COCHIN UNIVERSITY OF SCIENCE & TECHNOLOGY

MASTER PLAN

(Agenda 2030)

INTERNAL QUALITY ASSURANCE CELL

CUSAT, KOCHI 682 022

DECEMBER 2017

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(Agenda 2030)

INTERNAL QUALITY ASSURANCE CELL

CUSAT, KOCHI 682 022

DECEMBER 2017

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THE HON'BLE GOVERNOR OF KERALA

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OUR ACCOMPLISHMENTS AT A GLANCE

NAAC	A
MHRD-NIRF Rank 2015-16	30
MHRD-NIRF Rank 2016-17	86
Times Higher Education(THE) World University Rankings 2016-17	One among the 31 institutions in the country, and the only one in Kerala. In 801+
BRICS & Emerging Economies University Rankings 2017	250 – 300
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ACADEMIC PLANS

Basic Science

1. M Tech in Data Analytics

This course will be an interdisciplinary programme (IDP) that combines statistics, software development, and computer science. Data science is concerned with the acquisition, storage, retrieval, processing and finally the conversion of data into knowledge where the quantum of data is very large. The programme addresses the fundamentals and research issues in the area of Data Science and Data Analytics.

Learning outcomes of the course:

Apply statistics and computational analysis on big data, Expertise Big Data Analytics techniques, to develop the skill and technical expertise to build various technologies, infrastructure and platform to store, handle and mine big data.

Research Facilities required setting up the LAB:

The Data Science and Analytics Lab have to be set up with a vision to foresee it as a data driven innovation hub. The high-performance lab will be equipped with latest distributed and parallel computing facilities that can be utilized for solving big data analytics problems of all fields including engineering, medicine, business etc.

This is an inter disciplinary lab setup to bring together engineers, physicians, computer scientists and statisticians to develop novel ways to manage, analyse and visualize very large data sets. It is also intended to accelerate applications to industry funded projects. It also assists local and regional companies with their data analytics needs.

Service Type(s):

- Imaging
- Statistics
- Informatics

2. M.Tech. in Aquaculture Engineering

This is to attract and motivate students in Engineering to Aquaculture Engineering equip them as to undertake it as profession to help aqua-farmers in implementing sustainable aquaculture production systems with the available tools and devices. The process will be initiated right now to offer the programme from 2018 academic year. Introduction of electives at B.Tech. level (Civil, Mechanical, Electrical and Electronics)- i) Aquaculture, ii) Zero water exchange aquaculture system, iii) Recirculating aquaculture System, iii) Integrated Multitrophic Aquaculture system, and Project in aquaculture Engineering. Engineering education in support of aquaculture to be undertaken in collaboration with Cochin University College of Engineering, Kuttanad.

Aquaculture Engineering: Development and engineering of cost effective, user-friendly and efficient aquaculture production systems most appropriate to specific ecosystems and species concerned for sustainable fish production inclusive of maintenance of environmental health and delicate balance of nature, and their extension and implementation.

Requirements of M.Tech. in Aquaculture Engineering Defined, well qualified technical personnel to support the installation of aquaculture production systems is not available in the Country. This causes immense difficulties to Farmers and the aquaculture sector as a whole, and the situation attracts pseudo experts to dominate the scene and misguide the investors. Most of the occasions these ill qualified persons fail to trouble shoot and solve issues. An Aquaculture Engineer will fill the gap. An M.Tech. in Aquaculture Engineering must be capable to design and execute need based, species and location specific aquaculture production systems with sustainability, and to undertake Research and Development programmes.

Challenges: Putting together and blending of all components of aquaculture production systems in the curriculum integrating engineering and biology with justification to the concept of inclusiveness of environment and maintenance of the delicate balance of nature during production.

Prospects: India looks forward to double aquaculture production with in another five years. There is dearth of engineering skill in the business. Same is the situation Internationally and course envisaged here serves globally for sustained fish production for food and nutritional security.

Feeder Courses: Aquaculture Engineering is proposed to be offered as electives at B. Tech. (Civil, Mechanical, Electricals and Electronics) level at CUCEK along with project on the same, and equip them to take up Aquaculture Engineering as profession to help aqua-farmers in implementing sustainable aquaculture production systems, and to groom them to take up Aquaculture Engineering at M.Tech. level. A subcommittee to be constituted under the chairmanship of Dr. E.G. Silas will frame the curricula for both the programmes.

Infrastructure: The three facilities such as a) Aquaculture Medicine Production Unit (Lakeside Campus, CUSAT) b) Aquaculture Engineering Research Laboratory and c) Aquaculture Engineering Tools and Devices Production Unit have to be in place before commencement of the programme.

3. Integrated M.Sc program

Introduction

In the process of the fulfillment of the set objects of the Cochin University of Science and Technology, a Centre for Integrated Studies (CIS) is established in the year 2017-18 to offer 5-year Integrated Master's Degree courses in Science/ Marine Science subjects for imparting specialized education to the students on completion of their +2 level of education.

Courses offered by the Centre

The Centre offers 5-year integrated Master's Degree courses in Science (Physics, Chemistry, Biology/ Life Science/ Biotechnology and Mathematics/ Statistics) subjects.

Overview of the Course

The five-year Integrated M.Sc. (I. M.Sc.) courses of the Cochin University of Science and Technology are non-professional courses. They are not merely integrated programs that combine pre-graduate and post-graduate studies, but are also trans-disciplinary, cutting across several disciplines.

Admission

The present intake for the Integrated M. Sc. Program in Science is 60 (15 x 4). At the end of the 3rd Year the students will be integrated with the M. Sc. courses conducted by the Departments of Mathematics (8), Statistics (7), Biotechnology (15), Chemistry (15), Physics (15). This will be the approximate number of students allotted to the 5 participating Departments. Depending upon the choice and performance of the students, there may be a slight variation (+/- 2) in the number of students allotted to the Departments.

The curriculum is common to all the disciplines for the first four semesters. Students with biology background at the +2 stage and who had left mathematics after the 10th class are expected to put in the required efforts to learn mathematics. Similarly, students who left biology at the +2 stage are expected to learn biology. Students of Science subjects require significant amount of Mathematics and Computation throughout the 5-Year Programme. The University offers bridge courses in the first semester to facilitate this process. The students spend first two years of their programs at the CIS. The students are transferred to their parent Schools at the end of the fourth semester.

Facilities

The CIS will have full-fledged Laboratories and Class rooms to accommodate the large contingent of students. There will be separate Library for CIS in addition to the Libraries in the respective Departments and the Central Library. Central Library as well the Department Libraries are having a good collection of books and periodicals, computing facility with internet access, experimental laboratories and hostel accommodation on the campus. CIS Library will also be fully equipped to cater to the needs of CIS students. All

students admitted to the Integrated M. Sc. program will be provided with adequate hostel and mess facilities.

Flexibility

The credit system has the advantage of allowing the student choice of courses. The students are permitted to exercise their option of subjects either soon after admission, or at the end of first year, or at the end of second year or even at the end of third year in certain courses.

Research orientation

There will be a component of research project in the last year (5th year) of the Science program and students are also encouraged to take up internships in the vacation period. During the first three years, students will have to undertake at least one Summer Research Project outside the University. There will be provisions for open ended labs in the IV to VIII Semesters.

4. M.Sc Bioinformatics

The program provides competence in computational biology/bioinformatics by providing training in the areas of molecular biology, information technology, statistics and bioinformatics. The program provides hands on expertise in the essential multi-disciplinary fields of genomics, proteomics, protein engineering, metabolic pathway engineering, Pharmacogenomics, discovery of new drugs and vaccines, molecular diagnostic kits, Argo-biotechnology that comprise the core of Bioinformatics.

Bioinformatics has a strong interdisciplinary character. It can be considered to be a confluence of Biology, Computer Science, Information Technology, Mathematics, Chemistry, Physics, and Medicine with the objectives of developing tools to analyse biological, biochemical, biophysical data and to generate new knowledge in these areas.

As Choice Based Credit System is now followed in CUSAT already it is beneficial to students of different disciplines to take up this course along with their regular Syllabus. Considering the placement opportunities, they could reap the additional benefit of Bioinformatics data analysis skills.

The different areas where a Bioinformatician is sought are Bioinformatics Analyst, Bioinformatics Trainer, Bioinformatics 'C' Programmer, Bio-statistician, Assistant Professor, Bio/Pharmacy Informatics Associate, Techno Commercial Executive/Technical Executive, Research Associate, Associate Director - Clinical Data Management, Team Leader – Pharmacovigilance

The areas which could be discussed under this course are:

- Bio-molecules
- Object Oriented Programming
- Molecular Biophysics
- Molecular Cell Biology
- Applied Biostatistics
- Phylogenetic Analysis
- Genomics and Proteomics
- Sequence Analysis and Data Mining
- IPR Issues in Bioinformatics
- Bio-molecular Modelling
- Artificial Neural Networks
- Chemo Informatics
- Computer Aided Drug Designing
- Bio-Image Processing
- Pattern Recognition

Learning outcome

Bioinformatics Program will provide professional expertise in the areas of Biotechnology, and Information Technology. M.Sc. Integrated Bioinformatics course is beneficial to equip graduates with adequate skills to conceptualize, design and develop well designed software and databases for biologists.

5. M.Sc. in Microbiology

One reasons for proposing the New courses was also the fact that Cochin University of Science and Technology, does not offer any of these courses yet, and unlike the other universities does not have a School of Life Sciences or Biosciences. A lead in this direction is taken to offer two or more courses; taking steps towards establishing a School of Life Sciences and Technology.

There is a very strong demand for M.Sc. Microbiology courses, as indicated by the large number of students vying for these courses offered by the self-financing colleges, which are not very well conducted, nor affordable to the students. The advancements in the fields of science and technology, has enhanced the scope of microbiology, especially in the areas of medicine, pharmacy, diary, industry, clinical research, water industry, agriculture, chemical technology, environment and nanotechnology.

Job roles for a microbiologist based on qualification: A undergraduate degree in microbiology gives the opportunity to work in science laboratories and pathology labs. A PG in microbiology enables work in microbiology based industries like pharmacy, dairy, breweries and distilleries. Students can also pursue a doctoral degree. Students who complete PhD can take up teaching at universities and PG colleges. They can also take up a post-doctoral research.

The field of Microbiology includes areas such as Bacteriology, Virology, Mycology and Parasitology and medical microbiologists can find jobs identifying the agents of infectious diseases & devise ways to combat them. They also track down and identify new pathogens.

Self-employment can be done by setting up laboratories. District wise bacterial and viral disease tracking centres can be set as part of the Public health centres for surveillance of bacterial, viral and vecor borne diseases. These microbiologists can also monitor water and food supplies.

Food and dairy microbiology require expertise to prevents microbial spoilage of consumables, fights food borne transmission of diseases, and also makes food like cheese, yoghurt and wine.

6. M.Sc. in Biochemistry

Biochemistry is a branch of science which deals with chemical basis of life in plants and animals. That is it is concerned about the internal chemistry of biological systems of animals and plants. Since it is so vast and new phenomena are discovered every year, it is taught as a separate branch of biology. It addresses fundamental questions: How is food converted into energy or body substance? How is genetic inheritance translated into phenotypically expressed properties? How do enzymes, the biological catalysts, differ in power and specificity and controllability from other catalysts? How are nerve pulses transmitted, and how do we think? What is the chemical basis for health and disease? How are all living creatures alike, and how do we differ? How do pollutants and pesticides affect life? Can we meet human needs by manipulating the DNA of bacteria, plants, and animals?

One of the finest reason to study biochemistry is that it allows us to study ourselves and our chemical relationship with the environments. By studying the structures and functions of biomolecules - the energetics, interactions, regulation and downstream signalling of biochemical pathways - and comparing pathways from different species and organisms, you will gain an understanding and appreciation of how living systems operate, survive and die. One can study biochemistry as a part of graduation or post-graduation like in medical biochemistry, forensic biochemistry, agriculture biochemistry etc.

Scope and Career in Biochemistry

People who pursue career in the field of Biochemistry are referred as referred as Biochemists. Biochemists mainly study the structures and functions of enzymes, proteins, carbohydrates, fats, process of metabolism and the molecular basis of the action of genes. As a field Biochemistry has seen unprecedented growth because of its significant contribution towards the illumination and grasping of the DNA Structure.

Biochemists can work both in public and private sectors, usually involved in research related works and can work along with chemists, physicists, healthcare professionals, policy makers, engineers. They can also work for various organisations including hospitals, universities, agriculture, food institutes, education, cosmetics, forensic crime research, drug discovery and many more professionals. Some of the Public-sector companies that offer lucrative career are as follows

Drug Manufacturing Companies, Public Health Entities, Blood Service, Industrial Laboratories, Cancer research institutes, Research Departments, Educational Institutes, Environmental Pollution Control, Agriculture and fisheries, Forensic Science, Hospitals, Public Health Laboratories, Cosmetic Industries, etc

Job profiles:

Research Scientist, Clinical Scientist, Research Associates, Chemist Microbiologist, Biomedical Scientist, Pharmacologist Laboratory Technician, Lecturer in an Educational institution.

7. M. Sc. Data Science

The demand for data scientists has grown more than ever before with the advent of new data generating technology. The amount of data in the world is growing exponentially. From analysing tyre performance to detecting problem gamblers, wherever data exists, there are opportunities for a data analyst. A data analyst is in demand in various fields of the industry like

- Pharmaceuticals
- Computer Software
- Internet
- Research
- IT and Services
- Biotechnology

The proposed M.Sc Data Science programme covers the intersection of Computer Science and Statistics, machine learning and practical application with the aim of generating

insight into data as well as its communication in practice. The course will emphasize Big Data, covering not only traditional data management systems but also systems where data and/or its storage is unstructured.

Hence this course is conceived as an interdisciplinary course with expertise from the Departments of Statistics, Mathematics and Computer Science.

Course structure

It is conceived as a full time 2-year program. It is proposed to offer a 72 credit course as in the structure of a existing regular M.Sc course of the University with relevant core and electives spread out of the broad subjects given above. A combined Board of Studies is to include eminent practicing scientists and industrialists apart from academicians in the concerned relevant subjects.

Course format and assessment

Lectures, Tutorials; seminars and Laboratory sessions. Will be assessed through: coursework; written examinations and final project report.

Eligibility

A pass in any course with an undergraduate level of knowledge in Mathematics and Statistics.

8. Diploma in Aquatic Animal Health Management

Definition: Aquatic Animal Health Management: A process of assisting aqua-farmers in the practice of sustainable aquaculture production, maintaining environmental health by applying tools and devices and biological entitles eco-friendly and economically viable.

Expectations

Defined, well qualified technical personnel to support farmers at field level in implementation of sustainable aquaculture production under preventive health care mode is lacking, especially with the right mindset to be with farmers as one among them. This causes immense difficulties to farmers and the aquaculture sector as a whole, and the situation attracts pseudo-experts to dominate the scene and misguide the investors. Most of the occasions these ill qualified persons fail to troubleshoot and solve issues. An Aquatic Animal Health Manager shall fill the gap. A Diploma holder in Aquatic Animal Health Management must be capable to design and execute need-based, species and location specific aquaculture production systems with sustainability having preventive health care as the strategy.

Challenges

Putting together and blending of all components of aquaculture production systems in the curriculum with justification to the concept of inclusiveness of environment and maintenance of the delicate balance of nature during production integrating preventive health care.

Prospects

India looks forward to double aquaculture production with in another five years. There is dearth of Aquatic Animal Health Managers in the business. Same is the situation Internationally and course envisaged here serves globally for sustained fish production for food and nutritional security. The Infrastructure available at National Centre for Aquatic Animal Health is sufficient.

Feeder Courses

B. FSc (Bachelor of Fisheries Science)

Strategies for development of International Competence in Education

The proposed programmes will be developed in such a way that it will meet the International standards. The global concepts of the educational programmes in aquaculture engineering and aquatic animal health management will be integrated into the above programmes to attract international students with the support of foreign collaborating Institutions of the Centre such as Virginia Tech, USA, Bodo University, Norway and Sterling University, UK.

9. B.Voc/ M Voc Courses

The provision of a curriculum that is internationally attuned and attractive to high quality students who are rewarding to teach. We will adapt our curriculum to the needs and best interests of our students and ensure its relevance to contemporary societal and technological issues. Provide flexible modes of learning and teaching that meet the needs of part- time learners and, whenever feasible, address the needs of students with disabilities. We will embrace and engage with innovative teaching that is of uniformly high standard across subjects. We will add value by embedding elements of employability in our curriculum and increase and broaden the employment opportunities available to our students.

The centre is looking into viability of starting B.Voc/M Voc courses in

- Artificial intelligence
- Data analytics
- Signal and image processing
- Cloud Computing
- Education processes & Technology
- Quality Management
- Software development

Short Term courses viz 3 months course in the following fields is also proposed.

- Certificate in Consulting (Technology)
- Business analysis
- MOOC programmes in Business communication

Engineering Sciences and Technology

1. M. Tech. in Computer Science with specialization in Computational Linguistics

- Duration: 2 years (4 semesters)
- Number of Intakes: 25
- Eligibility: BTech in Computer Science, Information Technology

It is a two-year program in which students of computer science background get opportunity to learn how to apply computational knowledge for natural language processing that includes text understanding, information extraction and retrieval, and speech technology

The objectives of the program are

- To introduce computational linguistics
- To prepare them to work either in industry in the area of natural language processing or take up research.

2. M.Tech in Cyber Physical Systems

Cyber Physical system (CPS) emerges from smart embedded systems, people, objects and communication systems. The objective of M.Tech in Cyber Physical Systems is to produce post graduate engineers for effective advancing of research and development in computer science and digital worlds. The course aims to enhance the knowledge of working systems and infrastructure including those of hardware, software and networking. It also aims to adapt new technologies and undertake researches to design software that can manage big data centres and storages and also to develop methods to enhance the performance for an optimized result. CPS is more interdisciplinary, since it interacts with the physical world in many fields. Research in CPS is also collaborated with medical, biotechnology, geography, etc.

The course will help to acquire a better understanding of current working systems in terms of technological impact and underlying knowledge of creation. The researches in this

area promote development of systems like unmanned and autonomous vehicles, smart cities, smart health care etc.

Cyber physical systems changed interaction and communication between each other. It establishes a bridge between the physical world and cyber world with the help of sensors and actuators, these systems automatically collect information to enable communication. These systems are used to collect all distributed intelligence in the environment to gain a deeper knowledge of the environment. Now CPS is everywhere from IoT to Smart Cities, Drone to health care, volcano to aquatic monitoring.

Facilities Required

- Smart devices with sensing and computing capabilities.
- Wireless sensor network with fibre optic sensors and Micro electrical mechanical sensors.
- Artificial Intelligent Robots for performing skilful work including search and immediate response.
- Smart cellular access points.
- Grid and cloud computing environment and its control systems.
- Base stations operating in VHF band (to reduce energy requirement and improve the network capacity).
- Justification
- Computation, communication and control are the main aims of Cyber Physical System, targeting to develop a smart health care system to track and monitor health and also administer drug
- Critical medical information can be transmitted so we must provide importance for confidentiality and security.
- Privacy and safety for hybrid system architecture with smart sensors in distributed environment for estimation and control strategies.

Our research plan extends to develop efficient algorithms for cooperative, responsive and distributive storage, to enable controlled communication and consumption. Design and development of smart factories with future automation to future energy grids and interconnected mobility.

3. M. Tech. in Electro-Mechanical Systems

Required courses generally fall into the following categories of Applied mechanics, Mechanical systems, Control systems, Microcontrollers and Sensors and instrumentation. The topics addressed in this Course are Advanced Engineering Mathematics, Industrial Management, Sensors & Actuators and control Systems. The electives will be different as per the choice of students.

- Elective - I
- B. LABORATORY / PRACTICAL.
- Sensors & Signal Conditioning Lab.
- Mechatronic Systems Lab
- Seminar - I
- Elective – I: One subject to be chosen from the following subjects.
- Code Subjects ME105 Signal Conditioning and Data Acquisition System
- Wireless Communications
- Advanced Electrical Drives
- Application of Mechatronic Systems
- Advanced Microprocessor and Microcontrollers
- Industrial Automation
- Elective – II
- Elective – III
- B. LABORATORY / PRACTICAL
- Seminar - II
- Mechatronics Lab
- Elective – II: One subject to be chosen from the following subjects.
- Advanced Control System
- Micro Mechatronics Systems
- Digital Signal Processing
- Elective – III: One subject to be chosen from the following subjects.
- Product Design
- Digital Image Processing & Machine Vision
- VLSI Technology

4. M. Tech in Energy and Environment Management

To provide a strong foundation in basic and advanced knowledge in energy generation, conservation and management, enabling the graduates to excel in the various careers in effective utilization of energy in coherence with sustainable energy production

Topics addressed in this Course

- Energy Ecology and Environment
- Applied Mathematics and Computational Methods
- Bio-energy and Processing of Waste
- Environmental law & Enforcement
- Environmental Economics
- Elective-I
- Energy Laboratory
- Non-Conventional Sources of Energy
- Energy Auditing
- Integrated Energy Systems
- Industrial Energy analysis and Environmental Audit
- Industrial Waste Management
- Environmental Impact & footprint analysis
- Elective II
- Project
- Research Laboratory Training/assistantship
- Project
- Research Laboratory Training/ assistantship
- Energy Conservation
- Hazardous Waste Management
- Economics & Planning of Energy Systems
- Energy Policy & Planning
- Environmental Law
- Instrumentation & Control in Energy Systems
- Quantitative Methods for Energy Management and Planning
- Industrial Energy analysis and Environment audit
- Industrial and Commercial Applications of Renewable Energy Sources
- Alternative Fuels for transportation

5. M. Tech. in Industrial Engineering

To provide strong foundation in advanced knowledge in Industrial Engineering and Management, enabling the graduates to excel in careers in Industrial Engineering. Ability to design and conduct experiments using IE models and IT tools, to analyze and interpret the data leading to feasible solutions.

Topics and Brief content:

- Decision modelling
- Inventory and supply chain management
- Accounting and finance for management
- Marketing management
- Industrial engineering laboratory
- Decision modelling
- Facilities layout planning
- Manufacturing planning and control
- Human resource management
- Computational laboratory
- Statistics for management
- Work system design
- Management of technology and innovation
- Strategic management
- Management information systems
- Group technology and fms
- Reliability engineering and management
- Product management
- Project management
- Technical entrepreneurship
- Business ethics
- Computer methods in management
- Organisational behaviour
- Consumer behaviour
- Soft computing techniques
- Risk management and insurance
- Financial management
- Decision support and expert systems
- Systems modelling and simulation
- Data base management
- Enterprise resource planning
- Industrial scheduling
- Lean production management
- Investment management
- Takeovers and corporate restructuring
- Forecasting techniques
- Managerial economics
- Computer integrated manufacturing

6. M. Tech in Structural Engineering

To provide a strong foundation in basic and advanced knowledge in structural engineering, enabling the graduates to excel in the various careers in structural engineering field and infrastructural development and address the environmental aspects and sustainable issues related to infrastructure development

Evaluation of materials and structural systems subjected to both static and dynamic loads of extreme loading conditions generated by man-made and natural hazards. Design and validation of smart structure technologies for the structural health monitoring of different type of structures

Topics addressed in this course

- Structural Dynamics
- Theory of Elasticity and plasticity
- Experimental Stress analysis
- Design of Tall Structures
- Elective –I
- Structural Engineering Laboratory-I
- Seminar-I
- Industrial Training/Workshop
- Finite Element methods
- Design of Prestressed concrete structures
- Theory of plates and shells
- Elective II
- Design of Bridges
- Structural Engineering Laboratory-II
- Project
- Research Laboratory Training/assistantship
- Research Laboratory Training/ assistantship
- Forensic Engineering and Rehabilitation of Structures
- Structural Optimisation
- Modelling, Simulation and Computer Application
- Earthquake Analysis and Design of Structures
- Construction Project Management
- Structural Health Monitoring
- Geographic Information System and Applications
- Stochastic Processes in Structural Mechanics

7. M.Tech in Underwater Electronics

Oceans affect the human life in different forms. Hence the exploration of the sea has been receiving increasing attention around the world, primarily to exploit the vast untapped oceanic resources, such as oil and gas, minerals, fish, energy, water, etc. Apart from this, the ocean has the strategic importance especially for a country like India with a very lengthy seashore. The 21st century is supposed to be an extraordinary era of ocean exploration and exploitation, which requires highly sophisticated and innovative underwater systems and technologies for identifying, recognising and extracting the tremendous potential and valuable living and non-living resources available in the ocean. This can be achieved only through coordinated efforts for developing systems and products taking into account the global developments in this highly specialised area of technology. For this, highly skilled and trained manpower is essential.

