolet –B Radiation and Atmospheric Trace Constituents in relation to Climate Change

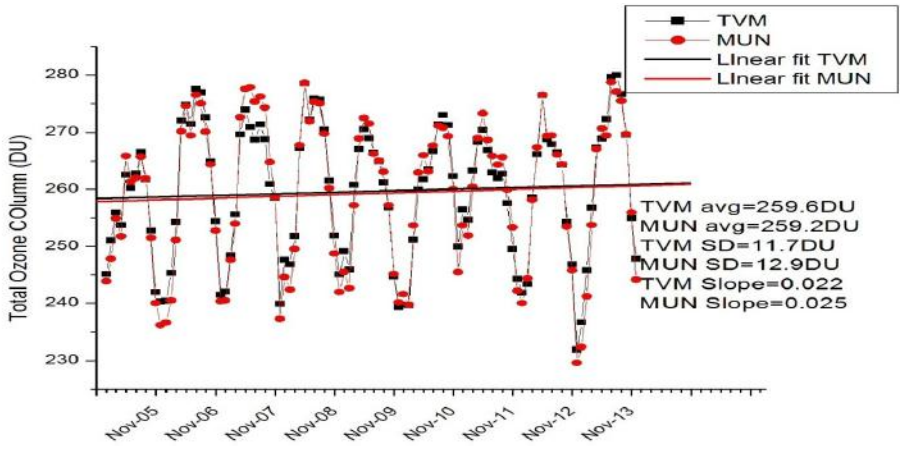


Fig. 3.1.1 Measurement of solar UV-B radiation

Nature of variation of solar ultraviolet-B (UV-B)radiation and minor atmospheric constituents, viz., total ozone and water vapour at a coastal station, Thiruvananthapuram where both the SW and NE monsoons are active are important parameters that control climate change in this region. The objectives of the project are to study solar UV-B radiation and atmospheric minor constituents, particularly ozone and water vapor at a coastal station like Thiruvananthapuram and another at a high altitude station like Munnar (>1600m ASL) in Kerala, south India both SW & NE where monsoons are active. This study is intended for FOUR consecutive years of normal monsoon, so as to derive a long-term trend in the parameters measured. Measurement of solar UV-B radiation & minor constituents will be carried out simultaneously for four years, the minimum period for achieving a long-term trend as per the World Meteorological Organization stipulation. The long term changes in Total Ozone Column (TOC) over two tropical stations i.e., Thiruvananthapuram (Lat. 8.522° N. Long. 76.909° E, Altitude 20 mASL) and Munnar (Lat.10.0892° N. Long. 77.0597° E Altitude 1600 mASL) are studied. In these two stations, Thiruvananthapuram is specially chosen because it is pristine coastal station situated near the sea level, whereas Munnar is a hill station located in the Western Ghats i.e. 1600 meters above the Earth surface. In the present study, the monthly mean and their standard deviation are computed from the daily values of TOC at these stations, retrieved from AURA Ozone Monitoring Instrument (OMI) satellite experiment during the period 2005 to 2013. The monthly mean of TOC are plotted with function of years for each month over the two stations for assessing the long term change in TOC per decade. The monthly and seasonal TOC variations are also analysed. Finally, analysis of yearly total ozone trend determined from both stations during the period of comparison indicates significant differences.

E. J. Zachariah

3.2 Measurement of Cloud Parameters and Cloud Modelling

In order to understand the distribution of rainfall and rain drop size pattern, CESS has been conducting rain related studies on clouds, their occurrence, altitudinal distribution and related parameters such as condensation particle concentration, liquid water content etc. Accordingly, ground stations have been set up at three locations viz.the CESS Campus (Coast), Braemore and Agumbe (Western Ghat / Sahyadri) for measuring cloud base height using equipment employing LIDAR technology of sounding clouds from the ground, giving time-distribution over a site along with cloud base height and vertical visibility. Condensation particle counters have been used to estimate the available concentration of condensation nuclei at the measurement location. These measurements have been useful in understanding the SW monsoon clouds and also in modelling cloud characteristics and its behaviour in the region. The fields stations are equipped with Ceilometer AWS, Disdrometer and Electric Field Mill and Water Based Condensation Particle Counter as available. During the thunderstorm months in Braemore, cloud occurrence begin by 10h, reach a maximum (~70-90%) in the AN, ascertaining convective cloud formation over hill slopes. It has been inferred that 70% of the events during the pre monsoon, SW monsoon and post monsoon are from stratiform clouds and 20% from convective clouds during the pre- monsoon and post-monsoon seasons. Remaining 10% is obtained from mixed phase clouds. During SW monsoon period convective events are only upto 5% and mixed phase events extend upto 25%. Convective events

are mainly during night time.

G. Mohan Kumar

3.3 Greenhouse Gases (GHG) Measurement in Kerala

Fig. 3.3.1 Sampler deployed for collection of water to air fluxes of methane

The increase of greenhouse gas concentrations in the atmosphere is a major driving force behind climate change. Since these gases disperse rapidly in the atmosphere, their impact on climate has to be assessed regionally and globally. Kerala with its unique geography and climatic conditions could be one of the most vulnerable regions to climate change. Relatively high standards of living achieved by the population exert high pressure on land and environment, further strengthening the climate forcing. The growth in the transport sector in terms of number of vehicles had been phenomenal, spewing out millions of tons of greenhouse gases. The GHG emissions from the network of natural wetlands as well as a large number of hydel and irrigation reservoirs have received some attention in the past, but require a comprehensive study. Mangrove forests require particular attention here, due to their ecological importance and the rich sediments where they grow. Estuarine discharges and land ocean interactions are important driving forces of climate change. Shalow sea off Kerala deserve particular attention due to the presence of a large number of estuaries in this region. Urban areas are another significant source of GHG emission, especially methane and carbon dioxide. Therefore, a study has been undertaken to measure atmospheric concentration of carbon dioxide, Methane and nitrous oxide, over Kerala and coastal ocean off Kerala for obtaining emission factors of above gases from major natural and anthropogenic sources (wetlands, coastal ocean, agriculture, forests, urban centres)to compute emission load.

Atmospheric concentration of carbon dioxide, methane and nitrous oxide were measured using gas chromatography. Emission samples were collected using flux chamber and brought to the laboratory for (Gas Concentration) GC analysis and estimation of fluxes. Ambient air samples were grabbed and analysed in laboratory using gas chromatography. The samples were collected in gas tight syringes, brought to the laboratory, and analysed on a Flame Ionisation Detector (FID) and Electron Capture Detector (ECD) in Gas Chromatograph (Perkin Elmer Clarus 5800 and NUCON 5765). The measurements were made through mobile traverses for urban emissions in Kochi and Thiruvananthapuram city area and suburbs. Gas samplers were used in the paddy fields of Palakkad and the forest swamps of Kulathupuzha.

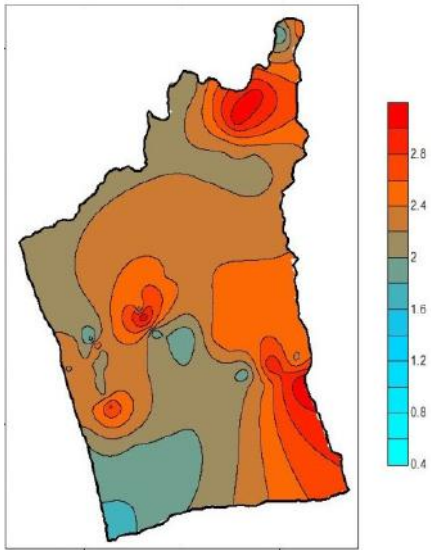


Fig. 3.3.2 Methane emission: May 2011 – Kochi urban area

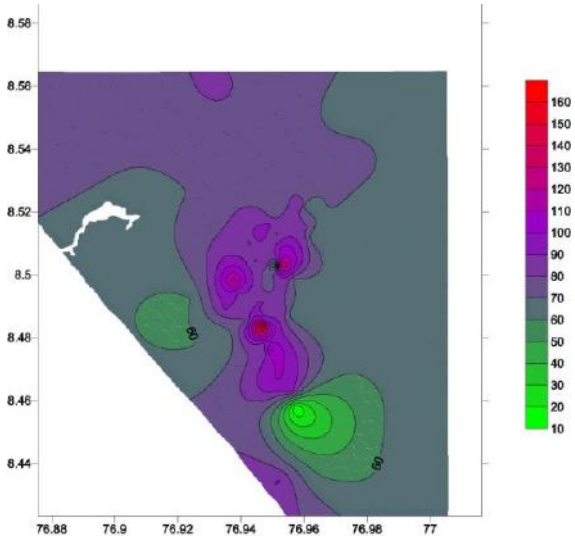


Fig. 3.3.3 Levels in CO_2 : October 2013 – Trivandrum urban area

The maximum values of ground level methane concentration in Kochi urban area duringwinter and summer seasons were 3.89 ppmV and 3.21 ppmV respectively, which were higher than background values as measured in nearby suburban areas. The maximum value of ground level methane, carbon dioxide and nitrous oxide in the Thiruvananthapuram urban area during October 2013 were 2.47ppmV, 742.59ppmV and 0.6ppmV respectively.

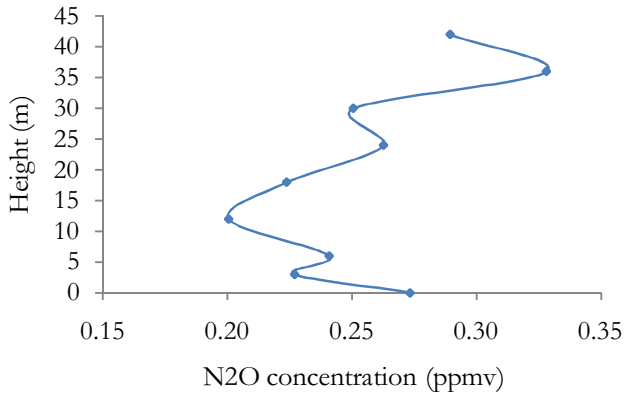


Fig. 3.3.4 Vertical Profile of N_2O in Trivandrum

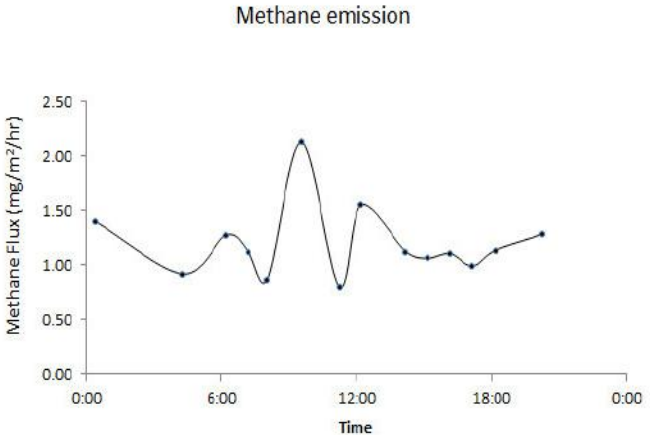


Fig. 3.3.5 Diurnal CH_4 emissions from planted rice paddy fields-Palakkad

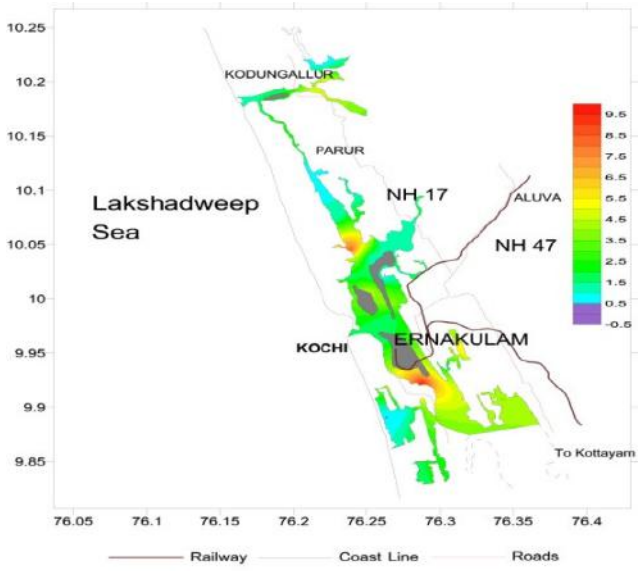


Fig. 3.3.6 Water to atmosphere fluxes of methane observed at the Vembanad estuary (Northern region)

It has been found that methane fluxes from the estuaries in Kerala are moderate to low(mean values in the range 1-4 mg/hr/m2). Observed fluxes from the high altitude hydroelectric reservoirs were also moderate to low (~2.0 mg/hr/m^2). Very high methane fluxes (118.7 mg/hr/m^2) and dissolved methane in water (20,868 nmol/l) have been observed in the forest swamps. The spatial extent of these water bodies are being very small their contribution to atmospheric concentration of these gases are insignificant.

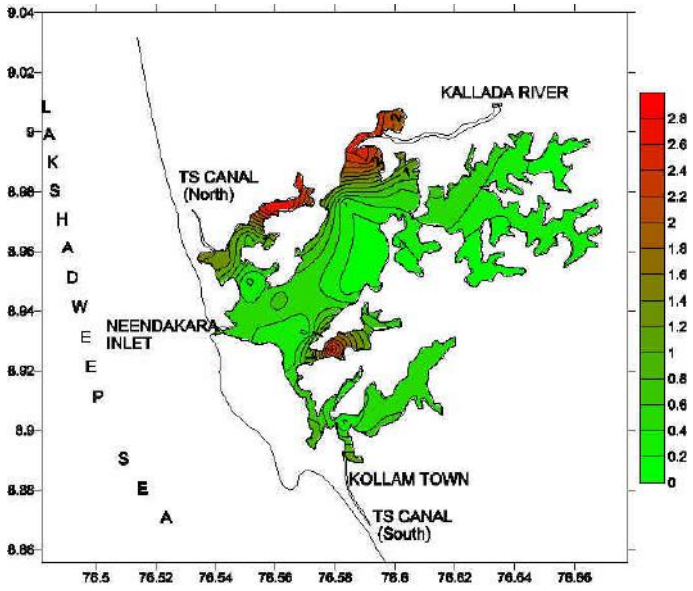


Fig. 3.3.7 Water to atmosphere fluxes of methane observed at the Ashtamudi Lake

Reduction in area under paddy cultivation has resulted in reduced methane emissions from this segment of wetlands. Methane emission from cattle farming in Kerala also shows a declining trend in recent years, primarily due to the reduction in the activity. CO_2 emission from automobiles shows an exponential growth, which corresponds to the rate of increase of the number automobiles in the State.The corresponding increase in CO_2 emissions from the industries sector has been only moderate to low, due to the relatively low rate of industrial development.

E. J. Zachariah

3.4 Modelling Atmosperic Pollution And Networking (MAPAN)

The Indian Institute of Tropical Meteorology (IITM) has initiated an air quality monitoring and atmospheric pollution modelling project with the objectives of setting up air pollution monitoring stations at selected strategic locations in India to continuously monitor the air pollutants and weather parameters to address questions related to short-term climate change and its impact. As part of this a station has been established in the NCESS campus at Thiruvananthapuram in 2013 with NCESS as a collaborator. The entire instrumental set up has been provided by the IITM Monitoring of the parameter has

commenced from February 2014. The station monitors 18 weather and air pollution parameters and the data is shared online with IITM, Pune. The station is equipped with Beta Attenuation Monitor, Serinus-10 Ozone Analyzer, Serinus-30 CO Analyzer, Serinus-40 NO_x Analyzer, Alpha 115 Hydro Carbon Analyzer, Athelometer Black Carbon Analyzer etc. The required calibration equipment such as Hydrogen Generator and Zero Air Generator and Gas Calibration System including Thermal Oxidizer has also been attached. There are also data acquisition hardware and software with complete power backup and automatic meteorological data acquisition system with the installation.

Fig. 3.4.1 MAPAN Station at NCESS

The station records continuous record Suspended Particulate Matter (PM10 & PM2.5), Carbon Monoxide (CO), Carbon Dioxide (CO_2), Ozone (O_3), Oxides of Nitrogen (NO, NO_x, NO_2), Methane (CH_4), Non-Methane Hydro Carbons, Black Carbon, Ambient Temperature, Relative Humidity, Barometric Pressure, Solar Radiation, Rain Gauge, Wind Speed and Wind Direction. Sample data plots are given as Fig. 3.4.2

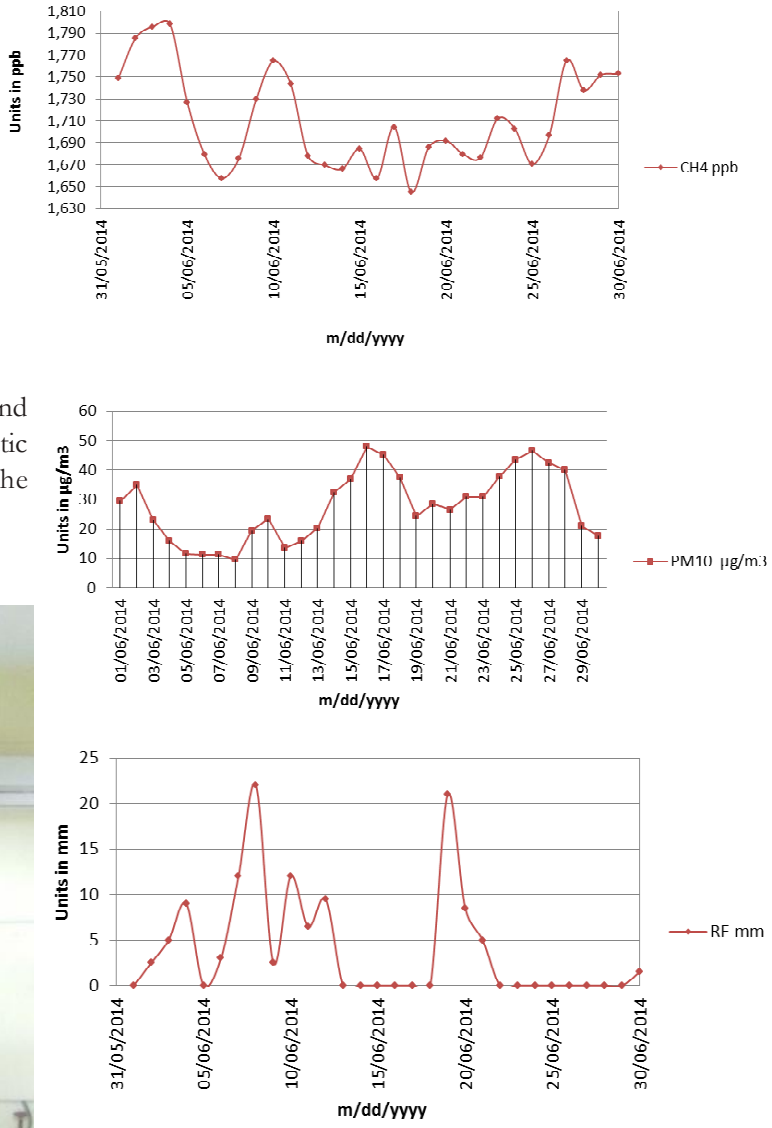


Fig. 3.4.2 Sample data plots

V. Muralidharan & E. J. Zacharia
MoES, GoI

Natural Resources and Environmental Management

4.1 Water Resources

4.1.1 Appraisal of Drinking Water Potential of Springs in the Pathanamthitta, Kottayam and Idukki Districts of Kerala

The main aim of this project is to establish springs as a large scale source of drinking water and to take measures for the maintenance of existing spring resources to prevent their extinction. In this study the focuse is the sustainable management of water resources through planning, development and utilization with consideration to technical, environmental, socio-economic and institutional factors thereby improving the quality of life. Studies on the chemistry of spring resources are important as they not only gather information on its quality and potential but also evaluate its hydro geochemical and biological significance as well as its variation with the environmental modifications and climate change The study area (Fig. 4.1.1.1) lies between 9^0 03' and 10^0 23' North Latitude & 76^0 37' and 77^0 30' East Longitude i.e., covering nearly 9995 km^2 in Central Kerala {Southern Western Ghats Region} covering Pathanamthitta, Kottayam and Idukki districts. Springs are selected for seasonal monitoring of physico-chemical analysis and discharge potential based on a set of parameters. Spring water qualities were determined in terms of physical, chemical and bacteriological properties using standard methods. The geochemistry and terrain characteristics of the spring watersheds were examined.

Fig. 4.1.1.1 Study area

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

noticed in spring waters and it may be due to diverse geo-envirofactors. The major ions are in the order of Cl (34-81%)>HCO_3(11-49%)>Ca (4-16%)>Na(0-12%)>K(0-5%)>SO_4(0-3%)>Mg(<2%)>NO_3(<2%). The amount of nutrients such as phosphates and nitrates were present well below the permissible level. The spring water of the study area have Cl dominant anion and Na dominant cation, indicating that the ground waters may be related to reverse ion exchange of Na-Cl waters and a small percentage of spring sources exhibiting dissolution and mixing influences.

K. Anoop Krishnan

4.1.2 Water and Sediment Quality Monitoring and Assessment of Estuaries of Kerala: a Case Study from Kochi Estuary and Periyar River

Heavy metals are one of the most serious pollutants in our natural environment due to their toxicity, persistence and bio-accumulation. They are introduced into the marine environment by domestic and industrial activities as anthropogenic pollutants. Studies on heavy metal pollution in coastal esturies are available all over the world during the last few years. As per the estimations made, the Indian rivers contribute 30% of sediments transported by the world rivers. Geochemical studies of bottom sediments of water bodies such as rivers, estuaries and marine environments are very helpful in understanding the different sediment sources, element distribution pattern and the intensity of heavy metal pollution. Trace metals in sediments can be used to reveal the history and intensity of local and regional pollution. Sediments provide a record of spatial and temporal history of pollutants. Heavy metals like mercury, lead and cadmium are very critical due to its non-degradable nature and toxicity even at very low concentrations. Among the heavy metals, mercury is a highly toxic pollutant, having many chemical species. Some of the metals like copper, iron, zinc and nickel in traces are essential for sustainence of life.

Due to urbanization, industrialization and related anthropogenic activities, large quantities of sewage and effluents loaded with toxic contaminants are discharged into the rivers and estuaries without proper treatment. Because of this uncontrolled discharge of sewage and industrial wastes most of the water bodies are under stress. This situation is not different in the esturies and rivers of the southwest coastal state, Kerala . Continuous monitoring and evaluation of water and sediment quality of all the important aquatic ecosystems that are located close to major development centers are very essential. Discharge of heavy metal rich effluents cause serious impairments not only to the human beings but also to the other organisms in the food web as well.

The objective of the present study is to assess the seasonal variability and cyclicity of heavy metals in sediment samples of the Periyar river and the Cochin estuary (Fig. 4.1.2.1). To appraise the heavy metal loading to the study area water and sediment samples from 22 stations were collected seasonally and analyzed. Total sampling stations were grouped under four zones viz. Harbour Zone (HZ), Marine Zone (MZ), Industrial Zone (IZ) and Background Zone (BZ) for detailed assessment of the pollution status of the region.

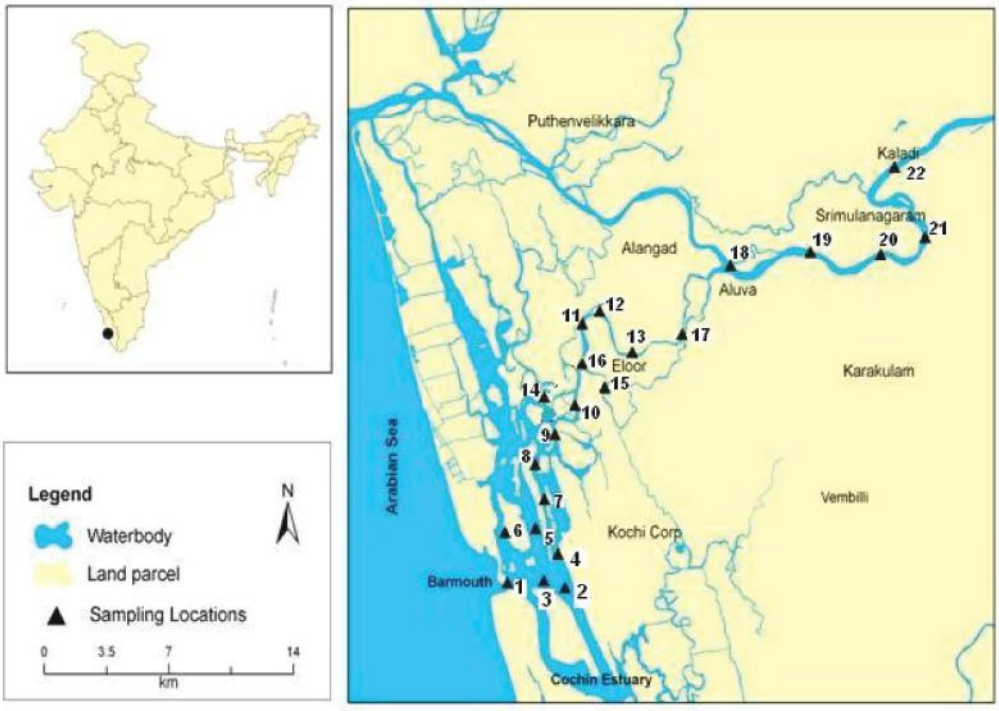


Fig. 4.1.2.1 Map showing study area and sampling locatins

Preliminary observations based on heavy metal concentration in sediments indicates that overall sediment quality of the lower reaches of Periyar

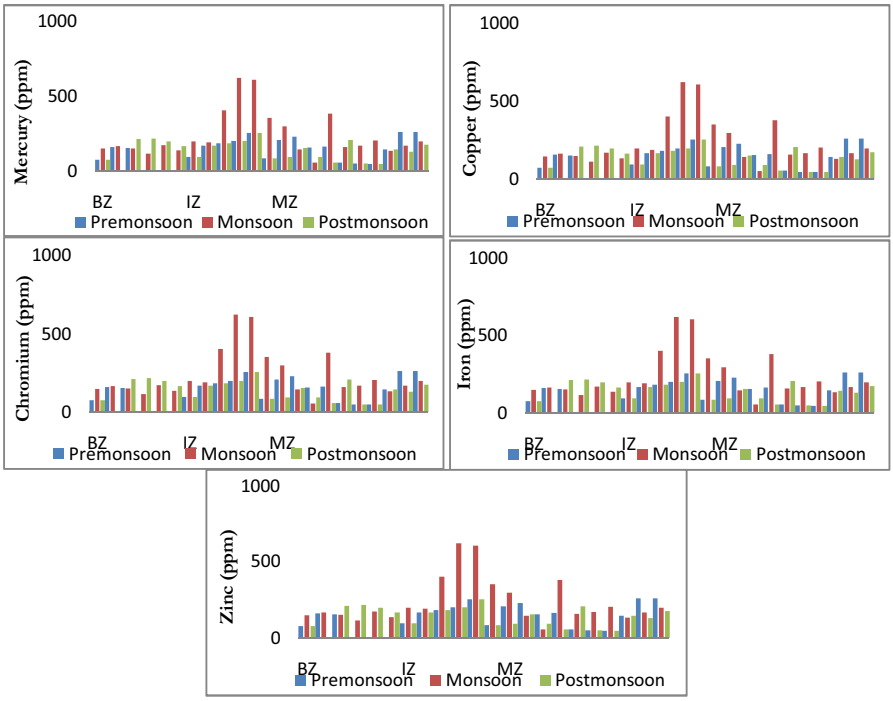


Fig. 4.1.2.2 Seasonal and zonal variation of various heavy metals in sediments

river is poor, being highly polluted with toxic heavy metals. Metal concentration in the sediments varied seasonally and significantly within a wide range of values. Observed metal concentration was higher in river estuarine areas blanketed by fine sediments. Total mercury concentration in the sediments varied from 0.11 ppm to 5.06 ppm. A very high concentration of copper (622 ppm) was noticed in the sediment samples compared with the standard (USPHS, 1997). Chromium showed a very high concentration of 682 ppm. Iron concentration ranged from 0 to 20.93 ppm and copper ranged from 0 to 622 ppm. Higher values for all the metals were observed in the waters adjoining the industrial zone. The observed concentration of zinc was high at all zones. From the results it is evident that the stations located at the upper reaches of the Periyar river are polluted and concentration of most of the heavy metal are high during the monsoon season which indicates anthropogenic sources. The detected levels of total metal contamination in many of the sampling locations were found high due to industrial activities. Seasonal and zonal variations of heavy metals in sediments are depicted in Fig. 4.1.2.2.

P. K. Omana

4.1.3 Rainwater Harvesting and Development of Additional Water Sources in the Medical College Campus-Athani, Thrissur

The Medical College Campus near Athani in Thrissur district with an estimated water requirement of 1.8 MLD faces acute water scarcity during summer seasons. In this context it was felt that the availability of water in the sources that are developed to cater to the demand of the campus can be augmented through rainwater harvesting and ground water recharge. However an understanding of the terrain and the nature of potential aquifer in the area is a prerequisite for the selection of appropriate techniques and sites for rainfall harvesting and to enhance groundwater recharge. As per the request of the District Collector, field surveys were carried out in the Campus of Medical College. The surveys were essentially for (a) an evaluation of the existing sources (b) locating additional potential source points for immediate development and (c) to work out strategies for augmenting groundwater availability in the area through rainwater harvesting and groundwater recharge measures in the campus.

Taking into consideration the terrain characteristics and the nature of aquifer in the area the best option available is to recharge the blanket type mottled zone of 8-10 m thickness in the elevated portion below the hard duricrust cap rock. This requires puncturing the hard strata at suitable places and to ensure entry of rainwater into these locations.

The easiest method is to provide (a) recharge pits adjacent to each of the buildings (b) pits in conjunction with the storm water drains adjacent to the roads. These pits of larger diameter and depth reaching to the mottled zone at regular interval can facilitate recharging of the underlying aquifer. Considering the treatable area of the campus of 50 ha with an average thickness of laterite aquifer of 8 m, has a volume of 4 million m^3 for recharge. The effective porosity of this layer taken as 25% can hold as much as one million m^3 of water. A part of it is likely to be drained gradually down the slope as subsurface seepage into the valleys. The important observation in the laterite terrain is that the rate of movement of groundwater is limited to a few meters per day. Hence the lower slope area will eventually be productive zone and the sources in this area will yield sufficient quantity of water even during an extended period of summer. Enhancing recharge to the existing pond, development of a new pond near the bore well, development of rainwater harvesting structure near the Indoor Stadium, development of recharge cum source

wells adjacent to buildings with a roof area of more than 500 sq.m, rennovation and utilizing the existing rainwater harvesting structure and provision of recharge trenches with pits by the side of main roads are some of the recommendations.

John Mathai

4.1.4 Augmenting Groundwater Recharge Through Rennovation of Ponds-A Model Study in Vadakarapathy Panchayat, Palakad District

As a follow up of the International Year of Water Co-operation, at the State level Committee meeting convened by the Hon'ble Chief Minister on 22.07.2013 it was suggested that water conservation works could be taken up in conjunction with rennovation of ponds in the Palakkad district. As a follow up, it was decided that CESS can carry out a model study to augment water storage in the large sized ponds in Vadakarapathy Panchayat where the rainfall is only one third of the State's average and scarcity of water is a prime concern. In addition the area is located in an overexploited region at an elevation of 200 m above MSL such that the water from the nearby reservoirs at a lower elevation cannot be trasmitted. All these factors point to in situ harvesting of rainfall and to facilitate groundwater recharge. Surveys carried out in the area has led to the delineation of the micro watersheds and the distinct hydro-geomorphic units in each watershed. All large sized ponds with their feeder channels have been identified. One micro watershed with acute water scarcity has been selected for the detailed study to suggest methods for rainfall harvesting and augmenting groundwater recharge for the sustainability of the existing sources especially ponds. Two sites have been identified for the execution of the model structures and the demonstration of water harvesting/conservation. The water availabilty in the vicinity will be monitored for one complete season to ascertain its success and for replication in similar terrain.

John Mathai

Fig. 4.1.4.1 Large ponds in the Ozhalapathy region with very limited water in March 2014. Note that water is confined to the depresion regions from where earth has been excavated. In the ensuing summer the ponds dry leading to virtual absence of water even for domestic use.

4.2 Terrain Analysis and Landuse Studies

4.2.1 Study of Landuse/Land Cover Changes as Linked to Climate Change in Central Kerala

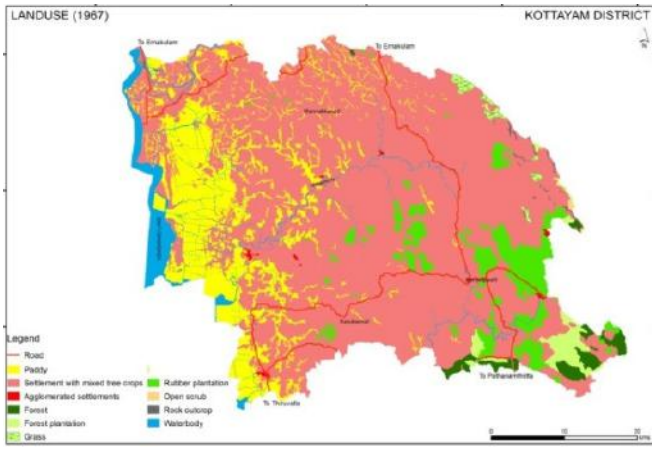


Fig. 4.2.1.1 Landuse -1967 of Kottayam district

The project on "Land use/ land cover change as linked to climate change in Central Kerala" (Plan 275) was a part of the Climate Change project under the Plan project scheme sanctioned by KSCSTE. Considering importance of the study some of the data have also been analysed for the entire State. Central Kerala formed original study area. Subsequently it was extended to the entire state. The Central Kerala stretching from the Achankovil basin in the south

to the southern boundary of the Bharathapuzha basin in the north is of special significance. This area is characterized by extreme topographic variations in Kerala ranging from the lowest point (-2m) in Kuttanad to the highest point, Anaimudi peak (2695m). The largest lagoon in the south-west coast of India, Vembanad lake, relatively wide coastal plain, undulated mid land, scarp slope and the plateau, all together provide this stretch a diverse landscape and ecological set up. Landuse and the human habitation in this stretch also have significant diversity.

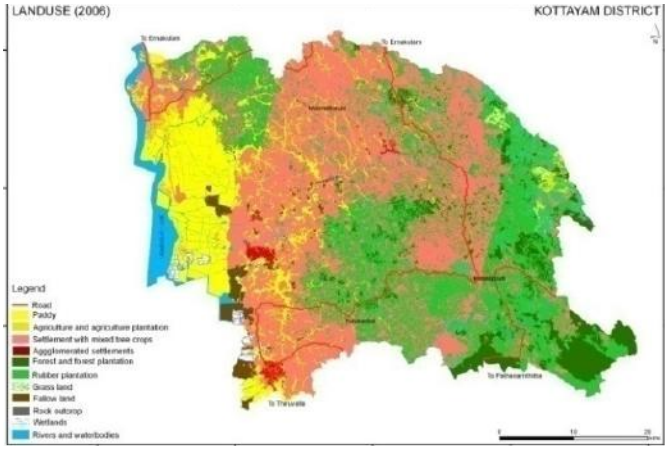


Fig. 4.2.1.2 Landuse -2006 of Kottayam district

Analysis of secondary data on land use highlight the changes experienced by Kerala. The changes vary spatially as manifested by the district level data. The Land use change affects the micro climate, however, its impact on the overall climate is yet to be ascertained conclusively. Time-series landuse maps for the Kottayam district has been prepared using imagery and the landuse change is well established though this exercise (Fig. 4.2.1.1 & 4.2.1.2).

Srikumar Chattopadhyay, Mahamaya Chattopadhyay, P. V. S. S. K. Vinayak & C. K. Sasidharan

4.2.2 Valley Formation and Geomorphic Processes under Tropical Wet and Dry Climate: Examples from Kerala

This project aims to understand the formation of river valley and geomorphic processes under tropical wet and dry climate from eight selected river basins in Kerala. Classifications of these eight river basins are based on their difference in geomorphic and climatic settings, their morphology, sediment character and morpho-tectonic features. Valapattanam, Bharathapuzha, Periyar, Kabani (east flowing), Achankovil, Kallada, Ithikkara and Neyyar river basins are studied.

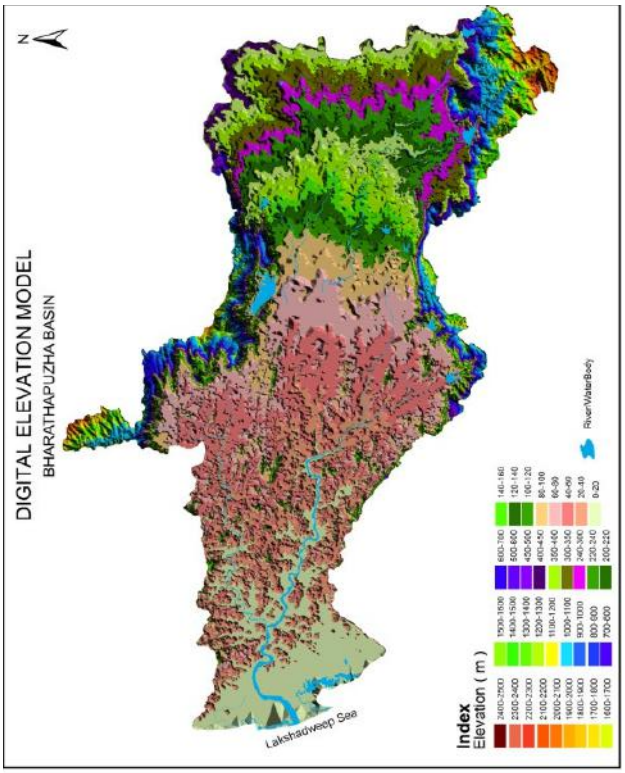


Fig. *4.2.2.1 Digital Elevation Model of Bharathapuzha basin*

Digital Elevation Model (DEM) of Bharathapuzha basin is given in Fig.4.2.2.1. Valley profiles of Ithikkara river are given in Fig. 4.2.2.2.

Table 4.2.2.1 Transverse Topographic Symmetry Factor (TTSF) - Kallada basin

Sl No	Points	TTSF	Bearing in ^{0}
1	P1	0.44	324
2	P2	0.02	333
3	P3	0.51	317
4	P4	0.12	321
5	P5	0.02	322
6	P6	0.10	356
7	P7	0.03	355
8	P8	0.33	349
9	P9	0.04	346
10	P10	0	No Change
11	P11	0.09	2
12	P12	0.14	126
13	P13	0.04	181
14	P14	0.41	183
15	P15	0.04	191
16	P16	0.26	220
17	P17	0	No Change
18	P18	0.88	240
19	P19	0.58	232
20	P20	0.54	220

Morphotectonic analysis of Kallada river basin has been attempted to decipher the role of active tectonics in modifying the basin symmetry. The tectonic control on the stream development is well evident from the shape of

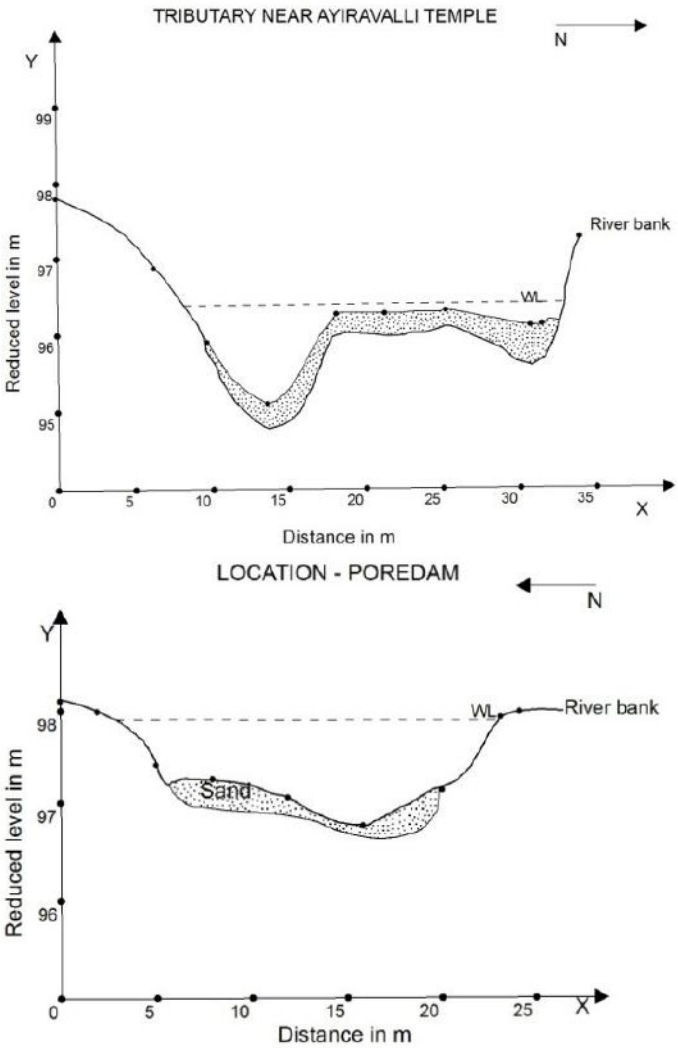


Fig. 4.2.2.2 Cross Profiles

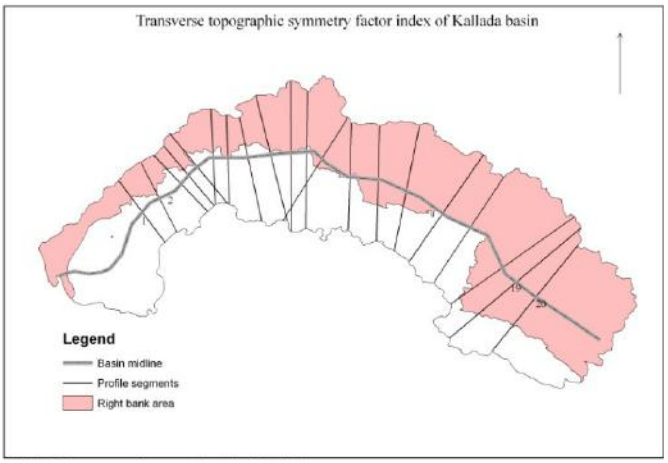


Fig. 4.2.2.3 Transverse topographic symmetry factor index of Kallada basin

the basin and drainage line alignment. The elongation ratio of 4.1 suggests that the basin is structurally controlled and tectonically active. Basin asymmetry factor showed a general tilting of basin towards the south-west direction. The Topographic Symmetry Factor ranges from 0.01 to 0.88 indicate differential tilting of the river basin. Shifting of river course in south west direction is observed in the highland from its source point to a distance of twenty kilometres. It is observed that the upstream (headward regions) parts of the river basin is more structurally controlled compared to the midland and lowland (Fig. 4.2.2.3 and Table 4.2.2.1).

Mahamaya Chattopadhyay

4.2.3 Geomorphic Evolution and Terrain Characteristics- A Case Study of the Achankovil River Basin, Kerala

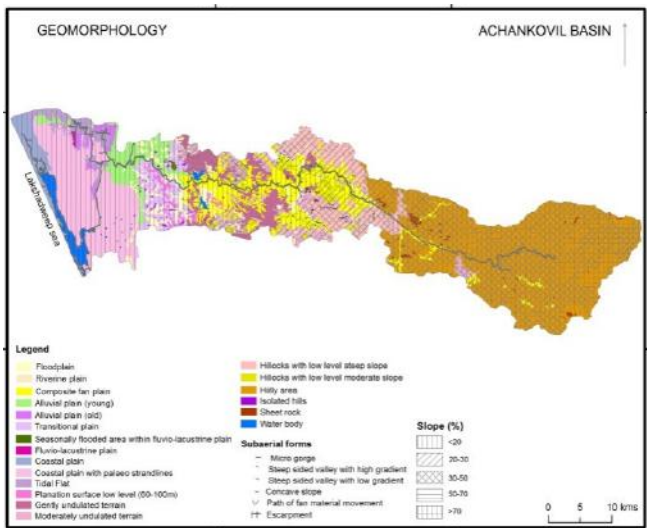


Fig. 4.2.3.1 Geomorphology of Achankovil basin

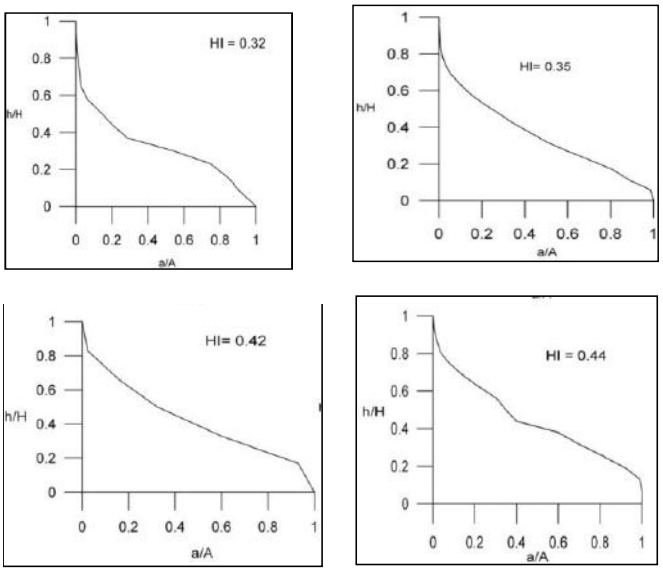


Fig. 4.2.3.2 Hypsometric curve of VIth and Vth order sub-basins

Table 4.2.3.1 Hypsometric parameters of selected VI and V order sub-basins of the Achankovil river basin

Sub-basin	Catchment area (km²)	Eh	a*	h*	Curve shape parameter				Ea
					h (0.2)	h (0.5)	h (0.8)	h(0.9)	
VI A	188.18	0.36	0.24	0.40	0.42	0.31	0.18	0.10	0.32
VI B	124.86	0.29	0.21	0.56	0.58	0.34	0.16	0.09	0.35
V 1	92.94	0.20	0.11	0.70	0.62	0.46	0.28	0.21	0.44
2	93.62	0.36	0.12	0.52	0.44	0.28	0.20	0.18	0.30

a - X coordinate of hypsometric curve slope inflection point, h* - Y coordinate of hypsometric curve slope inflection point, Ea – Hypsometric integral, Eh – Maximum concavity of hypsometric curve.*

Table 4.2.3.2 Selected morphometric and hypsometric data of VI and V order sub-basins of the Achankovil river basin

Sub-basin	Catchment area (km²)	Avg. bifurcation ratio ()	Drainage density (Dd)	Relative relief (R)	Mean elevation (z)	Z/R	a*	h*	Ea	Eh
VI A	188.18	4.62	3.77	1840	1000	0.54	0.24	0.40	0.32	0.36
VI B	124.86	3.85	4.035	1080	620	0.57	0.21	0.56	0.35	0.29
V 1	92.94	4.64	3.68	1740	1140	0.66	0.11	0.70	0.44	0.20
V2	93.62	4.75	3.94	1360	760	0.56	0.12	0.52	0.30	0.36

**Dd – Drainage density, R – Relative relief, Z – Mean elevation,*

Kerala with its high density of river basins and physiographic characteristics including high gradients manifests a number of geomorphic features different from the rest of South India and hence offers an excellent scope for the study of landform evolution and inter-relationship between the geomorphology and land use with the drainage basin as focal point. Terrain map of the basin has been prepared in order to depict diverse landform pattern (Fig. 4.2.3.1).

The present study aims to examine the importance of hypsometric analysis to decipher the stages of landform evolution and assess the influence of geologic and tectonic factors on topography. Analysis of morphometric and hypsometric parameters provide basic information regarding the evolution of drainage basin and their geological settings. Detailed analysis on these parameters have been done for all the VIth and Vth order sub-basins. The hypsometric curve indicates stage of landform evolution and denudational processes active in the region. For testing the hypothesis, hypsometric curves, hypsometric integrals (Ea), and maximum concavity of hypsometric curves (Eh) have been computed for all the sub basins covering different physiographic units and also for the entire Achankovil river basin. Values are given in Table 4.2.3.1-4.2.3.2 and the hypsometric curves are shown in Fig. 4.2.3.2. These data have been analysed to understand the evolution of the Achankovil river basin.

Mahamaya Chattopadhyay

4.2.4 Land System Analysis of the Kabani River Basin in Wayanad District, Kerala

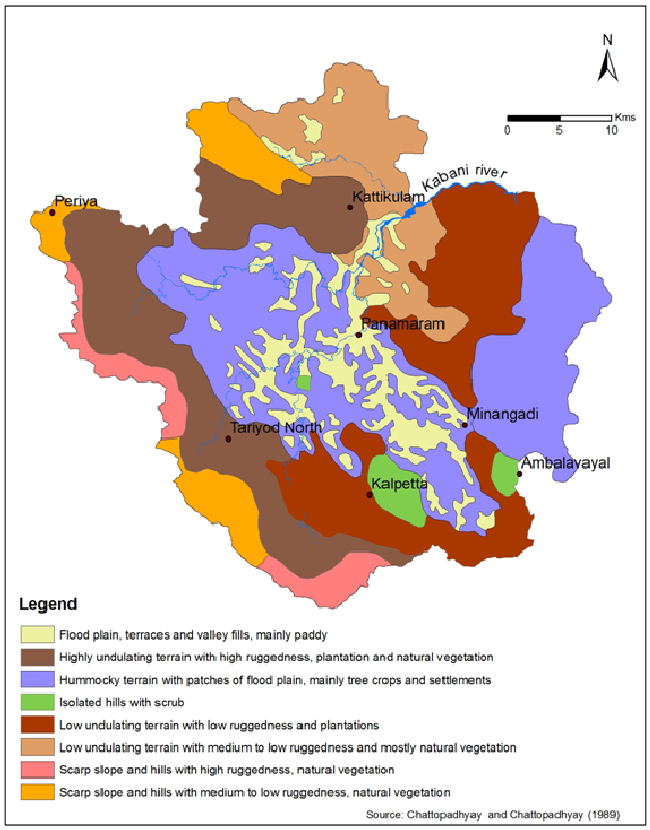


Fig. 4.2.4.1 Geomorphology and landuse - Kabani basin

The major objectives of the study are to analyse the geomorphic process acting on the land system in the Kabani river basin, to identify the geomorphic indicators that help to understand the geomorphic system and to predict landform changes. Methodology involves data extraction from topographical maps of 1:50,000 scale, IRS image and fields analysis of data using available techniques and application of GIS. Morphometric data and hypsometric data have been extracted from the toposheets. Data pertaining to terrain and current landuse have been extracted from images, supported by field work. Soil

samples were collected from the field and they were analysed in a soil testing laboratory under the Government of Kerala. SRTM and Aster DEM data were used for developing DTM. Aerial photographs are used for preparing land system maps for selected segments whereas GIS is used mainly for spatial analysis and synthesizing spatial and attribute data.Kabani is an east-flowing river that originates from the Wayanad plateau and drains through the states of Kerala, Karnataka and Tamil Nadu which is a tributory to the river Cauvery and confluences with the river Cauvery. It covers an area of 1648 km^2. Geomorphology, slope, geology, land use, soil and climate are the determining factors used for the land system classification. Seven land systems units are identified (Fig. 4.2.4.1). These are the floodplain/ valley fill and alluvial basins, low rolling terrain, moderately and highly undulating terrain, residual/ elongated hills, scarp slope and hummocky terrain. Human modifications through anthropogenic activities are very common in these land systems. During the reporting period land management plan for each land system has been proposed.

Srikumar Chattopadhyay

4.2.5 River Bank Atlas and Estimation of Sediment Deposits of the Ithikkara River

The Revenue Department of Kerala is vested with the responsibility of managing river systems in the State. Every district has a River Management Fund (RMF) under the control of Revenue Department. The department initiated the project in order to assess the minable quantity of sand from each river within the administrative jurisdiction of each panchayat and to develop appropriate river bank protection and management plans for maintaining the overall health of the river. The ultimate goal of this programme is eco-restoration of the rivers, balancing resource use and conservation, and to take decisions as far as river management is concerned. The work involved field mapping covering 100 m stretch from the bank on both sides of the river in cadastral scale (1:3960) to collect all details as specified in the instructions of the Revenue Department, filling up of data format covering all information about the river bank, measuring of cross sections at an interval of 500 m by using dumpy level, replotting of all data in a fresh cadastral map in laboratory and preparation of three thematic maps, namely landuse, manmade features and physical features. Topographical sheets in 1: 50, 000 , 1: 250, 000 and 1: 25, 000 scale were used for georeferencing cadastral maps and also to extract other relevant data. Digitisation of cadastral maps and extraction of three thematic maps of landuse, manmade features and physical feature were also carried out.

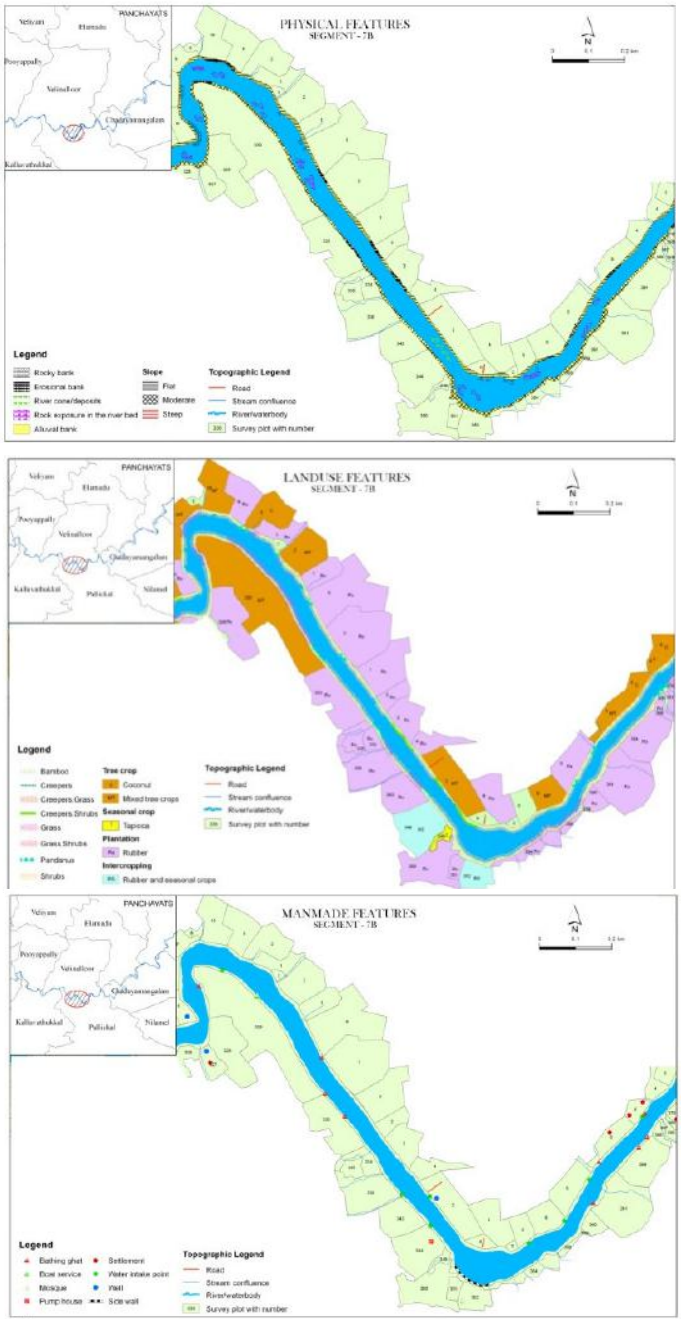


Fig. 4.2.5.1 Ithikkara river bank Atlas

Arc-GIS 10.1 software has been used for the GIS analysis and to format the maps. Out of the total length of 56 km from the source to the mouth a stretch of 42 km, that is flowing through the mid and lowlands with a possibility of sand accumulation has been mapped. The mapped part of Ithikkara river is traceable through 11 segments and is spread over 11 panchayats from Anchal to Adichanalloor. This atlas of Ithikkara river bank comprises of 82 plates. The maps produced gives necessary details about the river bank and the adjacent land. Large scale mapping showing status of river banks with particular reference to physical

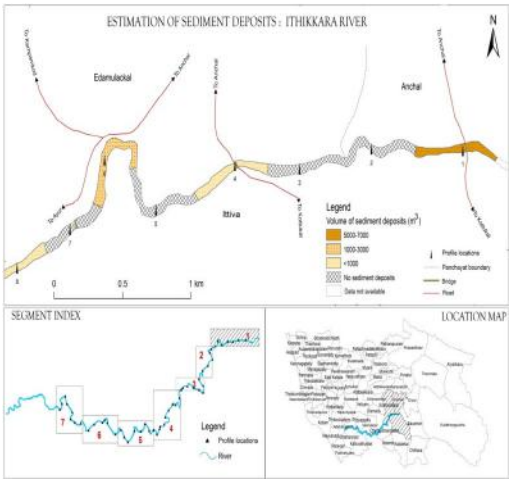


Fig. 4.2.5.2 Estimation of sediment deposits: Ithikkara river

features, manmade features and land use features are the salient characteristics of river bank mapping (Fig. 4.2.5.1). Assessment of river depth at regular interval has been done to quantify the amount of sediment deposits and water level. The thickness of sand bed up to 2m water depth from the summer waterlevel has been obtained for computation. A total of 51 profiles were done for assessment. It is found that the river has sediment reserve of 1,36,233 m^3 (Fig. 4.2.5.2).