The Department proposed to start an M.Tech programme in the area of Underwater Electronics to produce adequate human resource in this specialised area which is very important for the country.

Course Objective:

To create experts in the area of underwater acoustics and ocean Electronics for the development of marine sensors, underwater acoustic transducers and systems for Oceanographic applications, sensor technologies and systems to detect and classify buried objects under seabed. Also to give training in acoustic signal processing for identification and classification of targets such as submarines or fish shawls.

This course is conceived to be different from conventional one with strong support from industry and R&D institutions. Scientists from the following institutions are to be associated in forming the course structure and curriculum as well as adjunct faculty

- NIOT,
- NPOL,
- NSTL

- IIT, Madras
- IIT, Delhi

Course structure.

It will be a full-time 2-year program. The course structure is proposed to be similar to the existing regular M.Tech course of the University with 72 credits with relevant core and electives spread out in related disciplines. The course structure is to be formulated by a Board of Studies which includes academicians, scientists from R&D institutions and industrialists in relevant fields.

Course format and assessment

- Lectures
- Tutorials; seminars
- Laboratory sessions
- Short term attachment programme in industry.

The students will be assessed through the existing methods in the university such as coursework; written examinations and final project report and viva voce.

Eligibility

A first class B.Tech degree in Electronics and Communications Engineering or M.Sc in Electronic Science.

8. M.Tech in Sustainable Development

To learn how to analyse and comprehend basic principle of sustainable development in built environment and its planning and management, to visualise systematic process on environmentally water resource management and sustainable building construction and materials

To launch the skilful techniques on the application of cultural, economic, social, political, organisational and institutional factors combine to yield strategies, policies and projects that are unsustainable or sustainable.

Topics addressed in this Course

- Engineering design of Experiments
- Sustainable construction materials
- Sustainable water resource management
- Climatic design and planning of buildings
- Building Technology Laboratory
- Numerical methods in Engineering
- Advanced concrete technology & Sustainable construction Practices
- Water Resource engineering and management
- Coastal Zone Management
- Computational lab
- Research Laboratory Training/assistantship
- Project
- Research Laboratory Training/ assistantship
- Evolution of sustainable development
- Dimensions of sustainability
- Green building ratings
- Green building design and innovations
- Low carbon design and Technology
- Sustainable communities

9. M.Tech in Logistics And Ship Operations Management

India has a long coastal line of about 7500 km with its 20 major ports and more than 200 non-major ports. As shipping is the cheapest and environment friendly means of transport and with the simple of projects 'Sagar Mala' shipping industry is expecting a boom. This demands quantified logistician capable of inventory management, purchasing, transportation, warehousing and organising and planning for these activities. The different ship operation like characterising registration, classification, insurance, manning bunkering also requires qualified technical personals. Given this, a master programme is planned to be offered with focus on the following trust areas.

- Logistics
- Ship Operations
- Economics of Shipping
- Maritime Regulations and Laws

10.M. Tech in Project Management and Ship Surveying

Shipbuilding involves lot of operations managing materials process people, finance etc. Modern trends in Naval Architecture and newer technologies may pose challenges in project implementation which result in delayed project completion. The project engineers are to be updated with latest technological advances. This masters programme is aiming to bridge this knowledge gap.

Ship survey is a major activity along with shipbuilding and for assessing the seaworthiness of the ships, which demands technical personals with competency in the fields of naval architecture onboard machinery, instrumentation, safety and the related IMO regulations. The master's programme is designed to equip marine engineers and naval architect to meet the requirements of ship surveying, quantity surveying and costing and damage estimation.

Therefore, the M. Tech programme in Project Management and Ship Surveying is designed with the following thrust areas:

- **Project Management** with special emphasis on shipbuilding, port development and marine structures like oil rigs and platforms.
- **Ship Surveying** with an emphasis on the class requirement, quantity surveying and IMO regulations.
- **Economics and Financial Management** with an emphasis on cost estimation and ship insurances.

11.Integrated M.Tech. in Polymer Science and Rubber Technology

The Department plans to offer a five year integrated M.Tech. Programme in Polymer Science and Rubber Technology. The main aim of the course is to fill the gap areas of current Polymer Science and Rubber Technology courses offered by various Institutes. The ultimate aim of the course is to equip students with modern skills in designing, processing and testing of rubber and plastic products. The proposed curricular structure aims at creating knowledge on the basics of polymer science and rubber technology with more emphasis on processing and designing of polymer products.

12. M.Sc Electronic Science (with specilisation in Artificial Intelligence & Assistive Robotics)

The field of AI has achieved great progress over the last 10 years, ranging from self-driving cars to speech recognition and synthesis. Against this backdrop, AI has become a topic of conversation in more and more companies and households who have come to see AI as a technology that isn't another 20 years away, but as something that is impacting their lives today. There will be big winners and losers as collaborative technologies, robots and artificial intelligence transform the nature of work. Societies will face further challenges in directing and investing in technologies that benefit humanity instead of destroying it or intruding on basic human rights of privacy and freedom of access to information.

Assistive technology is an umbrella term that includes assistive, adaptive, and rehabilitative devices for people with disabilities and also includes the process used in selecting, locating, and using them. Assistive technology promotes greater independence by enabling people to perform tasks that they were formerly unable to accomplish, or had great difficulty accomplishing, by providing enhancements to, or changing methods of interacting with, the technology needed to accomplish such tasks. Due to assistive technology, people with disabilities have an opportunity of a more positive and easygoing lifestyle, with an increase in "social participation," "security and control," and a greater chance to "reduce institutional costs without significantly increasing household expenses.

This course would support the following program objectives and program learning outcomes

- Students will have a broad understanding of the fundamental theories, concepts, and applications of artificial intelligence/ assistive robotics.
- An ability to apply knowledge of computing and mathematics appropriate to the discipline.
- An ability to analyze a problem, and identify and define the computing requirements appropriate to its solution.
- An ability to design, implement, and evaluate a computer-based system, process, component, or program to meet desired needs.
- An ability to use current techniques, skills, and tools necessary for computing practice.

- Understand different types of AI agents
- Know various AI search algorithms (uninformed, informed, heuristic, constraint satisfaction, genetic algorithms)
- Know how to build simple knowledge-based systems.
- Demonstrate working knowledge of reasoning in the presence of incomplete and/or uncertain information

Course Outcomes

Upon successful completion of this course students will be able to:

- Identify problems that are amenable to solution by AI methods
- Select suitable AI methods to solve given specific problems.
- Make self-learning/adaptive control systems for robots or intelligent systems.
- The ability to design a system, component, or process to meet desired customer or population needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- The ability to apply mathematics, science, and engineering knowledge to identify, formulate, and solve engineering problems.
- The ability to design and conduct experiments, as well as to analyze and interpret data.
- A knowledge of state-of-the-art engineering bioinstrumentation as tools to analyze performance and solve engineering problems.
- The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.
- An ability to work professionally in the field of assistive robotics.

13.M.Sc Computer Science (Specialization: Artificial Intelligence and Robotics)

Artificial Intelligence is one of the most fascinating and promising areas of academic study that has emerged in this century. Robotics is a domain in artificial intelligence that applies different techniques for creating intelligent and efficient robots. This course intends to cover the areas in Computer Vision, Natural Language Processing, Computational Intelligence, Machine Learning and their applications in Robotics. The course would also focus in applications in areas such as mobile robots, autonomous vehicles and computational neuroscience. A broad spectrum of employment and research possibilities would open up for the students after the completion of this course.

The primary objective of this course is to enable students to design computers and machines that act similar to humans with as little human involvement as possible. This will give students a basic understanding of some of the more advanced topics of AI such as learning, natural language processing, agents and robotics, expert systems, and planning. The emphasis of the course is on teaching the fundamentals and providing a mastery of available software tools or programming environments. This helps to cultivate an active and relevant computational intelligence research and development community

Course Outcomes

Upon successful completion of this course students will be able to:

- Identify problems that are amenable to solution by AI methods
- Select suitable AI methods to solve given specific problems.
- Make self-learning/adaptive control systems for robots or intelligent systems.
- Demonstrate an understanding of issues related to optimality in human motor control.

14.Short-term programmes for skill development

The enhancement in the maritime activities and the inland water transportation, introduction of river-sea vessels will require skilled manpower for running and maintaining small vessels. The following short-term courses are proposed to be started to fill the skill gap and to generate income:

- **STCW Courses**
- **Advanced Fire Fighting Course**
- **NCVT Courses**
- **Hydraulic and Pneumatic Control Systems**

Scientific Computing

Integrated M. Sc. in Scientific Computing

Courses Offered:

Five year integrated M.Sc/MS programs in various basic subjects the areas of basic science, commerce, management and fine arts, such as Physics, Mathematics, Chemistry, Botany, Zoology, Commerce, Fine Arts, Commerce, Economics and management. These courses will be tightly integrated with appropriate computational subject so that each student will get a postgraduate degree with a specialization in two subjects one in basic subject of their choice and the second will be in Computer science.

Proposed Courses:

- Integrated BS/MS course with two main stream specialization
- Physics and Computer Science with specialization in Scientific Computation
- Chemistry and Computer Science with specialization in Scientific Computation
- Mathematics and Computer Science with specialization in Scientific Computation
- Biochemistry and Computer Science with specialization in Scientific Computation
- Zoology and Computer Science with specialization in Scientific Computation
- Botany and Computer Science with specialization in Scientific Computation
- Economics and Computer Science with specialization in Statistical Computation
- Commerce and Computer Science
- Management and Computer Science

Marine Science

With the Vision of Promotion of Sustainable Practices in Marine Sciences towards Societal Benefits and a Mission of Impart education, skill development, high quality training programs and conduct of advanced level research of acclaimed excellence, the marine science has a goal set to grow as an International Centre of Excellence / Eminence in Marine Sciences of South East Asia [Phase – 1, within the initial implementation period of 5 years] and a and Global Recognition in Phase – 2, 10 years.

Common subjects where collaboration with sister departments/ Schools from main campus is indicated :

- Marine Robotics – Electronics, Physics, Engineering
- Marine Sensors – Electronics, Ship Technology and Marine Engineering
- Marine Minerals – Civil and Mechanical Engineering
- Marine Pollution – Environmental Studies, Biotechnology
- Advanced Marine Materials – Materials Centre, Technology Faculty
- Marine Policy – Management and Applied Economics
- Environmental Sustainability – Environmental Studies, Legal Studies, Management, Applied Economics

1. M.Tech in Exploration Geophysics

Geophysics is the remote study of the Earth's interior through physical techniques – principally analysing seismic data, but also applying gravity, magnetic, electrical and electromagnetic methods. It is a key element of oil, gas and mineral exploration, and engineering site investigation.

This course prepares you to embark on a career in resource exploration, environmental and engineering geophysics. It provides the students with a broad range of practical skills, underpinned by a theoretical understanding that equips to become a professional in exploration of oil gas and minerals.

Demand for geophysicists continues to be high and this course has an exceptionally good possibility of job placement in various national and international agencies

Proposed Course Content

- Exploration Geophysics:
- Computational Inverse Theory
- Petrophysics and Petroleum Geology
- Seismic Reservoir Evaluation and Recent Developments
- Geophysical and Geological Field Methods and Geological Interpretation
- Gravity and Magnetic Methods
- Seismic Fundamentals and Acquisition
- Seismic Data Processing
- Seismic Reflection Interpretation and Sequence Stratigraphy

2. M.Tech in Geoinformatics

Geoinformatics is an interdisciplinary program for students who want to develop expertise in and applying geospatial technologies to solve world's most pressing real-world challenges in environmental, social and economic domains. Geoinformatics is a rapidly evolving field that brings meaningful insights to solve real world problems by bringing together technologies and tools required for acquisition, exploration, visualization, analysis and integration of various spatial data. There are several components of Geoinformatics that include cartographic geovisualization, GIS, Remote sensing, photogrammetry, spatial statistics, geostatistics, multivariate statistics and other advanced tools and techniques.

The core strength of the programme lies in its innovative curriculum that imbues present and future professionals on development and the use of cutting-edge geospatial technologies to emulate real-life problems. Over the period of study, students gain sound knowledge in the scientific principles behind computational and analytical foundation of Geoinformatics as well as its applications in domains such as conservation biology, urban planning, meteorology and natural resource management through hands-on exercises, training programmes, a semester long major project. Programme will have flexible options for choosing elective courses across different departments that support students to build career in the domain of their interest.

Spatial and non-spatial datasets are crucial for studies on environmental and sustainable development planning., The emerging need of geospatial technology has created

an unprecedented demand of trained manpower, who can contribute to production and analysis of these datasets. To fulfil the need of such trained professionals, the M.Tech in Geoinformatics offers a cutting-edge technology, which has the potential of providing consistent and timely information required for natural resource management. The programme, offered by the Department is intended to educate students and professionals about Remote Sensing/Geographical Information System/Global Navigation Satellite System and spatial modelling techniques. It also offers elective courses that help students in understanding the interdisciplinary applications of this ever-evolving technology. Students who complete this programme will possess the confidence and skills to attract a wide range of potential employers in both public and private organizations. This course will also provide a structured route to research and development in the area.

Proposed Course Content

- Principles of Cartography
- Principles of Remote Sensing
- Principles of GIS and GPS
- Digital Image Processing and interpretation
- Spatial Data modelling and GIS applications
- Law and Policy of maps and Remote Sensing
- Photogrammetry
- Multivariate Data Analysis
- Satellite meteorology
- Applications of Geoinformatics in Environmental issues, Groundwater hydrology, Watershed Management, Geoexploration

3. M.Tech in Atmospheric Radar Technology

Radars are conventionally used to detect and track aircraft, spacecraft, and ships at sea as well as insects and birds in the atmosphere; measure the speed of automobiles; map the surface of the earth from space; and measure properties of the atmosphere and oceans. Principles of radar have led to the development of other similar technologies such as sonar, sodar and lidar (laser radar) that permit detection of phenomena and targets in the oceans and in the optically clear air. In the recent decades, weather radar has advanced greatly and has played increasingly important roles that span a wide spectrum of meteorological and

climatological applications. Of particular importance has been its ability to detect and warn of hazards associated with severe local storms that include hail, tornadoes, high winds, and intense precipitation. Weather radar also monitors larger weather systems such as hurricanes that often include similar phenomena but can extend over very large areas.

In India, a dense network of the installation of Atmospheric- and Weather-Radars are proposed for improving weather prediction techniques, prediction of heavy rainfall events, cyclone warning, air traffic safety, extreme weather events, prediction of natural hazards, climate variability, strategic applications in sensitive areas, etc. Trained manpower in the field of atmospheric radars is inadequate in the country to meet the requirement in the near future. Indigenous development of the radar technology is essentially needed under the Make in India policy of the Government of India. In the fast technology advancement of our country, trained manpower and indigenous development of technology in key positions are of utmost importance. In view of the highly demanding situation, a M. Tech programme in Atmospheric Radar Technology is proposed.

4. M.Tech in Marine Pharmocognacy

The American Society of Pharmacognosy defines pharmacognosy as "the study of the physical, chemical, biochemical and biological properties of drugs, drug substances or potential drugs or drug substances of natural origin as well as the search for new drugs from natural sources." Over 70% of the earth's surface is covered by oceans which contain 95% of the earth's biosphere. Many different marine organisms have been explored for bioactive compounds. Some vertebrate animals include fish, sharks and snakes. Some examples of invertebrates are sponges, coelenterates, tunicates, echinoderms, corals, algae, molluscs and bryozoans. Some microorganisms include bacteria, fungi and cyanobacteria.The Marine Sector is considered to be the ultimate source for a wide spectrum of materials – include biomass, biogeo organic compounds, medicine, etc. Due to technological lapses and economic considerations the utilization of these treasure was limited to only a few materials.

The Course includes the studies of the traditional use of plants for medicinal purposes, of the Pharmacological qualities of traditional medicinal substances, of the

medicinal use of plant extracts, of chemicals derived from plants (including the identification of new drug candidates derived from plant sources), of the synthesis of natural bioactive molecules using biotechnology, of the interactions of herbs with other drugs and body, of the chemicals derived from marine organisms, Advanced Pharmaceutical Analysis, Herbal Drug Development & Standardization and Phytochemistry Practicals.

Intake from M.Sc. Chemistry/ Medicinal Chemistry/Marine Biology/ M.Sc. Pharmacology and B.Tech in Chemical Engineering/technology.

5. M. Tech Programme in Computational & Geophysical Fluid Dynamics

Earth's atmosphere and oceans exhibit complex patterns of fluid motion over a vast range of space and time scales. On the planetary scale they combine to establish the climate in response to solar radiation that is in homogeneously absorbed by the materials comprising air, water, and land. Spontaneous, energetic variability arises from instabilities in the planetary-scale circulations, appearing in many different forms such as waves, jets, vortices, boundary layers, and turbulence. Geophysical Fluid Dynamics (GFD) is the science of all these types of fluid motion. It seeks to identify and analyse the essential dynamical processes that lie behind observed phenomena. As with any other theoretical science of complex nonlinear dynamics, mathematical analysis and computational modelling are essential research methodologies, and there is a continuing search for more powerful, accurate, and efficient techniques

The field of atmospheric and ocean sciences has changed dramatically during the past 50 years. In India, the advances in atmospheric and ocean sciences have not been utilized fully for improved weather forecasting and climate prediction. The observation of atmosphere and ocean from space in India is as good as in developed countries but the huge amount of satellite data has not been utilized effectively. In numerical weather prediction and climate modelling India is lagging behind the developed world. This is because this area has been neglected by both the academic community and the operational agencies. This

requires talented manpower in the area of modelling research in the area of atmospheric and ocean sciences.

The proposed M. Tech Course in Computational & Geophysical Fluid Dynamics at CUSAT is a flexible, interdisciplinary program with a focus on addressing cutting-edge science questions about geophysical processes in our climate system and modelling. The program is structured in line with the other M. Tech Programmes of the University providing ample flexibility to the students to learn as per the course and the interest. Computational Geophysical fluid dynamics is an interdisciplinary field involving a broad range of topics and academicians from several university departments. The course is intended to be multi disciplinary for all Departments and Schools of Lakeside campus as well as Departments of Mathematics, Computer Applications and Computer Sciences.

6. M. Tech. in Applied Tropical Marine Biology

Tremendous baseline information on primary characteristics of varied marine ecosystems has been generated for the period. However, a renewed thrust has evolved in our actions, since the beginning of this decade, due to the paradigm shift in our approach to tackle various issues associated climate change, species variabilities and loss, increasing pollution and anthropogenic issues and other factors. Of late, monitoring, modelling and proposing management plans on ecosystem changes, extending from coastal estuaries, lagoons, mangroves, oceans to the arctic regions has widened the perspectives of our research priorities. The basic infrastructural facilities developed since this decade were, basic microscopes, with imaging systems for community evaluation and other applications, Green House Gas analytics for elemental & carbon analysis, ecology molecular and bioanalysis lab for genetic mapping, ecotoxicology lab, continuous flow through system for trophic level monitoring and biomarker studies, algal, zooplankton and mangrove culture facilities and marine biology wet lab for water and soil and benthic analysis.

7. M.Tech in Marine Genomics

The marine environment is the cradle of life containing 95% of the world's biomass and 38 (19 endemic) of the 39 known animal phyla. Apart from providing a third of the oxygen that we breathe and acting as moderators of global climatic change with a significant influence on the human population's terrestrial environment. These vast expanses are also an important source of high-protein food, contributing fundamentally to the planet's functioning, yielding some 60% of the total economic value of the biosphere and therefore comprise the largest untapped resource on earth. Marine and coastal environments include many diverse pelagic and benthic habitats such as open-ocean ecosystems, deep-sea communities including thermal vent ecosystems, kelp forests, mangroves, coral reefs and so on. Moreover, the marine microbial assemblages are diverse and unique and the challenge is to discover what functions are played by these microorganisms. Genomics is a highly emerging research area. Hence, rapid developments in genomics can afford new opportunities for applications in marine environment, particularly in the areas of Fish genome resources conservation and genetic enhancement. Certificate Courses - Short term training programs with duration of 2 to 4 weeks are also planned in the following emerging areas to attract stakeholders from foreign countries.

- Food safety management
- Genomic traceability
- Waste valorization
- Seafood retailing and export management
- Aquaculture for rural development

The students will be doing their internship in the industry which will help them to get hands-on experience and to acquire entrepreneurial skills.

8. Integrated M.Sc Marine Sciences

This programme could be offered as an interdisciplinary BSc-MSc Marine Sciences, handled collectively by all the five departments under School of Marine Sciences. This programme will have the advantage of large student base coming after plus two level, who

could be motivated to pursue undergraduate and post-graduate programmes in marine sciences leading to high quality trained graduates who could deal with the challenges in the field much more successfully.

A Five year Integrated M.Sc. in Geosciences with specialization in Marine Geology/ Marine Geophysics has already been sanctioned by the Academic Council of CUSAT.

9. M.Sc. Remote Sensing and GIS

The world seems to be experiencing natural disasters on an unprecedented scale. The impact of natural disasters is often much more severe in developing countries than in developed countries. During the last decade the Indian region has been particularly hard hit by natural disasters, such as drought, cyclones, floods, landslides and earthquakes.

With the help of technologies such as Satellite Remote Sensing, GPS and GIS, the effects of natural disasters on society and economic infrastructure can be reduced significantly, if they are made to good use. The challenge here lies in the realization of a comprehensive management system involving the acquisition, integration and analysis of near – real time data, algorithms or methodologies for the conversion of primary data into meaningful information, priority setting, scenario development and decision support tools, as well as technologies for the generation of management options, making optimum use of available resources and infrastructure. As of now, employment prospects are bright for trained manpower in Remote Sensing and GIS in ISRO, IMD, Universities, Department of Ocean Development, DRDO, State Government Departments as also in the private sector. There is also immense scope abroad.

The Department of Atmospheric Sciences and Physical Oceanography now proposes to offer a M.Sc. course in Remote Sensing and GIS to develop manpower with special skills in applications to Atmospheric, Oceans and Marine Sciences. The enormous amount of data gathered by the various satellites launched in the recent past needs appropriately trained scientists to analyse and utilize it in concerned applications.

- A Remote Sensing and GIS Laboratory has to be established
- to provide facilities for hands – on practical laboratory work in remote sensing and GIS
- facilitate research activities in the University in different fields using satellite data.
- offer training programmes to potential users in and outside the University.