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

4.3 Environmental Assessment

4.3.1 Exploring Inter Relationship between Environmental Degradation and Poverty: Selected Micro-level Case Studies across Kerala

Poverty- environmental degradation nexus is an important topic of interdisciplinary research at the global level mostly attempted by environmental economists. This study has been set within the framework of interactive human system and environmental system within the limit of Wayanad and Kannur districts of Kerala. The landuse map for Meppadi Panchayat for the year 2008 is given in Fig. 4.3.1.1. Work has been finalised and report submitted.

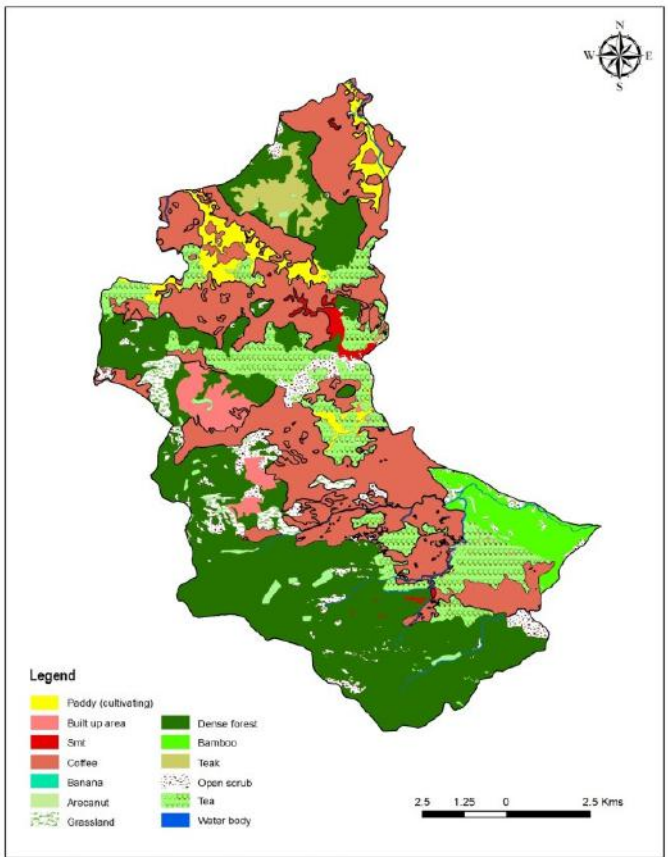


Fig. 4.3.1.1 Landuse (2008), Meppadi Panchayat

Srikumar Chattopadhyay

4.3.2 Study on Environmental Effects of Human Interventions in the Periyar River Basin, Central Kerala.

Rivers are among the most complex ecosystems on earth and is often most reflexive to the adversities of urbanization and industrialization. It is now widely accepted that protection and management of these systems must be integrated on river basin mode for achieving beneficial results. The study on Periyar river basin reveals that the basin environment has been severely impaired by human interventions particularly due to haphazard and unscientific mining and quarrying activities (Fig. 4.3.2.1). Indiscriminate mining is noticed in all the three physiographic provinces of the river basin, but at higher levels in the densitypopulated midlands and lowlands.

Clandestine mining and quarrying in the midland part of the Ernakulam district caters to the needs of the core development centre of Kerala, the Kochi city. As the Kochi city and the satellite towns require infrastructural facilities for several mega developmental projects, the areas adjoining the urban centre (s) are exploited for different types of construction materials like hard rocks, crushed sand,

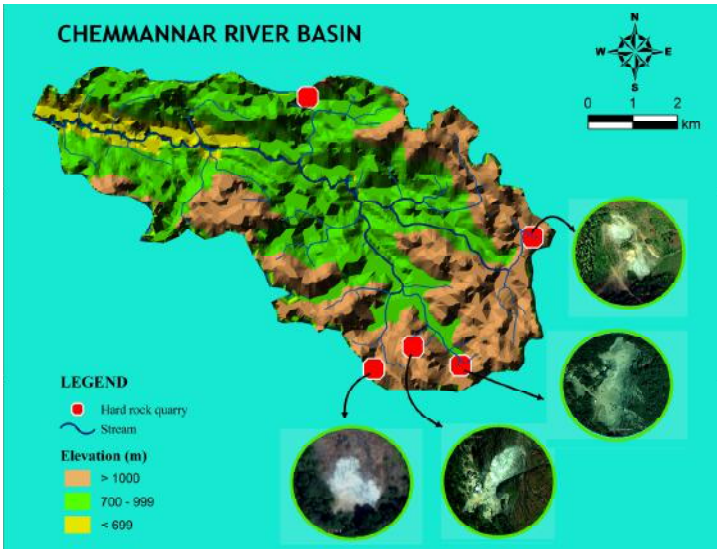


Fig. 4.3.2.1 Rock quarries in the catchments of the Chemmannar sub basin of the Periyar river basin that are disrupting the low order streams.

instream and floodplain sands, laterite blocks, brick earths etc. The impacts of mining and related activities rampant in the area, have far reaching consequences on the sustainability of the river and its resources. The impacts of mining, in most cases, leave permanent mark on the land which modifies significantly the actual geomorphology of the area. Apart from the land, air and the biological environments, the activity inevitably affects the socio-economic condition of the people as well. The dearth in the availability of river sand has resulted in widespread and indiscriminate extraction of hard rocks from the fragile hill ecosystems in the upper catchments of the river that fall mainly in the Ecologically Sensitive Areas (ESAs) of the Western Ghats (Sahyadris).

Rampant hard rock quarrying in the basin has now become a major threat to the surface water hydrology of micro watersheds in the basin. Out of the total rainfall contribution in the basin, a substantial portion is detained in the quarries as pitlakes which do not reach the master channel for fulfilling the geohydrological and ecological functions of the river. If the present trend continues severe environmental degradation in the quarrying-hit areas are inevitable. The seasonal physico-chemical analysis of water quality of various sources like rock quarry pits, wells, ponds and river water shows that, in general, the water quality is good as per the prescribed standard values of WHO (1997) and BIS (1991). If mining and quarrying are integrated with the regional development plan and regulated scientifically, the pit lakes left after quarrying can offer an alternate source of fresh water to the nearby development centres of the river basin environment.

K. Maya & D. Padmalal

4.3.3 Preparation of Mangement Action Plan for the Eco-Restoration of Vembanad Lake and Its Rivers (Agri-4)

Vembanad lake is one of the three Ramsar sites in Kerala and greatly influences the social, economic and environmental aspects of the state. However, the wetland is increasingly under severe stress due to various anthropogenic and environmental pressures. Though there are various studies and reports highlighting the internal and external factors impinging upon the very existence of Vembanad Lake and its inflowing rivers, there is no holistic management action plan that could be implemented for eco-restoration of the system. Therefore, a project has been conceived for preparing an implementable action plan for restoring the Vembanad lake and its river catch meets drained by Achankoil, Pamba, Manimala, Meenachil and Muvattupuzha rivers in line with the guidelines of National Lake and River Conservation Plan (NLRCP). The project aims to prepare position papers on the lake and its river catchment considering the state of environment of each lake and river system, compile an integrated environmental management action plan and formulate modular projects that could be implemented to mitigate the environmental issues.

Detailed inventory has been carried out of the various studies pertaining to the environmental aspects of the lake

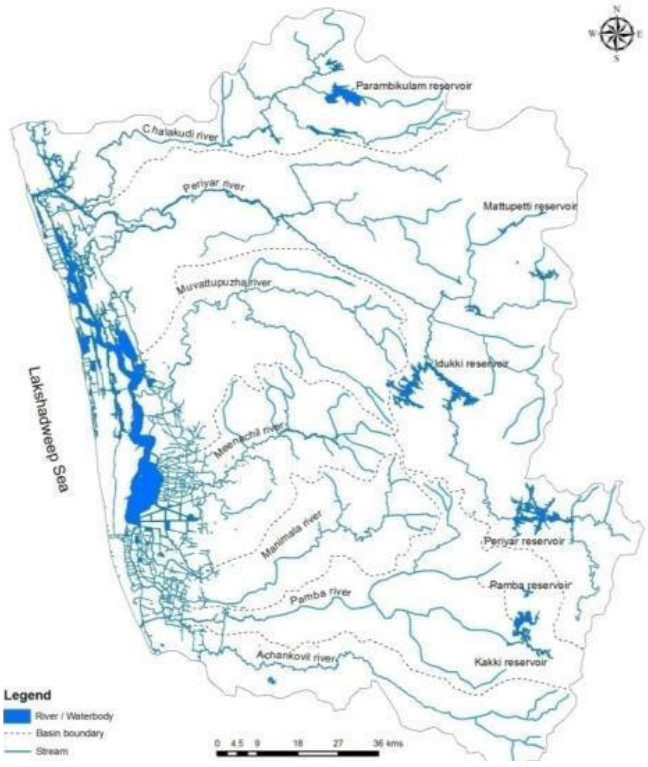


Fig. 4.3.3.1 Map of study area

and rivers, field level information gathered for assessing the state of environment of the ecosystems and environmental for delineating the environmental issues. Position papers on each of the five rivers have been compiled based on secondary data and field inventories which are being finalised. The environmental evaluation of the lake system is in progress. The map of the area taken up for the study is Fig. 4.3.3.1.

R. Ajayakumar Varma, K. V. Thomas, D. S. Suresh Babu & B. K. Jaya prasad
Funding: Agricultural Department, GoK

4.3.4 River Sand Audit of Idukki District, Kerala

Extraction of sand and gravel from the alluvial reaches of rivers is a global phenomenon. The activity is intense in countries that are subjected to rapid urban and industrial growth. Indiscriminate sand and gravel extraction from active channels and floodplains of rivers constitute a convenient source of fine aggregates in the ever expanding building sector. But it is now well understood that extension of sand and gravel from rivers at rates higher than the natural replenishments can impose serious environmental and socio-economic problems in the basin environment. The present scenario of river-born aggregate resource availability is bleak in the Kerala state as the sand resource in the river channels and overbank areas are almost completely exhausted due to unabated extraction in the past few decades. Rivers of Idukki district is not an exception. Sand is also being extracted mainly from the in-channel areas of Periyar, Muvattupuzha and Pambar rivers of Idukki district. Previous investigations of CESS (2004) revealed that sand mining was prevalent in 31 local bodies of Idukki district. A total of 3.808x 10^3 ty^{-1} of sand was extracted from 228 sand mining locations in the various rivers of the district. However, the sand extraction has come down drastically in recent years. In 2012, river sand mining was restricted to 7 local bodies of Periyar river draining the Idukki district only. The total quantity of sand extracted during this period from the Periyar river was to the tune of 33720 ty^{-1}. At present sand mining is limited to just 4 local bodies of the Periyar river and no sand mining is allowed in the Muvattupuzha, Manimala and Pambar rivers. At present, the authorized sand mining is very limited in Periyar river and is well within the natural replenishment levels of the river ecosystem.

D. Padmalal & K. Maya
Funding: Revenue Department, GoK

4.3.5 Coastal Ocean Monitoring and Prediction System (COMAPS)

The environmental health of our coastal ocean is an extremely important aspect from the conservation and development point of view. Therefore, the Ministry of Earth Sciences, Govternment of India initiated a project "Coastal Ocean Monitoring and Prediction System (COMAPS)", in which Coastal water quality monitoring is a major component. Under this national project to assess the sources, levels, pathways and effects of various pollutants in the coastal waters at identified hotspots NCESS is entrusted with the work along the coast of Kerala, Karnataka and Lakshadweep. Accordingly, seasonal variations of chemical, biological and microbiological aspects of the coastal hotspots identified via. Kochi, Mangalore and Kavaratti are being monitored over a long period.

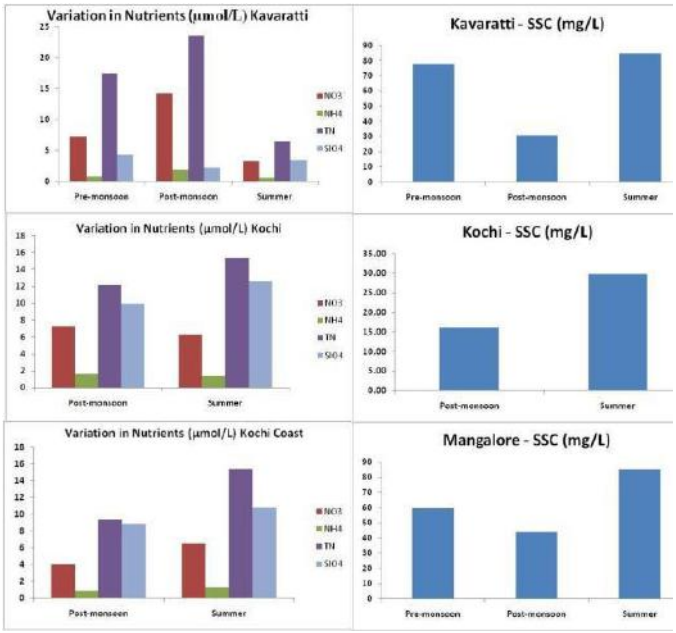


Fig. 4.3.5.1 Seasonal variations of Hydrochemical Parameters

During the year 2013-14, at all the three stations (Mangalore, Kochi and Kavaratti) sampling have been carried out systematically for the pre-monsoon, post-monsoon and summer seasons for hydrochemistry, sediment characteristics, marine biology and microbiology parameters. A total of 15 hydro-chemical parameters including nutrients were analysed. The sediment analysis was carried out for heavy metals (Mercury, Lead and Cadmium), texture and organic carbon content. Marine biological analysis included estimation of chlorophyll and phytoplankton, zooplankton and zoobenthos identifications. Total Viable Count (TVC), E.Coli (ECOL),

Streptococcus Faecalis (SFLO) like organisms were also analysed.

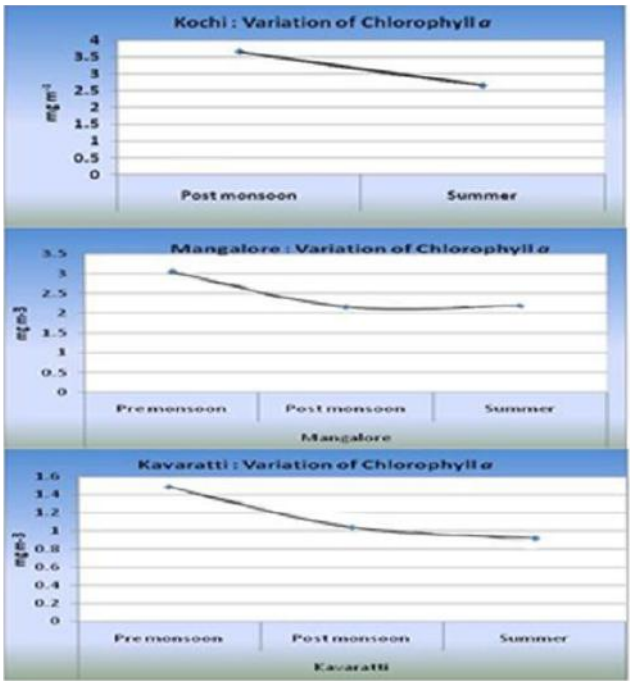


Fig. 4.3.5.2 Hydrochemical parameters based on the chlorophyll data

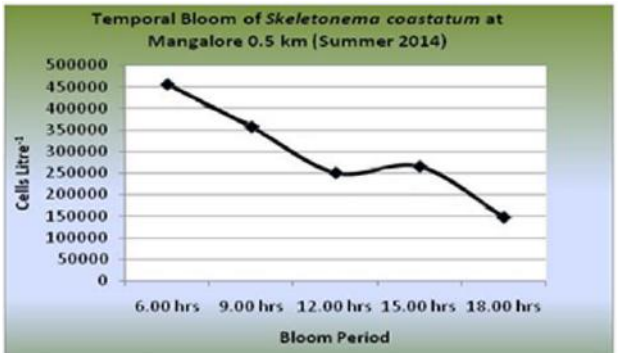


Fig. 4.3.5.3 Temporal blooms of Skeletonemacoastatum

The Fig. 4.3.5.1 presents seasonal variation of hydrochemical parameters at different locations. Generally no significant anomaly was found with respect to hydrochemical aspects in comparison to the previous years except in the case of dissolved oxygen. Based on the chlorophyll data (Fig. 4.3.5.2), Kochi could be classified as ultra mesotrophic region, Mangalore as mesotrophic and Kavaratti as oligotrophic region. A temporal non-toxic bloom of diatom *Skeletonemacoastatum* (>450000 cells L-1) was observed during the day hours of summer season 2014 at Mangalore (Fig. 4.3.5.3). However, if this species is replaced by a harmful one, having the similar niche, there may be chance of the bloom becoming toxic and hazardous. Otherwise, no harmful algal blooms was reported from any of the three stations. No anomalous variations have been observed in terms of other marine biological parameters. The annual mean values (Fig. 4.3.5.4) for TVC(Total Viable Count), ECLO (E.coli) and SFLO (Faecal Streptococci) at the Cochin estuarine region is found to be 23330 CFU/ml, 260 CFU/ml and 5750 CFU/ml respectively. In Mangalore the annual mean values for these parameters are 9890 CFU/ml, 140CFU/ml and 450CFU/ml respectively. In Kavaratti, the mean value for VCLO (Vibrio sps.), ECLO and SFLO are 9450 CFU/ml, 346CFU/ml and 2530 CFU/ml respectively. The less microbial count in Kavaratti may be due to the higher salinity observed in the region. There is a significant presence of Vibrio sp., including cholera in Kavaratti coastal waters which need surveillance considering its potential for proliferation. Kochi reported comparatively high microbial population throughout the study periods.

Fig. 4.3.5.4 The annual mean values of TVC, ECLO and SFLO in the coastal waters of Kochi, Mangalore and Kavaratti

R. Ajayakumar Varma & K. Anoop Krishnan

Funding: MoES, GoI

4.3.6 In-situ Bio-remediation of Landfill Pollutants: Maximising the Remediation Potential of Select Indigenous and Exogenous Microorganisms

The safe disposal of Municipal Solid Waste (MSW) is a challenging issue worldwide. Various waste management measures have been in use like recycling, composting, incineration etc, but still it is one of the most poorly managed sector in India. Sanitary landfilling is the predominant waste disposal alternative, but raises environmental concerns in the form of generation of Land Fill Gas (LFG) with methane as a major component and leachate which is an obnoxious effluent with many toxic compounds. Moreover, the issue of fugitive and residual methane emissions has still not been resolved.

Fig. 4.3.6.1 Experimental Set up

The study consists of using the technique of *in-situ* bioremediation to reduce the toxicity of Municipal Solid Waste (MSW) landfill pollutants: high concentrations of dissolved organics, inorganics and heavy metals in leachate and methane in the landfill gas (Fig. 4.3.6.1). The landfill is considered as a bio-reactor in the study in which the stabilisation of waste is accelerated by incorporating various interventions. Combined methane oxidation and *in-situ* treatment of leachate is proposed to be conducted using a consortium of microorganisms. The methane from the landfill soils is to be oxidised using methanotrophic bacteria. The organics, inorganics and heavy metals in leachate is proposed to be reduced using select chemoautotrophic bacteria as well as fungal species. The technique does not require costly installations for recovery and purification of LFG or for leachate treatment units.

The objective of the study is to determine the performance of a consortium of indigenous as well as exogenous microorganisms in reducing the toxicity of landfill leachate and generated landfill gases.

The study will estimate the quantity and quality of landfill gas and leachate produced from each of the landfill models; the oxygen/air requirement for optimal remediation of landfill pollutants; the growth rate of select indigenous and exogenous microorganisms in the system; the correlation of bacterial growth rate with the treatment efficiency; the bacterial kinetics of select species and the group performance of the exogenous bacteria with the indigenous bacteria. The exogenous microorganisms were selected based on their source, prospective remediation capability and growth conditions and were procured from Microbial Type Culture Centre, Chandigarh. These microorganisms are being cultured in the lab and will be inoculated into the two of the landfill models for enhanced bio-remediation and accelerated waste stabilization. The study aims to develop a comprehensive procedure to reduce the toxicity of landfill pollutants and design a landfill system to cater to municipal solid wastes based on the remediation efficiency of the interventions.

The physical models of the landfill to suit the purpose of landfill simulation and the installations for aeration, inoculation of microorganisms, re-circulation of leachate, collection of landfill gas from various locations and collection of leachate are complete. Aeration commenced

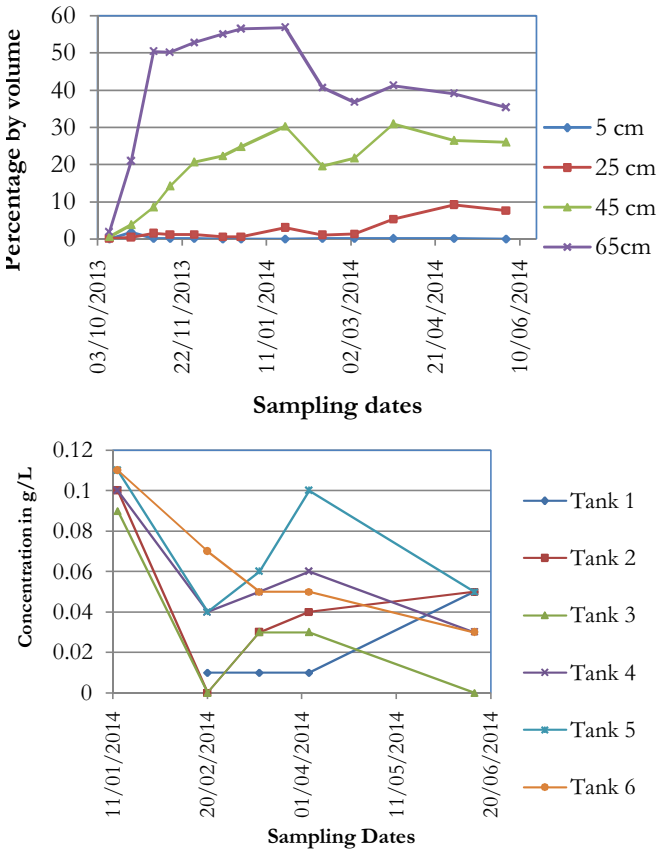


Fig. 4.3.6.2 Average concentration of CH4 in LFG with respect to depth (above); Copper in leachate from various models (below)

in 4 among the 6 landfill models. LFG is being monitored every two weeks since October 2013 and leachate every month from January 2014. The parameters estimated from LFG include Methane (CH_4)and Carbon dioxide (CO_2) (Fig. 4.3.6.2)and for leachate Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammonia-Nitrogen (NH_3-N), pH, conductivity and heavy metals copper (Cu), chromium (Cr), iron (Fe), zinc (Zn) and nickel (Ni). Micro organisms for biological treatment have been procured and are being cultured. Indigenous aerobic microorganisms in the system are to be identified and the cultured exogenous microorganisms inoculated in two of the aerated models, for enhanced bio-remediation.

K. Deepa Nair
Funding : DST, GOI

4.3.7 Environmental Studies of Kollam-Neendakara Wetland System and Associated Inlands

Ashtamudi wetland system (AWS), one among the 25 Ramsar sites of India is located in the Kollam District of Kerala on the southwest coast of India with paramount importance needing special conservation and management measures. The AWS is mainly constituted by the five wetland systems (Kureepuzha, Kandachira, Kanjirakottu, Kumbalathu and Chavarakayals) together with the Ashtamudi main lake.The rapid industrialization and human driven pressures imparts tremendous environmental effects to the estuarine wetland systems and have brought considerable decline in the water and sediment quality of the wetlands. The hydrochemical and geochemical attributes were determined for two different climatic periods i.e., in monsoon and non-monsoon and spatial distribution diagrams (Fig. 4.3.7.1) were prepared in GIS platform by using the analytical data sets.The extent of accumulation of heavy/trace metals in the recent sediments of Ashtamudi wetland system was also evaluated using Contamination Factor (CF) (Table 4.3.7.2), Pollution Load Index (PLI) (Table 4.3.7.1) and Geo-accumulation Index (I_{geo}) (Table 4.3.7.3) for the different seasons. Spatial distribution diagrams (Fig. 4.3.7.2) of each of the heavy/trace metals for the monsoon and non-monsoon seasons were also prepared in GIS in order to assess the variation of pollution in the entire qetland system. Comparing the data with the world shale averages for the concerned elements, it was found that Cr, Fe, Ni higher concentration, and Cu were in indicating high befouling rate. The Chavara kayal was found to be highly polluted with heavy metals compared to other sub-environments. Geo-accumulation index (I_{geo}) values of most of the elements (Cr, Fe, Co, Cu etc;) were in classes above zero pointing

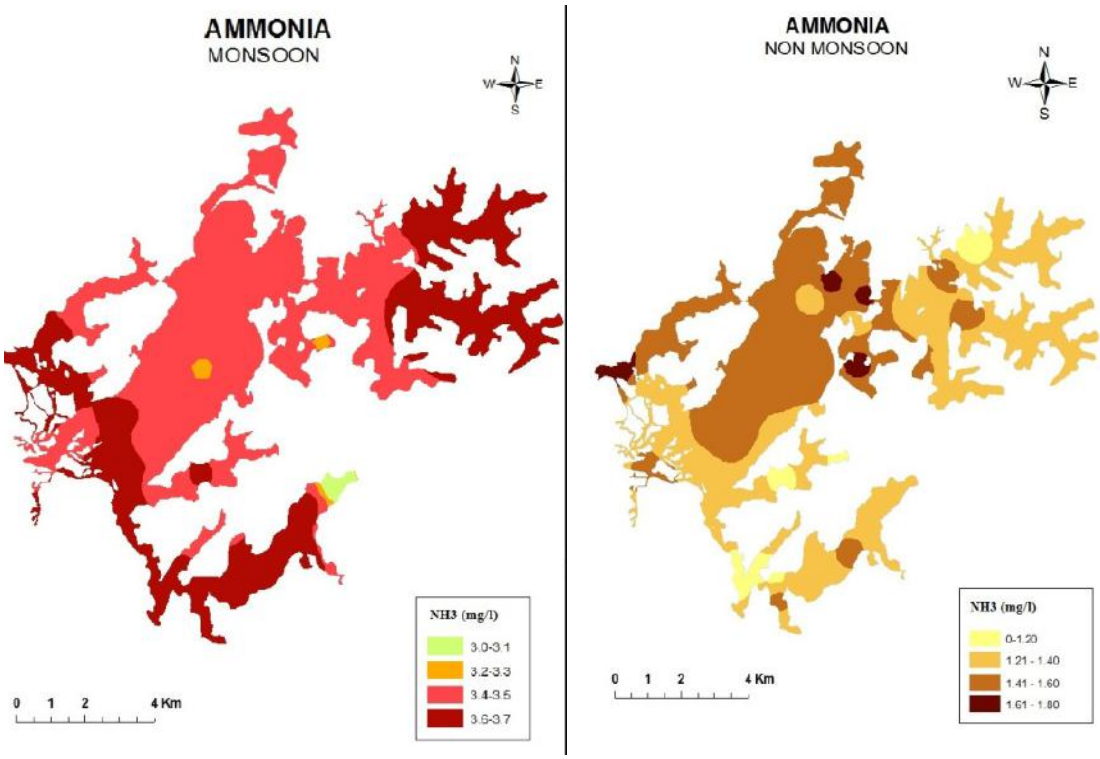


Fig. 4.3.7.1 Spatial distribution of Ammonia in surface waters of Ashtamudi wetland system

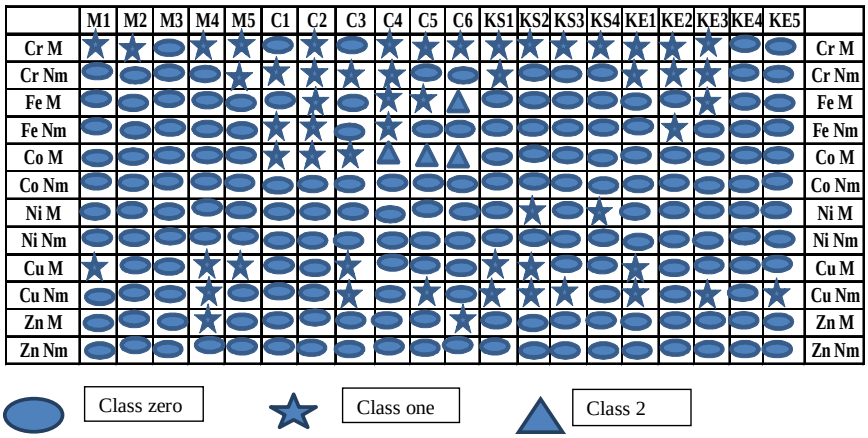
Table 4.3.7.1 Pollution Load Index in various sub-environments of Ashtamudi Wetland System

Sl. No.	Stations	PLI	
		Monsoon	Non- monsoon
1	Ashtamudi Main Lake	0.16	0.03
2	ChavaraKayal	0.37	0.12
3	Kureepuzha&KandachiraKayals	0.09	0.061
4	Kumbalathu&KanjirakottuKayals	0.39	0.1

Table 4.3.7.2 Concentration and contamination factor of elements in Ashatamudi Wetland System

Sl. No.	Elements	Seasons		World shale average (Avrg)	Contamination Factor (CF)		Pollution Status
		Monsoon	Non- Monsoon		Monsoon	Non- monsoon	
1	Cr	139.4-172.33 ppm	126.75- 143.66 ppm	90 ppm	1.55-1.91 ppm	1.41-1.60 ppm	Moderate
2	Al	0.56- 11.58 ppm	1.08- 10.23 ppm	80,000 ppm	Negligible	Negligible	NIL
3	Mn	0.025- 0.08 ppm	0.03- 0.47 ppm	900 ppm	Negligible	Negligible	NIL
4	Fe	3.72- 8.29 %	3.52-6.88 %	4.6 %	0.81-1.80 ppm	0.77-1.50 ppm	Moderate
5	Co	10-14.2 ppm	10-13.2 ppm	19 ppm	0.53-0.75 ppm	0.36-0.77 ppm	Low
6	Ni	72.8-99.75 ppm	51.4-83.5 ppm	68 ppm	0.76-1.47 ppm	0.76- 1.23 ppm	Moderate
7	Cu	50.2-70.25 ppm	39.4-83.25 ppm	45 ppm	1.12-1.56 ppm	0.88-1.85 ppm	Moderate
8	Zn	23.29-73.8 ppm	24.7-40 ppm	95 ppm	0.25-0.78 ppm	0.26-0.42 ppm	Low
9	Ti	0.56- 0.75 ppm	0.504-1.08 ppm	4600 ppm	Negligible	Negligible	

Table 4.3.7.3 Geoaccumulation index of heavy metals



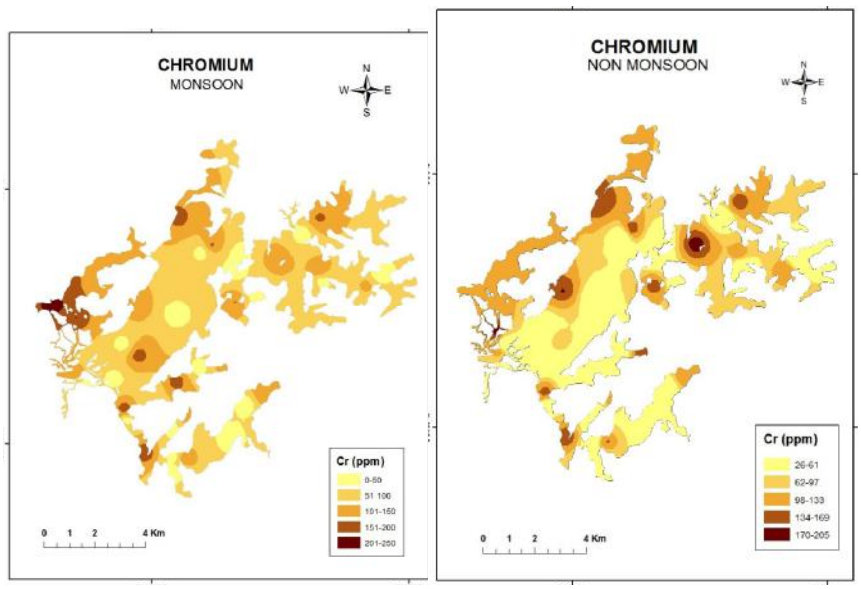


Fig. 4.3.7.2 Spatial distribution of Chromium in the surficial sediments of Ashtamudi wetland systems

towards high degree of pollution. A decadal comparative analysis on the accumulation of heavy/trace metals reveals the histrionic increase in the heavy metal deposition to the Wetland System which sheds light on the human driven geo-environmental impacts in the AWS and the exigent needs of sustainable conservation measures.

A. Krishna Kumar

Funding: Department of Port & Fisheries, GoK

4.4 Coastal Zone Management

4.4.1 Integrated Island Management Plans (IIMPs) for Lakshadweep Islands

The preparation of Integrated Island Management Plan (IIMP) for all the inhabited islands of Lakshadweep which is in accordance with the guidelines provided in the Island Protection Zone Notification of MoEF (2011) has been accomplished during the period. The plan preparation was supervised by a Technical Committee constituted by the Supreme Court of India in 2012 under the chairmanship of Justice R.V. Raveendran, Supreme Court Judge (Rtd.,). The entire island including the aquatic area were considered for the preparation of the IIMP plan. The digital data base in 1:4000 scale were utilized for mapping the different physical characteristics of the island. Areas indicating the dwelling units including the infrastructure projects such as schools, markets, hospitals, public facilities, road net work were brought into the digital map with all their characteristics. The conservation and preservation schemes were mapped separately. The data on the coral ecosystems which were mapped utilizing the satellite imageries during 2007 have been incorporated. Vulnerability map showing the elevation of the island wrt MSL has been worked out. This map will be utilized to address the vulnerability to human life and property. This will also help to identify suitable areas for locating dwelling units, infrastructure and appropriate safeguards measures to protect the life and property of the local communities. Mapping of the HTL and No Development Zone (NDZ) in the island has also been completed. An approach for the identification of Buffer Zone/Setback Line for conservation/ preservation in the islands has been worked out keeping the natural threats such as wave set up, horizontal shoreline displacement and sea level change in the islands.

The final draft report and IIMP plan in respect of 10 inhabited islands viz., Agatti, Amini, Androth, Bitra, Chetlet, Kavaratti, Kadamat, Kalpeni, Kiltan, Minicoy have been completed and submitted to the UT Lakshadweep for publishing in the website and for getting feedback from the public. Interaction with the public and field visits to the representative islands were also made during January 2014. Field work in three uninhabited islands has been completed and draft IIMP for the same has been finalised for submission to the funding agency.

T. N. Prakash

Funding: DST, UT Lakshadweep

4.5 Biophotonics

4.5.1 Assessing Biotic and Abiotic Stress Through Chlorophyll Fluorescence and Reflectance in Tropical Root and Tuber Crops

The project was undertaken to assess biotic and abiotic stress induced changes in tropical root and tuber crops under field conditions using multi-spectral fluorescence/ reflectance imaging and to develop suitable algorithm for monitoring CMD (cassava mosaic virus) infection in cassava plants.

Fig. 4.5.1.1 Photo of cassava (left) and false coloured sunlight induced fluorescence (right) imaging ratio F687/F759 of irrigated cassava.

The study involves measurement of fluorescence responses of plants at narrow Fraunhofer lines centered in the red at 687 nm and the far red at 735 nm. The multi-spectral imaging system developed for fluorescence/reflectance imaging of outdoor plants consisted of an Electron Multiplying CCD (EMCCD) monochrome camera (1024x1024 pixels, Model: LUCA-R-DL-604, Andor Technology, UK), coupled to a Nikon AF 35-70 mm zoom camera lens and six interference filters mounted on a rotating filter wheel, one each for the center and adjacent bands at 687.5 nm and 759.5 nm, a reflectance standard and a laptop computer. In addition to the fluorescence imaging, reflectance imaging was also carried as part of the study.

Wavelengths 531 nm and 571 nm were selected for Photochemical Reflectance Index (PRI) determination. The Fraunhofer Line Depth (FLD) principle is utilized to detect sunlight induced plant fluorescence. Two images are obtained for a specific band-one at the center wavelength and one at a wavelength adjacent to the band. By applying the FLD technique fluorescence intensity, F is obtained as

$$F = \frac{\left[d - c\left(\frac{b}{a}\right)\right]}{1 - \left(\frac{b}{a}\right)} \quad \text{..... (Eqn. 1)}$$

where, 'a' is the reference intensity at center wavelength, 'b' is the reference intensity at adjacent wavelength, 'c' is the target intensity at center wavelength, and 'd' is the target intensity at adjacent wavelength.
PRI is derived from reflectance at 531 nm and 571 nm as follows:

$PRI = (R_{531}-R_{571}) / (R_{531}+R_{571})$….. (eqn.2)
where, R_{531} is the reflectance image at 531 nm and R_{571} is the reflectance image at 571 nm.

The measured fluorescence image intensity ratio of F687/F759 was false-coloured (pseudo-color-mapped) for easy visualization of the difference between the healthy and stressed regions of plants. A colour bar was also provided which helped in categorizing the ratio values. In the colour bar, dark colour region (black, dark blue) represents low intensity values, whereas, faint colour region (yellow, white) represents high intensity value, and the colours in between represents values in the range between low and high. Sunlight induced chlorophyll fluorescence ratio (F687/F759) image of watered cassava plants are given in Fig. 4.5.1.1

From the fluorescence ratio images, it is observed that part of the leaf with less amount of chlorophyll reflects more light and has high fluorescence ratio values which are represented as faint colours in false colouring. The CMD infected regions in sunlight induced chlorophyll fluorescence images are visible as yellow spots and represents higher intensity, which indicates inhibition of photosynthesis function. The CMD infected leaves showed yellowing (chlorosis) which increased as the stress progressed.

Visualization of PRI images of cassava plant with CMD infection stress (Fig. 4.5.1.2 (d, h)) provides a clear indication of how the photosynthetic efficiency varies over level of CMD infection stress events. The CMD infected regions in images are visible as yellow spots and represents higher intensity, which indicates inhibition of photosynthesis function (Fig. 4.5.1.2 (f)). A clear distinction is noticeable in the PRI images between the healthy and chlorosis affected leaves of these plants. The lower values of PRI seen in the case of leaves with visibly no symptom indicate less stressful conditions, whereas the progressively higher values seen in CMD infected leaves indicate substantial stress. The increase in PRI of vegetation with stress shows the effectiveness of the technique in the monitoring of stress-induced changes in plants. The increase in PRI shows that de-epoxidation of the xanthophylls cycle occurs during stress events in plants.

In this study, we have presented a method for non invasive and non destructive detection of water deficit stress and cassava mosaic virus infection in cassava plants through remote sensing which can be extended to monitor a large area allowing long term measurement. On the other hand,using sunlight as a source of light for inducing fluorescence, passive remote sensing of vegetation characteristics through field and space missions is gaining acceptance.

Experimental data reported here demonstrate relationships between F687/F760 ratio obtained by imaging with net photosynthesis and total leaf chlorophyll content and is found that sunlight induced fluorescence imaging can be used to assess the photosynthetic efficiency of plants passively. The fluorescence images at 687 nm and 759nm and the fluorescence ratio images at 687/759 clearly displayed the level of infection, with normal regions shown in lower values whereas, higher

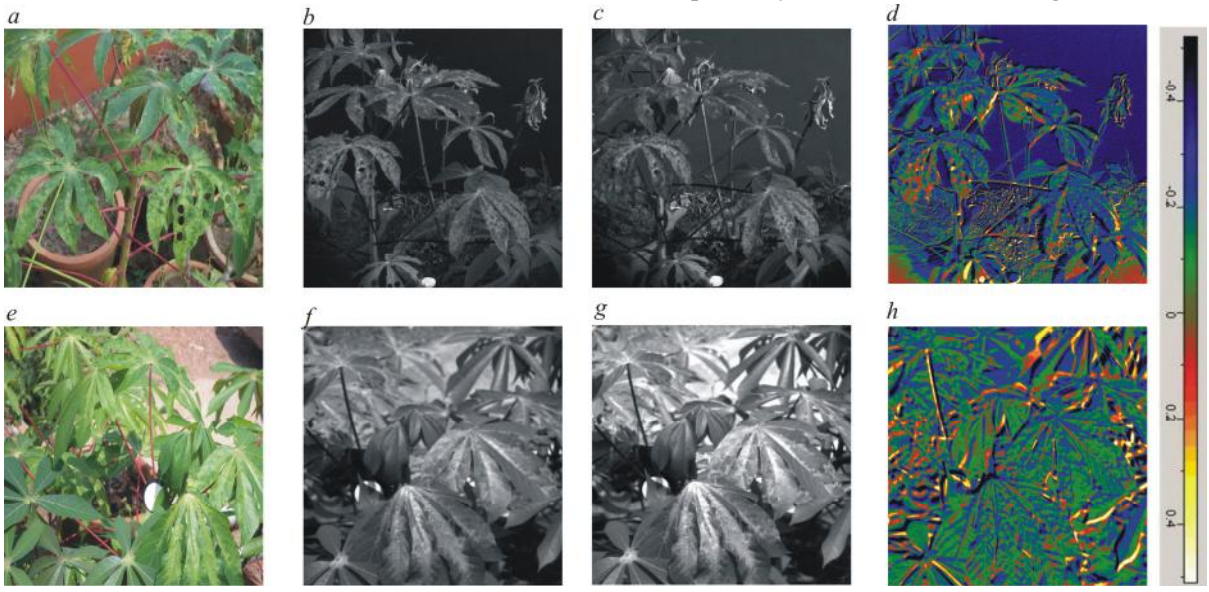


Fig. 4.5.1.2 Photographs (a,e), monochromatic reflectance images at 531 nm (b,f), monochromatic reflectance images at 571 nm (c,g) and false coloured PRI images (d,h) of 2 varieties of CMD infected cassava plants

grade infections like Grade- 4 shown in higher values. PRI imaging was used to investigate changes in the photosynthetic function of plants during CMD stress. The study results confirm the potential of PRI imaging as a passive remote sensing modality in crop health assessment. Based on the above results, it is proved that sunlight induced fluorescence and reflectance imaging can be extended to monitor a wide variety of vegetations for assessing actual vegetation health status.

N. Subhash & C. N. Mohanan

4.6 GIS and Remote sensing Applications in Natural Resources Management

4.6.1 Glimpses of Kerala Through Maps

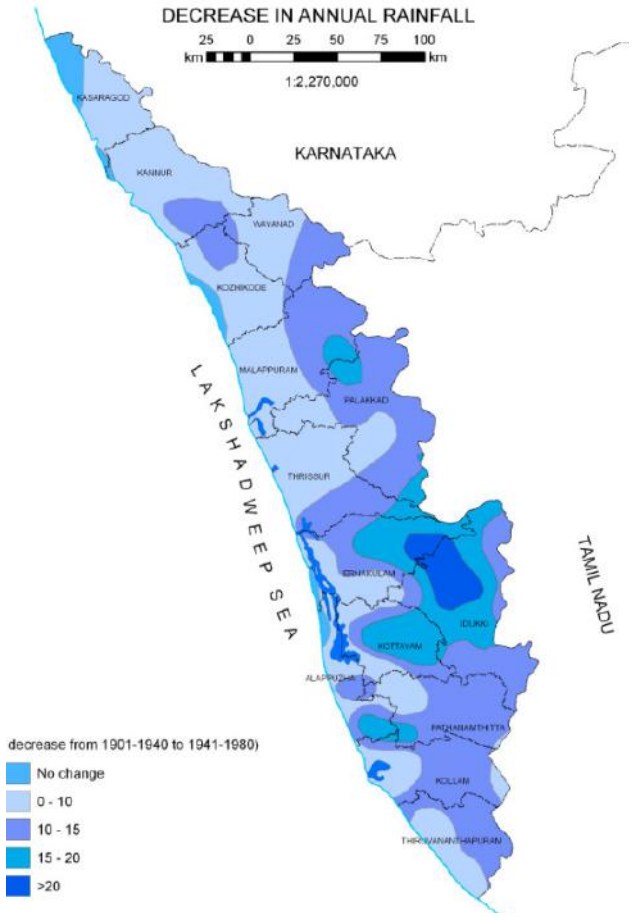


Fig. 4.6.1.1 Decrease in annual rainfall (1901-1940 to 1941-1980)

The volume on 'Glimpses of Kerala through maps' is a special type of Atlas consisting of 32 maps in 1:2 million scale. Apart from the administrative map, 31 maps are arranged under different biophysical, demography, social infrastructure and levels of development set up which is indicative of the rich natural resource base of the State of Kerala (Fig. 4.6.1.1). The Atlas was published.

Srikumar Chattopadhyay

4.6.2 River Bank Atlas of Kabani and Chalakudi river

The 'Kerala Protection of River banks and Regulation of Removal of Sand Act, 2001' is an act to protect river banks and river beds from large scale dredging of river and to protect their biophysical environment system and regulate the removal of river sand and for matters connected therewith or incidental thereto. In order to understand the condition of river banks there is a need for delineation of the river banks at cadastral level along with the natural/ anthropogenic activities taken place at different time periods. The Revenue Department , Government of Kerala is vested with the responsibility of managing river systems in the State. Each district has created a River Management Fund (RMF) under the control of Revenue Department. In this connection field surveys were conducted along the river banks of the Kabani and the Chalakkudi by the River Research Centre, Thrissur. CESS was mandated to generate GIS database and atlases for both the rivers utilizing cadastral level field data collected by the survey teams. The following are the major objectives of the project:

1. Convert the post field manuscript maps prepaired by the River Bank Mapping teams into digital thematic layers with WGS 84 datum and UTM Zone – 43 coordinate system using Arc GIS software.
2. Design of maps using appropriate cartographic symbols, colours and typonomy for man-made and natural features along with sand mining sites/ kadavus and existing river management plans using ARCGIS software.
3. Generation of digital vector thematic layers and multi-colour hard copy thematic maps in user-defined scales & River Bank Atlases for both Kabani and Chalakkudi river for the Revenue Department, Government of Kerala.

Table 4.6.2.1 Salient features of the riverbanks for the mapped segments of Kabani and Chalakudi rivers

Details	Kabani River	Chalakudi River
Total length of river segment mapped	61.05 Km	45.25 Km
Length of erosional bank on right river bank	848 M	Not mapped
Length of erosional bank on left river bank	320 M	Not mapped
Length of vegetated bank on right river bank	23.88 Km	44.53 Km
Length of vegetated bank on left river bank	52.38 Km	43.33 Km
Number of sand mining sites	19	16
Number of pump houses	58	80
Number of kadavus/bathing ghats	Not mapped	81

The post field maps prepared by the field team in the village cadastral maps have been thoroughly scrutinized; errors and mismatches were identified and corrected. The manuscript maps were scanned using A0 scanner under

Fig. 4.6.2.1 Manmade features of Kabani river Basin

PLATE 3

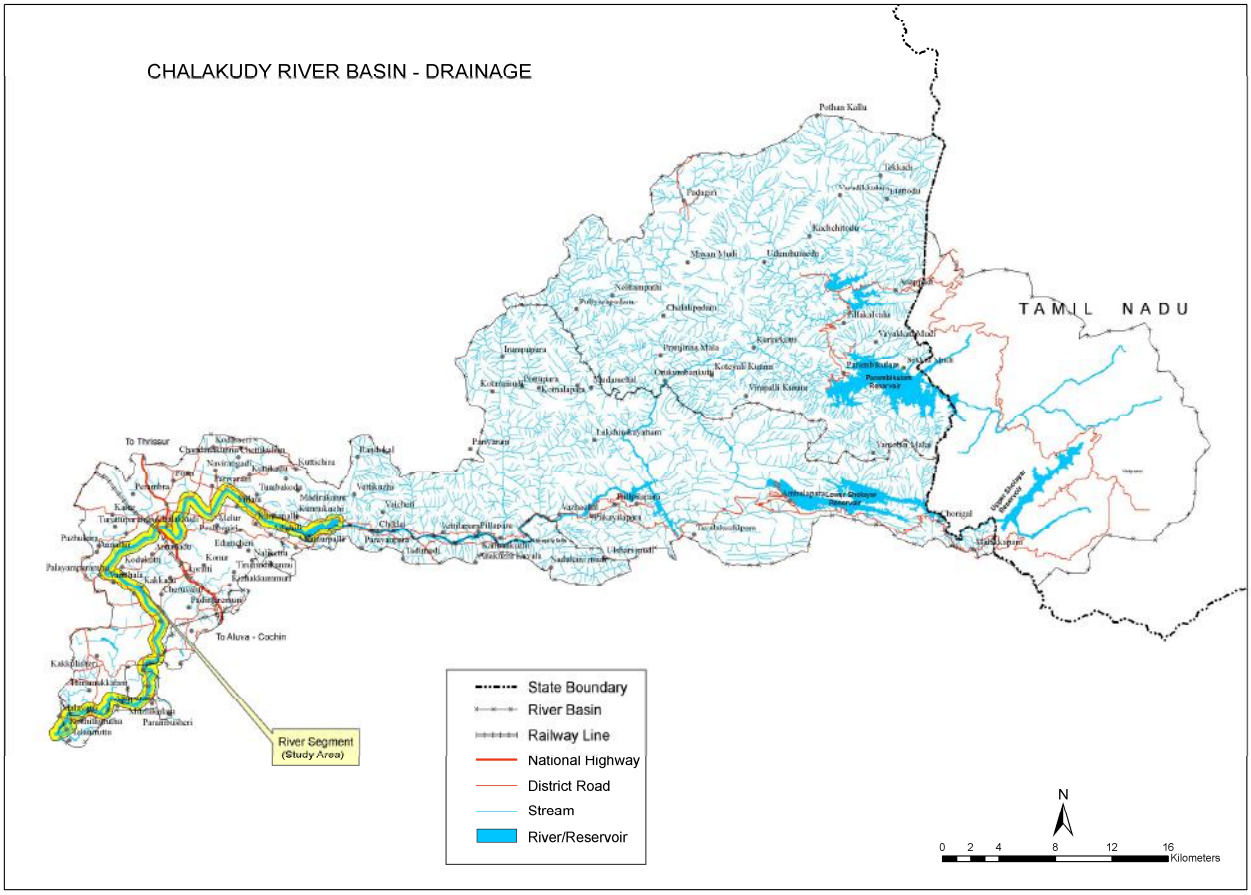


Fig. 4.6.2.2 Drainage set up of Chalakudy river basin

PLATE 4

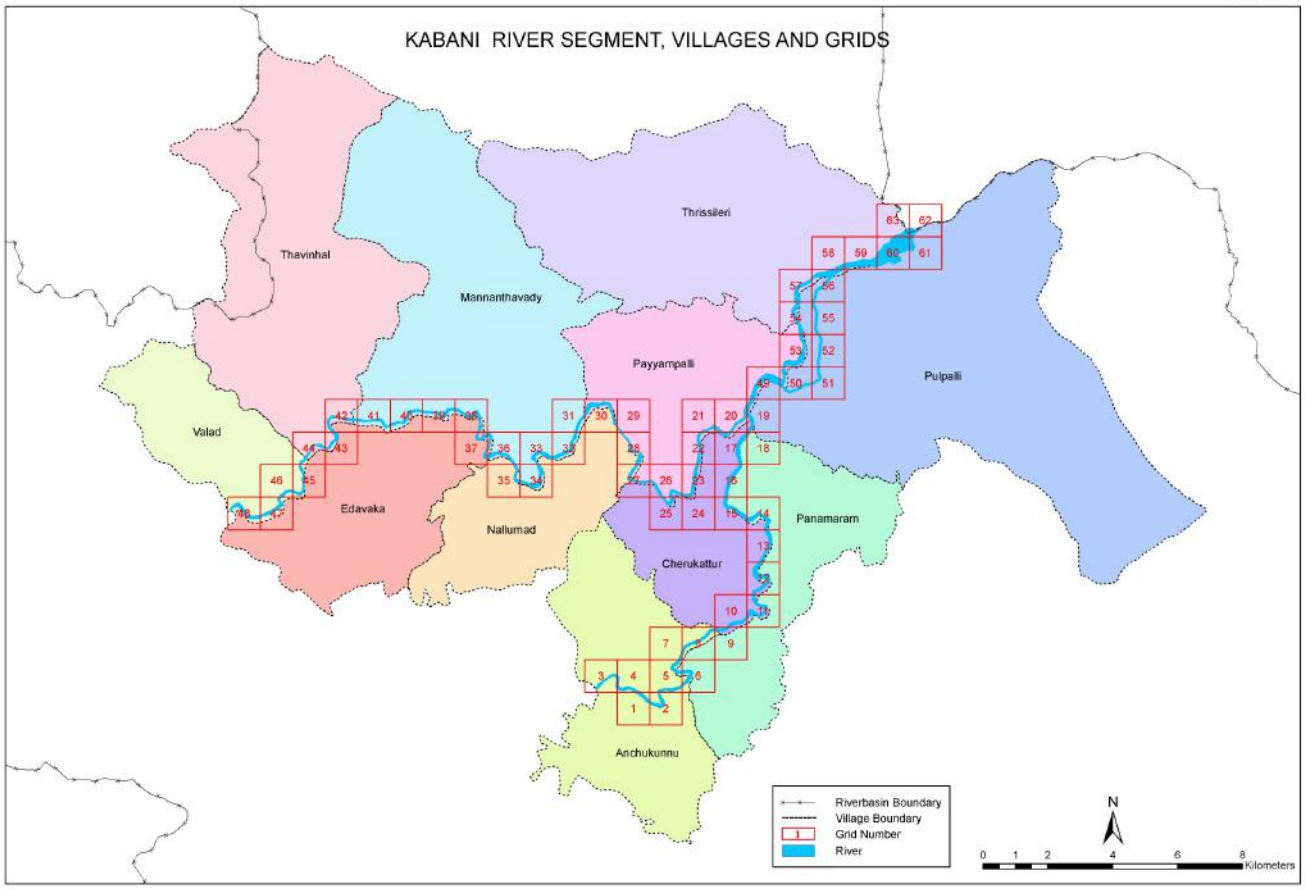


Fig. 4.6.2.3 Villages and grid set up of Kabani river basin

150 dpi resolutions in .tiff image format. The images have been cleaned and made ready for geo-referencing. The control points for the river segments have been identified for each sheet from the data base available in CESS and Google Earth. The sheets were projected in WGS 84 datum and UTM 43 zone coordinate system using ArcGIS software. The point, line and polygon features were vectorised using manual digitization process with reference to the geo-referenced image and shape generated files using ArcGIS. The Three major themes generated are manmade features (Fig. 4.6.2.1), Natural features and land use features as demarcated in the base maps by the survey teams. The survey parcels of both banks of the river have been polygonised and labeled with village survey numbers. The river segment has been gridded with uniform quadrilaterals. The themes are arranged in three sections such as Natural Features, Manmade Features and Landuse Features along with general maps to show the spread of basin (Fig. 4.6.2.2), relief and constituent villages and panchayats.