The Department already has three workstations with about 30 terminals and a Digital Image Processing (ENVI 3.4). The required facilities include hardware and software for image processing and Geospatial analysis as well as an array of ancillary and supporting equipment – input output devices including digitizers, image scanners, plotters, printers and data storage devices. Application software's are required to provide state of the art capabilities for image processing, modelling , statistical analysis and visualization. Specialization are planned in :

- Specializations in GIS – RS
- Marine Remote Sensing and GIS
- Marine Satellite Applications
- Atmospheric Remote Sensing and GIS

Spin off

- Introductory Ocean Remote Sensing (2-3 weeks – Certificate course)
- Multi Disciplinary Marine Remote Sensing Applications (6 months Course).
- Real time forecasting
- Sea Truth Survey
- Algorithm developments
- Hazard warning
- Consultancy

10. M. Sc. Programs in Industrial Fisheries with specialization in Sustainable Aquaculture, Aquatic Food Products Technology, and Fish Business Management

The existing PG programmes offered by the school are having high demand among prospective students and industrial patrons with excellent feedback. However, the proposed three PG programs in innovative areas in industrial fisheries are highly essential as these courses

- will attract more talents from within the country, from southeast Asian countries and also from other developing countries.
- will foster the global initiative towards meeting the objective of sustainable fisheries and aquaculture.
- will generate greater employment opportunities for students from marginalized sectors and rural population of the state.
- will pave the way for advanced and focused research to meet the societal needs.

Facilities required

- Grow-out farms for aquaculture training (1 hectare)
- Modification of existing hatchery complex for Seed production technology
- Laboratory fish genetics and molecular taxonomy
- Laboratory for aquatic food product development.
- Full-fledged ICT laboratory
- Pilot plant for seafood processing and value addition.

11.Post Graduate Diploma in Hydroinformatics

Hydro-informatics is the study, design, development, and deployment of hardware and software systems for hydrologic data collection, distribution, interpretation, and analysis to aid in the understanding and management of water in the natural and built environment. Hydroinformatics is the multidisciplinary application of information and decision support systems to address the equitable and efficient management and use of water for many different purposes. It sees application at all points in the water cycle, from atmosphere to ocean, and in artificial interventions in that cycle such as urban drainage and water supply systems. Hydroinformatics is an essential component in the functioning of researchers, stock holders, policy makers, administrators and project implementers.

Hydroinformatics also recognises the inherently social nature of the problems of water management and of decision making processes, and it includes mechanisms towards understanding the social processes by which technologies are brought into use and how they change the water system. Like other fields of informatics, hydroinformaticians have recognized the need for a larger global initiative to use technology for greater data integration and sharing in the field. International efforts to create databases like those found at the Global Runoff Data Centre, Global Hydrology Resource Center, and AQUASTAT have furthered

that goal. Freeware like CROPWAT (a computer program for the calculation of crop water requirements and irrigation requirements based on soil, climate and crop data) and open-source software like HYPE OSC (Hydrological Predictions for the Environment Open Source Code) have further added to the informatics tools available to hydrologists.

12.Post-Graduate Diploma in Wetland Ecosystem And Management

Kerala is one of the green States of India and is well known for its wetlands. There are about 217 wetland areas in Kerala and it accounts for as much as one fifth of the land area of the State. The unique wetland ecosystems of Kerala include marshy and water logged areas, vast polders (paddy cultivation areas) associated with backwaters, and lakes and the Myristica Swamps in the Western Ghat forests. Besides, Kerala contains a few wetlands of International / National importance. These include Vembanad – Kole, Ashtamudi and Sasthamcotta lakes which are also designated as Ramasar sites of Kerala. Wetland systems directly or indirectly support thousands of people providing goods and services to them. However, urbanization, developmental activities and mushrooming of residential complexes have fragmented the contiguity of the wetlands and destroyed its vegetation. Though there were no quantitative estimates on the rate of destruction of wetlands in Kerala, the qualitative degradation of the ecosystem is, more or less, well understood. The major issues facing the wetlands of Kerala are mainly related to pollution, eutrophication, encroachment, reclamation, mining and biodiversity loss. A good number of management programmes were initiated during the last five years for developing and implementing sustainable management plans for wetlands. The Kerala State Council for Science, Technology and Environment (KSCSTE) has prepared Management Action Plans for Vembanad, Sasthamkotta and Ashtamudi lakes. Centre for Water Resources Development and Management (CWRDM) has initiated Management Action Plan preparation for Vembanad, Ashtamudi, Sasthamcotta and Kottuli wetlands which are being implemented with support of Ministry of Environment and Forests (MoEF). In this scenario, the wetland ecosystem and management course will give students a thorough understanding of all aspects of wetland science and ecology required for the complex conservation, restoration and management issues associated with wetlands. Students will learn the theoretical and practical skills needed in the application of

a range of treatment of wetlands for pollution control and water management. Field and laboratory work will also cover the latest techniques in environmental analysis needed for contemporary wetland monitoring and experimentation.

The course goal is to develop a comprehensive understanding of wetland systems include: wetland classes and biodiversity, wetland hydrology and biogeochemistry, ecological processes critical to the systems evolution and continued stability, wetland ecosystem services, instrumental and environmental analytical techniques etc. Thus, it will train the wetland engineers and biogeochemists interested in environmental analysis and suitable for those studying a wide variety of aquatic systems.

13.Post Graduate Diploma in Marine Instrumentation

Recognizing the emerging need for encouraging indigenous design and development of marine instruments and servicing facilities the course has interdisciplinary interests. The Department of chemical oceanography have already been equipped with highly sophisticated instruments for training, research and consultancy in chemical studies on diverse aspects of the environment and has pioneered investigations in many areas. The department is planning to initiate a programme on design and development of some of the marine instrumentation and also expertise the students for handling sophisticated instruments for marine science research.

14.Post Graduate Diploma In Marine Biogeochemistry

The Department of Chemical Oceanography at Cochin University of Science and Technology is pioneered in ocean chemistry and continuously exploring the complex interplay between the biosphere, hydrosphere, soil and climate. Interests in the department are broad and far-reaching, encompassing a wide range of research expertise in the pollution studies, natural products and biogeochemistry as a part of interdisciplinary approach. In particular it deals the cycles of chemical elements such as nitrogen, phosphorous and carbon etc. and their interactions and incorporations into living things in the earth system with time.

The course goal is to develop a comprehensive understanding of biogeochemistry, especially of estuaries and open ocean systems. The course includes lectures and experimental expertise in understanding earth as a chemical systems, origin of earth systems, carbon chemistry biogeochemical cycles, inland and ocean water chemistry, instrumental and biogeochemical analytical techniques etc.

15.Post Graduate Diploma In Modelling And Data Validation

Last few decades mathematical modelling and applications become as a mandatory tool for better understanding of processes in earth system sciences. Mathematical models are an abstraction and duplication of the environmental systems and they are based on our understanding of the physical and chemical principles that govern the system. The modelling study includes the development of mathematical solutions to address specific question we have posed for the system and the models should not go beyond these questions. Almost all modelling studies have inherent approximations and errors associated with mathematical representation of environmental parameters.

Since numerical models are simplification of complex environmental systems, thus they are often associated errors and accuracy issues. In order to avoid these problems each models needs to go through calibration, data validation, data verification and sensitivity of model results. A series of studies have been carried out in deferent aspects of model calibrations and concluded to incorporate field data in modelling studies

This course is focused on a comprehensive indigenous development of mathematical models especially for earth system science studies and to expertise students in modelling studies. The course includes lectures on principles of modelling, calibration, data validation and applications of modelling in marine chemistry research.

16.Certificate programs in Introductory Remote Sensing with emphasis on Oceanography and Meteorology

- Certificate course in GIS
- Duration: 1 to 2 months

- Diploma Courses in Multi-disciplinary areas of Marine Sciences with emphasis on remoter sensing applications
- Duration : 6 months

Both the above programs are linked the Master's Program in Remote Sensing and GIS.

Humanities and Social Sciences

1. Certificate/ Diploma Course On Applied Data Science For Business Using R

As an interdisciplinary field, data science deals with tools and techniques that are used to extract knowledge or insights from large amount of structured or unstructured data. This field is an extension of other data analysis fields like data mining, statistical analysis and predictive analytics. Considering the importance of data science to provide better managerial insights and to make more accurate and precise decisions, the importance of this discipline in business has increased over the past few years.

This course aimed to provide training on:

- Mastering the software: This data science certification aimed to impart in-depth skills and knowledge covering very robust machine learning algorithms and techniques, which are supported by a most powerful statistical software, R.
- Real-life data exposure: This certification primary designed to expose the participants with real life business decision making situations, therefore, the focus will be more on real-life business projects, case studies, and R practical sessions.
- Tools and techniques: This course is oriented towards providing training on very robust tools and techniques (e.g, text mining, social media analytics, etc), which are very much essential in current business scenario, where majority of the data available are in instructed form.

Across all industries there is growing demand for skilled data science personals, therefore, an exposure to this course well-suited for job seekers at all levels of experience. Specifically this will benefited to professionals in the following areas:

- Management and IT graduates, who are looking for a new job into data science and analytics.
- Those who are working in software development, looking for a training which help them to have a career switch.
- Professionals who are looking to build their career in data analytics
- Professionals who have passion in the field of data driven decision making.
- Anyone with a genuine interest in the data driven business modelling.

Modules will be Introduction to data science & R, Understanding of data structure, Data Visualization and descriptive, Supervised and unsupervised learning techniques and Introduction to Hadoop and text mining.

2. Certificate Course On Data Analysis For Research & Publication

This course primarily designed in a very interactive hands-own training mode using most popular software packages, such as IBM SPSS & MPLUS/AMOS. Handled by eminent academicians who have great publication records in reputed international journals, such as Internet Research, Computers in Human Behaviour, International Journal of Manpower, Journal of Service Theory and Practice, etc.

This course will equip the participants to connect different phases of research, so as to come up with better research outcomes, that is, after this workshop the participants will be able to solve issues concerning the use right data analysis tools, interpret the results and its reporting to meet the research/ journal requirements.

Every data analysis section will be oriented towards reporting of the data analysis results in theses, research reports and top tier international journal publications. A day is devoted to the discussion of perspectives, in which the resource persons sharing their viewpoints or thoughts concerning a fundamental question: “How to publish in top tier academic journals?”

Different Topics like Univariate , Multivariate, Factor analysis, Regression analysis (bivariate and multiple), Mediation as well as Moderation analysis as well as Strategies for Academic Publication will be covered.

3. MA Applied Economics, will be augmented by specialisations in

(1) Econometrics and (2) Financial Economics. These programs may be considered for exclusive MA degree(s) and later the courses will be converted to an integrated programme in MA Economics.

RESEARCH PLANS

Basic Science Research

Basic science research, often called fundamental or bench research, provides the foundation of knowledge for the applied science that follows. This type of research encompasses familiar scientific disciplines such as biochemistry, microbiology, physiology, and pharmacology, and their interplay, and involves laboratory studies with cell cultures, animal studies or physiological experiments. Basic science also increasingly extends to behavioural and social sciences as well, which have no less profound relevance for medicine and health.

In the absence of information and insights generated from basic research, it is difficult to envision how future advancement in treatment of disease and disability will occur; physicians would increasingly be in the position of mechanics who do not know how engines work, or programmers who do not understand how computers store and compile information. Basic research is also a source for new tools, models, and techniques (e.g., knockout mice, functional magnetic resonance imaging, etc.) that revolutionize research and development beyond the disciplines that give rise to them.

Some of the major areas which have attracted the attention of the researchers in the faculty of departments of CUSAT is cutting-edge ideas in the field of Energy, Machine Learning, Orthomolecular therapy. The establishment of a **Centre for Interdisciplinary studies in Basic Sciences (CIBS)** is a vision formed in the concept of incorporating the research under multidisciplinary fields like Chemistry, Physics, Life Sciences, Mathematics, Statistics and Environmental Science under one umbrella.

1. Advanced Research group for Energy

The energy of the world needs to grow with the maturity of our technology. In the recent years, the change in technology paradigm has given rise to many other alternative sources of energy which can be harnessed through various cutting-edge technologies. Different countries have made massive investments for the development of wind farms, solar farms, dams along the rivers and tidal power stations. No doubt, dependency on fossil fuels

has reduced to some extent, but it may take several decades to reduce our dependence to a considerable extent. The fact is that fossil fuels cannot keep on meeting the world's energy requirements. The non-renewable source of energy like fossil fuels needs to be replaced, with a more sustainable energy resource. We need to keep in mind the consequences of using fossil fuels will only lead to the destruction of our environment. Alternate sources of energy need to be found out. CUSAT is proposing such a paradigm shift. We can create a new knowledge centre, which will help in the discovery of new, and innovative ways in energy harvesting.

Advanced Research group for Energy will seek sustainable technological solutions to significant energy-related challenges that impact not only the global economy but also our planet itself. In keeping with the "multidisciplinary" concept, research will be carried out within different scientific disciplines encompassing Physics, Chemistry, Biotechnology, Photonics, Material science, Nanotechnology and Engineering. The vision of the group is to;

- Facilitate a changeover to alternate energy technology and make notable global contributions in the field of energy.
- Ensure the overlap between research in materials/processes for harvesting, conversion, transport, and storage of energy.
- Narrow the distance between energy research and practical energy devices by technology transfer to industries.
- Setting up model systems within the university for the sustainable and clean handling of energy and extend to the public.

To achieve this, research in solar energy conversion, advanced energy materials/processes and bioinspired systems for energy conversions will ensemble under the group. The group will undertake fundamental scientific studies on new materials and new process as well as device fabrication/model systems giving thrust to specific areas like Energy Conversion and Conservation, Energy harvesting as well as Energy Transport and Storage.

Energy Conversion and Conservation Research (ECC)

Energy Conversion and Conservation Research (ECC) will pool various methodologies for solar/ heat energy conversion to electrical/chemical energy. Existing research on developing new processes/ molecules/ materials for solar to electrical energy conversion with focus on dye-sensitized solar cell, and perovskite solar cells will be extended. Research on bio-inspired systems for solar to chemical energy conversion with prime emphasis to Artificial photosynthesis research for developing photocatalyst for water splitting, CO_2 reduction and other biomimetic systems for small molecule conversions will be carried out as another practical approach for solar energy conversion. The advanced research will be done on understanding biological energy conversion systems and modelling biomimetic systems to get more insight into energy management by nature.

Magnetocaloric, thermoelectric materials, and rare-earth-free permanent magnets constitute the main topics in Materials for Energy Conversion field. Synthesis and characterization of novel thermoelectric materials for direct conversion of waste heat to electricity. Activities on magnetocaloric as well as high energy density rare-earth-free magnets have been recently started and will be the focus of research for the next few years. Development of engineering materials suitable for energy efficient aerospace and automobile applications will be the primary focus of the material for energy conservation.

Energy Harvesting Research (EH)

Energy Harvesting Research (EH) comprises various technologies to harvest omnipresent solar energy. The research will be carried out to develop improved materials and processes to harvest solar energy to be used in photovoltaic cells, artificial photosynthesis system and fuel cells. Research on materials for environmentally friendly, printable organic solar cells will be a special focus. Research on intensifying the harvested solar energy such as plasmon-assisted solar cells, photon up-conversion, and laser-induced periodic surface structuring for enhanced energy absorption rate of solar cells will be covered.

Energy Transport and Storage Research (ETS)

Energy Transport and Storage Research (ETS) field deals with storage of both electric energy in batteries and supercapacitors, and of chemical fuels like hydrogen and hydrogen peroxide. In the former area, we already have strong activities dealing with various aspects of Li-ion batteries as well as next-generation batteries including novel electrode and electrolyte materials. The focus in the latter area will be on hydrogen storage in metal hydrides and on chemical compounds, hydrogen peroxide stabilization and storage, utilizing peroxide for industrially important chemical synthesis.

Advanced Energy research at CUSAT will thus span across the full spectrum of energy harvesting, transport, storage, conversion and conservation. Within these fields, CUSAT has a proven record of quality, especially concerning materials/molecules for solar cells and batteries. There already exists several well-established collaborations and networks with leading universities and research institutes across the globe (University of Augsburg, NTU Singapore, University of Naples, and University of Barcelona). This collaboration will be further strengthened within the framework of Institute of Eminence and will extend to other university and research institutes which are actively involved in energy research (Tokyo metropolitan university, Hokkaido University). The scientific output will be of high standard, as will be evidenced by frequent publications in high-impact journals, patents and technology transfers. There will also be several relevant courses given at the master and Ph.D. levels, ensuring the education of qualified personnel in the area. The research group will organise programs (conference, workshop) in collaboration with government organisation and media to create consciousness among public about the research activities of group. The research group will apply for funding from central/state agencies to sustain research activity. The Strategic plan presented here describes a 15-year roadmap for scientific studies that will forward the cause of a sustainable and clean energy future for living earth.

2. Laser Surface Structuring for Energy Applications

Laser induced surface structuring on metals and semiconductors has emerged as a powerful technique for material processing in the micro-nanoscale. Surface morphology is a key factor in controlling the optical, mechanical, wetting, chemical, biological, and other properties of solid surfaces. Recently femtosecond laser induced periodic surface structuring (fs-LIPSS) has emerged as a novel and versatile technology for producing a large variety of micro and nanostructured materials suitable for a wide range of applications in photonics and material science. The LIPSS show a regular groove structure on target surface with a period on the order of the laser wavelength and oriented perpendicularly to the polarization of the incident light. The groove period forming on the material surface can be controlled by changing laser parameters, target material, and ambient condition. Even though many technological improvements are made in this area, the mechanism of LIPSS formation and precise control of groove period are still being deeply investigated. The large area periodic surface structures show a substantial reduction in reflection or enhanced absorption of light in the UV-VIS-IR range with respect to unprocessed silicon wafer. The increase in surafce area and enhanced energy absorption rate of processed silicon targets can be utilized in photovoltaic and other material science applications.

The work is envisaged as collaborative work between CUSAT and other institutes like Raman Research Institute, University of Naples Federico II, Italy.

3. Advanced Research group for Ayurveda

Many ancient civilisations have developed herbal medicines for the well-being of its subjects. India has a well-established traditional system of medicine, Ayurveda, which is more developed than any other herbal remedy systems in the world with sound founding principles, well-classified treatment methodologies and unique patient classification based on their physical and emotional characteristics. More than a treatment modality Ayurveda envisions a holistic approach to overall well-being and not just a treatment option. Founded on several ancient Sanskrit texts such as Ashangahridayam, Charaka Samhita, etc., the

Ayurvedic system has been developed into very specialised sub-areas in the various regions of India which also has to do with the diverse flora and fauna seen in their respective areas. Kerala, located in the biodiversity hotspot of Western Ghats has a unique distinction in this regard, with several traditional groups developing their unique versions of the Ayurvedic system utilising the local flora.

Currently, there is a growing demand for alternative remedies to western medicine throughout the world, especially for several chronic lifestyle diseases such as Diabetes, arthritis, hypertension, etc. as western medicine has given only symptomatic relief. In this context, there is a growing demand for the Ayurvedic remedies for the treatment of various ailments. However, the Ayurvedic systems have not been subjected to the rigorous scientific study to prove the cause and effect. Also, studies in the patient to patient variation in treatment efficacy have not been addressed. The reviews have great relevance as in the Ayurvedic system patients are classified based on 'Tridosha', the scientific basis of which is unknown. In this context, being situated amidst several well developed traditional Ayurvedic practitioners and biodiversity hotspot, CUSAT has identified the significance of this hotspot area.

The research group is envisioned to be an Interdisciplinary group comprising of scientists from various faculty such as Life sciences and Chemical Sciences as well as trained Ayurvedic Physicians. It will also utilise the expertise of Statisticians and Mathematicians and social scientists. It will include active collaboration with Government Ayurveda College, Tripunithura, Kochi, Kerala and Kottackal Arya Vaidya Sala Hospital, Kochi, Kerala. The main research focus of CEAYU will be identifying the molecular basis of the Ayurvedic system of treatment and further development of such therapies in the era of personalised medicine. The principal subject areas will be Ethnobotany, Ethnopharmacology, Medicinal Chemistry, Biological Chemistry and Molecular Biology, Pharmacology and Toxicology, Pharmacogenetics and Genomics.

What is envisaged is research laboratories in which interdisciplinary teams will attack problems related to the molecular basis of herbal remedies and their modes of action using

in vitro and in vivo models, the role of genetics in efficacy and toxicity to herbal remedies, synthesis of better compounds using medicinal chemistry, etc. There will be very active participation with the Ayurvedic researchers and physicians by collaborating with the Ayurvedic hospitals. It is envisioned that in the long run, in a span of 10 years, the intellectual property generated by the research group will lead to the development of drugs or treatment regimens resulting in technology transfer to companies and generation of significant revenue. This will support the long-term sustenance of the centre.

4. Molecular and Genetic Basis of Ayurveda

Many ancient civilizations have developed herbal medicines for the well being of its subjects. India has a well established traditional system of medicine, Ayurveda, which is more developed than any other herbal remedy systems in the world with robust founding principles, well classified treatment methodologies and unique patient classification based on their physical and emotional characteristics. More than a treatment modality Ayurveda envisions a holistic approach of overall well-being and not just a treatment option. Founded on several ancient Sanskrit texts such as Ashangahridayam, Charaka samhita, etc., the Ayurvedic system has been developed into very specialized sub-areas in the various regions of India. This also has to do with the various flora and fauna seen in respective areas. Kerala, located in the biodiversity hotspots of the Western Ghats have a unique distinction in this regard with several traditional groups developing their own unique versions of the Ayurvedic system utilizing the local flora. Currently there is a growing demand for alternative remedies to western medicine throughout the world, especially for several chronic lifestyle diseases such as Diabetes, arthritis, hypertension, etc. as western medicine has given only a symptomatic relief. In this context there is a growing demand for the Ayurvedic remedies for treatment of various ailments. However the Ayurvedic systems have not been subjected to the rigorous scientific study to prove the cause and effect. Also the patient-to-patient variation in treatment efficacy also not been studied. This is very important especially because in the Ayurvedic system patients are classified based on 'Tridosha', the scientific basis of which is not known. In this context, being situated amidst several well developed traditional Ayurvedic practitioners and biodiversity hotspot, CUSAT is proposing to

establish a Research Group in Ayurveda . This is envisioned to be an Interdisciplinary Research Group comprising of scientists from various faculty such as Life sciences and Chemical Sciences as well as trained Ayurvedic Physicians. It will also utilize the expertise of Statisticians and Mathematicians and social scientists. It will include active collaboration with Government Ayurveda College, Tripunithura, Kochi, Kerala and Kottackal Arya Vaidya Sala Hospital, Kochi, Kerala. The main research focus of CEAYU will be identifying the molecular basis of the Ayurvedic system of treatment and further development of such therapies in the era of personalized medicine. The major subject areas will be Ethnobotany, Ethnopharmacology, Medicinal Chemistry, Biological Chemistry and Molecular Biology, Pharmacology and toxicology, Pharmacogenetics and Genomics. A fully developed CEAYU will include research laboratories in which interdisciplinary teams will attack problems related to the molecular basis of herbal remedies and their modes of action using in vitro and in vivo models, the role of genetics in efficacy and toxicity to herbal remedies, synthesis of better compounds using medicinal chemistry, etc. There will be very active participation with the Ayurvedic researchers and physicians by collaborating with the Ayurvedic hospitals. It is envisioned that in the long run, in a span of 10 years, the intellectual property generated in the Research Group will lead to the development of drugs or treatment regimens resulting in technology transfer to companies and generation of significant revenue. This will support the long-term sustenance of the Research Group .

5. Advanced Sensor Research Group

Chemical sensing can play a pivotal role in the present degenerating world of increasing pollution, food adulteration and increased risk of human health issues. In the past few years, chemical sensing has gained much predominance to check the quality of air, water, soil and food which are the basic necessities of not only human beings, but also all living organisms. Currently, active research is being carried out in the field of fabrication of selective electrochemical, optical and fluorescent sensors for various pharmaceuticals, metal ions, food additives, biological molecules etc. Sensing is an important thrust area of research that has the scope of interdisciplinary approach which can lead to the development of sensor devices for the common man to monitor the environment, food and health. Hence the

necessity of creating a sensor research group incorporating various disciplines like chemistry, physics, biotechnology, photonics, electronics, environmental science, mathematics and statistics is evident.