The outcome of the project is two river bank atlases for the Kabani and the Chalakudi Rivers in cadastral scale with survey numbers and the three themes (manmade features, physical features and land use features) of the mapped river segments. There are 189 plates in A3 size for Kabani (Fig. 4.6.2.3) and 207 plates for Chalakudi River. Apart from the atlases there is a standardized and coordinated comprehensive spatial data base available in shape file format for further value additions and for temporal land use change detection. The large scale maps thus prepared will be helpful for detailed river bank protection planning, understand the extent of encroachments and erosion and depositional status along the banks. The maps can be utilized by the concerned local body authorities for planning eco-restoration activities such as bio-fencing and to prohibit effluent discharge and solid waste dumping into the river from different sources. All the departments which are interested in river management will find this map very useful.

B. K. Jayaprasad

Funding: Revenue Department, GoK

4.6.3 Creation of a Model GIS Database and Urban Information System for Malappuram Municipality under "State Urban Information System" (SUIS)

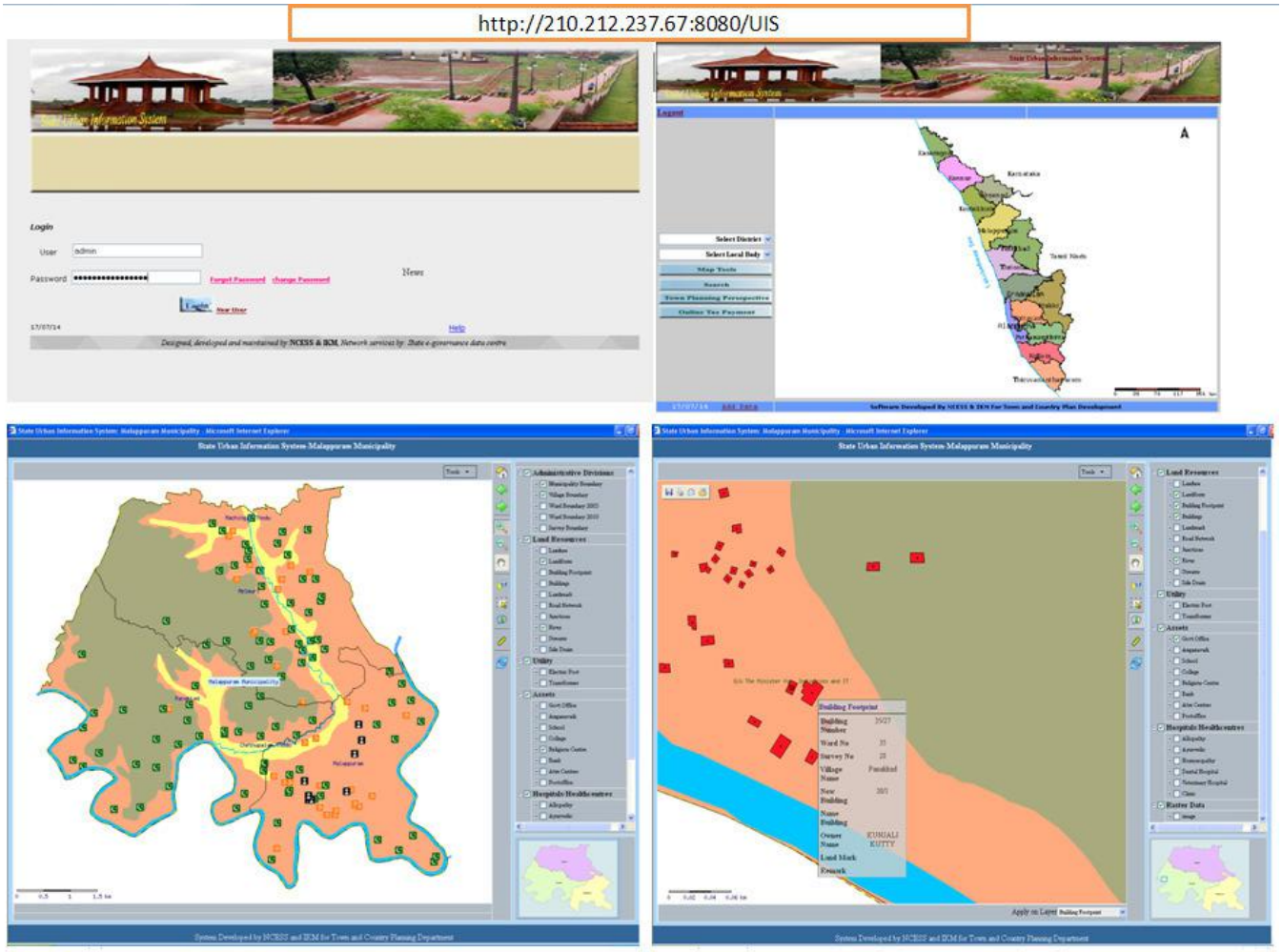


Fig. 4.6.3.1 Screen shot of GIS database and urban information system: Login page (left above), Startup page (right above), display of building point layer (left below) and indentifying a building to display building information (right below)

Urban Information System is the backbone for city planning. SUIS project is a collaborative programme of the NCESS, Information Kerala Mission (Local Self Government Department, Government of Kerala) and the Town & Country Planning Department, Government of Kerala. The main focus of the programme is to generate and disseminate spatial/non-spatial digital database including socio economic data in the Malappuram municipal area through a customized information system developed with the state-of-the-art techniques of Remote Sensing and Geographic Information System, supplemented by field survey.

World View 2 satellite data (with spatial resolution of 0.50 m Mx and 2 m PAN) was used in conjunction with Global Positioning System (GPS) and field survey data for preparing the database. WV02 satellite data was precisely geo-corrected using the Differential Global Positioning System (DGPS) values. Various thematic layers such as land use/ land cover, road network, water bodies, settlements, building foot prints etc, were derived. Individual village level cadastral sheets were scanned, cleaned and a mosaic of the municipality was made. These sheets were Geo-referenced with respect to the DGPS coordinate values. Cadastre was vectorized and linked to the survey parcels. The spatial database thus generated has WGS84 Datum and UTM Zone 43 projection. Attribute data with respect to the location, resource database including socio-economic data collected from the field has also been linked in a GIS platform.

By integrating the thematic layers and attribute data of societal importance, a web based user-friendly customized information system has been designed and developed in open source platform. The decision support modules provide flexible environment for data handling, resource

query, update analysis and provide inputs into the master/ zonal planning and utilities management. The user can explore, manipulate and extract reliable spatial database according to their requirement.

The major objective of this programme is to design, organize and establish a comprehensive information system in the urban local body for planning, management and decentralized governance.

The methodology involved establishment of Principal Reference Points, generation of Ground Control Points, thematic layers generation using WorldView2 satellite data, field updation socio-economic/physical survey and customized information system development.

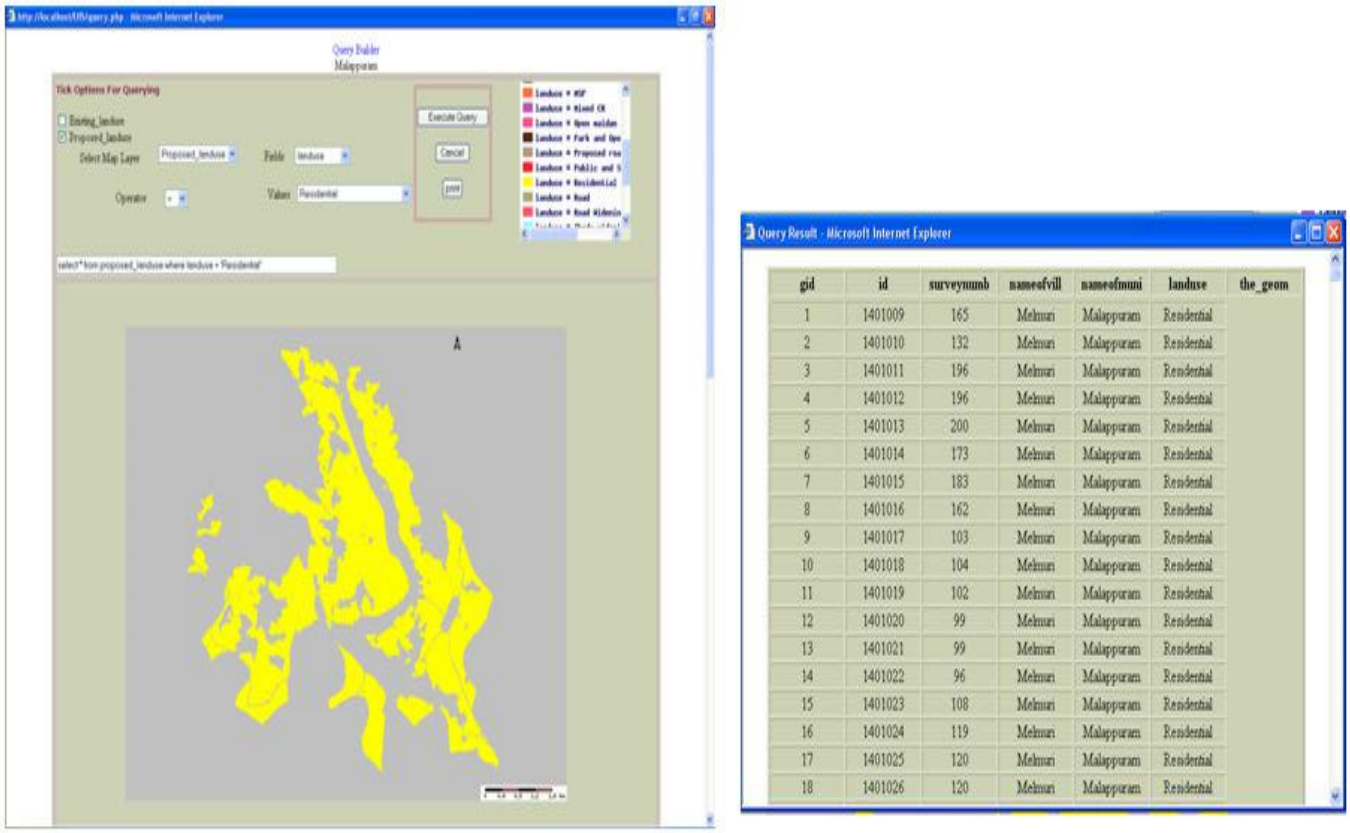
Prerequisite for developing an information system consists essentially of the following five components:

a) Data input in the form of spatial/non-spatial data and preparation
b) Thematic data generation from satellite data collection of administrative, town data and socio-economic data
c) Representation of spatial relations and structures;
d) Synthesizing techniques for spatial and geographical analysis
e) Development of urban spatial information system and generation of output.

For ease and accuracy of the survey process, the field survey has been divided into two components, viz., the physical and socio economic survey. Physical survey is meant for updating all the buildings and other tangible assets within the municipality. With electoral wards as the base door to door survey was conducted by surveyors and enumerators for recording the socio-economic status of the Municipality. Thus the base maps were prepared for 37 municipal wards with the footprints of the buildings.

Different work elements of the programme and its details are as follows:

a) Procuring data products and cadastral sheets
b) Base map generation
c) Establishing principal reference points and ground control points for GPS survey
d) Geo-reference satellite data and cadastre
e) Derive thematic layers of interest
f) Impart training to field surveyors and enumerators
g) Field data collection and supervision
h) Socio economic survey and data entry
i) Application development for data entry
j) Data Verification, validation, data updation and database integration



gid	id	surveynumb	nameofvill	nameofmuni	landuse	the_geom
1	1401009	165	Melmuri	Malappuram	Residential	
2	1401010	132	Melmuri	Malappuram	Residential	
3	1401011	196	Melmuri	Malappuram	Residential	
4	1401012	196	Melmuri	Malappuram	Residential	
5	1401013	200	Melmuri	Malappuram	Residential	
6	1401014	173	Melmuri	Malappuram	Residential	
7	1401015	183	Melmuri	Malappuram	Residential	
8	1401016	162	Melmuri	Malappuram	Residential	
9	1401017	103	Melmuri	Malappuram	Residential	
10	1401018	104	Melmuri	Malappuram	Residential	
11	1401019	102	Melmuri	Malappuram	Residential	
12	1401020	99	Melmuri	Malappuram	Residential	
13	1401021	99	Melmuri	Malappuram	Residential	
14	1401022	96	Melmuri	Malappuram	Residential	
15	1401023	108	Melmuri	Malappuram	Residential	
16	1401024	119	Melmuri	Malappuram	Residential	
17	1401025	120	Melmuri	Malappuram	Residential	
18	1401026	120	Melmuri	Malappuram	Residential	

Fig. 4.6.3.3 Screen shot of GIS Database and Urban Information System: spatial query (left) and result of spatial query (right)

k) Development of a customized GIS application software
l) Hosting the application in the internet
m) Report and geospatial atlas printing

Digital resource mapping and inventorying Malappuram Municipality was carried out using the modern tools of Geoinformatics. The spatial thematic layer information derived from the World View2 imagery was integrated with the cadastry in 1:4000 scale. The thematic layers were integrated with socio-economic database and were reproduced in WGS-84 Datum and UTM Projection. Hard copy output in A1 size was also provided as Atlas. The output covers the following:

- Cadastral database with survey parcels and attributes survey number with area measurements.
- Existing landuse/landcover information in cadastre scale
- Individual high rise buildings, clustered buildings (agglomerated structures) semi clustered settlements/sparse settlement areas.
- Socio economic data of all the properties linked with spatial data
- Spatial distribution of assets, utilities services, religious institutions and amenities
- The digital output is supplied in interoperable shape file format and mapfile for integration with other spatial and non-spatial data.
- Web enabled Information system
- Atlas and report

The customized application has been hosted in the site address http://210.212.237.67:8080/UIS/

B. K. Jayaprasad

Funding: IKM, Local Self Government Depatment, GoK

5.1 Approach & Methodology for Demarcaton of HTL and LTL for Coastal Regulation Zone

The Coastal Regulation Zone (CRZ) maps are prepared in 1: 25,000 and 1:4000 scales with the Survey of India toposheets and cadastral maps (revenue maps) respectively as bare maps. For policy decisions, CRZ maps in 1: 25,000 scale are sufficient while local level implementation is possible through CRZ maps in 1:4000 scale. The CRZ maps provide a spatial planning framework for coastal zone management. It provides setbacks around sensitive eco-zones restricting development and other activities close to it. Setbacks require specific reference lines and boundaries for its meaningful implementation. The High Tide Line (HTL) forms the cardinal reference line for determining setbacks for CRZ. The 100m, 200m and 500m CRZ lines landward from the HTL are the landward setback lines. The Low Tide Line (LTL) and the Territorial water boundary (12 NM) form the setback lines towards the sea.

High Tide Line & Low Tide Line

High Tide Level is normally defined as the water level at which the highest tide intersects with the vertical plane which is functionally different from the High Tide Line defined in the CRZ notification. According to the functional definition given by Ministry of Environment and Forests (MoEF) in the CRZ notification, the High Tide Line (HTL) is "*the line on the land up to which the highest waterline reaches during the spring tide",* which gives the combined effect of spring tide, wave set up and seasonal shoreline oscillations. LTL is defined as per the conventional Lowest Low Water Line (LLWL).

The NCESS follows the method which uses morphological signatures such as landward (monsoonal) berm crest, seawalls/ revetments/ embankments, permanent vegetation line, tidal flats, mudflats, rocks, headlands and cliffs to identify the HTL. The position of HTL is fixed with respect to identified reference points (GCPs) on the land, at intervals dependent on the coastal morphology. In the cases of estuaries, creeks, backwaters, Ground water points, etc., the upstream limit of tidal influence is determined based on whether salinity is 5 ppt or more. Salinity measurements and indictors like tidal barrages, presence of mangroves, tidal flats and reversal of flow are also used to identify the limit of tidal influence.

Cadastral/revenue maps are geo-referenced with WGS 84 datum and UTM projection using GPS measured GCPs at identified plot junctions, survey stones and other ground features identifiable both on the map and ground. Signature of the nearest HTL is identified and observed using GPS with reference to GCP and transferred to the map in GIS platform. Information from satellite images are used to verify the data collected and also to supplement the data wherever the area is not accessible. With the availability of high GPS and high resolution satellite data like the Quick bird, IKONOS, Cartosat and the Indian Resource Sat(P6) it is now possible to obtain an accuracy of less than 1 m for the demarcation of HTL / LTL. Information on LTL is generated from the hydrographic charts, satellite imagery and limited field mapping. Seaward limit of beach / tidal flat during the fair weather season when the beaches / intertidal zone has the maximum width is considered for identifying the LTL.

The most difficult part in preparing 1:4000 CRZ maps is the transfer of information from imageries to unprojected cadastral maps. This is overcome by using sufficient number of precise reference/control points spread over the entire study area for georeferencing and compartmentalizing the maps. The errors in reproduction of cadastral maps are minimized by taking proper precautions. The errors in georeferencing are controlled by taking precautions through selection of proper field GCPs and identifying the field GCPs in the cadastral as well as satellite images precisely.

Cadastral level CRZ maps prepared for a sector in the Vasai Virar Municipal Corporation are given in Figs. 5.1 and 5.2 respectively.

CRZ reports completed during the year 2013-2014 are listed in Table 5.1.1

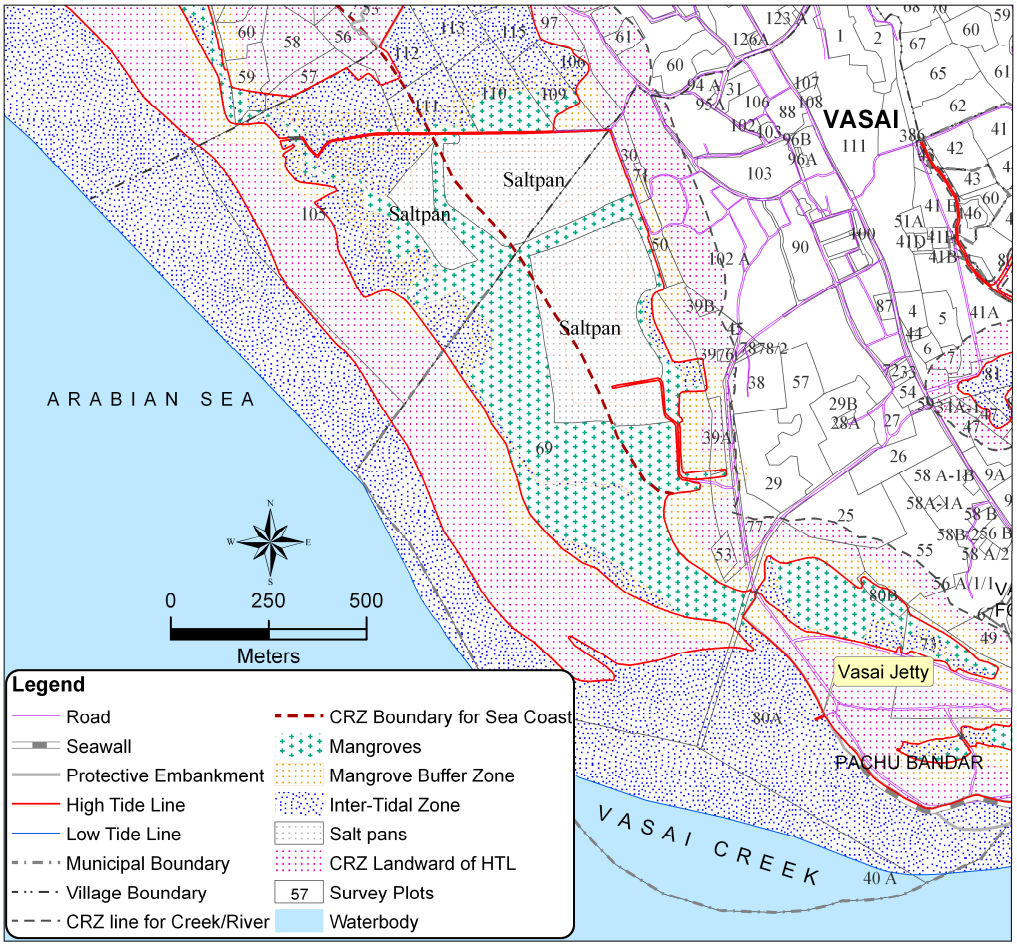


Fig. 5.1.1 CRZ map of Vasai Virar (part) in cadastral scale

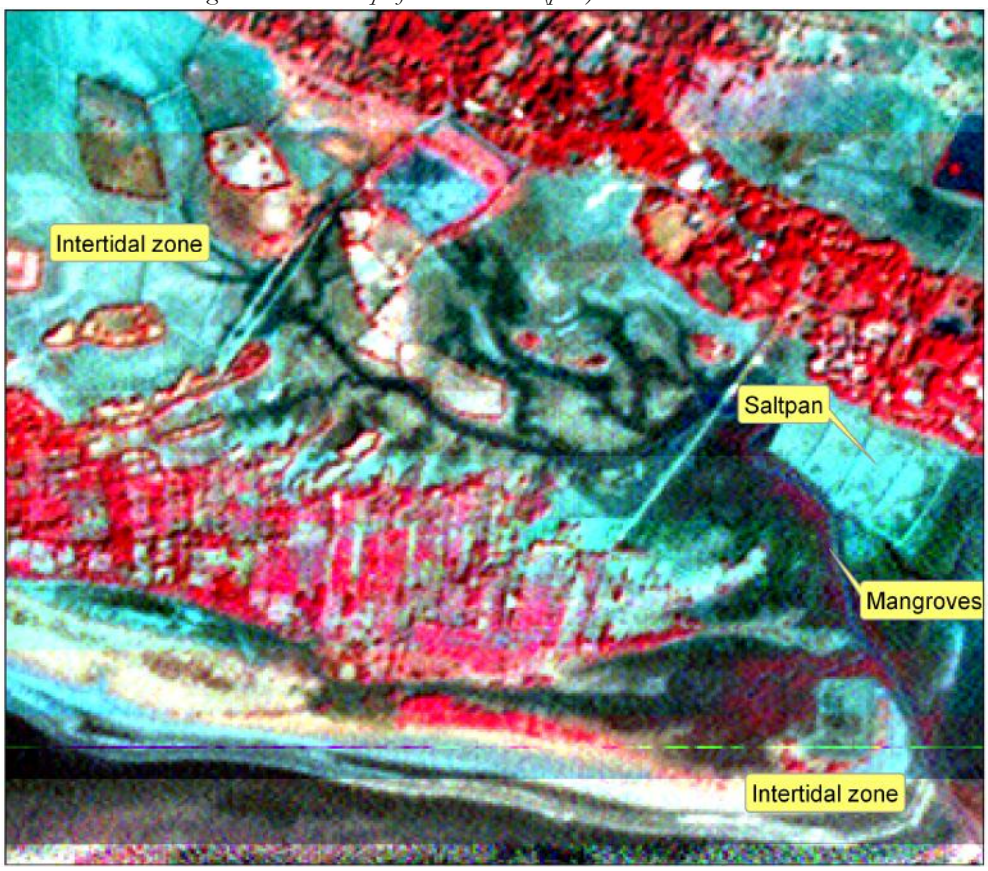


Fig. 5.1.2 FCC of satellite image - IRS P6 of Pachu Bandar area of Vasai-Virar showing different eco zones

Table 5.1.1 List of CRZ Reports completed during the period 2013-14

Sl No	Institution / Agency	Location	Project
1	Vizhinjam International Seaport Ltd., Trivandrum	Thiruvananthapuram	International container terminal at Vizhinjam
2	Central Public Works Dept., Kozhikode	Beypore, Kozhikode	Wharf construction
3	Sunny Field Hotels, Pvt. Ltd	Belapur, Navi Mumbai	Hotel construction
4	M/s. GAIL (India) Ltd	Mandve-Nagaon, Maharashtra	Gas pipeline
5	IREL, Chavara	Neendakara, Kollam	Heavy mineral mining
6	Kerala Sustainable Urban Development Project (KSUDP)	West Kochi, Ernakulam	Pumping station
7	Mahanagar Gas Limited, Mumbai	Bhiwandi & Kharghar creeks and Chena river, Maharashtra	Pipeline crossing
8	Mahanagar Gas Limited, Mumbai	Bandra and Mankhurd, (Mumbai)	Gas filling stations
10	M/s. Joseph P George	Kachore, Maharashtra	Development site
11	Waterline Hotels Pvt. Ltd	Anjangadi, Thrissur	Construction of villas & hotels
12	Kalpatharu Resorts Pvt. Ltd, Kollam	Paravoor, Kollam	Property development
13	M/s. M. Sathyan	Thiruvallam, Thiruvananthapuram	Development site
14	Pancard Clubs, Limited	Vechoor, Alappuzha	Water theme park
15	Daman Hospitality Pvt. Ltd.	Varkund, Nani Daman	Hotel development
16	Focus Maritime & Marine Services Pvt. Ltd	Ranjinoli, Maharashtra	Development site
17	Bharat Oman Refineries Ltd.	Vadinar, Gujarat	Crude oil terminal
18	Gregorian Public School,	Maradu, Ernakulam	School building
19	Korath Gulf Links Builders (P) Ltd.	Elamkulam, Kochi	Building site
20	Ullattil Hospitality Projects Pvt. Ltd.	Chennam-Pallippuram, Alappuzha	Resort development
21	Deedi Resorts Pvt. Ltd & Joys Beach Resorts Pvt. Ltd.	Thirumullavaram, Kollam	Resort development
22	Mahindra Holidays & Resorts India Ltd.	Thekkumbhagam, Kollam	Resort development
23	Shelter constructions Pvt. Ltd.	Thane, Maharashtra	Development site
24	Karuvanthala Resort Pvt. Ltd., Thrissur	Venkitangu, Thrissur	Hotel cum resort development

K. V. Thomas

Funding: Various Agencies

List of Projects

6.1 External Grant-in-aid Projects

Sl. No.	Project Title	Funding Agency	Principal Investigator	Division	Co-Investigators	Project Period	Total Outlay (Rs. in lakh)	Fund received during the year (Rs. in lakh)
1	Landslide stabilization schemes of Agricultural Department (AGRI 3)	Soil Conservation Unit, Dept. of Agriculture	Sri. G. Sankar	Geosciences	---	2009-13	0.19	0.00
2	Kuttanad development – study for preparation of management action plan for eco-restoration of Vembanad lake (AGRI 4)	Agriculture Department	Dr. R. Ajaykumar Varma	Envronmental Sciences	Dr. K. V. Thomas, Dr. D. S. Suresh Babu, Dr. C. N. Mohanan, Sri. B. K . Jayaprasad	2013-14	47.43	47.43
3	Coastal Ocean Monitoring and Prediction System along the coast of Kerala, Karnataka and Lakshad-weep islands (COMAPS 3)	Ministry of Earth Sciences, Govt. of India (through ICMAM)	Dr. K. V. Thomas Dr. R. Ajayakumar Varma	Chemical Sciences	Dr. K. Anoop Krishnan	2008-13	222.50	0.00
4	Sea water quality monitor-ring (COMAPS 4)	Ministry of Earth Sciences, Govt. of India (through ICMAM)	Dr. M. Samsuddin Dr. R. Ajayakumar Varma (Since 19-12-2013)	Chemical Sciences	Dr. K. Anoop Krishnan	---	323.00	105.00
5	Monitoring of water sediment quality parame-ters in the back waters of Cochin Port Trust (CPT 3)	Cochin Port Trust	Dr. P. K. Omana	Chemical Sciences	Dr. K. Anoop Krishnan	2012-17	25.20	4.59
6	Photo dynamic therapy laser design and develop-ment of photo dynamic therapy laser system (DBT 1)	Department of Biotechnology	Dr. N. Subhash	Atmospheric Sciences	---	2011-13	7.00	0.00
7	Inventory of Wetlands of Kerala (DECC 1)	Directorate of Environment & Climate Change	Dr. C. N. Mohanan	Environmental Sciences	Dr. A. Krishnakumar Sri. B. K. Jayaprasad	2011-13	7.61	0.00
8	Impact of sea level rise in Kerala coast (DECC 2)	Directorate of Environment & Climate Change	Dr. T. S. Shahul Hameed	Marine Sciences	Dr. K. V. Thomas (Co-ordinator) Dr. Srikumar Chattopadhyay, Dr. T. N. Prakash, Dr. L. Sheela Nair, Sri. John Paul	2013-16	67.80	30.89
9	Coastal hazard monitoring and early warning (DMD 1)	Revenue Department	Dr. K. V. Thomas	Marine Sciences	---	---	23.22	23.22

10	In-situ bioremediation of land fill pollutants: maximizing the remediation potential of select indegenous and exogeneous microorganism (DST 79)	DST	Smt. K. Deepa Nair	Atmospheric Sciences	---	2013-16	20.00	0.00
11	Geochemistry, paleomag-netism and isotope studies of mafic bodies in the Gwalior, Bijawas and Cud-dapah basins: a synthesis of paleoprotero-zoic large igneous provinces in India (DST 80)	Science and Engineering Research Board	Dr. T. Radhakrishna	Geosciences	Dr. Tomson J. Kallukulam	2013-16	34.20	26.50
12	Environmental studies of the wetland system of Kollam-Neendakara and associated inlands (FPD1)	Fisheries and Port Department	Dr. A. Krishnakumar	Environmental Sciences	Dr. Reji Srinivas, Dr. K. Anoopkrishnan, Dr.Tomson J. Kallukulam	2013-14	8.18	8.18
13	Hazard Vulnerability and Risk Assessment of the State as part of preparing disaster management plan for the state.(HVRA)	Revenue Department	Sri. G. Sankar	Geosciences	---	2011-13	4.56	3.11
14	Creation of a model GIS database for Malappuram Municipality under Spatial Urban Information System (IKM)	Information Kerala Mission	Sri. B. K. Jayaprasad	Central Geomatics Lab	---	2012-13	3.62	0.00
15	Study on depletion of heavy mineral content in the beach washings of IREL, Chavara (IRE 3)	Indian Rare Earths Ltd., Chavara	Dr. T. S .Shahul Hameed (Since 1-1.2011)	Marine Sciences	Dr. N. P. Kurian, Dr. L. Sheela Nair Dr. T. N. Prakash Dr. K. V. Thomas Dr. Reji Srinivas	2010-13	49.00	0.00
16	Generation of Geographic Information System of five particularly vulnerable tribal groups (PTG's) (KIRTADS)	KIRTADS	Dr. Archana M. Nair	Central Geomatics Lab	Sri. B. K. Jayaprasad	2010-13	1.86	0.00
17	Generation of tribal information system for Mannan & Urali commun-ication for KIRTADS (KIRTADS 2)	KIRTADS	Dr. Archana M Nair	Central Geomatics Lab	Sri. B. K. Jayaprasad	2012-13	1.47	0.00

18	Sediment budgeting studies for the mining site of Kerala minerals and metals ltd. Chavara (KMML 1)	Kerala Minerals and Metals Limited, Chavara	Dr. T. S. Shahul Hameed	Marine Sciences	Dr. K. V. Thomas Dr. N. P. Kurian Dr. L. Sheela Nair Dr. T. N. Prakash	2010-13	39.50	3.83
19	Cadastral scale CRZ maps for Urban areas in Kerala; Phase 1-Kozhikode, Kollam & Trivandrum Corporations and Varkala Municipality (KSCS 6)	KSCSTE	Dr. K. V. Thomas	Marine Sciences	Sri. D. Raju, Sri. S. Mohanan, Sri. M. Rameshkumar	2006-13	6.99	0.00
20	Cadastral scale CRZ Maps for urban areas in Kerala: Phase 2-Kochi Corporation, Maradu & Kanhangad Muncipalities (KSCS 17)	KSCSTE	Dr. K. V. Thomas	Marine Sciences	Sri. D. Raju, Sri. S. Mohanan, Sri. M. Ramesh Kumar Sri. M. K. Sreeraj Sri. M. K. Rafeeque	2011-14	25.00	0.00
21	Sea level Changes and its Impacts (KSCS 18)	KSCSTE	Dr. K. V. Thomas	Marine Sciences	Dr. T. S. Shahul Hameed	2011-16	81.54	3.89
22	Landuse/ land cover changes as linked to climate changes in Kerala (KSCS 19)	KSCSTE	Dr. Srikumar Chattopadhyay	Resources Analysis	Dr. Mahamaya Chattopadhyay, Dr. P. V. S. S. K. Vinayak, Sri. C. K. Sasidharan	2011-14	34.48	11.69
23	Solar UV-B radiation and atmospheric trace constituents measurements (KSCS 20)	KSCSTE	Dr. G. Mohan Kumar	Atmospheric Sciences	Dr. E. J. Zachariah	2011-14	23.19	3.12
24	Monitoring global changes impacts in Sahyadri (Western Ghats) (KSCS 21)	KSCSTE	Dr. C. N. Mohanan	Environmental Sciences	Dr. A. Krishna Kumar Sri. B. K. Jayaprasad	2011-14	63.46	38.18
25	Greenhouse gases monitorring (KSCS 22)	KSCSTE	Dr. E. J. Zachariya	Atmospheric Sciences	Sri. C. K. Sasidharan	2011-14	36.90	18.70
26	Geomorphic evolution and terrain characteristics: a case study of the Achankovil River Basin, Kerala (KSCS 23)	KSCSTE	Dr. Mahamaya Chattopadhyay	Resources Analysis	Dr. K. Raju	2011-13	7.86	4.00
27	Paleoclimate and sea level records in the late quaternary sediments of coastal wetlands of Pallickal and Achankovil river basins, Kerala-its implications on coastal evolution (KSCS 24)	KSCSTE	Dr. D. Padmalal	Environmental Sciences	Dr. K. Maya	2011-13	10.54	2.60

28	Modelling Atmospheric Pollution & Netwroking (MAPAN)	Indian Institute of Tropical Meterology	Dr. V. Muralidharan Dr. E. J. Zachariah (Since 31.10.2013)	Atmospheric Sciences	---	2013-17	20.32	4.84
29	Monitoring Indian Shield Seismicity with 10 BBS to understand seismotectonics of the region using V-sat connectivity (MoES 5)	Ministry of Earth Sciences, Govt. of India	Srikumari Kesavan (Since 26-07-2011)	Geosciences	---	2010-13	13.93	3.59
30	Establishment and maintenance of wave guage stations in the coastal waters of the southwest coast of India (MoES 6)	Ministry of Earth Sciences, Govt. of India	Dr. L. Sheela Nair	Marine Sciences	Dr. T. S. Shahul Hameed Dr. N. P. Kurian Dr. K. V. Thomas	2010-13	27.18	1.50
31	Paleo fluids in the petroliferous basins of Western Offshore India (MoES7)	Ministry of Earth Sciences, Govt. of India	Dr. V. Nandakumar	Geosciences	Dr. K. Narendra Babu	2011-14	265.67	13.68
32	Heavy mineral chemistry in different source rocks and coastal sediments of SW coast of India: understanding provenance and processes in Placer deposit formation (MoES 8)	Minisry of Earth Sciences, Govt. of India	Dr. G. R. Ravindra Kumar	Geosciences	Dr. T. N. Prakash	2012-15	18.36	0.00
33	Establishment and maintenance of wave guage stations along the southwest coast of India (MoES 9)	INCOIS, MoES, Govt. of India	Dr. L. Sheela Nair	Marine Sciences	Dr. Reji Srinivas Dr. T. S. Shahul Hameed	2013-17	98.49	27.71
34	Shoreline mapping for west coast of India (MoES 10)	ICMAM, MoES, Govt. of India	Dr. K. V. Thomas	Marine Sciences	Dr. T. S. Shahul Hameed	2013-18	190.00	29.20
35	Research on soil piping in the high-lands and foot-hill of Kerala to avoid the disaster (NDMA 1)	National Disaster Management Authority	Sri. G. Sankar	Geosciences	Dr. R. Ajayakumar Varma, Dr. Sekhar L. Kuriakose (HVRA Cell), K. Eldhose	2012-15	49.73	0.00
36	Application of Space Technology for the development of Kerala (PLG 13)	Kerala State Planning Board	Sri. V. N. Neelakandan	Central Geomatics Lab	Mr. B. K. Jayaprasad	2008-13	12.62	0.00
37	River bank mapping (RBM 1)	Revenue Department, Govt. of Kerala	Dr. Srikumar Chattopadhyay	Resources Analysis	Mr. John Mathai	2011-13	5.40	0.71
38	River bank mapping of Ithikkara river (RBM 2)	Revenue Department, Govt. of Kerala	Dr. Srikumar Chattopadhyay	Resources Analysis	Mr. John Mathai, Dr. Mahamaya Chattopadhyay	2011-13	4.89	2.88
39	GIS map preparation and hard copy generation for Chalakkudi & Kabani river (RBM3)	Revenue Department, Govt. of Kerala	Sri. B. K. Jayaprasad	Central Geomatics Lab	Dr. K. Raju, Dr. Archana M. Nair	2012-13	5.54	0.00

40	River sand auditing-Periyar (RSA 1)	Revenue Department, Govt. of Kerala	Dr. D. Padmalal	Environmental Sciences	Dr. K. Maya	2009-13	24.66	0.00
41	Sand auditing of Rivers (Manimala, Periyar & Muvattupuzha) in the Idukki district (RSA 3)	Revenue Department	Dr. D. Padmalal	Environmental Sciences	Dr. K. Maya	2012-13	9.84	0.00
42	Soil based plant nutrient management plan for agro ecological zones (SPB 2)	State Planning Board	Sri. B .K. Jayaprsad	Central Geomatics Lab	---	2010-13	13.6	0.00
43	Updating Natural Resource and Environment Data Base Covering Coastal AEZ (SPB-3)	State Planning Board, Govt. of Kerala	Sri. B. K. Jayaprasad	Central Geomatics Lab	---	2012-13	8.00	0.00
44	Physical, chemical & biological monitoring study at dredging site in Vembanad lake (TCL 2)	Travancore Cements Ltd.	Dr. P. K. Omana	Chemical Sciences	---	2008-13	1.15	0.57
45	Conservation and nourishment of beaches of selected tourism locations of Kerala (TD 2)	Dept. of Tourism, Govt. of Kerala	Dr. K. V. Thomas	Marine Sciences	---	2006-13	20.04	0.00
46	Preparation of Integrated Island Management Plans for Agatti and Chetlat Islands U. T. of Lakshd-weep (UTL-6)	UT of Lakshadweep	Dr. T. N. Prakash	Marine Sciences	Dr. K. V. Thomas Sri. D. Raju	2011-13	45.33	0.00
47	GPS facilitation, GIS mapping & customization for soil mapping and soil nutrient management plan preparation (VFPCK)	Vegetable and Fruit Promotion Council Keralam	Sri. B. K. Jayaprasad	Central Geomatics Lab	Dr. Archana M. Nair	2011-13	11.08	0.00

6.2 Consultancy Projects

Sl. No.	Project Title	Funding Agency	Division	Project Period	Total Outlay (Rs.in lakh)	Fund Received during the year (Rs.in lakh)
1.	Delineation of HTL/ LTL and prepation of CRZ Status Report	Vizhinjam International Sea Port Ltd., Trivandrum	Marine Sciences	2013-14	3.45	0.00
2.	-do-	Karuvanthala Resort Pvt. Ltd, Thrissur	Marine Sciences	2013-14	3.15	0.00
3.	-do-	Sunny Field Hotels, Pvt. Ltd	Marine Sciences	2013-14	9.00	
4.	-do-	M/s. M. Sathyan , Thiruvallam, Trivandrum	Marine Sciences	2013-14	1.32	0.00
5.	-do-	Deedi Resorts Pvt. Ltd. & Joys Beach Resorts Pvt. Ltd.	Marine Sciences	2013-14	2.25	2.25
6.	-do-	GAIL (India) Ltd.	Marine Sciences	2013-14	15.00	0.00
7.	-do-	Kerala Sustainable Urban Development Project (KSUDP)	Marine Sciences	2013-14	3.15	0.00
8.	-do-	Mahindra Holidays & Resorts India Ltd.	Marine Sciences	2013-14	1.32	0.00
9.	-do-	Joseph P. George	Marine Sciences	2013-14	4.05	0.00
10.	-do-	Waterline Hotels Pvt. Ltd.	Marine Sciences	2013-14	3.15	0.00
11.	-do-	Kalpatharu Resorts Pvt. Ltd., Kollam	Marine Sciences	2013-14	1.50	0.00
12.	-do-	IREL, Chavara	Marine Sciences	2013-14	4.35	2.17
13.	-do-	Mira Bhyandar Municipal Corporation	Marine Sciences	2013-14	1.56	0.00
14.	-do-	CZMP Thane – Sindhudurg	Marine Sciences	2013-14	147.74	35.60
15.	-do-	CZMP Vasai- Virar Municipal Corporation	Marine Sciences	2013-14	30.00	0.00
16.	-do-	Pancard Clubs, Ltd.	Marine Sciences	2013-14	3.60	3.60
17.	-do-	Daman Hospitality Pvt. Ltd.	Marine Sciences	2013-14	7.65	7.65
18.	-do-	Focus Maritime & Marine Services Pvt. Ltd.	Marine Sciences	2013-14	8.10	8.10
19.	-do-	Bharat Oman Refineries Ltd.	Marine Sciences	2013-14	8.40	8.40
20.	-do-	Gregorian Public School, Maradu	Marine Sciences	2013-14	2.93	2.92

21.	-do-	Korath Gulf Links Builders (P) Ltd.	Marine Sciences	2013-14	3.15	3.15
22.	-do-	Ullattil Hospitality Projects Pvt. Ltd.	Marine Sciences	2013-14	3.60	3.60
23.	-do-	Ansal Buildwell Ltd., Vechoor, Kottayam	Marine Sciences	2013-14	3.60	3.60
24.	-do-	UKN Properties Pvt. Ltd., Kozhikode	Marine Sciences	2013-14	3.15	3.15
25.	-do-	Mahanagar Gas Limited, Mumbai	Marine Sciences	2013-14	7.65	6.88
26.	-do-	IL & FS Palghar, Thane	Marine Sciences	2013-14	15.00	15.00
27.	-do-	Orange Country, Bangalore	Marine Sciences	2013-14	3.68	0.00
28.	-do-	Shelter Constructions Pvt. Ltd.	Marine Sciences	2013-14	15.00	15.00
29.	-do-	Central Public Works Dept., Calicut	Marine Sciences	2013-14	2.40	2.40
30.	-do-	Shrivawala Estate Developers Ltd.	Marine Sciences	2013-14	4.05	4.05
31.	-do-	Adani Petronet (Dahej)	Marine Sciences	2013-14	20.25	20.25
32.	-do-	Hazira Infrastructure, Adani House	Marine Sciences	2013-14	8.10	8.10
33.	-do-	Vaswani Resort Pvt. Ltd.	Marine Sciences	2013-14	7.65	7.65
34.	-do-	Hi-Rise Builders-Developers Thalassery, Kannur	Marine Sciences	2013-14	3.15	3.15
35.	-do-	Cochin Port Trust , Cochin	Marine Sciences	2013-14	15.00	7.50
36.	-do-	Harbour Engineering Department Chilakkoor, Varkala	Marine Sciences	2013-14	1.05	1.05
37.	-do-	NHAI – Vadodara – Mumbai Express Way	Marine Sciences	2013-14	6.18	3.09
38.	-do-	Joshua Generation Ministries Trust, Ernakulam	Marine Sciences	2013-14	3.45	3.45
39.	-do-	CMFRI, Vizhinjam	Marine Sciences	2013-14	0.67	0.67
40.	-do-	Mighty group, Montana Developers Pvt. Ltd., Mumbai	Marine Sciences	2013-14	8.40	8.40

6.3 Plan Projects

Project Code	Project Title	Principal Investigator	Division	Co-investigators	Period	Total outlay (Rs. in lakh)	Expenditure during the year (Rs. in lakh)
PLAN 234	Measurement of cloud parameters and cloud modeling	Dr. E. J. Zachariya	Atmospheric Sciences	---	2005-14	187.37	3.96
PLAN 266	Quaternary evolution of the coastal plains of southern Kerala	Sri. P. John Paul	Marine Sciences	---	2007-14	36.50	0.55
PLAN 270.	Water, sediment quality monitoring and assessment of estuaries of Kerala: a case study from Kochi estuary and Periyar River	Dr. P. K. Omana	Chemical Sciences	---	2008-14	10.87	1.05
PLAN 274.	Kerala Resources Information System & Services (KRISS)	Dr. M. Samsuddin	Central Geomatics Lab	---	2009-14	102.00	2.55
PLAN 282	Graphitization process in Kollam District, Kerala	Dr. Ansom Sebastian	Training & Extension	---	2010-13	4.49	1.59
PLAN 283	Valley formation and geomorphic processes under tropical wet and dry climate: examples from Kerala	Dr. Mahamaya Chattopadhyay	Resources Analysis	Smt. C. Sakunthala	2011-14	3.13	4.38
PLAN 284	Land system analysis of Kabani river basin	Dr. Srikumar Chattopadhyay	Resources Analysis	---	2011-13	2.44	2.26
PLAN 285	Appraisal of drinking water potential of springs in the Pathanamthitta, Kottayam and Idukki districts of Kerala	Dr. K. Anoop Krishnan	Chemical Sciences	Dr. A. Krishnakumar	2011-13	2.83	1.31
PLAN 286	Study on the environmental effects of human interventions in the Periyar river basin: Central Kerala	Dr. K. Maya	Environmental Sciences	Dr. D. Padmalal	2011-14	2.30	3.66
PLAN 287	Long- term environmental and socio-economic impacts of landslides: a study in selected parts of the western Ghats region in Kerala	Dr. K. Raju	Training & Extension	Sri. G. Sankar	2012-15	9.65	2.69
PLAN 288	Hydrological modeling of Greater Cochin urban agglomerate in the context of Sustainable Urban Water Resource Development (SUWRD)	Dr. Archana M. Nair	Central Geomatics Lab	Dr. Reji Srinivas Dr. A. Krishnakumar	2012-15	21.23	1.34
PLAN 289	Assessing the biotic and abiotic stress through chlorophyll fluorescence and reflectance in tropical root and tuber crops	Dr. N. Subhash	Atmospheric Sciences	Dr. C. N. Mohanan	2012-13	5.8	0.56

6.4 R & D Plan Laboratory Infrastructure Projects

Project Code	Project Title	Coordinator	Division	Expenditure during the year (Rs. in lakh)
PLAN 101	XRF Facility	Dr. G. R. Ravindra Kumar (SIC)	Geosciences	8.61
PLAN 102	Upgradation of Geosciences laboratories	Head - GSD	Geosciences	16.10
PLAN 103	Strengthening of Ecological Laboratory	Head - ESD	Environmental Sciences	4.46
PLAN 104	Upgradation of Atmospheric Sciences Laboratories	Head - ASD	Atmospheric Sciences	9.93
PLAN 105	Upgradation of Chemical Laboratory	Head - CSD	Chemical Sciences	9.22
PLAN 106	Upgradation of Library Facilities	Librarian	Training & Extension	5.51
PLAN 107	Publication of monographs / memoirs / annual report/newsletter	Director	Publication Committee	2.40
PLAN 108	Outreach/ training / extension /exhibition/LAN and other technical facilities	Head - TED	Training & Extension	5.20
PLAN 110	Seminars/workshops/meetings	Director	---	1.58
PLAN 111	Marine Laboratory Infrastructure Development	Head - MSD	Marine Sciences	27.69
PLAN 112	Geomatics Laboratory Infrastructure Development	Head - CGL	Central Gemoatics Lab	9.13
PLAN 117	Upgradation & Maintenance of CESS LAN	Director	Central Geomatics Lab	2.17
PLAN 118	Development of Laboratory for Resource Analysis Division	Head - RAD	Resources Analysis	2.62
PLAN 100	Research & Development general expenditure	Director	---	102.17

6.5 R & D Plan Building Infrastructure Projects

Project Code	Project Title	Co-ordinator	Expenditure during the year (Rs.in lakh)
PLAN 120	Upgradation of centralized air conditioning & facilities of CESS buildings	Registrar	3.17
PLAN 158	Estate Development	Registrar	0.27
PLAN 166	Campus Greening	Chairman, Campus Green Committee	1.29

Honours, Awards & Academic Activities

7.1 Honours & Awards

Mr. Udayakumar P. has been awarded Ph. D. Degree under the Faculty of Environmental Sciences, Cochin University of Science and Technology for his thesis 'Assessment of Heavy Metals in the Environmental Compartments of the Central and Northern coast of Kerala, India'. Dr. P. P. Ouseph, Scientist F (Rtd.), Chemical Sciences Division was his supervising guide.

Mrs. Vandana M., Project Fellow, Resources Analysis Division has secured the Young Geographer Award for the paper ' Exploring nexus between poverty and environmental degradation to plan for sustainable development' at IIG Meet at University of Burdwan, West Bengal during 11-13 November, 2013.

Mr. Shaji Johnson, Research Scholar, Resources Anlysis Division has secured the Young Geographer Award for the paper ' Coastal Vulnerability Assessment: A case study of Thiruvananthapuram, west coast of India' at NAGI Meet, Chennai during 12-14 December, 2013.

7.2 Membership in Committees

Dr. A. Krishnakumar

Member, Expert Committee for the scientific study of Athani Quarry, constituted by the District Collector, Wayanad.

Member, Expert Committee constituted by the District Collector, Malppuram for studies on environment and water flow in the site proposed for the construction of hospital in the Kottakkal village, Tirur taluk of Malappuram district.

Dr. C. N. Mohanan

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

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

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

Member of the State Level Committee to assess the feasibility of construction of biowall instead of sea wall in the coastal areas by the State Biodiversity Board.

Member of the State Level Committee to assess the impact of conversion of paddy land for the expansion of BPCL project and Petrochemical unit of State Biodiversity Board.

Member of the State level committee to assess the impact of conversion of paddy land in Thrikkakara north and Aluva west villages, Ernakulam district by the State Biodiversity Board.

Dr. E. J. Zachariah

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

Dr. G. R. Ravindra Kumar

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

Dr. K. V. Thomas

Member, Project Advisory Committee of INCOIS, Hyderabad.

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

Member, KCZMA Sub-committees to look into various CRZ issues implementation, policies, violations and reports.

Member, Lakshadweep Coastal Zone Management Authority.

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

Dr. N. P. Kurian

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

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

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

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

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

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

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

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

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

Dr. R. Ajayakumar Varma

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

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

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

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

Member, Task Force on Greening Rural Development constituted by the Ministry of Rural Development, Govt. of India.

Member, Management Committee of Centre State Technology Transfer Institute.

Dr. T N Prakash

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

Convenor of the Research Committee of CUSAT, member of the Permanent Doctoral Committee of Geography, constituted by the University of Kerala.

Dr. T. Radhakrishna

Member, Evaluation of the UGC-Kothari PDF applications.

Member, MoES representative for a JRF interview at PSG Institute Coimbatore.

Member, Selection Committee for the post of Associate Professor of the Indian Institute of Geomagnetism, Mumbai.

Member, UNESCO-IGCP 597 National Working Group.

Member, Assessment Committee of Scientific and Technical personnel of Indian Institute of Geomagnetism, Mumbai

Sri. G. Sankar

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

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

Member, Expert Committe for making recommendations in the modernisation of Kerala Foresr Department, Govt. of Kerala.

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

Member, Expert Committee constituted by the State government as well as the Ministry of Earth Sciences to

suggest immediate mitigation measures to mitigate Varkala Cliff Vulnerability.

Convenor, DST PAC meeting at CESS during February 20-22, 2014.

Sri. John Mathai

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

Member, Expert committee for the formulation of Scientific Mining Policy of Kerala State.

Member, Technical Committee, Disaster Management - Mullaperiyar Dam, Govt. of Kerala.

Sri. V. Muralidharan

Secretary, ISRS-Tvpm Chapter and EC Member, IMS-Tvpm Chapter.

Sri. P. Sudeep

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

7.3 Visits Abroad

Dhanya, V (UGC-SRF) completed three months stay in Germany in connection with Green Talents Programme, funded by Federal Ministry of Education and Research (BMBF). During the period, a working paper titled 'Towards decentralised watershed management in Kerala, India, micro-watersheds as new political scales of management' has been prepared. A research proposal on 'Public participation in the context of multi-level water governance in Kerala and Germany - A comparative perspective' has been proposed to avail 'German Chancellors Fellowship' from Alexander von Humboldt Foundation.