The prime objective of advanced sensor research group includes development of Potentiometric, voltammetry and fluorescent sensors for environmental pollutants, food additives and biological molecules. Enzyme immobilized biosensors. Metal oxide gas sensors for specific breath markers in exhaled breath of human beings which in turn can help in easy and early diagnosis of chronic diseases, Surface Enhanced Raman Spectroscopy substrates for the detection of molecules in fluid environment, Prototype infrared sensor with chalcogenide glass as the sensor platform for the detection and determination of the composition of complex organic samples including biomolecules. Fibre optic sensor for biochemical sensing applications like temperature, pressure, strain etc. The group also envisages development of Inorganic thin film transistor based chemical and bio Sensors, Self assembled photonic crystals for chemical sensing, Application of the developed sensors for clinical analysis and in monitoring environment and food quality. Interpretation of data obtained from the experimental research based on statistical tools and Fabrication of disposable sensor devices.

The group will involve in exhaustive research that include determination of analytes of interest that adversely affect environment, food quality and analytes of biological and clinical interest, application of the developed sensors in the analysis of water, soil, food, blood and other body fluids where challenges due to interferences from other molecules other than the molecule of interest will pop up and have to be overcome and simultaneous determination of two or more analytes can be carried out wherever possible. Thus this period will focus on basic and advanced research where chemistry, physics, biotechnology, photonics, environmental science, mathematics and statistics are involved. The sensors that have been successfully developed can be fabricated to devices that can be used for the analysis of samples. Here the major role is to be played by the discipline electronics along with the other disciplines.

The interdisciplinary research requires the participation of industries within the locality and people involved in similar area of research outside India like Polish Academy of Sciences, University of Southampton, UK etc. This will strengthen the research group and make the outcome more productive.

Metal oxide nanostructures for chemo-resistive gas sensors for breath analysis

Metal oxide gas sensors are widely preferred due to the low cost, easy production, compact size and simple measuring electronics. Nano-structured gas sensors are also gaining much attention due to better sensitivity, selectivity and response speed. The small size and ability to be integrated into electronic devices make them highly suitable in fields like industrial emission control, household security, vehicle emission control and environmental monitoring. One dimensional ZnO nanorods are attractive candidates for gas sensor applications because of their increased surface to volume ratio compared to other morphologies of ZnO and most importantly they provide an easy path way for electron transfer. There are several techniques such as doping, forming hierarchical structures which can be employed to improve the gas sensing properties especially to lower the operating temperature of metal oxide nanostructure based gas sensors. Among the various methods available, forming hierarchical structures using metals (Au, Ag, Pt, Pd) or metal oxides (CuO, Cu2O, TiO2, SnO2 etc.) is an effective way to enhance the various properties of metal oxide gas sensors. Presently, our group is working towards the development of metal oxide based gas sensors for detecting specific breath markers in exhaled breath of human beings which in turn can help in easy and early diagnosis of other chronic diseases. For example breath markers with their average concentrations for healthy and unhealthy humans is different higher being for unhealthy human: acetone (diabetes), ammonia (kidney disease), carbon monoxide (lung inflammation), dimethyl sulfide (liver disease), ethane (schizophrenia), hydrogen cyanide (bacterial infection) and nitric oxide (asthma). The nanostructures will be functionalized to respond to specific biomarkers. The sensors also must preferably work at room temperature. Since all these sensor performance parameters are closely related to material characteristics and operational conditions, it is crucial and highly essential to investigate and optimize these parameters to fulfil the above requirements.

Development of nanostructured SERs substrates for detection of biomolecules

Surface Enhanced Raman Spectroscopy is a sensitive technique used for the detection of molecules by adsorbing molecules on to the metal surface there by, enhancing the Raman signal by several orders of magnitude. Current efforts in SERS substrate development aim to prepare reproducible highly sensitive SERS-active nanostructures with a narrow distribution in their enhancement factor (EF) values. SERS is widely used for the development of diagnostic assays and optical imaging tools due to its sensitivity. SERS has been used for specific applications such as DNA sequence analysis, SERS microscopy, bio sensing, diagnostics, imaging, and clinical translation owing to its advantages such as minimal photobleaching, and low background from water. SERS technologies have also progressed towards application in microscopy and small-animal in vivo imaging. Ability to mount the SERS active molecules on the tip of optic fibre enables in vivo and in situ detection of particles. The potential non-invasive utility of SERS is highly valuable for live imaging. Significant progress has also been achieved in the application of SERS for tissue imaging. We are making efforts towards the development of colloidal core-shell based SERs substrates suitable for the detection of molecules in a fluid environment and patterned nano surfaces suitable to be affixed on optic fibre tips for in vivo detection of biomolecules.

Cell imaging using up conversion materials for advanced diagnosis

Imaging of biomaterials using luminescent nanoparticles has potential applications in disease diagnosis and therapy. Up conversion luminescence is the emission of high energy photon (usually visible) on exciting with low energy photon (usually IR). The "optical transmission window" of the biological tissues in near-infrared (NIR) range (750-1000 nm) allows for deeper light penetration and results in lower auto fluorescence and reduced light scattering, thus producing increased image contrast. Therefore, probes that are excitable in NIR range are preferable for both in vitro and in vivo imaging. Up conversion luminescent nanoparticles (UCNP) are now widely being studied for bio-imaging, and bio-sensing applications since the excitation used is IR. These materials can revolutionise the in vivo

imaging since it is possible to design an imaging probe in which both excitation and emission can penetrate the skin.

UCNPs hold promising biomedical applications, including live imaging for cancer diagnosis, bio-probes to detect disease biomarkers, drug delivery systems, and photodynamic therapy (PDT) in cancer therapy. UCNP modified using corresponding bio molecules can be used for targeted imaging of cancer cell. For example, folic acid modified UCNP can be used for imaging cancer cell in which folate receptors are active. A recent study showed that silica-coated UCNPs could, in addition to tumour imaging, activate a platinum prodrug and display cytotoxicity against cisplatin-resistant ovarian carcinoma cells. A multiphoton microscope coupled with an IR excitation can be used to acquire high-quality cell images in the presence of UC nanocrystals, benefitting from the absence of autofluorescence. Thus, imaging studies based on upconversion-luminescent nanoparticles can further extend to detection of disease.

The work is envisaged as collaborative work between CUSAT and other institutes like IIT Mumbai, IIT Roorkee, RRCAT-Indore, Central University of Kerala, Universitat Politècnica de Catalunya, Nanyang Technological University and the University of Barcelona.

6. Orthomolecular Research

Orthomolecular is the term that comes from the Greek word "ortho", which means "correct" or "right molecule". The concept of Orthomolecular Medicine is put forward by Linux Pauling, the most famous scientist in the History of Chemistry and Molecular Biology. The research group envisages in studying the Ortho-molecular part of Ayurvedic Medicine.

The nutritional approach helps maintain good health, improve health through proper diet, and cure and treat illness. Orthomolecular medicine has been used widely, though controversially, for both physiological and psychiatric conditions. Some commonly treated afflictions include colds, heart disease, cancer, depression and schizophrenia. It can provide dramatic recovery when nothing else has worked.

Using its broadest definition, people who take a daily multi-vitamin pill to supplement their diets are practising orthomolecular medicine–they are trying to "correct" the nutritional deficiencies in the food they eat.

Proper orthomolecular therapy is an intense, directed and thorough approach to nutrient supplementation. It takes into account individual nutritional needs by age, sex, activity, stress and the presence of disease. In this respect, it aims to employ "custom-made" therapies which, unlike conventional pharmaceutical preparations, remedy the underlying causes of diseases to prevent further problems. In effect, orthomolecular medicine helps the body help itself out of an imbalanced or diseased state.

Orthomolecular therapy is not meant to be a replacement for standard medical treatment, but a complementary approach which is better suited to particular disorders. For orthomolecular physicians, nutrition, which has been widely ignored in medical training, is the main component of all treatment.

The main difference between Modern Medicine and Ayurvedic Medicine is that Modern medicine tries to control the disease using chemical compounds which were not necessary for the normal functioning of the human body or any living organism. Most of the drugs currently used by the modern medicine are either new to the human body or even existed ever before.

On the other hand, both Orthomolecular and Ayurvedic Medicine try to cure the decreases entirely by using natural compounds which is necessary for the normal functioning of the human body and living organism. Both the Orthomolecular and Ayurvedic experts strongly rely on the scientific fact, that human body needs many chemical compounds either synthesised by the body or obtained from food, for the normal functioning, and disease is a severe lack of such chemical compounds. Therefore, medicine should be obtained from natural sources, and it should be chemical compounds which are necessary for the normal functioning, sustaining or progression of life. This research group will try to find the right molecule/molecules from Ayurvedic medicines for effective cure or control of the disease.

Now it is widely accepted that Modern Pharmacology is greatly succeeded in increasing the average lifespan of a human being by providing a large number of lifesaving medicines, but miserably failed in two critical aspects of increasing the maximum lifespan of a human being and building a "Disease Free World".

On the other hand, excessive use of modern medicine has created a world which has been forever riddled with new and unforeseen medical challenges. While most of our "Domestic Animals" are free from almost all types of virus and microbial attacks including HIV, the immunity of human beings are decreasing exponentially. Pharmaceutical Industry desperately tried to infect Domestic Animals with HIV but has failed miserably. While more than 30% US citizens are suffering from chronic diseases as per US Government records, People of Lakshadweep are living more or less without much medical assistance in their day to day life. The underlying cause of such diseases, whatever it may be, modern medicine has always been challenged with such scenarios. Furthermore, it is of utmost importance that by utilising the power of Ayurveda we can strive towards a "*Disease Free World*".

The focus of the group would be to conduct research about the discovery as well as improvement of Ayurvedic Medicines, and interactions with local Hospitals and Industries dealing with the Ayurvedic paradigm of medicine. The group would be a collaboration of Biochemistry, Chemistry, Bioinformatics and Ayurvedic Industries as well as Hospitals. The high-performance computational facility might also contribute a lot to these studies.

7. Nuclear and Neutrino Physics

Neutrinos are abundantly found in nature. The Sun, the stars and the atmosphere produce millions of neutrinos every second. Most of these neutrinos pass through our body, and we do not realize it. They can even pass through the earth and come out on the other side. The reason they can do this is that they interact decidedly less with anything that comes in their path. In simple words, an interaction is something that changes the property of the particle-like its speed, direction etc. For example, light rays from a torch cannot penetrate a wall because particles of light interact with the wall and get scattered before they can get to

the other side of the wall. Since neutrinos interact very weakly, they are harmless. Neutrinos can also be made artificially. They are produced in radioactive decays and in nuclear reactors.

Though neutrinos are found in abundance, due to their weakly interacting nature, studying these particles in the laboratory is extremely difficult. In spite of it, Scientists have devised methods to detect these particles and to study them.Neutrinos were initially thought to be massless particles, but recent experiments suggest that they indeed have a very small mass. These trials found an essential discovery about neutrinos. They discovered that neutrinos change from one type to another as they travel. For example, an electron neutrino that is produced in the Sun converts itself into a muon neutrino or a tau neutrino on its flight to the earth. This conversion is called as neutrino oscillation.

It was the discovery of this property of neutrino oscillation that suggested that neutrinos have mass. Neutrino oscillation not only happens in neutrinos produced in the Sun, but they also occur in all the neutrinos irrespective of where they are produced. The fact that neutrinos have mass has implications on the current understanding we have about the Universe and in sciences like Nuclear Physics, Particle Physics, Astro Physics and Cosmology. This makes the study of neutrinos a fascinating domain in scientific research. The 2002 Nobel Prize for physics was awarded to research related to Neutrinos.

The discovery of neutrino oscillations is just a first step, and several questions are still unanswered. The field of neutrino physics has attracted worldwide attention, and there is a need to understand many questions put forth by the phenomena of neutrino oscillations. The Super-Kamiokande neutrino observatory in Japan, Sudbury Neutrino Observatory in Canada, Gran-Sasso Lab in Italy, IceCube Neutrino Observatory in the South Pole are some of the existing neutrino laboratories. A few years ago an initiative began to take shape leading to the idea of the India-based Neutrino Observatory (INO), a modern world-class laboratory in India for studying neutrinos.

The recent advances in the understanding of structure and dynamics of atomic nuclei have ascertained this topic to be a versatile probe to study a variety of phenomena in finite many-body systems. The principal objective is to devise a new theoretical tool with which

we can unravel several fundamental aspects of statistical and quantum physics as depicted by hot and rotating nuclei. CUSAT is palnning to carry out theoretical investigations targeting the topics of microscopic approach for GDR built upon warm and rotating nuclei, constructing a phase diagram for transition from superconducting to normal phase as a function of spin and temperature. CUSAT will also be extending the covariant density functional theory to study rotational spectra of hyper-nuclei, experimental detection of sterile neutrino in collaboration with FERMI lab.

The work is envisaged to be carried out as a collaborative activity between CUSAT and institutions like IIT Roorkee, TIFR, SINP, IUAC-New Delhi, RIKEN-Japan, Mississippi State University-USA and FERMI lab-USA.

8. Gravitation, Astrophysics and Cosmology

Understanding the origin, evolution and the rich structure of our universe is the primary goal of modern cosmology. This involves probing the dynamics and constituents of the universe and the formation and evolution of galaxies. Some of the major challenges in this area are related to dark matter, dark energy which causes accelerated expansion of the universe and gravitational waves. The main thrust will be on modelling the nature and evolution of dark energy and dark matter, understanding the nature of gravitational waves generating from various high gravity events like black hole collisions, neutron start collisions etc. Studies will also be carried out for understanding the nature and properties of neutrinos, especially sterile neutrinos which is a possible dark matter candidate.

Cosmology: Large-Scale Structures in the Universe

The inhomogeneous distribution of matter in the universe is potentially the most potent probe for this purpose. Observations indicate that the dominant component of matter is dark. The distribution of this dark matter (DM) can in principle be traced by the distribution of luminous galaxies. However, the galaxy distribution, measured by their clustering, does not precisely reflect that of the matter. The relative clustering of galaxies with respect to that of the underlying DM is called the galaxy bias. It is essential to understand the connection

between galaxies and DM to realise the full potential of using the matter distribution as a probe of the universe.

The goal of this proposal is to develop a physically motivated model for galaxy bias from very small to large scales across cosmic history. For this, we will use GALFORM semi-analytic model for galaxy formation and extensive numerical simulations at the Institute for Computational Cosmology (ICC), Durham, UK. GALFORM computes various physical processes that control galaxy formation and predicts a large number of properties of the galaxy population at any redshift. We will also use large numerical simulations, notably EAGLE, one of the most realistic hydro-dynamical simulations of galaxy formation. Basically the work is intended for understanding the origin and development of structures like galaxies in the universe, constraining galaxy clustering using GALFORM and EAGLE, baryonic effects on the clustering of DM halos, clustering of halos in alternative gravity model and constraining cosmological parameters from future surveys in the next decade.

The work is envisaged to be carried out as a collaborative activity between CUSAT and institutions like IUCAA-Pune, Institute for Computational Cosmology, Durham-UK, Hyderabad Central University-Hyderabad, M G University-Kottayam, Kerala and FERMI lab-USA.

9. Complex System Studies (CSS)

The CSS will take up challenging interdisciplinary problems related to the collective phenomena in socio-economic and biological systems from a physics perspective. The broad themes of research will include epidemiology of directly transmitted diseases in society, understanding collective behaviour in complex adaptive systems, the evolution of cooperation in biological and social worlds, systemic risks in economic systems etc. The virtual centre will closely collaborate with the proposed Computational modelling and Data Science Group. Also, the research group will promote education and research in the area of Complexity Science by conducting training programmes and workshops for students at all levels.

It is expected that the research group would be able to attract researchers of international talent to come over and spend a year or two at the centre and carry out research in close collaborations with faculties of the university and interact with students. The Collaborating Institutes will be I MSc-Chennai and FIAS-Germany.

10.Halo and Galaxy Bias Studies

The present theoretical understanding of halo and galaxy bias rely on numerical fits to large N-body simulation and galaxy formation data. We plan to improve this by incorporating Machine Learning techniques to reproduce dark matter halo bias and galaxy bias. Specifically, we will use large N-body simulation and galaxy formation data to train sophisticated machine learning algorithms. The trained algorithms are expected to efficiently reproduce the galaxy bias which will be crucial for extracting cosmological parameters from current and future surveys. The work will be carried out as collaborative work with IUCAA-Pune.

11.Molecular Dynamics Simulations and Density Function Theory

Molecular dynamics (MD) is an advanced simulation method for studying the physical movements of atoms and molecules and is thus a type of N-body simulation. The nature of intense laser-matter interaction and its possibilities in material science, industry, and medicine can be studied in detail using this computationally expensive simulation. This computational method calculates the time-dependent behaviour of an atomic or a molecular system. Since light-matter interaction (spectroscopy) in one of the intensive research topics of many departments, MD simulation facility will strengthen the ongoing research activities at CUSAT.

New materials usually are found by trial and error processes which are very time-consuming. However, now with the advances in computational techniques such as Density Functional Theory, modelling the behaviour of actual or hypothetical materials has become possible enabling the scientists to discover properties of materials formerly unknown, as well as to design novel materials. The work to understand the nature of intense laser-matter

interaction and its possibilities in material science, the industry will be carried out in collaboration with Raman Research Institute, University of Naples Federico II, Italy, Indira Gandhi Center for Atomic Research, Kalpakkam.

12.Magnetic Nanostructures

Considering the recent success of commercialised magnetic random access memory (MRAM) and domain wall based multi-turn sensors, research in magnetism in upcoming years will undoubtedly be driven by the hunt for prospective energy efficient and scalable memory and logic devices. To advance in this field, there is a clear need for novel materials, as well as material combinations, which depending on the application could provide a significant degree of spin polarization, strong anisotropies, low to no magnetisation and ensure efficient conversion between spin and charge currents. In this respect, the magnetism research group at CUSAT envisages to work on magnetic vortices and skyrmions, which are promising candidates for the future high-density data storage devices. The viability in the control of vortex structures will be investigated by preparing magnetic nanostructure arrays with different thickness. Based on a comprehensive understanding of the shape anisotropy effect on the dynamic process of magnetic vortex creation, a new means of vortex-state control that enables the global and local reconfiguration of vortex structures in closely packed nanostructure arrays will be investigated.

Micromagnetic is a continuum description of the behaviour of the magnetisation vector field in ferromagnetic structures of the size of micrometres and below. Primary applications are the study and design of magnetic storage media and spintronics. Advances in nanofabrication now allow us to manipulate magnetic material at micro and nanoscales. The need for design, modelling, and simulation of magnetic nanostructures have granted a significant boost to the methods of micromagnetic simulations and analyses. Here, it is proposed to investigate the ground state spin configuration of ferromagnetic nanostructures using micromagnetic simulations. The particular focus will be on studying magnetic vortices and skyrmions.

The work is envisaged as collaborative work between CUSAT and other institutes like Augsburg University, Nanyang Technological University and CSIR-NIIST.

13.Titanium-based alloys

Titanium and its alloys gain attention in the recent past due to its unique mechanical properties which enable it lead a crucial role in aerospace industry, biomedical field and automobile industry. The corrosion resistance, matching Young's modulus with human bone and biocompatibility of Ti-based alloys make it a suitable candidate for manufacturing of artificial heart valves, cardiac simulator, urinary track reconstruction, and replacements in dental structures, knee, shoulders, hip etc. Young's modulus of Ti alloys (55-110 GPa) is close to the human bone (4-30 GPa) and far less than steels (~206 GPa) and Co-based (~240 GPa) alloys. The alloy attains these special properties via turning the phase transformation which in turn affect the microstructure and the crystal structure and hence properties. So, the present plan is to focus on the turning of phase transformation via alloying and heat treatment. The aim of the present study includes the preparation and characterisation of the alloy using non-toxic elements like Nb and Mo and then studying its correlations with Young's modulus, hardness etc. The main characterisation includes phase variation studies using XRD and microstructural characterisation using SEM and TEM.

CUSAT and Indira Gandhi Centre for Atomic Research, Kalpakkam will be working on this.

14.Quality and Reliability Research

Reliability and Quality is a broad interdisciplinary area that requires considerable research input for advancing theory and practice. Research and development projects may be performed dealing with industrial oriented problems such as:

- Reliability and life testing evaluations of complex products, electronic and mechanical systems.
- Development of probabilistic approaches and Statistical theory related to Quality and Reliability.
- Studies on QMS and other Certifications systems

- Studies on service and manufacturing quality improvements
- Reliability-based designs, Reliability centred maintenance

Many departments and centres in CUSAT already are involved in certain activities related to quality and reliability. For example, STIC at CUSAT is involved in testing and calibration of instruments. The advanced research group could conduct short-term courses in Measurement and Calibration for quality with the cooperation of the this research group and vice versa. Similar collaboration is possible with departments like Statistics, SOE, Electronics, Computer Science and Engineering, PSRT etc.

Many industries require consultancy services in the highly specialised knowledge areas of quality and reliability. This research group could cater to this need especially to the industrial city of Cochin, Kerala.

15.Microbiology and Infectious Disease

Microbiology Research using Metagenomics, Metabolomics and Transcriptomics

The research group will study the application of genomics to the study of the unculturable bacteria or VBNCs (Viable but not culturable). The technique metagenomics, for the study of bacterial communities as whole has enabled the making microbiology boundless: This will involve studying the microbial association, interactions and hence communications, key to understanding their ecology and hence their impact on human wellness and health. The Department through its various activities will study the key role of healthy gut microbiome which is crucial to the normal functioning of the body, and also the effect of dysbiosis in specific disease conditions. The various ailments that result from the disturbance of such exceptional balance range from the disorders of the gastrointestinal tract such as (irritable bowel syndrome) IBD, which includes Crohn's disease (CD) and ulcerative colitis (UC), gastrointestinal malignancies and complex multifactorial disorders such as obesity, allergy, diabetes and neurological diseases such as Alzheimer’s and Parkinson’s. In this background, the implications of understanding the role played by the changing gut microbial communities associated with such diseases is extremely relevant for their therapeutic management. From its part in understating the diversity of microbes and their interactions in the environment, to

their role in mining the infinite diversity of unculturable for their bioactive and to their roles in disease and health, the scope of metagenomics and metabolomics is immense. With this background, following projects are proposed:

Microbial Ecology

- Metagenomic Survey of the Arabian Sea and the Bay of Bengal
- Marine phage metagenomics
- Metagenomics for the study of the microbial communities of the mangrove ecosystems
- Community genomics of gut of deep-sea fishes for novel biomolecules and diversity

Microbiomes in diseases and disorders-as therapeutics

- Interaction of gut microbiome and diabetes in the population of Kerala-to understand the role of gut microbiomes in diabetes-associated kidney failures
- Microbial communities associated with colorectal cancers
- Investigation of the relation of human gut microbiome to irritable bowel syndrome
- Human gut microbiome and its implications for Alzheimer's disease

Metabolomics of marine endosymbionts

- for the discovery of new pharmaceuticals
- bioactive with anticancer properties
- with antibiofilm activities
- with anti-inflammatory activities

Metabolomics of the human gut microbiomes in Alzheimer's disease.

- For biomarkers development

Metabolomics of Tuberculosis infection-Exploration of potential markers

- For biomarkers development
- For epidemiology

16.Virology Research

In Kerala, viral infections are a major public health burden, with more than a million reported cases yearly. Over the past decade, Kerala has witnessed outbreaks of several new, emerging

and reemerging viral pathogens including Chikungunya virus, Dengue virus, Influenza virus, Japanese Encephalitis virus, Hepatitis virus, mumps, measles, Chickenpox virus and Kyasanur forest disease virus. Additionally, it was reported that the incidence of cancers caused by Papillomavirus (cervical cancer), Hepatitis virus (liver cancer), and Epstein-Barr virus (nasopharyngeal carcinoma and lymphoma) are also spreading at an alarming rate in different parts of Kerala. In order to prevent and cure any virus diseases affecting the health of the people in Kerala and billions of people worldwide, a continued, high end research which allow us to understand the molecular biology of viral infection, replication, pathogenesis as well as their potential to re-emerge as threats is essential. Even though the number of viral diseases reported from Kerala is very high, currently there is no well-established virology laboratory for virology research and education in the state. Department of Biotechnology conducts research in the area molecular virology. The research group focuses on the mechanisms behind virus-induced oncogenesis and to determine how virus infection can cause severe health problems, including cancer. The long-term goal of the virology research program in the Department is to focus on developing cutting-edge research and postgraduate training and to become Kerala's Research Group in virology and viral disease prevention.

The Research Group in Virology aims to:

- Be a principal Research Group for advanced virology research for better understanding viruses and virus-associated diseases
- Develop new laboratory techniques for the diagnosis of various kinds of viral infections
- Develop antiviral agents and translate novel research findings to clinical applications
- Collaborate with national and international research institutes and universities for developing diagnostic kits and antiviral agents of viral infections including Chikungunya virus, Dengue virus, as well as oncogenic virus infections
- The Research Group also aims to offer a post-graduate course in virology

Over the next ten years, the Research Group in Virology will be established, and the long-term goals of the Research Group will be achieved. The Virology Research Group will also encourage training in viral diseases and postgraduate course in virology. The knowledge

gained from the Research Group 's research goals will have a significant impact on several aspects of viral infection, including research in identifying antiviral drugs for the treatment of pathogenic viruses, and vaccine development. The virology field and the biomedical community will benefit from the research findings of the Research Group in the years to come, and it will advance the mechanistic research of viral infections, which is crucial to prevent and treat viral diseases.

17.Translational Cancer Biology & Signaling Research

Cancer is among the leading causes of death and represents a significant burden of disease worldwide. It is known in India since Vedic times and is depicted in the ancient text book Susruthasamhitha as 'Arbuda'. Cancer, a chronic disease has emerged as a complex health issue of this era, with growing cases registered throughout India, especially in the state of Kerala which is encountering drastic environmental and lifestyle variations. The key to more successful outcomes in cancer management is early diagnosis and intervention. However, the economic burden of cancer care treatment is the highest compared to all other diseases, with the cost of a single hospitalization exceeding the average annual per capita expenditure of more than 60% of the population. To make cancer diagnosis and therapeutics simpler, effective and affordable, researchers have extensively embarked upon discovery and validation of new mechanisms and targets in human cancer, and translation of the results into medical benefits. During the course of tumor progression, cancer cells acquire a number of characteristic alterations which reflect alterations in the cellular signaling pathways that in normal cells control cell proliferation, motility, and survival. Many of the proteins currently under investigation as possible targets for cancer therapy are signaling proteins that are components of these pathways. Similarly, the identification of tumor specific markers aiding enhanced specificity and sensitivity in cancer diagnosis is an equally significant part of cancer biology research. The complex process of transforming such scientific discoveries, arising from laboratory, early clinical, or population studies, into clinical applications to reduce incidence, morbidity, and mortality in cancer is considered translational cancer biology. To achieve the translational goals, the Advanced Research Group for Biotechnology and Biomedical Research would focus on the development of next-generation

in vitro, ex vivo and in vivo cancer models, which are expected to predict the outcome of cancer treatments in the clinic. These would include a variety of mouse cancer models, 3D-ex vivo cultures of mouse tumors and patient-derived tumor tissue and stem-cell based organoids. Additionally, it is also in the large interest of the institution, to explore the molecular signal aberrations and cross-talks in cancer, so as to identify tumor-specific molecules which could be used for targeted therapeutics aiding cancer therapy with fewer side effects and detrimentally to the normal tissue. Large number of patient samples required for the investigation would be obtained through collaborative initiatives with cancer Research Group s in and around Kochi, like the Cochin Cancer Centre, Amrita Institute of Medical Science and Early Cancer Detection Centre etc and from institutions like the Regional Cancer Centre and the Malabar Cancer Centre which are also well acclaimed cancer hospitals in Kerala. The Research Group would highly benefit from such active collaborations in the long run and it is envisioned that in a span of 10-15 years, the Research Group would be amply equipped to showcase technologically advanced bench-to-bedside cancer-related products, process patents and an array of peer-reviewed publications deemed to its credit.

18.Biomaterials & Regenerative Medicine

Organ and tissue loss through disease and injury motivate the development of therapies that can regenerate tissues and decrease reliance on transplantations. Regenerative medicine, an interdisciplinary field that applies engineering and life science principles to promote regeneration and can potentially restore diseased and injured tissues and whole organs using biomaterials. Some regenerative medicine therapies, including those designed for wound healing and orthopaedic applications, have received FDA approval and are now commercially available. While the field of tissue engineering has promised to develop materials that can promote tissue regeneration for the entire body, such promises have not become a reality.

Biomaterial science has experienced steady and steady growth in many companies investing large amounts of money into the development of new products. The challenge

existing in the field of biomaterials science is the simultaneous enhancement of tissue regeneration by minimizing immune responses, inhibiting infection, cost of production of biomaterials and the skill. The challenges of indulging in biomaterial research are diverse. Surface modification of materials, immobilization of signalling groups on surfaces, development of synthetic materials with controlled properties for drug and cell carriers, biologically inspired materials that mimic natural processes, and design of sophisticated three-dimensional architectures such as a biological microelectromechanical systems. Investing the workforce and skills in Biomaterials developed can find applications and revenue in organ regeneration, wound healing, implantable drug delivery systems, drug development, extracorporeal assist devices etc.

Biomaterial science encompasses elements of medicine, biology, chemistry, tissue engineering and materials science. Development in fabricating sophisticated grafts and tissue mimics and technologies for integrating grafts with host vasculature is interdisciplinary. Translational regenerative medicine is still in its infancy, and significant basic research investment has not yet achieved satisfactory clinical outcomes for patients. Currently, there are many obstacles and opportunities in translational regenerative medicine of stem cell therapy and tissue engineering for the safe and efficient regeneration of functional tissue. Tissue engineering has experienced significant progress due to the recent emergence of nanotechnology. Increased tissue regeneration can be achieved on almost any surface by employing novel nano-textured surface features. It calls for multi-disciplinary and inter-disciplinary cooperation to ensure the development of the best possible regenerative therapies. The department of biotechnology, advanced material science and the department of polymer science can contribute intellectual and manpower support and along with state of the art preclinical and GMP facilities, which can raise the standards of the proposed Research Group to international levels. A wedlock between scientists of our proposed Research Group and renowned healthcare departments will ensure most significant patient benefit.

19.Biomedical Nanoscience and Nanotechnology

In recent years, use of nanotechnology in medicine has expanded to a wide range of applications. Nanoparticles are being used to improve the efficacy of disease diagnostics, therapy and regenerative medicine. Although there is intensive research that's happening in this area there are many translational challenges that need to addressed that relates to the toxicity, sensitivity and bio-distribution of these novel nanoparticle-based systems. In the proposed center, we intend to work on different areas, addressing the existing translational challenges that include (i) development of novel diagnostics/contrast agents (ii) development of nano-drug delivery systems for different pathological conditions (iii) development of nano-theranostic agents wherein we can combine therapeutics and contrast properties together for image-guided therapeutics (iv) using nanotechnology in regenerative medicine to improve the functionality of existing technologies. We can focus our research on different disease models that include cancer, neurological and immunological disorders and regeneration of bones, cartilages or organs such as the liver. Location of our centre near to premier super speciality hospitals such as Amrita Institute of Medical Sciences and Cochin Cancer Research Center will give us an excellent opportunity to collaborate with clinicians and take their expert advice for product development even at the developmental stage. We can also test the products in primary patient samples under in vitro conditions to get an initial evaluation of the deliverable which will give us a lead to further product improvement. As mentioned above collaborating with clinicians will play a very critical role in this translational venture. In addition to clinical collaboration, we also can extend partnership to core molecular biology scientists working in the area of cancer, immunological or neurological disorders wherein the response of the developed product can be studied at a molecular level which will help to improve our product further. For example for cancer, we can initiate collaborations with leading international cancer research groups in institutions such as Harvard, MD Anderson, Dana-Farber/Brigham and Women's Cancer Center wherein we can test our product in these leading labs to get an expert opinion about the molecular level changes that need to be further worked on. There is always a space for patents for unique ideas in the field of nanotechnology. This will also enable us to initiate start-ups based

on these patents. With collaborations with leading clinicians, and premier research institutes abroad we envision to do clinical trials for the developed products in India or abroad according to FDA guidelines which will be breakthrough for the centre.

20.Neuroscience and Brain Research

Neuroscience is one of the fastest growing inter-disciplinary research areas of modern research. However, in India Neuroscience research have not picked up the pace and there are very few research centres that are working in the field of neuroscience, especially in the area of Neurodegeneration. Modern lifestyle and diet are thought to be the major factors that influence susceptibility to many neurodegenerative diseases. Also, the improvements in the modern health care system have had a major role increasing human lifespan. However, this Population ageing in developing countries like ours could lead to major economic, health and public policy issue, because growing number of this population will be living with various neurodegenerative diseases like Alzheimer's and Parkinson's. Recent studies indicated that the burden of multiple neurological disorders is already greater than other chronic non-communicable diseases and infectious disease. Currently, we have a Centre for Neuroscience at the Department of Biotechnology. Centre for Neuroscience was established in 2000 with the following objectives:

- To bring together the Industries, medical colleges, hospitals and research facilities.
- To organise workshops, meetings, lecturers and awareness programmes.
- To takes up extension activities like conducting neurological surveys, diagnosis, clinical and scientific testing.
- To establish a platform for advanced research in the field of neuroscience by bringing together both clinical and preclinical researchers.

The research interests of the Research Group includes studying molecular aspects of Neurogenesis, Brain Cancer, Epilepsy, Neurotransmitter receptors and its functional regulation in relation to Diabetes and pancreatic regeneration, Parkinson's, Alzheimer's disease and other neurodegenerative diseases, Neural stem cell research, Alcoholism, Drug Addiction, Aging, Hypoxia, Herbal medicines for Brain disorders, Hypoglycemia and Spinal cord regeneration. It provides opportunities for students from India and abroad to do research activities in the fields of Molecular Neurobiology. Currently, the Centre is collaborating with

Sree Chitra Thirunal Institute of Medical Sciences and Technology, Trivandrum in the field of Parkinson's disease. The availability of clinical sample is enhanced by such collaboration. With the current focus on translational research such collaboration is expected to bring increased funding. Research problems in the field of Neurosciences are complex and solution needs expertise in varying fields. Members of the Centre are also actively building interdisciplinary teams with faculty members of another department at CUSAT, such as Polymer Science and Rubber Technology, Electronics, Physics, Applied Chemistry and Inter-University Centre for Nanomaterials and Devices (IUCND). The centre is actively pursuing research collaboration with foreign Universities. Various faculties from School of Medicine, National University of Singapore is collaborating with the centre for the research activities. As part of the research initiative Centre also conducted a Joint international conference with the National University of Singapore in the field of Neuroscience and Biotechnology. The centre is taking initiatives to conduct an exchange of students and faculty between both Universities, which will enhance the visibility and research standards of CUSAT. Centre has also initiated discussions with few scientists from Germany on applying for research grants to DFG, Germany. Also proposed is a joint workshop to be held at CUSAT for the exchange of ideas and future DFG funding. Also, Collaborative research proposals with few Universities in the USA are also being initiated. Overall with the addition of new members Centre's activity is poised to take a giant leap in the next ten years.

21.Stem Cell Research

During last two decades, stem cell research has gained a lot of impetus and has shown promise in regenerative therapy for various incurable diseases. The potential to heal diseases once considered incurable such as cancer, heart disease, various neurodegenerative diseases like Parkinson's disease, amyotrophic lateral sclerosis, spinal cord injuries, stroke and severe head injuries by regenerating cells, is now within the grasp of scientists and medical experts, due to the advancement of stem cell research. Currently, the stem cell research conducted at the department is focusing on neuronal, epidermal and haematopoietic lineage, mainly focusing on the Molecular and cellular characterisation of stem cells and also on translational aspects of cell transplantation therapy. Department is primarily focusing on building

collaborative research and has initiated joint projects with various faculties from other departments like Polymer Science and Rubber Technology and, Chemistry and Nano Centre. Along with the faculties from the Department of Polymer Science and Rubber Technology and Sree Chitra Thirunal Institute of Medical Sciences and Technology, Centre is developing a biodegradable Three-dimensional (3D) matrix for stem cell culture, which could help produce more and better quality stem cells for disease treatment and regenerative therapy. Stem cell transplantation research for spinal cord injury and Parkinson's disease is also being conducted in collaboration with Sree ChitraTirunal Institute for Medical Sciences & Technology (SCTIMST) Trivandrum, which is one of the leading medical research hospital in Kerala. Research collaboration has been initiated with some reputed labs in Germany to study the role of various cytokines in proliferation and differentiation of Neural stem cells, which will have implications in cell transplantation in neurodegenerative diseases. Down the line we envision successful preclinical trials from the department which could be translated into stem cell-based clinical trials in collaboration with the medical hospitals in Kerala and abroad.

22.Bioinformatics and Systems Biology (SB)

Systems biology is most often the development of mechanistic models of whole cells, and fundamentally depends on the applications of mathematical and computational modelling. This term formed the thrust in the last decade, juxtaposing with the completion of the Human Genome Project (HGP) and the concomitant march of 'omics technologies, namely transcriptomics, proteomics and metabolomics. The meaning of "system" in SB depends on the problem at hand, the objectives of the study, and the choices made in the art of mathematical modelling. A general systems theory was applied to biology in the late 1960's. Systems biology has fuzzy boundaries, overlapping with several post-genomic era fields such as synthetic biology, systems microbiology, systems biotechnology, integrative biology, systems biomedicine, and metagenomics. Studies of metabolic networks, gene regulatory networks, and protein-protein interaction networks in microbial organisms have significantly contributed to this, and indeed to the identity of systems biology. Microorganisms are convenient models for systems studies as decades of genetic and

biochemical work have generated deep insights, and the resulted in sophisticated molecular biology techniques for experimental manipulation. Besides, they can be readily and rapidly cultured in inexpensive media, providing ample material for controlled experiments, with several being pathogens of humans, plants, and domestic animals, and therefore of medical or environmental interest, or are important in industrial processes and therefore are relevant for biotechnology. Furthermore, microbial organisms are unicellular, and the cell membrane provides a convenient boundary that delineates the "system" for genome-wide studies. In the past, microbes have been used in numerous systems studies, three types of biochemical networks, roughly corresponding to three different levels or "omes", have been mostly studied in the past: gene regulatory networks protein interaction networks and metabolic networks. When prior knowledge of modularity allowed the assumption of decoupling, systems studies on biochemical subnetworks or cross-networks were possible. Examples of this include modelling of the cell cycle in yeast, specific metabolic pathways, and signal transduction pathways. Several pioneering studies integrated responses across individual "omes". Examples of this include studies of transcriptome and proteome responses to perturbations in metabolic pathways, the effects of a transcriptional regulator on central carbon metabolism in Bacillus subtilis, and coordinated analysis of the minimal bacterium Mycoplasma pneumonia, including analysis of its mRNA, to name a few. Relevance of the study: Bioinformatics tools for systems biology

The need for effective exchange of formal, quantitative systems biology models led to the development of the Systems Biology Markup Language (SBML), which aimed to develop a computer-readable format for the representation of biological processes. SBML provides a well-defined format which different software tools can use for the exchange of biological models with high fidelity. The graphical notation for the representation of biological processes has been proposed recently (Systems Biology Graphical Notation, SBGN). Workbench (SWB) is a framework that allows different components for systems biology to communicate, exchange models via SBML, and reuse capabilities without understanding all the details of each component implementation. Another highly useful tool is CellDesigner, a Java-based program for constructing and editing of biochemical networks.

An independent simulator of models encoded in SBML is COPASI, which can simulate models based on ordinary differential equations (ODEs) as well as stochastic models using the Gillespie's algorithm. COPASI provides tools for visual analysis of simulation results, and can also perform steady-state and metabolic control analyses Just as new technologies and instrumentation have aided acceleration of biological research accelerates, biological databases have become an indispensable partner in such research. Concomitantly secondary biological databases have emerged: that capture the properties and processes in biochemical networks. The ecosystem of such databases and associated tools includes metabolic pathways databases organised around the BioCyc project, database of human biological pathways, database of interactions between small molecules and proteins, and databases of protein-protein interactions. While these databases attempt to reconstruct and organize information about interactions between cellular components, they also attempt to build higher-level knowledge and theories about the biological processes they are concerned with. Such in silico knowledge is essential, as the integral complexity of most biological processes is beyond what is comprehensible to the human mind. Therefore, development of these "systems biology databases" often represent important foundations for quantitative modelling of biological systems. In some cases, these databases allow a direct export of mathematical models. Also, the first collections of mathematical models of biological processes (databases of models), were concerned solely with archiving and curating the models in SBML for future reuse and refinement. Much needed bioinformatics tools for systems biology research are the tools for visualization of network structures and network overlay of simulated and experimental data. These tools include yEd graph editor for editing networks, and tools for visualization of 'omics data in the context of biochemical networks, such as Cytoscape and Pathway Tools Omics Viewer. However many more such tools are necessary to aid advances in SB. Future prospects To understand the relevance of "systems" thinking for future biochemical research, it is important to remember that we know most of the components in many biochemical systems, often in exquisite detail, yet understand little about the interactions of these components to produce coherent temporal and spatial behaviours that are the characteristic of biological systems. On the other hand, bioinformatics has originally grown from the need to provide tools and handle increasingly large amounts

of biological data. As a discipline bioinformatics continues to grow in this important role, but is also increasingly merging and contributing to systems approaches to provide tools necessary for perhaps the most exciting phase in the development of biological sciences. The use of mathematical and computational models in SB is essential to rigorously account for the inherent complexity of biological systems. This complexity is due to the diversity of components (genes, proteins, and metabolites), the high selectivity of their interactions, and a non-linear nature of these interactions, which together render the behaviour of biological systems intractable to perception. The computational models used in biochemical SB typically require iterative building and stepwise improvements based on the comparison with experiments. Once sufficiently refined, such models can be used to predict the behaviour of the biochemical system under different perturbations, or hypothetical conditions that may be of interest but are not feasible in experimental settings (e.g., when they are too expensive for practical implementation, or when the analysis of many different conditions is desirable. However, in the new era of systems biology, mathematical models are more than just tools for integrating observations, making testable predictions, or for high throughput in silico experimentation. Highly refined mathematical models also serve as the embodiments of our current knowledge about specific biochemical systems. Mathematical and computational models that underpin biochemical studies may involve different levels of detail and scale, depending on the objectives of the study, what is known a priori, and what additional information is accessible experimentally. For example, protein complexes may be studied comprehensively or the focus may be on a subset of proteins responsible for a specific function, such as protein import into mitochondria. Most of the so-called bottom-up approaches, which start from the descriptions of interactions, focus on a part of the biological system because we lack a comprehensive information about the system of interest. Nevertheless, bottom-up approaches provide highly useful frameworks for the integration of diverse knowledge, for example, the principles established from decades of biochemical work with the information accessible only with the latest experiments. In contrast, top-down approaches are largely data-driven, with the caveat that their comprehensiveness is limited by the limitations in experimental approaches. For example, in one of the most comprehensive metabolomic studies to date, 198 out of an expected 453 primary metabolites

were quantified simultaneously in cells grown in minimal medium. Therefore, in such applications advances in technology drive the level of "comprehensiveness" that can be achieved. Many biochemical processes can be conceptualized as complex dynamic networks on the molecular level, and studies of biochemical networks are assuming centre stage in systems biology. Measurements on different 'omics levels provide different, often complementary views of the functions of molecular networks. Increasingly, we are interested in the crosstalk between the genes, transcripts, proteins, and metabolites that the gene's expression impacts upon. Increasingly sophisticated models will be required to account for increasingly accurate and comprehensive experimental measurements. Systems approaches have already provided a deeper understanding of diverse biochemical processes, from individual metabolic pathways, to signaling networks, to genome-scale metabolic networks. Therefore, we can safely predict that systems thinking will become even more pervasive in future. The role of formal mathematical and computational models in systems approaches renders the role of bioinformatics increasingly important for systems biology research." Cancer SB: One area of focus is cancer SB. As cancer explicitly spans multiple scales, modelling of interactions and communications across scales can help to create an extremely complex and dynamic system. This combinatorial approach will give greater leverage to SB in order to evaluate these relations/interactions, both qualitatively as well as quantitatively. Cancer SB can therefore integrate genetics, signaling pathway, epigenetics cellular behaviour, clinical pre-clinical manifestations, epidemiology, etc. Putting together these various components derived from various reductionist approaches by basic clinicians can give greater insight to understanding the underlying processes. Incorporation of 'omics' and imaging technologies can add to increasing clarity to these processes and help to predict responses to various interventions. The Department has currently developed a Cancer Net tool which facilitates the investigation of protein protein interactomes comprising of Cancer and Non-cancer protein databases.

23.Advanced Mathematics

Research will be carried out to obtain a new method to solve the well-known Ten Martini conjecture. That is to show that the spectrum of the discrete Schrodinger operator

associated with the almost periodic Mathieu potential is a Cantor-like set. This conjecture was settled and many modified proofs are also available in the literature. Our goal is to provide a purely operator theoretic solution to this conjecture. The available techniques are mostly number-theoretic in nature. We will consider the sequence of discrete periodic Schrodinger operator as the approximating sequence. Here the Borg-type theorems and the spectral approximation results will be useful in approximating the spectrum of almost periodic Mathieu operator. Also, these approximating sequence can be treated as pre-conditioners. The Korovkin-type theorems concerning different modes of convergence of pre-conditioners shall be applied here. Hence we hope to obtain a much easier and efficient method to solve the Ten Martini conjecture and thus to have a better understanding of the spectrum of almost Mathieu operator.

It is worthwhile to notice that the almost Mathieu operator arises in the study of quantum Hall effect, which is the quantum mechanical version of Hall effect observed in two-dimensional electron system. Hence the spectrum of this operator is a very important quantity in quantum electrodynamics. We expect that our results will find applications in this direction.

Studying the Finite basis problem and its connections with automata's to address some interesting issues connected to automata, languages and their decidability is a research problem. The ongoing research activates will be continues with special thrust on extending the results available in the structure theory of regular semigroups to regular rings, in particular to von Neumann Algebras. Research on Category theory and Universal Algebras will be focused. The possibility of extending the cross-connection theory available for normal categories to arbitrary categories will be explored. The finite basis problem for semigroups will be the focus. We have already conducted a series of lecturers in this topic in 2015 during the erudite visit by Prof. M. Volkov of Ural Federal University, Russia. Finite basis problem for semigroups has already attracted much attention among researchers, and this problem is very much related to the decidability problem of languages.

Finite basis problem and its connections with automata's will be studied in this phase and we expect to address some interesting issues connected to automata, languages and their decidability. Structure theory of regular rings and C*- algebras will be the focus of research. Structure theory of regular rings and C*- algebras will be the focus of research.

One of the important area of research that we propose to strengthen in the coming years is the fast-growing area of SCALE FREE NETWORKS OR SMALL WORLD PHENOMENON. It is well known that the most of the real world networks such as biological networks, world wide web, protein-protein interaction networks etc follow this phenomenon. Study and analysis of spectra of such huge networks are quite challenging. We propose to study this. So also an in-depth study of more properties of biological networks. One M.Phil dissertation on this notion is already completed. This is an up-and-coming area of NETWORK SCIENCE, which links graph theory and theoretical computer science . These research trends will definitely contribute to activities on Digital India. CUSAT is also actively involved in strengthening Mathematics Education in the country under the aegis of National initiative on Mathematics Education(NIME). We have some international collaboration under the forum of Creative Mathematical sciences Communications initiated in the Institute of Mathematical sciences.