7.4 Ph. D Students

Name of Research Scholar	Title of the thesis	Guide	University
Arjun S.	Numerical modelling of tides and coastal flooding	Dr. N. P. Kurian	CUSAT
Anu Baburaj	Fluorescence imaging of corals	Dr. N. Subhash	CUSAT
Balakrishnan M.	Landuse/land cover change and its implication on mountain ecosystem – a case study in parts of Southern Sahyadri	Dr. Srikumar Chattopadhyay	Kerala
Dhanya V.	Environmental resource management in Achancovil river basin- a watershed based approach	Dr. Srikumar Chattopadhyay	Kerala
Divya V.	Ecological studies along elevational gradients in a transect in southern Western Ghats, with special reference to forest soil	Dr. C. N. Mohanan	Kerala
Hema C. Nair	Water quality and drinking water potential of the ground water resources of Kallada and Ithikkara river basin Kerala, SW India	Dr. D. Padmalal	CUSAT
Noujas V.	Numerical modelling studies on coastal hydrodynamics and sediment transport regime of the Central Kerala Coast	Dr. N. P. Kurian	CUSAT
Prabitha V. G.	Early detection of tissue abnormalities by optical imaging	Dr. N. Subhash	Kerala
Prasanth C. S.	Fluorescence monitoring of periodontal bacteria and treatment of periodontal infections by photodynamic therapy	Dr. N. Subhash	Kerala
Prasad R.	Sediment dynamics in coastal waters	Dr. N. P. Kurian	CUSAT
Praveen M. N.	Geological aspects of the eastern part of betal belt, Central Indian tectonic zone	Dr. G. R. Ravindra Kumar	CUSAT
Raji S. Nair	Multi spectral imaging	Dr. N. Subhash	Kerala
Ranikrishna L.	Tropical freshwater myristica swamps of Kerala and its ecological and evolutionary significance	Dr. C. N. Mohanan	Kerala
Silpa. B. L.	Morphodynamics of the Beaches of varying energy regimes of Kerala Coast	Dr. Reji Srinivas	CUSAT
Sreejith C. S.	Evolution of the lower crust in the neo-proterozoic Kerala Kohndalite Belt (KKB) southern India: petrological and geochemical constraints and implications for Gondwana assembly	Dr. G. R. Ravindra Kumar	Kerala
Sreekanth T. S.	Characterization of tropical rain fall in terms of drop size distribution at surface, its variation with altitude and comparison of rain rates with satellite measurements	Dr. G. Mohan Kumar	Kerala
Tiju I. Varghese	Beach and estuarine evolution of Kollam coast during Holocene	Dr. T. N. Prakash	CUSAT
Vandana M.	Land system analysis of Kabani river basin	Dr. Srikumar Chattopadhyay	Kerala
Vishnu Mohan S.	Quaternary geology of the coastal lowlands of Southern Kerala, SW India	Dr. D. Padmalal	CUSAT
Aparna G Nair	Solar UV-B insolation and atmospheric trace gases at ground: comparison with satellite data in climate change scenario	Dr. G. Mohankumar	Kerala
Ganapathy	Impact of human activities in the generation of land disturbances in humid tropical highland areas- a case study in Idukki district, Kerala	Dr. K. Raju	Kerala
Ragi P. N.	Causes and impacts of landslides in Panamaram and Mananthavadi watersheds of Kabani river basin, Kerala	Dr. K. Raju	Kerala
Sheikha E. John	Mining and quarrying in the river catchments of Central Kerala around Kochi city, SW India- consequences and sustainable development strategies	Dr. K. Maya	Kerala
Arun Lal	Geofluids within the sedimentary basins of Western Offshore, India	Dr. V.Nandakumar	Kerala
Soumya G. S.	Lithosperic Processes (Neoproterozoic Anthrosites in South India, a comparative study to delineste petrogenesis and India's position in Rodinia Assembly)	Dr. T. Radhakrishna	Kerala
Shaji J.	Coastal zone management: a case study of Thiruvananthapuram coast	Dr. Srikumar Chattopadhyay	Kerala
Unnikrishnan U.	Common Property Resource (CPR) Management in the lowlands of Thiruvananthapuram district with special reference to surface water resource	Dr. Srikumar Chattopadhyay	Kerala

Jayalekshmy S. S	Urbanization trend of Kerala over a period of 1961-2011.	Dr. Srikumar Chattopadyay	Kerala
Revathy Das	Integrated geoenvironmental studies of the locustraine wetlands of Kerala in climate change paredigms for conservation and management.	Dr. A Krishnakumar	Kerala
Viswadas V.	Studies on hydrogeochemical & hydrological aspects of various streaming Karamana river near Sree Parasuramaswamy Temple, Thiruvallam, Thiruvananthapuram district, Southern India	Dr. K. Anoop Krishnan	Kerala
Mereena C. S	Inland waterways of Kerala: a geographical and economical analysis of west coast canal	Dr. Srikumar Chattopadhyay/ Dr.K. Raju (Co-guide)	Kerala
Jobish E. A.	Coastal zone management: A case study of Eranakulam coast	Dr. K.Raju	Kerala

7.5 Post Graduate Studentship Programme

CESS supports post graduate students by awarding studentships, to improve research aptitude among students in different areas of Earth Sciences. During the academic year 2013-14, 69 applications were received from meritorious students from different parts of Kerala and nine of them were awarded studentship of Rs. 2000/- month during the period of their P.G. dissertation work in CESS. The details of students who were awarded the studentship are given in the table below:

Sl. No.	Name of Student	Affiliation	Topic of Dissertation	Supervisor
1	Mahesh Ravi Babu G.	Adikavi Nannaya University	An approach to the field measurements and laboratory techniques for the analysis of sediment samples along the Kerala coast, SW India	Dr. T. N. Prakash
2	HarshaVardhan	Adikavi Nannaya University	Disaster management strategies for landsubsidence due to soil piping- a case study in Western Ghats, South India	Sri. G. Sankar
3	Vasudha K. M.	Adikavi Nannaya University	Geological aspects of soil piping in Idukki district in Kerala	Sri. G. Sankar
4	Aiswarya Philip	Kerala University	A study on wetland depletion due to urbanization in Thiruvananthapuram Corporation using Remote Sensing	Sri. B. K. Jayaprasad
5	Neenu S. Kumar	Kerala University	Revival of Kanjirakode Kayal: A GIS Approach	Dr. K. Raju
6	Aswathy U. S.	Kerala University	Adsorptive removal of Pb (II) from aqueous solution using TiO_2 nanoparticles: Kinetic and equilibrium modelling	Dr. K. Anoop Krishnan
7	AryaVijayan	Kerala University	Removal of orange G from aqueous solution using ragi husk: Batch adsorption studies	Dr. K. Anoop Krishnan
8	Anupama T.	Kannur University	Water Quality of Periyar river in and around Kochi Metro, Kerala, India	Dr. K. Maya
9	Reena Thomas	Kannur University	Hydrogeochemistry of Kumbalathu and Kanjirakkottu Kayals, Kollam, Kerala	Dr. A. Krishnakumar

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

Name of Student	Affiliation	Topic of Dissertation	Supervisor
Gembali Dinesh	Adikavi Nannaya University	Neogene stratigraphy and sedimentology of southern Kerala, SW India	Dr. D. Padmalal
Ravi Kiran D.	Adikavi Nannaya University	Quaternary geology and geomorphic evolution of Paravur basin, Kerala, SW India	Dr. D. Padmalal
Famiza N. M.	Adikavi Nannaya University	Texture and heavy mineralogy of the sediments of Mogral river and adjoining beach environments, Kerala, India	Dr. D. Padmalal
Soorya K. V.	Kannur University	Chemical characterization of some selected borehole core sediments from the coastal lands of southern Kerala, India	Dr. D. Padmalal
Narendra Reddy B.	Adikavi Nannaya University	An approach to the field measurements and laboratory techniques for the analysis of sediment samples along the Kerala coast, SW India	Dr. T. N. Prakash
Sujatha G.	Adikavi Nannaya University	Surface water chemistry, geochemistry and influence on groundwater quality: a comparative study of Chavara Kayal with Ashtamudi lake, Kollam, Kerala, SW India	Dr. A. Krishnakumar
Jayanthi N. B. S. T. Sundari	Adikavi Nannaya University	Hydrogeochemical studies of Ashtamudi Wetland System, Kollam, Kerala, SW coast of India	Dr. A. Krishnakumar
Gopika B. S.	Kerala Unversity	Hydrogeochemical studies of Kureepuzha and Kandachira Kayals of Ashtamudi Wetland System, Kollam, Kerala	Dr. A. Krishnakumar
Maya T. K.	Kannur University	Transfer of nutrients and some selected cations through Periyar river, Kerala, India	Dr. K. Maya
Anupama V. T.	Kannur University	Water quality of Periyar river in and around Kochi Metro, Kerala, India	Dr. K. Maya
Shashirekha N.	Kannur University	Kinetic and isotherm profile of congo red adsorption onto TiO_2 nano powder	Dr. K. Anoop Krishnan
Jiffin Sam	Kerala Unversity	Hydrogeochemical candidature of marine ecosystemin and around the coastal waters of Kochi Barmouth	Dr. K. Anoop Krishnan
Sai Sree	Kerala Unversity	Appraisal of hydro and geochemical aspects of coastal regions of Kavaratti Island, India	Dr. K. Anoop Krishnan
Anitha Ravi	Central University of Karnataka	Forest degradation of Neyyar catchment area-using Remote Sensing and GIS	Shri. B. K. Jayaprasad
Divya D. S.	Central University of Karnataka	Morphometric studies of Pamba river basin using Remote Sensing and GIS	Shri. B. K. Jayaprasad
Chandana K.	Adikavi Nannaya University	Sedimentological and Minerological studies of a sedimentary formation-Karichal Cliff, Kerala, South India	Dr. Reji Srinivas
Revathi B.			
Saranya U.			
Tanuja P.			
Beenu Ravi	Kerala University	Treshhold of natural spring in Amayizhanjan Basin	Dr. Reji Srinivas

7.7 Internship / Summer Training

Sl. No	Name of Student	Name of Institution	Name of Supervising Scientist
1.	Aswani A. S.	Dept. of Geology Anna University, Chennai	Dr. T. N. Prakash
2.	Anu Baby	Visvesvaraya NIT, Nagpur	Dr. R. AjaykumarVarma
3.	Arya P. V.	Visvesvaraya NIT, Nagpur	Dr. R. AjaykumarVarma
4.	Jilu Susan John	Visvesvaraya NIT, Nagpur	Dr. R. AjaykumarVarma
5.	Priyanka Mariam Thomas	Visvesvaraya NIT, Nagpur	Dr. R. AjaykumarVarma
6.	Rosa Ephrem	Visvesvaraya NIT, Nagpur	Dr. R. AjaykumarVarma
7.	Sonu G. Kumar	Visvesvaraya NIT, Nagpur	Dr. R. AjaykumarVarma
8.	Parvathy K. G.	NIT, Surathkal, Karnataka	Dr. K. V. Thomas
9.	Aswini G. S.	Mar Baselios College of Engineering and Technolgy, Trivandrum	Shri. B. K. Jayaprasad
10.	Christy J. Panicker	Mar Baselios College of Engineering and Technolgy, Trivandrum	Shri. B. K. Jayaprasad
11.	AparanaVelayudhan	Mar Baselios College of Engineering and Technolgy, Trivandrum	Shri. B. K. Jayaprasad
12.	Aswathy T. A.	Government Engineering College, Thrissur	Shri. B. K. Jayaprasad
13.	AswathyVijayakumar K.	Government Engineering College, Thrissur	Shri. B. K. Jayaprasad
14.	FathimaHesna M. S.	Government Engineering College, Thrissur	Shri. B. K. Jayaprasad
15.	Monajitha A. S.	Government Engineering College, Thrissur	Shri. B. K. Jayaprasad
16.	Nima K. N.	Government Engineering College, Thrissur	Shri. B. K. Jayaprasad
17.	Sheeba L.	Regional Centre, Anna University,Tirunelveli	Shri. B. K. Jayaprasad
18.	Rebekah S.	Regional Centre, Anna University,Tirunelveli	Shri. B. K. Jayaprasad

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Fig. 8. 1 A screen shot of the Online Public Acess Catalogue (OPAC) software in NCESS Library

Acquisition policy of the library is in tune with the ongoing programs of the centre. The major services provided by library are Reference Service, Document Delivery Service, Membership, Reprint Service, Internet access to electronic full-text journals, Article Alert, e-mail alert, Special access arrangements, and Online Public Access Catalogue (OPAC) to users. Library provides Inter Library Resource Sharing facilities with a number of major R&D and Academic Institutional Libraries. Books are arranged according to the Dewey Decimal Classification (DDC) system. In addition to the scientific community of NCESS, the library is open to scientists and researchers of other Institutions and Universities for reference.

In the process of enhancing library services using modern ICT technologies the library had been automated using open source Integrated Library Management Software KOHA, cutomised and maintained by the library staff. Online Public Access Catalogue (OPAC) search is provided to users and is available on LAN.

Publications

9.1 Research Papers

9.1.1 In Journals

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Krishnakumar, A. (2014). Response to climate change: base line scenario and sustainable human development with special reference to Kerala Initiatives, Proc. of the National Seminal on Lakes, Rivers and Wetland Ecosystems – A Climate Change perspective, pp. 39-48

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9.2 Project Reports

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Divya P. Nair, Mahamaya Chattopadhayay (2013). Changing land use and cropping pattern of a tributary stream watershed of Karamana river basin, Thiruvanantaapuram, Kerala, Department of Geography, University Colege, Thiruvananthapuram, 51 p.

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Mahamaya Chattopadhyay (2013). Geomorphic evolution and terrain characteristics-a case study of Achankovil river basin, Kerala, Interim report submitted to the Kerala State Council for Science, Technology and Environment,Thiruvananthapuram, 87 p.

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Srikumar Chattopadhyay & Suresh Kumar, S. (2013). Glimpses of Kerala through maps, Centre for Earth Science Studies, Thiruvananthapuram, 93 p.

Srikumar Chattopadhyay (2013). Exploring the interrelationship between poverty and environmental degradation- selected micro-level case studies across Kerala, Centre for Earth Science Studies, Thiruvananthapuram, 191 p.

9.3 Books / Edited Volumes / Monographs

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10.1 Mapping as a Tool for Environmental Management and Planning

The seminar on "Mapping as a tool for Environmental Management and Planning" was organized in CESS on 24th June 2013, to update the developments in mapping science. Two Atlases namely 'Glimpses of Kerala through Maps' and 'River bank Atlas of Ithikkara' were released on the occasion. Sri. K. M. Chandrasekhar IAS, Vice Chairman, State Planning Board inaugurated the seminar and released the Atlases. Prof. (Dr.) V. N. Rajasekharan Pillai, EVP, KSCSTE presided over the function and Dr. Nivedita P. Haran IAS, Additional Chief Secretary, Govt. of Kerala and Director General, IMG offered felicitations. Dr. N. P. Kurian, Director, CESS and Dr. Srikumar Chattopadhyay, Head, RAD, CESS are also seen on the dias.

10.2 Inauguration of OSF Facility for North Kerala

Inauguration of OSF for North Kerala by Dr. M. K. Muneer, Hon'ble Minister for Panchayats & Social Welfare (left), Inauguration of SMS facility in Malayalam for Kozhikode by Prof. A. K. Premajam, Mayor, Kozhikkode Corporation (right)

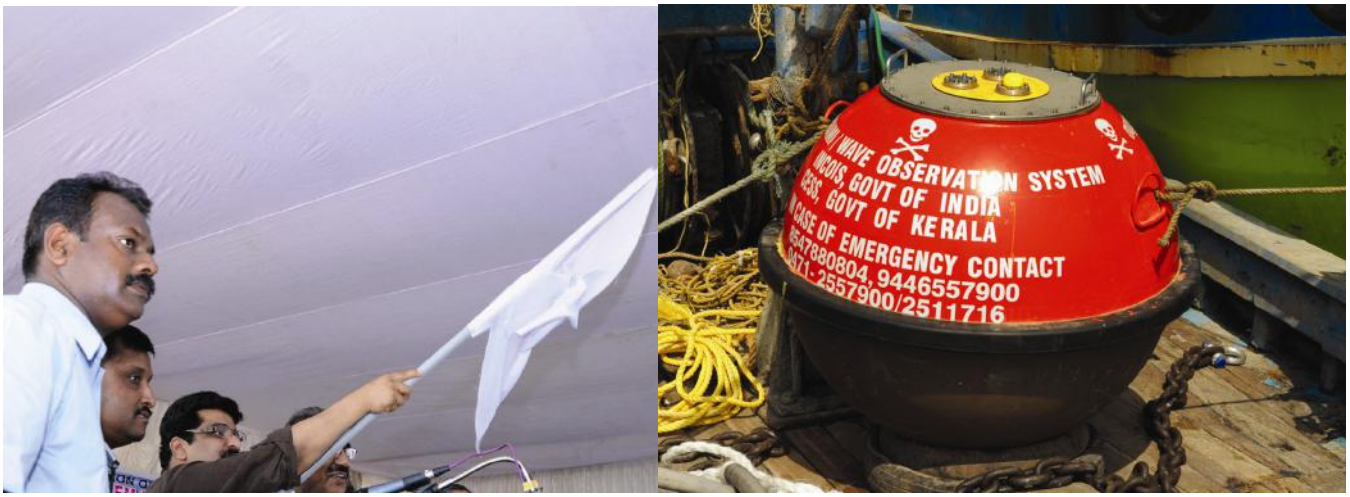
A function was organised at Kozhikode on 26th April 2013 in connection with the inaguration of Ocean State Forecast (OSF) station in north Kerala. The function was presided by Shri. A. K. Saseendran, MLA. This was followed by the

flag-off of the Wave Rider Buoy for deployment off Kozhikkode and launching of the OSF service for north Kerala by Dr. M.K. Muneer, Hon'ble Minister for Panachayats and Social Welfare. Prof. K. Premajam, Mayor Kozhikkode inauguarated the OSF - SMS facility for Kozhikode.

10

Organisation of Awareness Programmes and Press meet

A series of awareness programmes were conducted during 15th March – 24th April 2013 in which people from different levels consisting of government officials, local panchayat members, councillors, members of harbour development committees, fishermen welfare societies and organisations participated. A press meet was arranged on 25th April 2013 in which representatives/reporters from all the local and national newspapers and TV channels attended. Dr. T. M. Balakrishnan Nair (INCOIS), Dr. L. Sheela Nair and Dr. Reji Srinivas participated in the press conference and briefed on the details of the project –"Establishment and Maintenance of Wave Gauge Stations along the Coastal Waters of Kerala" and its benefits.



Flag off ceremony of launching of Wave Rider Buoy (left), Wave Rider Buoy and mooring assembly kept ready for deployment (right)

10.3 Invited Lectures/ Chairing of Technical Session

Dr. D. Padmalal

Chaired the Technical session "Environmental aspects of lakes" in the National seminar on Ground Water and Lakes: Recent Advancements and Environmental Aspects and delivered a keynote paper on Holocene evolution of the fresh water lakes of southern Kerala, SW India, Nagpur, during 20-21st February 2014.

Delivered an invited talk on the Environmental effects of soil quarrying with special reference to water resources in the National Seminar on Soil quarrying and its impact on ground water resources at Bishop Kurialachery College of Women, Amalagiri, Kottayam, 27th September 2013 .

Dr. E. J. Zachariah

Delivered a lecture on Urban Climate at a workshop on climate change at Payyanur College, organized by the Rotary Club of Payyanur Mid Town, January 2014.

Dr. K. Anoop Krishnan

Delivered a lecture on Chemistry of Seawater: Quality Monitoring and Challenges in international Conference on Emerging Frontiers and Challenges in Chemistry (ICEFCC-2014) at Department of Chemistry, All Saint's College, Trivandrum, INDIA, 18th February 2014.

Dr. K. V. Thomas

Delivered a lecture as a Resource Person on Coastal Zone Management in the Backdrop of global warming, Winter School Programme organized by Kerala Agricultural University, Thrissur, 19th November 2013.

Delivered a lecture as a Resource Person on Coastal Resource for the 'MoEF – World Bank' ICZM Training Programme organized by the M.S.Swaminathan Foundation, Chennai, 21st June 2013.

Delivered a lecture as a resource person on Coastal Regulatory Zone – An overview of CRZ provisions, workshop organized by the Town and Country Planning Department, 18th March 2014.

Delivered a lecture as a Resource Person on Coastal Zone Regulation India, Winter School Programme organized by Nansen Environment Research Centre, Kochi, 5th November 2013.

Delivered a lecture on Coastal Regulation Zone and Fisherman livelihood security in the workshop on Fisheries Management organized by KUFOS and Ministry of External Affairs for the members of the Indian Ocean RIM Association for Regional Co-operation at Kochi on 18th December 2013.

Dr. N. P. Kurian

Delivered a talk " Emerging trends in coastal ocean studies with particular reference to littoral process "and chaired a session in the Natinal Symposium on Coastal Oceanographic Studies: Modelling and Observations, Kochi,10th May 2013.

Delivered a talk " Coastal Hazards and its Management " in the 35th Indian Geographers Meet and International Conference at the University of Burdwan, West Bengal, 12th November 2013.

Dr. R. Ajayakumar Varma

Attended International Conference on Ecosystem Conservation, Climate Change and Sustainable Development (ECOSAD-2013) and chaired a session on Waster Management & Pollution Abatement, Thiruvananthapuram, 10th May 2013.

Attended the Conference on Right to Water & Sanitation organized at Kerala Institute of Local Administration (KILA), Thrissur by the Forum for Discussion on Water Conflicts in India, Pune and chaired a Session on Approach to Right to Sanitation in India and delivered a talk on Building a Right to Sanitation Campaign in Kerala, 26th September 2013.

Attended the National Workshop on Formulation of a policy framework on solid and liquid waste management as part of Nirmal Bharat Abhiyan of Ministry of Drinking Water & Sanitation, Govt. of India organized by the Asian Development Bank, May 20-21, 2013. Made two invited presentations, (1) Draft guideline for implementation of solid and liquid waste management projects in rural India as part of Total Sanitation Campaign and (2) Malinya Mukta Keralam Campaign – A comprehensive action plan for upgradation of the state of sanitation and waste management.

Attended Zero Waste Fellowship Programme for the youth of Himalayan region organized by the Zero Waste Himalaya Network and Thanal, Bangalore and delivered a talk on Policy and Governance aspect of Solid Waste Management, 22nd September 2013.

Delivered a lecture on Environment & Sanitation in the

one-day state-level training programme organized by the Kaarshaka Sangam, Thiruvananthapuram, 29th June 2013.

Delivered a lecture on Geophysical methods for Ground water exploration as part of the Training Programme for engineers on Groundwater Exploration and Management organized by the Civil Engineering Dept., College of Engineering, Thiruvananthapuram, 9th December 2013.

Delivered a talk on Environment, Water resources, Sanitation & Waste management in a two-day workshop organized by the Kerala Karshaka Sanghom at EMS Academy, Thiruvananthapuram, 29th October 2013.

Gave a lecture as a Resource Person on Coastal Zone Management in the Backdrop of global warming, Winter School Programme organized by Kerala Agricultural University, Thrissur, 19th November 2013.

Gave a lecture as a Resource Person on Coastal Resource for the 'MoEF – World Bank' ICZM Training Programme organized by the M. S. Swaminathan Foundation, Chennai, 21st June 2013.

Gave a lecture as a resource person on Coastal Regulatory Zone – An overview of CRZ provisions, workshop organized by the Town and Country Planning Department, 18th March 2014.

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Gave a lecture on Coastal Regulation Zone and Fisherman livelihood security in the workshop on Fisheries Management organized by KUFOS and Ministry of External Affairs for the members of the Indian Ocean RIM Association for Regional Co-operation at Kochi on 18th December 2013.

Chaired a session on 'Waste Management & Pollution Abatement' in the International Conference on Ecosystem Conservation, Climate Change and Sustainable Development (ECOSAD-2013) at Thiruvananthapuram, 5th October 2013.

Delivered an invited talk on Water security of Kerala, Seminar on Environmental Conservation, Kerala Development Congress organized by Kerala Sastra Sahitya Parishat at Ernakulam, 27th December 2013.

Delivered an invited Talk on Environmental Impact Assessment Notification, 2006 in the ENVIS Training Programme, KSCSTE at Science Centre, Kannur and STIC, CUSAT, Kochi during 14-25 february 2014.

Dr. T. N. Prakash

Gave an invited talk on Integrated Island Management Plans (IIMP) for Islands at the Refresher Course on Integrated Coastal Zone Management organized by the National Coastal Sustainable Coastal Management, MoEF, Chennai at the College of Fisheries, Mangalore, 31st October 2013.

Delivered a talk on Beach Sediment Budgeting in the Indian National Conference on Harbour and Ocean Engineering (INCHOE-2014), NIO, Goa, during 5-7th February 2014.

Sri. B. K. Jayaprasad

Delivered a lecture on Bhoomi Sasthrathile Noothana Sangethangal for shooting in connection with the documentary production for IT @ school by the Kerala State Film Development Corporation, 12th February 2014.

Delivered a lecture on Geoinformation Sciences for Geographic Research in the National seminar on New Paradigms in Geographic research, Govt. College Kariyavattom, Sponsored by Department of Collegiate Education during 20-21st March 2014.

Sri. John Mathai

Delivered a lecture on Environmental regulations and its linkages to Disaster Risk Management- one day course on Disaster Risk Management, IMG, 4th June 2013.

Chaired a session in the seminar on Learning from Uttarakhand, ILDM, 12th September, 2013.

Delivered a lecture on Rainwater Harvesting and Ground Water Recharge in Kerala in the seminar on Soil Quarrying and impact on Groundwater resources, BK College, Kottayam, 28th September 2013.

Delivered a lecture on Impacts of quarrying in Western Ghats in the semiar on Gadgil-Kasturirangan reports and agricultural Issues in Western Ghat region, Calicut, organised by Society for the Protection of Environmnet Kerala, 5th December 2013.

Delivered a lecture on Natural Hazards causes and Mitigation, in the special meeting of officers of Fire and safety, Ernakulam, 20th February 2014.

10.4 Papers Presented in Conference/ Workshop / Symposium / Seminar

Name	Conference/Symposium/ Seminar	Title of the paper
Noujas V.	COSMOS 2013 at Kochi (NPOL) during 9 -10 May.	Coastal dynamics along a mudbank dominated coast
Thomas K. V. Prakash T. N.	Seminar organized by IREL Manavalakurichi	Sediment budgeting for Qualifying minable beach placer deposit
Thomas K. V.	APSRAC, Hyderabad on 28th October 2013	HTL delineation and CRZ
Sheela Nair L. Sundar V. Kurian N. P	HYDRO 2013 International Conference, IIT Madras during 4-6th Dec, 2013	Study of Seasonal Variation in Sediment Transport along the SW Coast of India
Prakash T. N. Sheela Nair L. Shahul Hameed T. S.		Impact of 2004 cyclone in the Lakshadweep islands
Sarath Raj E. K. Prasad R. Sheela Nair L. Reji Srinivas Balakrishnan Nair T. M.		Influence of wind on wave climate along the Kerala coast
Noujas V. Badarees K. O. Thomas K. V.		Shoreline management plan for a mudbank influenced coast along Munambam – Chettuwa in Central Kerala
Sheela Nair L.	International workshop on Ocean Wave Energy 2013, IIT, Madras during 2-3rd December 2013	Wave power for Lakshadweep islands
Thomas K. V.	Seminar on Kerala Vikasana Congress organized by Kerala Sasthra Sahitya Parishath at Kochi on 27th December, 2013.	Conservation of Natural Resources
Thomas K. V.	Workshop on Coastal Zone Management in South Asia organized by the Centre for Science and Enviroment (CSE) during January 19-21, 2014	Climate change and coastal vulnerability
Vandana M.	IIG meet at University of Burdwan, West Bengal, during 11-13 November 2013	Exploring nexus between poverty and environmental degradation to plan for sustainable development
Lijith P. Nair		Implications of quantitative analysis in characterizing drainage basins- an example from Bharathapuzha river basin, Kerala
Shaji Johnson	NAGI Meet, Chennai during 12-14, December, 2013	Coastal Vulnerability Assessment : A case study of Thiruvananthapuram, West coast of India
Baiju R. S. Faisal A. K. Vimexen V. Ajmal K. Samsuddin M. Anoop Krishnan K.	National Conference on Sedimentation and Tectonics with Special Reference to Energy Resources of North-East India & 30th Convention of Indian Association of Sedimentologists during 28-30 November 2013, organized by Department of Earth Sciences, Manipur University, Canchipur, Imphal	Textural and geochemical imprints of sediment environs in an urban-fringe estuarine and adjoining shelf region, SW India
Faisal A. K Vimexen V. Sibin Antony	Kerala Science Congress 'KSC 2014' held at KVASU, Pookode, Wayanad, during 28-31 January 2014	Distribution and cycling of nutrients along the barmouth of Kochi: Half-decadal (2007-2012) Assessment from a COMAPS hotspot site
Radhakrishna T.	Indian Geophysical Union National Workshop on Dharwar to Deccan traps: an Integrated geoscientific approach, National Workshop at SRTM University, Nandedu on 28-31August 2013	Interplay of geochemistry and palaeo-magnetism: some Indian examples and the quasi-integrity of Archaean cratons in the Indian shield.
Radhakrishna T.	3rd International Symposium of PCGT at Jhansi on 23-26 November 2013	Indian palaeomagnetism in understanding the Precambrian crustal growth and tectonics.