Rapid and continuous growth in the number of computer networks (including Internet) users, the exponential increase of volume of transmitted data require a sharp increase in the performance and quality of communication links and multimedia data transmission networks. In this regard, all world research centers and international standardization organizations conduct intensive studies to create the ultra-high speed next-generation networks. High practical demand for the NGN-networks determines the timeliness and relevance of development of theoretical framework for designing the networks of this class. The new models, methods of their study, computation algorithms and a software package, developed within the Project, will have not only practical value, but will also effectively used in the innovative engineering developments of the project and will make a considerable contribution in the development of mathematical reliability theory, queuing theory and theoretical fundamentals of designing the NGN-networks.

Within the proposed work it is planned to develop the yet poorly studied in the world scientific literature single-line and multiline queuing models with unreliable servers, operating in the random environment for estimation of the major performance characteristics of wireless millimetre-wave and centimetre-wave communication channels. A novel research will be conducted on the tandem (multiphase) stochastic systems with the MAP input flow, cross-traffic and PH-distribution of service time on the phases of the system. Queues of this class adequately describe the wireless networks with linear topology operating under IEEE 802.11-2012 protocols. The theory of adaptive stochastic polling will be developed for the study of characteristics and structure optimization of the base stations in broadband wireless networks in the presence of interference and "hidden stations." New mathematical methods will be developed for performance evaluation and design of self-organizing millimetre-wave MESH-networks, which are one of the main directions of NGN development. The unstudied yet models of controllable stochastic systems with MAP input flow will be developed to choose the optimal strategy of control in cellular networks and hybrid data transmission systems, based on laser and radio wave technologies. It is supposed to develop a new set of models of queuing theory and teletraffic theory for access and radio resources control in wireless broadband networks, particularly in mobile LTE (Long Term Evolution) networks. The elaborated methods, algorithms and software will be used for engineering development of design prototypes of software and hardware means for NGN networks.

The novel models and methods for their investigation, which are to be developed in the framework of the Project, have no analogues in the world scientific literature. This is explained mainly by two following reasons. The first reason is that the concept of NGN (next generation networks) as an open standard packet infrastructure, based on data-communication networks under IP (Internet Protocol) that is able to effectively support the whole range of existing applications and services, providing the required scalability and flexibility and allowing to respond to new bandwidth and functional requirements and has replaced the concept of 3G and 4G networks (the old concept of ISDN (Integral Service Digital Network)) only by the end of the 20th century. The second reason is a high

complexity of the object of research and impossibility to apply the traditional methods of teletraffic theory and queueing theory. Currently, there are practically no integrated solutions allowing to adequately model the LTE 4G and 5G networks, taking into account their specific features. The manufacturers of equipment for next-generation networks need these solutions to assess the effectiveness of the developed concepts and the carrier operators need them to plan the network infrastructure with an account of the required quality of service. Taking into account that the first commercial launches of 5G mobile wireless networks are planned in 2018 - 2020, there is a need for the development of mathematical models for the analysis performance characteristics of quality control mechanisms and radio resource sharing mechanisms in LTE networks. High theoretical significance and scientific novelty of the expected results are substantiated by the new models which are planned to be developed in the framework of the project, which is to generalise the existing ones, including the classic Erlang, Kelly and Basharin models. Authors of the project have a significant experience both in practical realization of computer networks, as well as in analytical modelling and computer simulation of modern telecommunication systems with account of the following features: complicated nature of information flows in such networks which exhibit burstiness complex probabilistic distribution of duration of transmission and processing of information, versatile disciplines of dispatching by customers access, mechanisms of service, management by customers retrials, servers breakdowns and recovering, etc. In particular, there exists an essential background in modelling of telecommunication systems in terms of queueing systems with batch Markovian, Marked Markovian and semi-Markovian arrival processes with phase-type or semi-Markovian distribution of service time and having the following specific features: queues, operating in the random environment, controlled queues with parametric policies (multi-threshold, hysteresis, etc) of control by customers admission (including systems with session arrivals), service rate, number of active servers, etc, retrial queues, tandem queues, unreliable queues, including systems with different strategies of servers reservation, queues with disasters, feedback queues and so on.

Extensive experience of the authors of the project in analytical and computer modelling of modern telecommunication networks, which is reflected in monographs and

papers published in high rating peer-reviewed Russian and International journals, including joint papers of Russian and Indian participants of this project, as well as in patents in the field of the topic of the project, ensures that the formulated problems will be successfully solved and the proposed goals will be achieved.

Due to the high practical need for the NGN-networks, a considerable number of foreign studies of this class of networks have appeared in recent years. References to these studies are partly given in section 1.4 of this application. Research works close to the subject of the project are being conducted in the United States (Kettering University), UK (Imperial College g.London), France (Institute INRIA), Belgium (University of Ghent), Korea (Seoul University), India (University of Science and Technology), Hungary (Budapest University of Technology), which also shows the relevance of the studies proposed in the present research project.

24.Aquatic Animal Health Management

The earth, covered with 71% water, is an aqueous planet, and more than 80% phyla are seen in the marine, brackish and freshwater ecosystems. Human survival along with that of the fauna and flora is dependent on the health of the aquatic environment. Globally there is degradation of these ecosystems leading to declining in biodiversity and productivity. This is mainly due to the increasing anthropogenic activities in the marine systems beyond their carrying capacity. This will drastically affect productivity and food security. The only one option left is to focus on the aquatic ecosystem as a whole to protect it from further deterioration and decline in biodiversity, and even though very hard, to strive towards bringing it back to its pristine glory. At this juncture, the aquatic system is considered as 'global entity' and, programmes have to be undertaken accordingly having in mind the National and International requirements in aquatic animal and aquatic environment health management, and utilisation of the aquatic resources for well being of humanity through biotechnological interventions.

Thrust will be on the development of novel diagnostic methods which are more sensitive and rapid, conduct of surveillance programme, extension of diagnostic services at

National and International level, support to aquatic animal health education and extension, maintenance of a collection of pathogens and parasites of aquatic animals as a repository, monitoring transboundary movement of fishes and emerging diseases, and risk assessment involved in exotic species introduction. The Centre will strive for getting accredited by Network of Aquaculture Centres in Asia Pacific (NACA)/World Organization of Animal Health (OIE)/ Marine Products Export Development Authority (MPEDA) for certification of transboundary movement of aquatic animals.

Development of Aquaculture Medicines and live feeds based nutritional prophylaxis will be augmented under this programme. This involves therapeutics, prophylactics, novel antimicrobials, probiotics, bioaugmentors, vaccines, immunostimulants, hormones and their antagonists, dsRNA, anaesthetics all having aquaculture grade to be generated at the Centre and transfer the technology to the industry. Development of Aquatic microalgae-based live feed organisms for aquaculture larval production system will be given due importance. The work elements include the development of mass production technologies including photobioreactors, algal vaccines, and identification of new microalgal feed organisms for the larvae of fish species newly introduced into aquaculture. Aquaculture Nutrition will be looked in to prophylactic aspect apart from attainment of growth by incorporating all ingredients required for holistic nutrition at all stages of life at any culture condition. Immunology of finfish and shellfishes will be in focus. Besides understanding species specific immune systems, the thrust will be on understanding the mechanism of immunostimulants, immune modulators and vaccines and on the ways and means by which they can be improved in efficacy because the environment plays a key role in the immune system. The metagenome from aquatic environments and microbiome from aquatic animals will be investigated for the successful design of microbial management strategies in aquaculture for disease prevention and productivity enhancement.

Research and extension on Aquatic Toxicology and Environmental Health Management will be another focus area of research in aquatic animal health. Main focus will be on the aquatic environment of Indian subcontinent with a perspective of fish health. This is different from pollution monitoring currently being undertaken by the Pollution Control

Board. *Here the novel philosophy is to think as fish thinks and assess the quality of the system accordingly*. In that case the pollution control norms will have to be rewritten to bring up the quality of the industrial effluents not to cause any stress or disturbance to the aquatic animals. Fish cell line based toxicological assessment of the effluents will be introduced as a novel approach in assessing the quality of the effluents discharged to the aquatic systems. This will be fed back to the Pollution Control Board to impose measures to improve the quality of the effluents to meet the requirements. The Centre will strive for getting accredited by the Central Pollution Control Board for aquatic environment health assessment. Recirculating aquaculture systems and zero effluent discharge technologies will be extended at various levels to conserve water usage in aquaculture and to establish bio-security. This group will also focus on the bioremediation of impaired aquatic environment by innovating technologies for application in aquatic system in general, and aquaculture environment in particular. Restoration of degraded aquatic ecosystems through bioremediation will be undertaken at National level as consultancy programs.

The research and educational programmes under this area will be developed in collaboration with Virginia Tehc., USA, Nordland University Norway and several other National Institutes in India.

Aquaculture Engineering

At the National level, the requirements of research programmes and facilities for Developing, Standardizing and Popularizing Sustainable Aquaculture Production Systems such as Recirculating Aquaculture Systems (RAS), Integrated multitrophic aquaculture systems (IMTA), and Zero water exchange aquaculture production systems (ZWEAPS) have been recognized. Such an initiative should catalyze the rapid spread of intensification of aquaculture with sustainability. As the need of the hour is intensification of aquaculture production inclusive of the same in small holdings, wherefrom much of the fish biomass used to be generated, novel, user-friendly and economically viable intensive aquaculture technologies were to be developed befitting to the diverse, but at the same time ecologically sensitive aquatic environment. This intense need to the aquaculture sector regarding

innovations in RAS, IMTA, and ZWEAPS, tools and machinery and their accessories and the right kind of technical manpower will be met from the research initiatives under the area aquaculture engineering. There will be Production Facility as National Facility for Sustainable Aquaculture Production Systems (NaF-SAPS) by integrating expertise from science and engineering Faculties.

This initiative will have the capability to bring out need-based tools and devices based on the feedback from farmers who are the end users of any such technologies. Today, most of the tools are imported. The requirement of research for developing tools and devices for Zero Water Exchange Aquaculture Production System include designing ponds for circulation of water and collection of detritus at the centre of pond, designing bunds which shall not breach and will not permit the entry of carriers of infection. designing must be location specific and cost-effective, designing of cost-effective line ponds for aquaculture systems, intensive Pond Aquaculture Technology, devices for bottom aeration and bottom water movement, automatic feeders and integrated sensors to satisfy demand feeding, underwater imaging systems, online monitoring systems, use of solar power, wind power, free energy and hybrid in operating the systems, and test kits for water quality monitoring. Under Recirculating aquaculture Systems, the developments will be in designing RAS for individual species considering its specific requirements and table size production systems, designing RAS for specific purposes like nursery rearing, genetic selection programmes and broodstock maintenance taking into consideration both species and programme specific requirements combining biofloc with RAS and the engineering and biofilters required for this combination, designing RAS for individual species considering its specific requirements, designing cost effective and user friendly solid removal systems, highly efficient aeration systems, protein skimming systems, less expensive substrata for attachment of nitrifiers in the designing of high efficient nitrifying bioreactors, improvisation of existing rapid sand filters, cartridge filters, protein skimmers, drum filters, use of solar power and free energy in operating the systems and modular designs. In the developments of Integrated Multitrophic Aquaculture (IMTA) production Systems thrust will be on designing offshore and inshore IMTA, location specific, designing cost-effective durable underwater structures

as cages, anchors etc., designing rafts, underwater aeration systems, underwater imaging systems, online sensors, feeding devices, use of solar power, wind power and free energy and hybrid power sources in operating the systems.

Under this programme 'Scampi Improvement System Kuttanad (SISK)' will be developed with intensive research efforts for improving the boordstock of scampi and producing genetically improved SPF Scampi for Scampi farming throughout Asia in collaboration with national institutions and other stakeholders,

Aquatic Biotechnology

Drug discovery and development from marine biological systems to combat disorders and pathogens of man and animals (both aquatic and terrestrial) be a priority area of research. It is envisaged to establish and maintain with sustainability a National Facility for Marine Extracts and Genetic Resources for Bio-active Molecules with global standards for drug discovery and development from marine biological systems for human beings and animals under one roof. The National Consultation on 'Pharmaceuticals and Bio-fuel from marine Biological Systems – Status, Constraints and the Way Forward' convened from 1st to 3rd February, 2016 by National Centre for Aquatic Animal Health, CUSAT, sponsored by Department of Biotechnology, and University Grants Commission, Government of India under the 21st Century Indo – US Knowledge Initiative ended with the recommendation to establish a National Facility for Marine Extracts and Genetic Resources for Bio-active Molecules at Cochin University of Science and Technology. Scripps Institution of Oceanography, USA, the leading Global Institution in Marine Natural Products, shall impart the technical know-how and help in setting up the facility and to augment research on focused areas of National importance having a Global impact. There is ever-growing demand for novel drugs for combating diabetes, cardiovascular disorders, cancers, multiple drug-resistant bacteria (especially *Mycobacterium*), systemic fungal pathogens, neurodegenerative disorders, arthritis and several more of human beings. There is an urgent requirement for drugs to manage pathogenic *Vibrio*, *Enterocytozoon hepatorenal* (EHP), White spot syndrome virus, a protozoan parasite, *Zoothamnimum*, and the metazoan parasite,

Argulus, in aquatic animals. Several can be added from animal husbandry perspective. Heavy investment and state of the art infrastructure under one roof are required to address such issues. The National Consultation meet identified CUSAT as an excellent platform to have such a facility as it has huge Science and Technology infrastructure, besides the proximity to the Research Institutions such as Central Marine Fisheries Research Institute and Central Institute of Fisheries Technology.

A Marine Algal Biotechnology Facility will be developed envisaging focused research in marine algal biotechnology in the areas such as novel isolation and cultivation strategies from marine algae, development of a panel novel marine micro-algal species as live feed and functional food in aquaculture aimed at food and nutritional security, development of mass production systems of marine microalgae for ready application in aquaculture, development of marine algae based biofuel from lipid and hydrocarbon rich algal species, microalgal productivity enhancement in aquatic systems for CO_2 sequestration, novel bioactive molecules of biomedical and industrial importance from marine algae, edible vaccines from marine microalgae for aquaculture applications and the development of genomic and metabolic resources and genetic and genomic engineering tools for indigenous marine algal species for developing genetic, genome and metabolic engineering and synthetic biology platforms.

Research community in the Country will always have a need for relevant but economical models of development for microbiology, physiology, toxicology and biomedical realm. Though research employing aquatic animal models was once justified by the relative simplicity and ease of culture of these animals that often led to a useful economy of scale, now many of these models are so well established that biomedical research wouldn't be the same without them. The comparative approach of using aquatic species permits identification of patterns of morphological and regulatory organisation, leading to insights relevant to numerous areas of biological investigation such as development, physiology, behaviour, genetics, evolution, and ecology. However, the availability of the single-lineage species with genetic purity and a platform to conduct cutting-edge research are the major scientific lacunae in Indian context to perform analysis using aquatic animals. A platform

for research on aquatic animals (especially invertebrates) through the National facility National Facility for Aquatic Animal Models and Cell Cultures will be developed under this programme .

The existing culture collection of marine microorganisms and algae will be made to a world-class culture collection with different isolates from the Indian Ocean to transform into a Repository for Marine Microorganisms and Algae. The culture collection will make accessible to researchers from National and International Institutions to explore for different biotechnological applications. Also, In the climate change scenario, it is utmost important to preserve the marine microbial biodiversity in a culture collection for future generation and the planet. Under this facility, exclusive facilities for novel cultivation, maintenance and preservation of the microorganisms will be developed. The developments in this area will be in collaboration with Scripps Institution of Oceanography, USA and other National Institutions focusing on the area.

Refuse management technology

Any material which is left out after use is refuse. These materials, named otherwise as waste materials, create innumerable environmental issues leading to environmental degradation and slow death of the earth. The most appropriate way to tide over the situation is to consider any refuse as raw material of another industrial process. A systematic and scientific approach to collect, process and utilize theses precious raw materials will pave way for development of several industrial processes and there by cleaning up of the earth. Commencement of an M.Tech. programme in Refuse Management Technology, implementation of research programmes to develop cutting edge technologies for developing an array of fine technologies will boost up industrial and agricultural sectors having environment at the central stage. The University stands by the concept that 'Development is any process which is in favour of the environment'

Rejuvenation of Riverine Systems

Rivers are blood vessels of mother earth and their death is an indication that earth is marching towards its death. This realization has lead to initiative process and programmes by which the root causes of death of rivers are found out and remedial measures implemented at practical level with people's participation. This will be a conglomeration of several disciplines from basic to applied having all those are committed to wards posterity can join. Beginning from Kerala the programme will spread to throughout the country.

Ecosystem services

What one gets out of an ecosystem has not been quantified, and this situation delimits and incapacitates to gauge the impact of anthropogenic activities all over the globe. Termed as **'Ecosystem Services'** the University envisage to coordinate an array of processes and activities by which services which mankind gets out an ecosystem is quantified for another thousand years. All recent advances in physical, chemical, and biological sciences, computational and information technologies besides engineering will be made use of to arrive at the desired information. This will include a movement of the University facilitating all interested in participating.

Engineering Sciences and Technology Research

Technology and Engineering is a power field, field with the capability to change the world literally and figuratively. Engineering Science, together with Technological advances certainly has the capability of changing the perspective with which we view the world. Research in the field of engineering and technology is an approach to the world, a critical way to understand and explore and engage with the world. Many of the world's most significant engineering challenges will be met decades in the future by the next generation of engineers and scientists. To inspire and prepare today's students to become tomorrow's innovators; we must bring forth new ideas and avenues in the field of Engineering Science and Technology. CUSAT has envisioned a research proposal whereby multiple disciplines in the engineering field can conjoin and conceive a research group which deals with innovations in the engineering as well as technological domain. CUSAT presents research ideas that can help the future generation in multiple avenues.

The establishment of a **Centre for Interdisciplinary studies in Engineering Sciences and Technology (CIEST)** is a vision formed in the concept of incorporating the research under multidisciplinary fields of all engineering and technology fields under one umbrella.

1. Cyber-Physical System

Research in the area of smart healthcare system is advancing into new forays of multiple technological domains. In the recent years, numerous technological advances in the field of electronics have lead to an integration of multiple domains into one, where a symbiotic relation between the domains could be conceived. Healthcare systems like many other domains continuously needs support from the engineering domain may it be the software or the hardware side of patient diagnosis and disease management. CUSAT would be setting up a Cyber Physical system whereby we could envisage a new Smart system which can ease with diagnosis of diseases, management of patient information and to establish a robust communication system. Development of such a system can help with information

sharing between multiple practitioners. It could also help in instant delivery of services for the patients as well.

CUSAT is planning to introduce research oriented post graduate courses in the future to enhance the research potential and to maintain the standard in par with the world class universities.

Research potential is huge in this area, as it is wide spread, and one of the most challenging area of research ranging from system-level management, to control and to data analysis.

- Computation, communication and control are the main aims of Cyber-Physical System, targeting to develop a smart health care system to track and monitor health and also administer drug
- Critical medical information can be transmitted so we must provide importance for confidentiality and security.
- Privacy and safety for hybrid system architecture with smart sensors in distributed environment for estimation and control strategies.
- Our research plan extends to develop efficient algorithms for cooperative, responsive and distributive storage, to enable controlled communication and consumption.
- Design and development of smart factories with future automation to future energy grids and interconnected mobility.

Cyber physical systems changed interaction and communication between each other. It establishes a bridge between the physical world and cyber world with the help of sensors and actuators, these systems automatically collect information to enable communication. These systems are used to collect all distributed intelligence in the environment to gain a deeper knowledge of the environment. Now CPS is everywhere from IoT to Smart Cities, Drone to health care, volcano to aquatic monitoring.

- Smart devices with sensing and computing capabilities.
- Wireless sensor network with fiber optic sensors and Micro electrical mechanical sensors.
- Artificial Intelligent Robots for performing skillful work including search and immediate response.
- Smart cellular access points.

- Grid and cloud computing environment and its control systems.
- Base stations operating in VHF band (to reduce energy requirement and improve the network capacity).

The Data Science and Analytics Lab have to be set up with a vision to foresee it as a data driven innovation hub. The high performance lab will be equipped with latest distributed and parallel computing facilities that can be utilized for solving big data analytics problems of all fields including engineering, medicine, business etc.

This is an inter disciplinary lab setup to bring together engineers, physicians, computer scientists and statisticians to develop novel ways to manage, analyse and visualize very large data sets. It is also intended to accelerate applications to industry funded projects. It also assists local and regional companies with their data analytics needs.

In alliance with different biological scientific community data processing and visualization tool development can be developed. The lab requirements include an Animal Cell Culture Lab, Microbiology Lab, Bioinformatics Infrastructure Facility- information handling tools and techniques and a Computational Lab.

2. Cyber Security in Cyber Physical Systems

Cyber Security in Cyber Physical Systems (CPS) is interdisciplinary by nature. Security of Cyber Physical Systems is an important area of research. Cyber security research focuses on devising robust defense mechanism so as to prevent hackers from gaining control over sensitive information or resources. Information transfer over a network is constantly under threat from snooping as well man in the middle type of attacks. Our research aims to provide identity authentication and creation of unique signatures to enhance the security of CPS. Bridging the gap between multiple domains has always been a challenging problem statement. By envisaging a centre like this we can certainly lead the way in developing quality metrics for unique signatures in the Cyber Physical Systems. This research will require setting up of a Cryptography laboratory, setting up of ASIC laboratory for designing secure chips and servers with high performance computation facilities.

3. Internet of Things

Communication protocols have been designed for specific applications in mind. With the proliferation of low power embedded systems, lightweight sensors and actuators form the end points in a network. A swarm of intelligent devices communicate and collectively gather information about the state of a system. Decision making is at the central hub, yet its execution is at an end point which is dependent on the lifetime of a battery. Lightweight protocols need to be developed in this context to reduce the energy consumption. Intermediate nodes in a network acting as repeaters are continuously affected due to protocols that are heavily handshake based. A low power communication protocol which uses the collective intelligence needs to be researched for Internet of Things. This research would require setting up of an IoT testbed infrastructure with testing and measurement facilities, simulation of attack and defence in a network, a network of embedded hardware devices for distributed computation.

4. Intelligent Sonar Systems

CUSAT is carrying out numerous projects and research activities in the area of ocean electronics especially in Sonar Signal Processing which includes Target Localization, Tracking & Recognition, Underwater Acoustic Imaging, Navigation, Communication and Maritime Surveillance. Most of these applications demand computationally intensive procedures and algorithms such as Hidden Markov Models, Bayesian Probabilistic Models, Deep Learning Neural Networks, Sparse Signal Processing etc., which cannot be handled or are not feasible to be implemented on traditional sequential computing systems.

One of the biggest challenges for today's sonar systems is to provide more capability range, some targets, speed, etc. while meeting ever more stringent SWaP (Size, Weight and Power) constraints. The present proposal aims to device these systems using the computational power of CPU cores and accelerator cores to exploit the inherent parallelism associated with the mentioned algorithms. The massive parallelism and significantly increased computing power of GPUs offer the potential for realising innovative new

capabilities in underwater channel modelling and processing that were previously infeasible due to the limitations of having only a few processing cores to commit to the task.

5. Robotics and Artificial Intelligence

It is proposed to introduce innovative robotics technologies that will enable robots to work together with humans in human environments, contributing to all kinds of services and labor beyond 'confined' industrial environments. The centre shall foster the growth of knowledge and innovative skills, promoting national and international collaboration leading to world-class R&D and technology incubation giving rise to new generation knowledge entrepreneurship bridging the gap between mind to market. The Centre with the synergetic partnership of the industries shall be a place producing innovative products of global standards and hence establish INDIA as a brand name in the field of robotics.

6. Nanoantennas for Wireless Communications

Next generation communication systems get data rate increase using multiple transmit/receive antennas (MIMO). Since many antennas are to be accommodated into a small device, antennas have to be very small. For these small antennas with adaptive switching are to be used at millimetre wave frequencies, nanomaterial characterization at these frequencies is a promising research area which will be carried out in the first phase.

7. Microwave /Terahertz Imaging

Microwave imaging is an efficient tool for the early detection of diseases like cancer. Also since the radiation is noninvasive, it is safe for humans of all ages and health conditions. Use of terahertz will improve the resolution and better detection which is also useful in security applications.

8. 5G/LTE communication

The communication at millimetre waves is highly efficient regarding bandwidth. Different research work in this area include the development of new waveforms and efficient modulation schemes, device to device communication, smart antenna systems etc.

9. Intelligent Assistive Robotics

In the last decade robotics has stepped out from industrial applications into human society as helpers, rehabilitation devices, welfare supervisors, and entertainment aids. Out of all these applications, human-assistive robots are likely to play a major role in improving the lives of persons with disability due to old age, disease or injury. It is needless to say that Asian countries like India are lagging behind in this very important field of research. Assistive robotics is highly multi-disciplinary and involves many different research fields. The main objective of the proposed Intelligent Assistive Robotics laboratory is to develop specialized man-power through rigorous basic and experimental research in major aspects of assistive robotics that includes rehabilitation robots, wheelchair robots and other mobility aids, and manipulator arms for the physically disabled. The proposal also has a provision to support students without adequate laboratory setup to perform remote experiments on a costly physical set-up in laboratories. Thus, in brief, the main activities to be undertaken in this project are:

- To develop highly skilled human resources – graduates with PhD and Masters' degrees - in assistive robotics through collaborative basic and experimental research.
- Lead researchers in the university can learn from data and can develop a low-cost visually navigated smart wheel-chair and similar platforms with the support of high computational facilities available in the institute.
- Deep Learning can be used to make a next-generation system with a better performance
- For developing a visual tracking system for operating the wheelchair as an automated guided vehicle (AGV) to give mobility
- To make an integrated navigation system with both embedded and off-board sensors for safe navigation of the wheelchair
- For designing a self-organising control architecture for a redundant manipulator for natural execution of actions desired by the disabled user;

- To make an evolvable hardware system for controlling assistive robots and wheelchairs adaptively
- To develop specialized manpower in assistive robotics through collaborative basic and experimental research
- To conduct practical experiments on assistive robotic systems

10.Machine Vision

Machine vision is an area of industry that is growing rapidly and working its way into many engineering fields. Vision-based robotic assembly and quality control systems, that have been a topic of continued research interest for almost four decades. It has now matured to a point where they can be effectively applied to advanced robot-based assembly and quality control tasks. In modern industrial assembly and quality control processes, there is a strong need for advanced robot-based object detection and recognition, object grasping and for the capability to perform assembling operations in non-structured environments with randomly positioned objects. In order to keep pace with the rapidly evolving vision systems, wide range of skills and knowledge related to the mechanical set-up, electrical controls and software has to be familiarized.

The proposed vision laboratory exposes postgraduates and researchers with hands-on laboratory courses in machine vision. Experiments will equip them with design-oriented approach and hence open-ended. The students, after learning the basics, devise their own schemes to accomplish their task objectives using the available laboratory equipment and software packages, thus greatly enhancing their ability to solve real-world engineering problems. The main objectives to be covered under the proposal are as follows:

- To perform high-quality research on computational vision and modelling, machine learning, and pattern recognition
- To solve practical vision problems with direct application to the real world.
- To carry out advanced interdisciplinary research in the broad areas of automation and robotics.
- To generate trained manpower through degree programs of Ph.D., &masters and training.

- To take up industrial projects with specific deliverables in the areas of automation and robotics
- To conduct outreach programs through workshops and training programs.

11.Robot Locomotion

The type of locomotion used will change depends on the environment where the robot is employed. Wheeled robots are the most common locomotion scheme used since they are typically quite energy efficient and simple to control. However, other forms of locomotion may be more appropriate for a number of reasons, for example traversing rough terrain, as well as moving and interacting in human environments. A major goal in this field is in developing capabilities for robots to autonomously decide how, when, and where to move. However, coordinating a large number of robot joints for even simple matters, like negotiating stairs, is difficult. Autonomous robot locomotion is a major technological obstacle for many areas of robotics, such as humanoids. So further research should be done in robot locomotion to explore practical reliable locomotive ways. By familiarizing robots based on various locomotive systems like wheeled locomotion, legged locomotion, etc. the researchers can formulate innovative techniques for practical implementation.

Locomotion laboratory exposes postgraduates and researchers with hands-on laboratory courses indifferent locomotion techniques. Experiments will equip them with design-oriented approach. The students, after learning the basics, devise their own schemes to accomplish their task objectives using the available laboratory equipment and software packages, thus greatly enhancing their ability to solve real-world engineering problems. The main objectives to be covered under the proposal are as follows:

- Develop a strong understanding of the fundamentals of locomotion approaches employed in various environments
- Develop strong teamwork and communication skills to solve complex electro-mechanical problems across disciplinary boundaries
- Design, develop and implement intelligent innovative locomotion movements

12.Intelligent Controllers and Systems

The goal of our research is to build machines which exploit their natural dynamics to achieve extraordinary agility and efficiency. In an age where "big data" is all the rage, we still have relatively limited data from robots in these regimes, and instead rely mostly on existing models and model-based optimization. The proposed laboratory focuses to work on optimization algorithms by exploiting structures in the governing equation and control application. With the proposed laboratory, the controlling systems will act like a backbone to the intelligence in robots. It is also proposed to investigate dynamics and control for serial manipulation robots, swarm robotics, and internet of things, unmanned underwater vehicles.

The main objective of the proposal is to develop specialized algorithms for next-generation robotic systems. This proposal has a vision such as students and research scholars from other disciplinary can take the data and develop their algorithms here. Those can be done in collaboration with other robotics laboratories. Thus in brief, the main activities to be undertaken in this project are:

- To develop highly skilled human resources in Data analysts through experimental research.
- Source of robot motion data given to other researchers for developing their own algorithms on it.
- Complex Deep Neural Networks and other algorithms can be implemented with the available resources in the proposed laboratory.
- High-speed processing can be achieved for Real-time object detection, tracking, SLAM etc.
- High-performance computing facility for analyzing and controlling systems in real time
- Embedded computing platforms like Nvidia Jetson with GPU-accelerated parallel processing for real-time high-speed image processing inside the embedded board itself.
- A self-adaptive learning system that evolves multiple neural networks incrementally from simple to complex tasks for robotic control;
- To develop specialised manpower in Artificial Intelligence for robotics.
- To develop self-learning robots for the future with learning-to-learn and other approaches.

13.Human-Robot Collaborative Systems

In the past couple of years, collaborative robots have seen an incredible rise in the robotics market. In Human-robot collaboration the robot assists the human operator, means the machine does not replace the human, but complements his capabilities and relieves him of arduous tasks. From a research perspective, the possibility for robotic manipulators to directly work alongside humans has stimulated a variety of novel research fields in recent years. From an industrial perspective, this newly available technology has been accepted by big manufacturing as well as small and medium enterprises. The familiarization of advanced collaborative robots available in the industry will provide the students with hand-on training and thus help to bridge the gap between the production line and academia. For developing such system the laboratory facility should incorporate high-performance sensors, intelligent control technology and state-of-the-art software technologies

The proposed laboratory shall provide facilities to test and develop the following aspects of Human-robot collaboration,

- Safety aspects of HRC, including injury assessment, safety monitoring and metrics, and safety control methods
- Human perception, prediction and intention estimation
- Sensing devices and situational awareness for HRC
- Human-robot activity allocation and scheduling
- Ergonomic aspects in HRC, including human augmentation devices

14.Humanoid and Legged Systems

Researchers need to understand the human body structure and behaviour (biomechanics) to study humanoid robots. Human cognition is a field of study which is focused on how humans learn from sensory information in order to acquire perceptual and motor skills. This knowledge is used to develop computational models of human behaviour and it has been improving over time. It has been suggested that advanced robotics will facilitate the enhancement of ordinary humans. The goal of the proposal is to build humanoid and/or legged systems software frameworks to achieve long-term goals in its controlling,

path planning and high level task execution. Natural Language processing also in cooperated for communication with the system in natural language.

Our vision of the future is how humans interact with a large number of devices and robots in a human-robot community. To develop the research and educational foundation for such a future, we propose establishing a multi-robot research and education facility.

To work towards a future of the human-robot community, we need to develop techniques for multi-robot perception, control, learning from experience, and human-robot interaction. We need to explore how multiple robots can help each other perform better and exchange information efficiently to achieve useful tasks. We have extensively studied how individual robots operate in human environments and have investigated and developed multi-robot systems in customised environments.

Humanoid robots, especially with artificial intelligence algorithms, could be useful for future dangerous and distant space exploration missions, without needing to turn back around again and return to Earth once the mission is completed.

We are planning for industry collaborative courses in the humanoid robots. We also expect the multi-robot facility to play a major role in education. The university has been offering several courses that already use small numbers of simple robots to work towards these goals.

15. Offshore Renewables and Advanced Marine Vehicles

Increasing demand for energy, shortage of fossil fuels besides the increase in environmental pollution had led to considerable interest in renewable energy sources and is becoming more critical than ever. Solar energy, for instance, has already been proved as a viable source of clean energy that is beginning to replace or supplement the energy needs from fossil fuel. Likewise, the energy from ocean waves, tides and currents (including the natural flow of water in rivers), if efficiently tapped, are great sources of green energy.

However, the technologies to draw this energy efficiently and economically from oceans are still in the future.

The development and management of efficient waterways for Inland Water Transport systems require constant monitoring. To ensure the channels are free from erosion and silting, periodic hydrographic surveys and mappings are necessary. Conventionally, manned survey vessels fitted with modern survey equipment are deployed to undertake this mission. However, the development of unmanned vehicle technologies such as Unmanned Aerial Vehicles (UAVs), Unmanned Underwater Vehicles (UUVs) and Unmanned Surface Vehicles (USVs) are gradually replacing the conventional methods of survey and mapping. Developing such technologies is essential to the future of maritime community nationally and internationally.

In addition to navigation, an efficient IWT system calls for new and improved designs of cargo and passenger vessels. 'Smaller, lighter and faster' vehicle designs are the need of the day. This calls for advances in research in the field of high-performance marine vehicles such as planning crafts, hydrofoil crafts, hover crafts, WIGs and other hybrid design concepts.

The growing technology demands in the above-mentioned areas have led the Department of Ship Technology to envision a new and revamped research curriculum that would encompass all the above areas and is believed to cater to the needs of the maritime community. Given this, the thrust areas of research in which the department propose to focus its attention on are in **Ocean Renewable Energy Technologies-** especially from ocean waves, winds and currents, **High-Performance Marine Vehicles -**new and improved design techniques for building lighter and stronger crafts, **Unmanned Marine Vehicle Systems-**for monitoring and surveying of offshore and inland waterways and **Ocean Resources and Mining Engineering.** These programmes is interdisciplinary requiring association with other disciplines such as the Department of Electronics, Computer Science, Ocean Technology etc.

Another area that is gaining importance in the country is Inland Waterway Transport (IWT) system. Despite the advance of modern ground and air transportation, waterways continue to fill a vital role in the transportation of people and goods. This is because water-based transportation is universally recognized as the cheapest, fuel-efficient and environment friendly mode of transport. This renewed interest has led the Government of India to pass the National Waterways Act of 2016 to turn 111 rivers across India into national waterways. But the decision to make inland waterways navigable requires constant and steady water flow at a set minimal limit depending on the tonnage of weight to be shipped. This has to be managed artificially by constructing necessary infrastructures such as locking barrages to hold water for vessel movement, building embankments to create port terminals and ensuring minimum water depth by regular dredging. In addition, design of efficient inland vessels, navigational aids, terminals and communication facilities are also essential.

It is clear that a coordinated development of IWT systems and supporting infrastructures and technologies are necessary for the future of shipping and tourism. The prospects for IWT look promising. However, development of infrastructure and modernisation and enhancement of the fleet using cargo and passenger vessels with modern, optimal designs are issues that need to be addressed suitably. In view of this, the PG programme in IWT offered is expected to focus on the thrust areas of **Design and development of efficient vessels** and other transportation systems best suited for the inland waterways and **Development of river-sea transport** combining the coastal sea transport.

16.Sustainable Materials Technology

Development and advancement of human societies closely related to materials. Understanding of the relationship among structure, properties, processing and performance of materials is an intelligent way of designing new materials. Advanced materials and processing methods have become essential to the enhancement of the quality of life, safety, industrial and economic growth. As more and more elements are developed by exploiting our mother nature-earth, we tend to face a crisis in future.

Corrosion not only has economic implications, but also social and these involve the safety and health of people either working in industries or living in nearby towns. The use of corrosion inhibitors constitutes one of the most economical ways to mitigate the corrosion rate, protect metal surfaces against corrosion and preserve industrial facilities. Green corrosion inhibitors are biodegradable and do not contain heavy metals or other toxic compounds. It is intended to develop new green inhibitors based on naturally occurring substances to inhibit the corrosion of metals in acidic and alkaline environment.

The ultimate objective of the research programme is the development of Cost Effective, Environment-Friendly Corrosion Resistant Materials and Coating such as Green inhibitor, sacrificial anode, surface coating etc. The is interdisciplinary in nature with other disciplines such as Polymer Science, Marine Engineering etc.

17.Advanced Polymer Materials, Biomaterials & Nanomedicine

Developing a world-leading research centre for translational research outputs in regenerative biomaterials and nano-medicine should be of utmost importance in this new era of environmental degradation. By anchoring research activities and exploring excellence of the complementary research groups of the university as well as leading institutes of the country related to the theme proposed we can certainly develop novel health care technologies that can promote skill building, enhanced efficiency as well as innovative commercial products that can certainly act as the centres revenue source. The centre in the long-run aims to generate considerable impact on many frontiers such as in improving the quality of life of the population suffering by but not limited to cancer, bone degenerative, neurodegenerative and cardiovascular disease.

Rapidly ageing population coupled with increased standard of living and life expectancy has resulted in an expanding pool of patients in cardiovascular disease, neurodegenerative diseases, cancer, osteoporosis and metabolic diseases such as diabetes. Clinicians are on the lookout for new methods of treatment paradigms not only in development of drugs but also in novel delivery methods. Organ failures in aged patients have increased the demand for tissue engineering because of the lack of availability of organ

donors. Recent advances in the basic understanding in stem cell biology have opened a new vista on our ability to do tissue regeneration and repair in a clinical setting which is expected to herald a new era in the treatment of these diseases. In this context biomaterials are of significant importance because of their ability to provide scaffolding matrices for the growth of cells and development of 3D structures.

Nano-medicine can revolutionize cancer therapy with the indigenous ability to execute expected pharmacokinetic activity, real-time non-invasive visualization and intrinsic targeting and offer a high therapeutic index in vivo. The interesting intersection of biomaterials and nano-medicine thus generated offer smart opportunities for envisage new bio-functional molecules and phenomena to resolve several present clinical challenges.

Developing stimulus-responsive biomaterials with easy-to-tailor properties is a highly desired goal of the tissue engineering community. A novel type of electroactive biomaterial, the conductive polymer, promises to become one such material. Conductive polymers are already used in fuel cells, computer displays and microsurgical tools, and are now finding applications in the field of biomaterials. These versatile polymers can be synthesised alone, as hydrogels, combined into composites or electrospun into microfibres. They can be created to be biocompatible and biodegradable. Their physical properties can easily be optimized for a specific application through binding biologically important molecules into the polymer using one of the many available methods for their functionalization. Their conductive nature allows cells or tissue cultured upon them to be stimulated, the polymers' own physical properties to be influenced post-synthesis and the drugs bound in them released, through the application of an electrical signal. It is thus little wonder that these polymers are becoming very important materials for biosensors, neural implants, drug delivery devices and tissue engineering scaffolds

By merging the fundamental concepts and governing principles of the powerful approaches- biomaterials and nano-medicine the synergy realized is the next-generation multi-functional modes of therapy for several unresolved healthcare challenges. It should also be mentioned that currently there is a shortage of facilities in Kerala where an

interdisciplinary group of researchers work together to solve specific problems and this center will fill that gap.

Advanced facilities for research in Polymer Materials

Thrust Areas proposed under the research group:

- Conducting polymer based systems for super capacitor/micro capacitor applications.
- Polymer nanocomposites for piezoelectric applications
- Recycling of plastics/biodegradable polymers
- Development of adhesives and coatings from renewable resources
- Advanced materials for energy harvesting and energy storage
- Rubber nanocomposites / Epoxy nano composites for EMI shielding applications
- Magnetic nanocomposites for water purification

Objectives

- Undertake challenging research projects in the advanced polymer technology area to meet the future requirements of our society.
- Establish comprehensive research facilities under the same umbrella to attract intellectuals from around the globe.
- Mould high quality human resources to undertake future challenges.
- Serve as a link between industry and academia in the country.

This will be a collaborative work between Department of Polymer Science and Rubber Technology, Department of Physics and Department of Electronics.

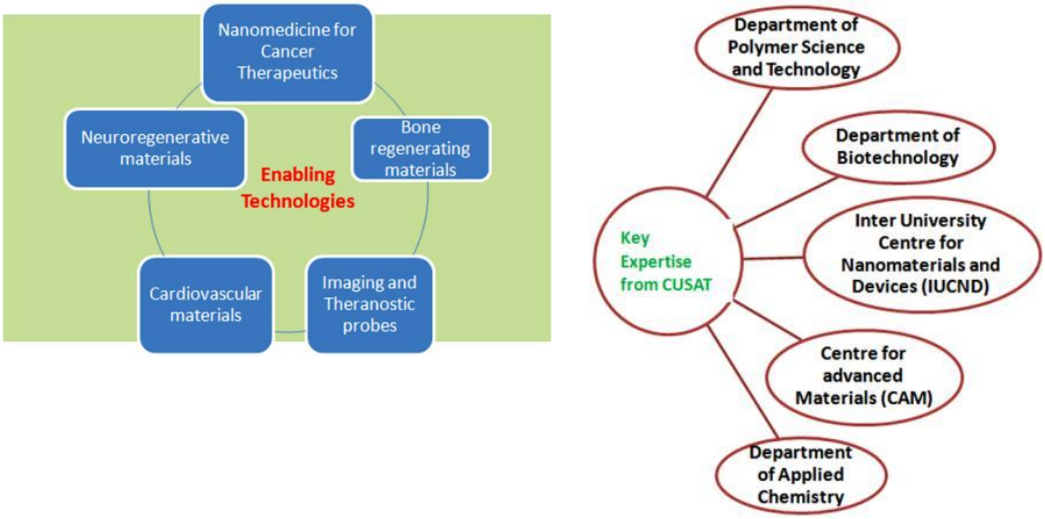
Advanced facilities for research in Biomaterials and Nanomedicine

Objectives:

- To be an independent, self-sustained research Centre with international standard
- To contribute to a knowledge-base and training for promoting scientific and technological research of excellence towards health care challenges thus reinforcing the social and economic development of the country and also contribute to world-wide
- To foster knowledge transfer and exploitation by promoting interactions and transnational collaborations between the Centre and other renowned organizations the country in related field and abroad and to generating useful intellectual property that can help to support in the long-term the sustainability of the proposed Centre

- To generate high performance innovative technologies which has an impact in society related to regenerative and precision medicine and improve the international visibility of the country
- To inspire talent from other states and various parts of the country to reinforce and re-invent the scientific capacity of the Centre that will contribute to improved competitiveness
- To establish training sessions to generate of highly-skilled researchers by offering need of the hour education and training programs for both Ph.D. students and Post-doctoral fellows

This will be a collaborative work between Department of Polymer Science and Rubber Technology, Inter University Centre for Nano-materials and Devices , Centre for Advanced Materials., Department of Applied Chemistry and Department of Biotechnology.



18.Natural Language Processing

Natural language processing has been in existence for more than fifty years. During this time, it has significantly contributed to the field of human-computer interaction in terms of theoretical results and practical applications. As computers continue to become more affordable and accessible, the importance of user inter-faces that are effective, robust, unobtrusive, and user-friendly–regardless of user expertise or impediments–becomes more pronounced. Since natural language usually provides for effortless and effective communication in human-human interaction, its significance and potential in human-computer interaction should not be overlooked–either spoken or typewritten, it may

effectively complement other available modalities,1such as windows, icons, menus, and pointing; in some cases, such as users with disabilities, natural language may even be the only applicable modality.

The field of natural language processing should examine on how it relates to human-computer interaction. We need to focus on its history, interactive application areas, theoretical approaches to linguistic modelling, and relevant computational and philosophical issues. The taxonomy for interactive natural language systems should be examined based on their processing requirements and also must be reviewed based on related applications. Linguistic coverage issues must be explored so that the development of natural language widgets and their integration into multimodal user interfaces are done with ease. These multimodal user interfaces must also be integrated with the embedded systems as well as the internet of things so that any applications based this paradigm can be reviewed with accuracy.

The centre plans to address the complex problem of understanding and processing natural language in both speech and text mode. To conduct such a research on both basic and advanced aspects of language technologies we need to develop basic and advanced tools for language processing. These tools should be developed such that they can be a deployable technology for Indian Languages in the areas of machine translation, cross-language information retrieval, text summarization, plagiarism detection and author identification. Through the use of parallel computing and computer vision, we can create a niche for ourselves where we combine the robust algorithms developed for language processing can be speed up for faster processing.

The Department of computer science is currently undergoing research programmes in the areas of Natural Language Processing. Human Computer Interaction. Computer Vision. Parallel and Distributed Computing, Internet of Things and Embedded Systems.

In pursuit of excellence in the area, we plan to converge to the areas of research where in we have enough expertise like Artificial Intelligence & Machine Learning. Natural Language Computing. Large scale data processing and analytics. Cyber Physical Systems. Advanced Data Mining & Bioinformatics.

19.Dynamic Capability Assessment of Infrastructure

Assesment of the dynamic capability of infrastructural elements is extremely important these days as severe damages have been reported in some of the recent natural disasters such as Hurricane Harvey (2017), Hurrican Irma (2017), the Nepal Earthquake (2015), Cyclone Hudhud (2014), Cyclone Phailin (2013) etc. Dynamic loads on structures include traffic, wind, earthquakes, wave action etc. Buildings subjected to earthquakes are typical examples of structures subjected to dynamic loads. Long span suspension bridges and slender tower structures also have to be analysed for their perfromance under the dynamic action of wind. Other examples of cyclic loading include machine foundations subjected to vibrations, offshore structures subjected to hydrodynamic loads, cooling towers subjected to wind loads etc.

Existing structures such as bridges, multi-storeyed buildings, cooling towers, offshore structures etc. may also fail at a lower than expected strength when subjected to repeated cyclic loading. This lower strength depends on the rate of loading, the stress ratio, the maximum stress and the number of cycles. Various parameters such as load carrying capacity, stiffness degradation, ductility characteristics and energy absorption capacity of structural members have to be evaluated to assess the dynamic performance under cyclic loads.

Use of sustainable materials and technology in construction is a significant topic of research in the current scenario. Research activities are being carried out at CUSAT to develop alternative sustainable construction materials such as cold bonded quarry dust aggregate concrete. It is important to conduct life assessment studies before using the newly developed construction materials for major works such as bridges, multi-storeyed buildings, cooling towers etc. The feasibility of using the newly developed materials for major structural works can also be evaluated.

The equipment proposed for dynamic testing is a Computer controlled servo hydraulic dynamic testing system with a capacity of +/-1000kN. This machine is expected to carry out fatigue & static loading tests on a wide variety of materials including concrete.

The precise control of frequency and displacement in this machine is electronically controlled via the hydraulic based servo controlled close loop system. The major components of this equipment are load frame with hydraulic lifting jacks & control panel, servo hydraulic actuator, control system and control software and flexure testing attachment. This proposal envisages the setting up of a sophisticated dynamic testing facility currently unavailable in any engineering college under the jursidiction of the univeristies in Kerala.