Nandakumar V.	ASPIRE workshop on 29th March at the Department of Geology, Kariavattom Campus on November 2013	Techniques and Methodologies in fluid Inclusion Studies.
Ajayakumar Varma R.	1st meeting of the State Committee for the International Year of Water Cooperation, chaired by the Hon'ble Chief Minister at the Govt. Secretariate on 22nd June 2013.	The proposal for preparing a management action plan for eco-restoration of Vembanad Lake and connected river systems
Maya K. Padmalal D. Baburaj B. Narendra Babu K.	International Symposium on 'Role of earth system science & human prosperity held at Hyderabad during 23-25 October 2013.	Water quality assessment of a small tropical river basin, Southwest coast of India.
Krishnakumar A. Vinduja V.	National Conference Heavy metals in the Environment organized by School of Environment Sciences, MG University, Kottayam during 28-30 November, 2013.	Heavy metals in a riverine environment- A study of Karamana river, Thiruvananthapuram district, Kerala
Krishnakumar A.	30th Convention of Indian Association of Sedimentologists and National Conference on Sedimentation and Tectonics with special reference to energy resources of North-East India held at the Department of Earth Sciences, Manipur Unversity, Imphal during 28-30 November 2013.	Geochemical and Textural Characterization of the sediments of Neyyar river, Kerala originating from Western Ghats
Ajayakumar Varma R.	Seminar on the Environmental Conservation in Kerala Vikasana Congress organized by the Kerala Sastra Sahitya Parishat on 27th December 2013 at Ernakulam.	Water Security
Padmalal D.	Regional seminar on Water conservation in Kerala- Impacts and Challenges, Central Ground Water Board, Trivandrum on 27th March 2014.	Holocene evolution of the fresh water lakes at Southern Kerala, SW India
George T. Sherin A. P. Shareekul A. Zachariah E. J. George T. Sherin A. P. Zachariah E. J.	Conference on Urban Environmental Pollution at Beijing, China during 17-20 November 2013.	Analysis of Urban heat island in Kochi, India, using a modified local climate zone classification. Atmospheric methane mixing ratio in a south Indian coastal city interlaced by wetlands.
Anu Baburaj P. V. Subhash N. Anil M. K. Rani Mary George Nita S. Praksh T. N.	22nd National Laser Symposium (NLS 22) held at Manipal University during 8-11 January 2014.	Application of Laser-induced Fluorescence for early detection of heat induced bleaching in corals
Vishnu R. Anil Kumar V. Sarat Krishnan K. Hamza Varikoden Subi Symon V. N. Murali das S. Mohan Kumar G.	YOTC-AMY workshop during 16-18 May 2011, Beijing, China	Characteristics of southwest monsoon clouds over a tropical station using a Ceilometer and a Modified Electric Field Mill
Vishnu R. Anil Kumar V. Subi Symon V. N. Murali das S. Mohan Kumar G.	ARWPCC-2011 during 10-11 March 2011,Tirupati	Detection of thundercloud formation over a mountain slope using Lidar and Supporting measurements with a modified Electric Field Mill.
Sheela Nair L. Sundar V. Kurian N. P. Sarath Raj E. K. Prasad R. Sheela Nair L. Reji Srinivas Balakrishnan Nair T. M.	HYDRO-2013 international conference at IIT Madras during 4-6 December 2013.	Seasonal Variation in Sediment Transport along the SW coast of India. Comparative evaluation of erosion accretion criteria for a tropical beach Influence of wind on wave climate along the Kerala coast, SW coast of India

Prakash T. N.	Indian National Confernce on Harbour and Ocean Engineering (INCHOE-2014) at NIO, Goa during 5-7 February 2014	Shoreline changes and reef strengthening at Kavaratti Island in Lakshadweep archipelago

Extension

11.1 Earth Day 2013

Observations of Earth Day 2013: Dr. P. V. Joseph, Emiritous Professor, CUSAT is the special invitee to the celebration; Dr. T. Radhakrishna, Scientist-G & Head, Geosciences, NCESS, and Dr. Srikumar Chattopadhyay, Scientist G & Head, Resouces Analysis, NCESS are also seen (Left), Dr. P. V. Joseph, Emiritus Professor, CUSAT, delivering a special talk (middle) and students interaction with scientists (right).

Earth Day 2013 was observed in CESS on 22nd April 2013. Events like Open House, invited talk and Quiz competition were arranged as part of the observance. Dr. P. V. Joseph, Emeritus Professor, CUSAT delivered a talk on the topic 'Climate Change'. Quiz programme was lead by Dr. V. Sasikumar, Former Scientist of NCESS. Students and teachers from K.V. Akkulam, K.V. Pangode, K.V. Pattom, Loyola School, Central school, VSSC, Trivandrum and S.N. College Varkala participated in the programme. Director-in-Charge, CESS distributed prizes for the winners of quiz competition.

11.2 Exhibition

11.2.1 26th Kerala Science Congress

A view of the stall at 'Sastrajalakam-National Science Expo-2014' as a part of 26th Kerala Science Congress

NCESS participated and arraged a stall at 'Sastrajalakam-National Science Expo-2014' exhibition organized as part of 26th Kerala Science Congress. The exhibition was arranged at Kalpetta during 27-31 January 2014. Along with the

display of Scientific Posters an LCD TV was installed and documentaries on coastal erosion and landslides was displayed. Also demonstrated applications of GIS.

11.2.2 Karshikamela 2013-2014

A view of Pavilion in Karshikamela-2014 Exhibition

NCESS participated and arranged a pavilion in 'Karshkamela-2014' exhibition held at New Man College Ground, Thodupuzha, Idukki district during 26th December to 1st Jnauary 2014.

11.3 Lectures for students

Dr. R. Ajayakumar Varma delivered the special talk on Solid Waste Mangement (left) and students discussion with Scientists (right) on the occasion of students visit from Christ Nagr Higher Secondary School, Kowdiar, Thiruvananthapuram

Dr. Ajayakumar Varma delivered a talk on Solid Waste Management as part of students visit in NCESS, Christ Nagar Higher Secondary School, Kowdiar, Thiruvananthapuram, 11th October 2013.

Dr. Ajayakumar Varma delivered two lectures, Theory & Practice of EIA and A case study on carrying out EIA, in the Refresher Course on Environment organized by the UGC Academic Staff College of Calicut University, Kozhikode, 15th June 2013.

Dr. Ajayakumar Varma delivered a lecture on the procedures of EIA as part of the Take-off Training for outgoing B. Tech. students of Civil Engineering organized by the Pankaja Kasthuri College of Engineering & Technology, Kattakkada, 1st June 2013.

Dr. Ajayakumar Varma delivered a talk on Fostering Scientific Temper in the Science Day Programme organized by the Kerala Agricultural College, Vellayani, 26th February 2014.

Dr. Ajayakumar Varma delivered lecture on Waste Management to the MBA students of College of Engineering, Thiruvananthapuram (CET), 25th October 2013.

Sri. B. K. Jayaprasad delivered a lecture on The Potential uses of GIS technology in Public Health for MPH students of AMCHSS, SCTIMST, 19th February 2014.

Sri. G. Sankar delivered a lecture on landslides and land subsidence at Govt. College, Kottayam, 11th December. 2013.

Sri. G. Sankar has given lecture on landslides and land subsidence at Technical School, Vannapuzha, 29th January 2014.

Sri. John Mathai delivered a lecture on Earthquake Hazard Zonation in the seminar on Natural Hazards Mitigation and Management organised by Dept. of Geology, Govt. College Kottayam, 12th December 2013.

Sri. John Mathai delivered lecture on rainwater harvesting and ground water recharge in Kerala in the seminar on Soil Quarrying and Impact on Groundwater resources, B. K. College, Kottayam, 28th September, 2013.

Sri.V. Muralidharan delivered an invited lecture on Climate Change and its Global Impacts in a Science Camp for about 125 students organized by the Thiruvananthapuram District Kudumbasree Mission at the Mar Gregarious Service Centre, Nalanchira, Thiruvananthapuaram, 20th September 2013.

11.4 Earth Science Forum

Four scientific lectures by eminent personalities were organised : (i) Presentation by Dr. P. Nandakumaran, Regional Director, CGWB on the topic "Ground Water Resources of Kerala- Status, Challenges & Opportunities" in connection with the Foundation Day of The Society of Earth Scientists on 17 April 2013, (ii) Prof. (Dr.) Raghuram Murtugudde, Department of Atmospheric and Oceanic Science, Earth System Science Interdisciplinary Centre, University of Maryland, USA gave two lectures: (a) Do we really understand ENSO? on Monday, 27 May 2013 and (b) Regional Earth System Prediction for Decision-Making on Tuesday, 28 May and (iii) Prof. Tim Jennerhan, Bremen University, Germany delivered a lecture on 'Human activities of ecotourism in Java, Indonasia on 11th June 2013.

11.5 Campus Green Committe

One tower light and a welcome lamp have been commissioned during October 2013. Steps were taken to avail subsidy for biogas plant. Proposal for installing paper shredders one in each division was mooted during November 2013. Replaced the old fans in the canteen with energy efficient fans with 5 star rating. Energy efficient community choolas – 3 Nos have been installed in the canteen. Letter to avail subsidy from ANERT was issued. Different types of LED tubes were displayed in the Canteen to rationalise its utility with description on the savings involved in using LED bulbs instead of normal tube lights. Sub- Committee formed for installing an incinerator in the campus. Non-metal paper and plastic waste disposal have been streamlined. Earth Hour 2014 was observed on 28/03/2014. Mr. Renjan Mathew, President, WWF Trivandrum Office addressed the scientific community on this occasion. A quiz competition was held and CFL bulbs were distributed to the winners.

All routine activities like cleaning the campus, procurement of garbage bags, and pruning of trees, connected with CGC were carried out.

11.6 Earth Watch Centre / Dynamic Planet

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

11.7 Recreation Club

11.7.1 Sports Day 2013

11.7.2 Oneday Trip to Thenmala

11.7.3 Onam

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

Committees

12.1 Statutory Committees: CESS (till 31.12.2013)

12.1.1 Research Council

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

12.1.2 Management Committee

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

12.2 Statutory Committees: NCESS (from 01.01.2014)

12.2.1 Governing Body (GB)

Dr. Shailesh R. Nayak — *President*
Secretary, Ministry of Earth Sciences, Government of India
Prithvi Bhavan, Lodhi Road, New Delhi

Dr. S. K. Das — *Member*
Advisor, Ministry of Earth Sciences, Government of India
Prithvi Bhavan, Lodhi Road, New Delhi

Sri. J. B. Mohapatra — *Member*
JS&FA, Ministry of Earth Sciences, Government of India
Prithvi Bhavan, Lodhi Road, New Delhi

Sri. Anand S. Khati — *Member*
JS, Ministry of Earth Sciences, Government of India
Prithvi Bhavan, Lodhi Road, New Delhi

Dr. Milind Wakdikar — *Member*
Ministry of Earth Sciences, Government of India
Prithvi Bhavan, Lodhi Road, New Delhi

Dr. S. Rajan — *Member*
Director, National Centre for Antartic & Ocean Research (NCAOR)
Ministry of Earth Sciences, Government of India
Headland Sada, Vasco-da-Gama, Goa

Dr. M. A. Atmanand — *Member*
Director, National Institute of Ocean Technology (NIOT)
Velacherry-Tambaram Main Road, Narayanapuram
Pallikaranai, Chennai

Director — *Member Secretary*
National Centre for Earth Science Studies
Akkulam, Thiruvanathapuram

12.2.2 Governing Council (GC)

Dr. Shailesh R. Nayak — *Chairman*
Secretary, Ministry of Earth Sciences, Government of India
Prithvi Bhavan, Lodhi Road, New Delhi

Dr. Somnath Dasgupta — *Member*
Vice Chancellor, Assam University
Indian Institute of Science Education and Research (IISER)
Silchar, Kolkatta

Sri. J. B. Mohapatra — *Member*
JS&FA, Ministry of Earth Sciences, Government of India
Prithvi Bhavan, Lodhi Road, New Delhi

Shri. B. N. Satpathy — *Member*
Sr. Adviser (E & F & S & T)
Planning Commission, New Delhi

Shri. Anand S. Khati — *Member*
JS, Ministry of Earth Sciences, Government of India
Prithvi Bhavan, Lodhi Road, New Delhi

Dr. S. K. Das — *Member*
Advisor, Ministry of Earth Sciences, Government of India
Prithvi Bhavan, Lodhi Road, New Delhi

Dr. S. Rajan — *Member*
Director, National Centre for Antartic & Ocean Research (NCAOR)
Ministry of Earth Sciences, Government of India
Headland Sada, Vasco-da-Gama, Goa

Director — *Member Secretary*
National Centre for Earth Science Studies
Akkulam, Thiruvanathapuram

12.2.3 Finance Committee (FC)

Sri. J. B. Mohapatra — *Chairman*
JS&FA, Ministry of Earth Sciences, Government of India
Prithvi Bhavan, Lodhi Road, New Delhi

Shri. Anand S. Khati — *Member*
JS, Ministry of Earth Sciences, Government of India
Prithvi Bhavan, Lodhi Road, New Delhi

Manager (Finance) — *Member*
National Centre for Earth Science Studies
Akkulam, Thiruvananthapuram

Programme Officer, NCESS — *Member*
Ministry of Earth Sciences, Government of India
Prithvi Bhavan, Lodhi Road, New Delhi

Registrar/ Chief Manager — *Member*
National Centre for Earth Science Studies
Akkulam, Thiruvananthapuram

Project Management Head — *Member Secretary*
National Centre for Earth Science Studies
Akkulam, Thiruvananthapuram

12.2.4 Research Advisory Council (RAC)

Dr. Somnath Dasgupta *Vice Chancellor, Assam University* *Indian Institute of Science Education and Research (IISER)* *Silchar, Kolkotta*	*Chairman*
Director NIOT/ Nominee *National Institute of Ocean Technology* *Velacherry-Tambaran Main Road, Narayanapuram* *Pallikaranai, Chennai*	*Member*
Director NGRI/ Nominee *National Geophysical Research Institute* *Uppal Road, Habsiguda, Uppal* *Hyderabad, Andra Pradesh*	*Member*
Prof. A. D. Rao *Centre for Atmospheric Sciences,* *Indian Institute of Technology* *New Delhi*	*Member*
Dr. M. V. Ramanamurthy *ICMAM Project Directorate* *NIOT Campus* *Velacherry-Tambaram Main Road* *Pallikkaranai, Chennai*	*Member*
Senior Scientist *National Centre for Earth Science Studies* *Akkulam, Thiruvananthapuram*	*Member Secretary*

12.3 Internal Committees

12.3.1 Heads of Divisions

Director, CESS	*Chairman*
Dr. T. Radhakrishna *Geosciences Division*	*Member*
Dr. K. V. Thomas *Marine Sciences Division*	*Member*
Dr. E. J. Zachariah *Atmospheric Sciences Division*	*Member*
Dr. Mahamaya Chattopadhyay *Resources Analysis Division*	*Member*
Dr. R. Ajayakumar Varma *Training & Extension Division*	*Member*
Sri. B. K. Jayaprasad *Central Geomatics Laboratory*	*Member*
Dr. P. K. Omana *Chemical Sciences Division*	*Member*
Dr. D. Padmalal *Environmental Sciences Division*	*Member*
Sri. M. A. K. Rasheed *Registrar-in-Charge*	*Member*
Dr. D. S. Suresh Babu *Technical Secretary*	*Convenor*

12.3.2 Material Purchase

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

12.3.3 Library Management

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

12.3.4 Canteen

Dr. T. S. Shahul Hameed	Chairman
Dr. D. S. Suresh Babu	Member
Sri. M. Mohammed Ismail	Member
Sri. G. Lavanya	Member

12.3.5 Campus Development Committee

Dr. K. V. Thomas	Chairman
Dr.V. Nandakumar	Member
Sri. G. Sankar	Member
Dr. L. Sheela Nair	Member
Sri. D. Raju	Member
Smt. Indu Janardanan	Member
Sri. K. Eldhose	Member
Smt. K. V. Padmaja Kumari	Convenor

12.3.6 Campus Green Committee

Dr. V. Nandakumar	Chairman
Sri. John Paul	Member
Dr. K. Raju	Member
Sri. S. Mohanan	Member
Sri. M. Ramesh Kumar	Member
Sr. N. Nishanth	Member
Smt. K. V. Padmaja Kumari	Member

12.3.7 Complaints Committee to combat Sexual harassment at work place

Dr. L. Sheela Nair	Chairperson
Mrs. G. Lavanya	Member
Dr. J. K. Tomson	Member
Dr. Susha Janardhanan	External Member

Staff Details

13.1 Directors office

Dr. K. Somasunder	Director-in-Charge (from February2014)
Dr. N. P. Kurian	Director (till January 2014)
Dr. D. S. Suresh Babu	Technical Secretary (from August 2013)
Sri. N. Rajasekharan Nair	P. A to Director (till November 2013)
Sri. C. K. Sasidharan	Scientist-E2 & SIC,TC (till August 2013)
Sri. S. Sidharthan	Scientist-E2 & SIC, WIC (till May 2013)
Smt. T. Remani	Helper (Gr. 1)

13.2 Atmospheric Sciences Division

Dr. E. J. Zachariah	Scientist-F & Head
Dr. G. Mohan Kumar	Scientist-F (till May 2013)
Sri. V. Muralidharan	Scientist-F (till October 2013)
Sri. Mohammed Ismail	Technical Officer (Gr. 4)
Smt. Nita Sukumar	Technical Officer (Gr. 1)

13.3 Chemical Sciences Division

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

13.4 Central Geomatics Laboratory

Dr. M. Samsuddin	Scientist-G (on deputation)
Dr. K. K. Ramachandran	Scientist-F (on deputation)
Sri. B. K. Jayaprasad	Scientist-E1
Dr. Archana M . Nair	Scientist-B
Sri. P. B. Vibin	Technical Officer (Gr. 1)

13.5 Environmental Sciences Division

Dr. R. Ajayakumar Varma	Scientist-G
Dr. C. N. Mohanan	Scientist-F & Head (Till November 2013)
Dr. D. Padmalal	Scientist-E2 & Head (Since November 2013)
Dr. K. Maya	Scientist-E2
Dr. A. Krishnakumar	Scientist-B

13.6 Geo Sciences Division

Dr. T. Radhakrishna	Scientist-G & Head
Sri. John Mathai	Scientist-G
Dr. C. P. Rajendran	Scientist-G (on long leave)
Sri. G. Sankar	Scientist-F
Dr. G. R. Ravindra Kumar	Scientist-F (till Jnauary 2014)
Dr. V. Nandakumar	Scientist-E2
Ms. Sreekumari Kesavan	Scientist-E1
Dr. Tomson J. Kallukalam	Scientist-B
Sri. N. Nishanth	Technical Officer (Gr. 2)
Sri. S. S. Salaj	Technical Officer (Gr. 2)
Sri. K. Eldhose	Technical Asst. (Gr. 2)

13.7 Marine Sciences Division

Dr. K. V. Thomas	Scientist-G & Head
Dr. T. N. Prakash	Scientist-F
Dr. T. S. Shahul Hameed	Scientist-F
Dr. L. Sheela Nair	Scientist-E2
Sri. P. John Paul	Scientist-E2
Dr. D. S. Suresh Babu	Scientist-E2
Dr. Reji Srinivas	Scientist-B
Sri. D. Raju	Technical Officer (Gr. 5)
Sri. S. Mohanan	Technical Officer (Gr. 5)
Sri. A. Vijayakumaran Nair	Technical Officer (Gr. 5)
Sri. M. Ajith Kumar	Technical Officer (Gr. 5)
Sri. M. Ramesh Kumar	Technical Officer (Gr. 5)
Sri. M. K. Rafeeque	Technical Officer (Gr. 1)
Sri. M. K. Sreeraj	Technical Officer (Gr. 1)
Sri. Louis William	Helper (Gr. 2)

13.8 Resources Analysis Division

Dr. Srikumar Chattopadhyay	Scientist-G & Head (till June 2013)
Dr. Mahamaya Chattopadhyay	Scientist-E2 & Head (Since June 2013)
Smt. C. Sakunthala	Technical Officer (Gr. 5)
Sri. K. Surendran	Stenographer (Gr. 1)

13.9 Training & Extension Division

Dr. R. Ajayakumar Varma	Scientist-G & Head (Since December 2013)
Dr. E. Saravanan	Scientist-E1 (till July 2013)
Dr. Ansom Sebastian	Scientist-E1
Dr. K. Raju	Scientist-E1
Smt. S. Najumunniza	Technical Assistant (Gr. 5)

13.10 Library

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

13.11 Administration

Sri. P. Sudeep	Registrar (till October 2013)
Sri. M. A. K. H. Rasheed	Registrar-in-Charge (from October 2013)

Sri. M. Philip	*Internal Audit Officer (on deputation)*
Smt. K. V. Padmaja Kumari	*Assistant Registrar*
Sri. T. D. Bashardeen	*P. A. to Registrar*
Sri. R. Haridas	*Section Officer*
Smt. K. Viswabharathy	*Section Officer*
Sri. C. M. Youseph	*Section Officer (on deputation)*
Sri. M. Madhu Madhavan	*Section Officer*
Smt. R. Jaya	*Section Officer*
Smt. G. Lavanya	*Section Officer*
Sri. S. Krishnakumar	*Office Asst. (Gr. 2)*
Smt. Femi R. Sreenivasan	*Office Asst. (Gr. 1)*
Sri. P. Rajesh	*Office Asst. (Gr. 1)*
Smt. P. C. Rasi	*Office Asst. (Gr. 1)*
Smt. Smitha Vijayan	*Office Asst. (Gr. 1)*
Smt. K. S. Anju	*Office Asst. (Gr. 1)*
Sri. P. H. Shinaj	*Office Asst. (Gr. 1)*
Smt. D. Shimla	*Office Asst. (Gr. 1)*
Smt. S. Beena	*Office Asst. (Gr. 1)*
	(on deputation from Revenue Department)
Smt. V. Sajitha Kumari	*Office Asst. (Gr. 1)*
Smt. Seeja Vijayan	*Office Asst. (Gr. 1)*
Smt. Indu Janardanan	*Technical Officer (Gr. 1)*
Smt. P. Prabhavathy	*Stenographer (Gr. 1)*
Smt. N. J. Saramma	*Typist (Gr. 1)*
Smt. K. Prasanna	*Typist (Gr. 1)*
Smt. M. K. Radha	*Typist (Gr. 1)*
Sri. N. Jayapal	*Clerical Asst. (Gr. 2)*
Sri. K. R. Satheesan	*Clerical Asst. (Gr. 2)*
Sri. M. Parameswaran Nair	*Skilled Assistant*
Sri. N. Unni	*Helper (Gr. 1)*
Smt. S. Vimala Kumari	*Helper (Gr. 1)*
Sri. P. S. Anoop	*Helper (Gr. 1)*
Smt. P. S. Divya	*Helper (Gr. 1)*
Sri. B. Rajendran Nair	*Helper (Gr. 2)*
Sri. P. Saseendran Nair	*Helper (Gr. 2)*
Sri P. Rajendra Babu	*Helper (Gr. 2)*
Sri. K. Sudeerkumar	*Driver (Gr. 1)*
Sri V. Chandran Nair	*Helper (Gr. 1)*

13.12 Retirements

Sri. V. Muralidharan
Scientist-F
Atmospheric Sciences Division
superannuated on
31st October 2013

Sri. C. K. Sasidharan
Scientist-E2, SIC
Technical Cell
superannuated on
31st August 2013

Dr. Srikumar Chattopadhyay
Scientist-G & Head
RAD & TED
Resources Analysis Division
superannuated on 30th June 2013

Dr. Saravanan E.
Scientist-E1
Training & Extension Division
superannuated on 30th June 2013

Dr. G. Mohan Kumar
Scientist-F
Atmospheric Sciences Division
superannuated on 31st May 2013

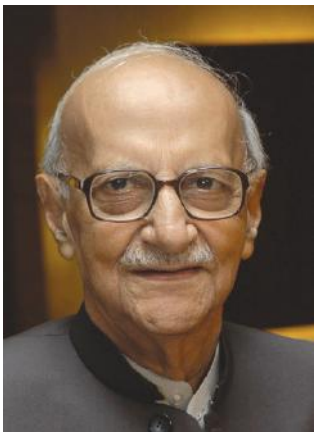
Sri. Sidharthan S.
Scientist-E2, SIC
Web & Information Cell
superannuated on 31st May 2013

Dr. G. R. Ravindra Kumar
Scientist-F
Geo Sciences Division
superannuated on
31st January 2014

Dr. C. N. Mohanan
Scientist-F & Head
Environmental Scinces Division
superannuated on
30th November 2013

Sri. Rajasekharan Nair
PA to Director
superannuated on
30th November 2013

13.13 Obituary



Sri. Subrata Sinha, former Director of CESS (01.11.1989-31.12.1991) expired on 19th January 2013 at Kolkata. He joined CESS after an illustrious career in the Geological Survey of India where he superanuated as Deputy Director General. He was a keen and respected environmentalist, and involved intellectually with a number of NGOs and had published innumerable articles and papers on environmental issues. At CESS, he pioneered Panchayath Resource Mapping Programme in cadastral scale , which was adopted by many states in their development programmes. His demise is mourned deeply by his wife Suchitra, sons Sukanto and Sujan and their family.

Balance Sheet

CENTRE FOR EARTH SCIENCE STUDIES, AKKULAM, TRIVANDRUM
(A unit of Kerala State Council for Science, Technology & Environment. Govt. of Kerala)
Consolidated Balance Sheet as on 31st December 2013

Liabilities	Sch No	*As at 31.12.2013*	*As at 31.03.2012*	Assets	Sch No	*As at 31.12.2013*	*As at 31.03.2012*
Capital Reserve	4	7,81,02,551	8,29,45,669	Fixed Assets	1	7,81,02,551	8,29,45,669
General Reserve				Current Assets	2	9,32,67,004	10,87,17,452
Plan fund from GOK		2,75,26,268	-				
Non Plan fund from GOK		(4,88,72,094)	-	Loans & Advances	3	9,08,82,782	5,00,24,803
Current Liablities	5	5,26,40,958	2,04,69,873				
Unspent balance							
Grant in aid projects	6	3,34,44,506	2,72,01,663				
Divisional Core projects	6	57,61,845	84,00,910				
Service component projects	6	1,58,04,081	99,48,237				
Consultancy projects	6	4,06,48,404	3,30,72,654				
Corpus fund	6	5,71,95,819	5,44,52,484				
Grant (GOK)	6	-	51,96,435				
Total		**26,22,52,337**	**24,16,87,924**	**Total**		**26,22,52,337**	**24,16,87,924**

Registrar (Incharge)

Director

Thiruvananthapuram
September 18, 2014

CENTRE FOR EARTH SCIENCE STUDIES Thiruvananthapuram

AUDITOR'S REPORT
As per our report of even date attached

For Mohan & Mohan Associates
Chartered Accountants
FRN: 2092S

MOHAN & MOHAN ASSOCIATES TRIVANDRUM CHARTERED ACCOUNTANTS

R.Suresh Mohan
Partner M No 013398

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National Centre for Earth Science Studies

Ministry of Earth Sciences, Government of India

Akkulam Trivandrum

Balance Sheet as on 31st March 2014

Particulars	Sch No	As at 31.03.2014
		₹
Liablities		
Capital Reserve	1	7,98,02,697
General Reserve		
Plan fund from GOK	2	1,72,52,325
Non Plan fund from GOK	2	(2,68,78,796)
Corpus fund	3	5,84,21,083
Research Program Fund		-
Unspent Balances of Projects	4	8,68,59,105
Operations and Maintenance Fund	5	1,30,66,365
Current Liablities	6	16,41,197
Total		**23,01,63,975**
Assets		
Fixed Assets	7	7,98,02,697
Current Assets	8	11,84,76,089
Loans & Advances	9	3,18,85,189
Total		**23,01,63,975**
Schedules forming part of accounts	15	

AUDITOR'S REPORT

As per our report of even date attached

For Mohan & Mohan Associates
Chartered Accountants

R.Suresh Mohan
Partner M No.013398
FRN: 2092S

Registrar

Director

Thiruvananthapuram
September 18, 2014