Objectives

- To develop an advanced testing facility for assesing the flexural behaviour of structural members under repeated dynamic loads
- To develop innovative retrofitting and rehabilitation technologies
- To evaluate feasibility of using alternate sustainable materials for structural works
- To promote high quality research in the areas of Structural engineering, Construction technology and Building materials.

Thrust Areas

- Seismic Performance Evaluation
- Retrofitting and Rehabilitation of Dynamic Systems
- Performance of Framed Machine Foundation
- Dynamic Residual Strength of Innovative Materials
- Offshore Tower Structure Optimization
- Fatigue Life Assesment
- Vibration Control and Monitoring
- Optimised Gust Flutter Design
- Structural Life Cycle Assesment
- Dynamic Material Characterization
- Sustainable Building Technology

20.Advanced Studies in Industrial Engineering

Objectives

- To develop a research group for advanced training and research in Industrial Engineering.
- To develop the ability to design, implement, and evaluate a computer-based industrial engineering system or/and process to meet desired needs with appropriate consideration for public health and safety, cultural, social and environmental considerations.
- To develop the ability to design and conduct experiments using IE models and IT tools, to analyse and interpret the data leading to feasible solutions.
- To develop methods to analyse a problem, identify and formulate the industrial engineering principles appropriate to its solution.

Thrust Areas

- Decision Modelling
- Risk Management
- Inventory and Supply Chain Management
- Project Management
- Facilities Layout Planning
- Reliability Engineering
- Manufacturing, planning and Control
- Systems Modelling and Simulation
- Forecasting Techniques
- Industrial Scheduling

21.Multi Domain Instrumentation

Instruments have revolutionized how we look at the world and refined and extended the range of our senses. From the beginnings of the development of the modern scientific

method, its emphasis on testable hypotheses required the ability to make quantitative and ever more accurate measurements—for example, of temperature with the thermometer (1593), of cellular structure with the microscope (1595), of the universe with the telescope (1609), and of time itself (to discern longitude at sea) with the marine chronometer (1759). Instruments have been an integral part of our world's growth since explorers first set out to map the continent.

The research plan includes strengthening the present research areas and to start programmes in frontline research areas. The present areas of research will be fitted into the proposed plan.

Research plan proposed:

The research activities of the Department need to be restructured in order to reach a level of global competence in the context of Institution of Eminence with global outlook. This requires research activities in front line areas with a scope for 15- 20 years and substantial investment by way of money and manpower. To restructure the research plan we propose to concentrate in the following areas and fit the present activities within these areas. These areas are chosen keeping in mind the long term prospective and based on the R&D scope for many years. In addition to the faculty, the man power for the programme will be derived from PG students (appox. 70) and research scholars (approx. 100) who will be placed under the faculty members in various research areas.

- Mems and Microsystems laboratory
- Analytical instrumentation with emphasis in lab-on chip type devices
- Control, navigation and robotics instrumentation
- Embedded, virtual and intelligent instrumentation
- Sensors, signal processing and image processing including applications in biomedical instrumentation
- Materials science for instrumentation
- Environmental and ocean instrumentation
- Optical and optoelectronics instrumentation
- Computational facilities

22.Socially Relevant Research Proposals

Agro-Helpline using Deep Learning

The current scenario of reluctance towards adopting agriculture or considering it as a profession of the general population can be changed with this project as it offers them guaranteed results. Also every state will be able to feed themselves without having to depend on other states. With more people adopting agriculture as their livelihood it can be a permanent solution for malnutrition existing in the country. Increased production of crops in the country can regulate the price of food ensuring the accessibility even to the poor.

The project aims to achieve very high accuracy in climate prediction by making use of weather sensor data available from thousands of sensors installed across the country and the satellite imagery of regions in various formats like the visible imagery, infrared imagery and water vapour imagery. The work will use a combination of both data applying deep learning algorithms to sense patterns and make predictions of rainfall, temperature and natural calamities which are the pivotal information in determining the outcome of any crop. With the help of this system the farmers can be informed about what to crop and when to crop to ensure maximum result The centre will aim at promoting agriculture in every state of the country by promising guaranteed results with accurate climate prediction.

Career-Guidance using Recommender Systems

A recommender system is designed which takes multiple parameters into account including academics of the child, family background, aptitude and skill set of the child, his/her interest, current employability status in the country and the changing employability trends for past years. The details from the child including academics, family background and his/her interest can be collected using forms and submitted to the server. The aptitude and skill set of the child can be evaluated by conducting online tests whose results are also added to the server. The tests will be designed by psychology and education experts which will precisely evaluate a child for identifying his/her aptitude. The employability trends and current status can be obtained from the employment exchanges across the country and other

sources. A combination of all this information will be used to build a profile for each child and based on the profile of the child and his/her peer profiles, interest registered and current employability status, best suited career paths will be recommended. The system is also capable of recommending skill sets required to pursue a particular career if the skill set is lacking. The system will also obtain feedbacks of its recommendations in the future for self-learning so as to improve its recommendations and user satisfaction.

The proposed system can prove to be a solution for unemployment in the country as upcoming generations get to follow careers of their interest which can help them to excel in their fields and thereby contributing to the progress of the country.

This system will guarantee employability for the younger generation in the country by enabling them to pursue a profession of their interest. A recommender system can be created which can identify the career suited for a child based on their interest and recommend the same.

Healthcare Support (Cloud Computing)

Cloud computing has recently emerged as a new paradigm for hosting and delivering services over the Internet. Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.

Any country needs enhanced health care system for economical, technological and social development. Development of health care system necessitates large no of manpower, especially when a patient needs continuous monitoring. Using Internet of Things (IoT) condition of a patient can be monitored and controlled remotely. Here present E-Health care system by using cloud computing and web services for remote monitoring and controlling. It provides automatic update of measured parameter of patient as well as it sends alert mail by using SMTP (Simple Mail Transfer Protocol).

We need shift from need based health monitoring to preventive health monitoring service. So this Cloud computing based Health care system helps users to maintain their health and prevents users from falling in disease. Different components of the system are communicating via web services. Web services helps user to maintain its health record remotely and access health parameters anywhere around the globe. Feedback and counseling is also provided with the usage of web service. All these web services are envisioned to host on the cloud service. The central database is also residing on the cloud service. Develop the system using the modern design patterns and complete object oriented concepts.

The proposed automated health care systems not only monitors basic health parameters of the subject but also provides a platform for the storage of health records, which on demand can be invoked by the subject or relevant physician via web service accessible around the globe that is hosted on cloud in real time.

The research group will facilitate an enhanced way to provide health monitoring and controlling and a platform for the storage of health records, which on demand can be invoked by the person or relevant physician via web service accessible around the globe that is hosted on cloud in real time.

Cloud computing can bring a paradigm shift to the health care world and also provide an improved patient care and reduce overall health care costs. It can help organizations share information stored across disparate information systems in real time and prescribe the necessary action in case of emergency.

Transportation Solutions using IoT

The Internet of things, as a trend of internet development in future, may revolutionize our daily life in that all the people, devices at work, home or other places can communicate with each other in real time as long as they are online. It integrates many modern techniques and introduces new services and opportunities to human beings. Cloud computing is another trend in IT industry which decreases computing, storage and other function from traditional desktop and portable PCs, all the functions can be realized in cloud computing platform. In

other words, end users only need some simple input-output devices to enjoy powerful processing ability and convenient service in computing platform.

Wireless sensor networks, consisting of a great many sensor nodes which has functional modules of sensing, data processing and communicating, progresses more and more mature in the wake of evolution of micro electro-mechanical systems (MEMS) technology, wireless communications, and digital electronics.

Data processing and storage are working on cloud computing platform. Local traffic administration divisions can release real-time traffic information on the cloud platform that can be accessed and supervised by authorized staffs. Traffic monitoring system utilizes wireless sensors to obtain real-time traffic information, such as traffic condition in each road, amount vehicles in the road, average speed of mobiles, unlawful act and so forth. After processing these data necessary information can be send to authorised persons using SMTP protocol or even by sending messages to mobile phones.

The development of cloud computing, internet-of- things and wireless sensor networks has opened a new horizon for solving the increasing transportation issue in cities and in highways. Implement a novel intelligent internet-of- vehicles administration system, for continuous monitoring and controlling of the road traffic and notify if any accident occurs to respected authority. Thereby reduce the after effects of the accidents.

With the development of internet-of- things, WSN, cloud computing and other techniques like machine learning, it is foreseen that future traffic management system will employ such low cost and high-efficiency techniques to provide the pubic with more convenient, fast.

Signal processing: Radar and mobile communication

Post processing of raw data from radar and mobile towers are always challenging due to noise. Filtering noise and retrieving original data in real time is the need of the hour for fast communication systems.

Non-destructive testing of materials

Civil and mechanical engineering structures require frequent testing for fracture analysis, which rely on non-destructive testing methods. Signal processing combined with microwaves can be effectively used for precise measurement.

Image processing for medical applications

Medical field relies largely on electronic equipment for diagnostic purposes. Processing of MRI or X-ray data without loss in information calls for high level image processing. Nowadays, all hospitals store test results of patients in digital form. Lossless transmission of imaging tests will require huge memory as well as bandwidth. Lossless compression is a necessity in this context.

Scientific Computing

Computational science (also scientific computing or scientific computation (SC)) is a rapidly growing multidisciplinary field that uses advanced computing capabilities to understand and solve complex problems. It is an area of science which spans many disciplines, but at its core it involves the development of models and simulations to understand natural systems.

Algorithms (numerical and non-numerical), mathematical and computational modelling and simulation developed to solve science (e.g., biological, physical, and social), engineering, and humanities problems , Computer and information science that develops and optimizes the advanced system hardware, software, networking, and data management components needed to solve computationally demanding problems, the computing infrastructure that supports both the science and engineering problem solving and the developmental computer and information science all comes under the purview of Scientific computing.

In practical use, it is typically the application of computer simulation and other forms of computation from numerical analysis and theoretical computer science to solve problems in various scientific disciplines. The field is different from theory and laboratory experiment which are the traditional forms of science and engineering. The scientific computing approach is to gain understanding, mainly through the analysis of mathematical models implemented on computers. Scientists and engineers develop computer programs, application software, that model systems being studied and run these programs with various sets of input parameters. The essence of computational science is the application of numerical algorithms and/or computational mathematics. In some cases, these models require massive amounts of calculations (usually floating-point) and are often executed on supercomputers or distributed computing platforms.

Recognizing that computational modelling , high performance computing and data science is a fundamental research area of the imminent future; the University seeks to set up a world class computational/data analysis facility to address emergent problems of national

and global importance in the field of science and engineering. This new effort will provide the same importance to computational science as experimental and theoretical in the scientific discovery by conducting fundamental and applied research. The work is envisaged to be carried under the **Centre for Interdisciplinary studies in Scientific Computing(CISC).**

1. Computational modelling and data science research group

The computational modelling and data science research group will focus on applications that are aligned with experimental expertise in and around University in the physical, chemical, biological, material and engineering sciences. It will also put special emphasis on the algorithm-development to process, analyze, and manage massive datasets, especially in Astrophysics, Gravitations, Cosmology, Nuclear and neutrino physics, Nuclear medicine, Nuclear energy, Socio-economic systems, Micro magnetic simulations, Density functional theory, Machine learning, Bioinformatics, Computational biology, Computational chemistry, Molecular dynamics simulations, Computational material science and Computational drug design to bridge many core areas in science. It will also conduct prime research on Mathematical modelling , Optimization techniques, Differential equations, Wavelet methods, Statistical inference, Stochastic processes, Design of experiments, Probability theory, Time series, Regression analysis, Spectral methods, Numerical techniques, Preconditioning and various approximation techniques.

The group will focus on solving complex physical, chemical, materials and biological problems through modelling and simulations. Some of the thrust areas of this research group include biomimetic catalysis for small molecule activation, transport properties of membrane proteins, ion channels as therapeutic targets, interaction of metals and small molecules with proteins, role of proteins in metal toxicity, designing of nano-medicines. Special focus will be given for developing visual data analysis tools that can be customize and used by the experimentalists and theoreticians, developing algorithms that are scalable and resource-efficient. Besides, it will provide high-performance computing (HPC) hardware and software solutions to campus wide research community and educational and research institutions in and around Kochi, Kerala state and rest of the country through sharing of resources.

Collaborating Departments: Applied Chemistry, Physics, Mathematics, Statistics, Environmental Science, Biotechnology, Computer Science, Computer Applications

2. High-throughput "in vitro" "drug discovery"

Revenue of the worldwide pharmaceutical market is more than One trillion USD in 2015 and India has no role in the present market. This reveals the importance of scientific intervention in the field and the drug discovery is intended to be with a focus on chemical compounds in Ayurvedic Medicine along with other biological computations. Studies have to be conducted with chemical compounds in our Ayurvedic Medicine along with drugs in the present Modern Medicine.

Biological computation is the most important part of Biotechnology and the development of biotechnology is going to influence even the daily life of common man in a higher dimension than the information technology. Therefore, we cannot ignore these fields of study. Our field of study includes cell organelles simulation study, Reaction pathway study, study of strength and durability study of biological materials (many biological materials have more strength than steel) etc.

In general a complex computation can be done using the present high power server class computer packed in single box. We can even purchase an eight processor motherboard with each processor having 32 cores and with a RAM up to 512GB/processor. This is sufficient for many of the applications but real Biological computations can be done only with HPC. Genetic information data (GENOME Data) size alone is heading towards Exa byte (million Tera-byte) mark. Even with HPC handling this huge data is not possible, however we can even take some relevant portion of this data for our study.

The following database has to be created and regularly updated

- Genome Database (Small portion of the existing database, Eg Microorganisms, Pathogens affecting human body, etc.)
- Protein Database
- Compound Database
- Reaction Database (All Chemical reactions are stored as Database)
- Drug Database (Database of all drugs approved by Agencies like Food and Drug Administration of USA.)
- X-Ray crystallography data of the proteins
- Path way Database (connecting links of chemical reactions)

- and many more

It would be beneficial for the scientific community if a Three-dimensional Drug and Compound Database is created. Available drug and compounds data in both Ayurvedic and modern medicine is highly primitive which has to be converted in to usable one. What is available, is the Chemical equations and simplified diagrams of compounds and drugs in computer readable format. This has to be converted into three-dimensional computer readable format. We don't need any molecular dynamics package for this, because the package using at present by the international community is now available in free and open format. Students and Researchers of all developed countries have their own on database. Unfortunately, we don't have such database facility. This is one of the main hurdle in the development of new drugs and the study and impact of existing drugs in various situations. Converting chemical equation to three-dimensional useful data can be done with a good personal computer. But converting the entire database can be done only with HPC. In most cases we need large collection of three-dimensional structural data of compounds.

Yet another challenging field is the Molecular level study. Once a new compound identified from Ayurvedic Medicine, many simulation studies have to be conducted to study the interactions with the functional protein in our body, how this molecular interacts with cell organelles etc. Simulation Study packages for many different types of molecular based study are also available in free and open format (eg GROMCS, AutoDock). But when we use large number of molecules we are helpless without HPC.

CUSAT will be focusing on in vitro study of therapeutic effect of compounds and many derived compounds found in our traditional Ayurvedic medicine using the enormous computational power of a HPC.

Building three-dimensional compound and drug database and make it available to the students studying in Indian Universities and Research Organizations.

There are large collection free and open source software developed and used by International Research community. But it is difficult to install these software for beginners we will provide an good environment for the researchers studying in India.

We will also utilize this environment for our research work such as Designing new drugs, Molecular level interactions of various important drugs and compounds with the parts of cell organelles. Identifying possible reactions using compounds, reactions and reaction path ways with in human cell. Simulation studies of human cell to understand the functions of cells organelles etc.

3. High Resolution Regional Climate Modelling & Man Power Training

Improved and reliable forecast of climate and climate projections requires intense computational capacity to carry out integrations of climate models with very high resolution and high complexities involving the coupled feedback processes between atmosphere-ocean-biosphere & cryosphere. Adequate computing facility is required for the Department of Atmospheric Sciences to carry out a variety of high resolution numerical experiments with climate models. Necessary R&D is required in this field which can be only achieved using HPC facilities.

CUSAT is already involved in the compute intensive R&D programs including the very high resolution regional climate projections over Peninsular Indian region for next 100 years which is proposed to be done with the available supercomputing facility available in our country. Research is also progressing to improve monsoon prediction capability in seasonal scale using coupled atmosphere-ocean general circulation models. Since there are lots of heterogeneity involved in the spatial and temporal distribution rainfall over Indian region, there is an urgent need to examine the seasonal climate change at regional levels. For example during 2016 monsoon season, when all India mean monsoon was by and large normal, Kerala state received nearly 30% deficit rainfall which leads to scarcity in the water availability starting from drinking to irrigation. Hence, climate needs to be attempted at regional level by using ultra high resolution regional climate models and mere statistical downscaling from coarse resolution global climate models has to be replaced by high resolution regional climate models

The entire range of these R&D activities of the CUSAT involves the simulations of multiple versions of the climate models in the ensemble framework across various scales

starting from a season to a a decadal range. These entire works require intense high performance computational facility of the order of a few Tflop/s to Pflop/s capability. The required architecture is MPI .

4. Four Dimensional Data Assimilation (4DVAR)

Numerical Weather Prediction being an initial value problem, is very sensitive to the prescribed initial conditions. Data assimilation is the technique by which an optimal initial condition is obtained to initialize a numerical weather model. Variational data assimilation schemes are among the most widely used assimilation scheme. Due to the inherent limitations like, the utilization of static background error covariances, in the three-dimensional variational (3DVar) scheme, the four dimensional variational assimilation method (4DVar) is expected to be a better candidate and perform better than 3DVar. The 4DVar scheme is known to be more complex and computationally expensive than the 3DVar method. While there are some studies which have utilized 3DVar techniques over the Indian region to investigate systems such as tropical cyclones, there are very few such studies that have utilized 4DVar techniques over the Indian region using high resolution mesoscale models.

The inherent importance of flow-dependent background error covariances for producing better analyses in a data assimilation system is well-known. Use of flow-dependent error covariances can be facilitated in a data assimilation system through the use of ensembles of model forecast which is the present state of the art method widely attempted world over.. Previous studies have established that assimilation of observations using ensemble based data assimilation systems like Ensemble Kalman Filter (EnKF) produces more robust analyses as compared with the more popular assimilation techniques like 3DVar. However, such studies are practically not seen in literature as far as simulating mesoscale weather features over the Indian domain is concerned.

Both the 4DVAR assimilation as well as ENKF assimilation do provide for improved and better forecasts as both of them take into account the flow-dependent nature of the background error covariances and avoid the so called 'errors of the day' which is seen in the

3DVAR assimilation simulation. Unlike 4DVAR, ENKF is simpler to implement. However both 4DVAR assimilation and ENKF assimilation require High Performance Computational (HPC) facility and demands computational capability of the order of a minimum few Terra flops (Tflop/s) if not penta flops(PFlop/s) capability machines and such studies which are extremely important over the Indian region cannot be undertaken unless a very good HPC facility is available. As the number of ensemble in the family increases ,the computational requirement also increases. With the proposed HPC the Department of Atmospheric Sciences together with the Department of Statisics of the Cochin University of Science & Technology can undertake such data assimilation studies and high resolution location specific weather forecast which is extremely important. Real time prediction of high impact/extreme weather events on a regional scale will also be attempted.

5. Three-dimensional Coupled Hydrodynamic-Ecosystem Model

A hydrodynamic numerical model of an estuary is a tool that can be used to understand the details of the estuarine circulation and mixing. A model that can simulate the observed salinity field, tidal water-level variations and currents, once set up, could be appended with ecosystem models to address several multi-disciplinary issues related to water quality, fisheries, ecology, environment, etc. of the Cochin backwater, which could not be investigated using any observational technique. Development of such a detailed model would require a high performance computing facility.

A hydrodynamic model based on an open source modelling package is available currently for the Mandovi and Zuari estuarine systems in Goa, central west coast of India (Vijith etal. 2016). This is the only other estuary in India where such a model exist. The development of the model is, however, computationally intensive. The Mandovi-Zuari model required 96 processors (8 nodes with 12 processors each) on a 133 Teraflop machine located at the CSIR-CMMACS in Bangalore. With this configuration the model took 180 hours for a year long simulation, which is the minimum requirement for addressing a reasonable research problem. A similar computational requirement is expected for the proposed Cochin backwater model.

The development of a three-dimensional coupled hydrodynamic-ecosystem model of the Cochin backwater system would make the Department of Physical Oceanography in CUSAT one of the leaders in the field of estuarine research in this country. It is expected that this modelling system could be then ported to other estuaries of India.

6. Advanced Sonar Signal Processing

Cochin University Centre for Ocean Electronics (CUCENTOL) in Department of Electronics is carrying out numerous projects and research activities in the area of ocean electronics especially in Sonar Signal Processing which includes Target Localization, Tracking & Recognition, Underwater Acoustic Imaging, Navigation, Communication and Maritime Surveillance. Most of these applications demand computationally intensive procedures and algorithms such as Hidden Markov Models, Bayesian Probabilistic Models, Deep Learning Neural Networks, Sparse Signal Processing etc., which cannot be handled or are not feasible to be implemented on traditional sequential computing systems.

One of the biggest challenges for today's sonar systems is to provide more capability range, number of targets, speed, etc. while meeting ever more stringent SWaP (Size, Weight and Power) constraints. The present proposal aims to device these systems using the computational power of CPU cores and accelerator cores to exploit the inherent parallelism associated with the mentioned algorithms. The massive parallelism and greatly increased computing power of GPUs offer the potential for realizing innovative new capabilities in underwater channel modelling and processing that were previously infeasible due to the limitations of having only a few processing cores to commit to the task.

7. Underwater Target Tracking, Localization and Classification

The complex acoustic environment of ocean characterized by a multitude of noise-like-signals and signallike-noises, results in a bewildering mix of signal and noise, which demands the need of specialized systems with sophisticated spatial filtering techniques such as array beamforming for extracting the signals of interest. Tracking and Localization also involve the use of beamforming techniques like Minimum Variance Distortionless Response

(MVDR) as well as Linear Constraint Minimum Variance (LCMV) with direction of arrival (DOA) estimation using methods like Multiple Signal Classification (MUSIC), Minimum Norm-Method (MNM) and Estimation of Signal Parameters by Rotational Invariance Techniques (ESPRIT), which demand increased levels of computational complexity. Concomitantly, autonomous arrays capable of performing most or all of the processing in situ are necessary for mission-critical applications. High gain acoustic sensors need to be deployed from many small platforms such as quiet boats for maritime surveillance in high clutter of the littoral undersea environment. This results in high-element-count sonar arrays with increasing data rates and associated signal processing.

A typical sonar beamformer with an array of 20 to 1000 hydrophone elements demands a computational requirement of 10,000 GFLOPS for matched field processing, in the case of a single look direction. When N look directions are needed at once, the computational requirement also gets increased by N times. In the case of adaptive beamforming using MVDR algorithm, the processing stages include Fast Fourier Transform (FFT) computation, Covariance Matrix Factorization as well as Weight Adaptation and Beamforming. If N denotes the number of sensors, F indicates the number of frequency bins and B is the number of beams per bin, FFT requires N such tasks with the complexity of each task being 8 log2F. Covariance Matrix Factorization needs F tasks having a complexity of 33N2 for each task and Weight Adaptation & Beamforming demands FB tasks with a complexity of 8(N2 + N) for each task. Such processing stages are ideal candidates for massive parallel computation. A common dual GPU machine will take approximately 20-25 days for training a 10 billion parameter neural network having a computational workload of the order of approximately 10 TFLOPS, in order to identify targets from a particular look direction. A high performance computing (HPC) facility with a cluster of multi-GPU platforms hosted by one or more CPUs capable of performing heterogeneous computing, harnessing the parallel computing power of the many-core GPUs, provides an ideal solution to this problem with minimal programming complexity.

8. Artificial Intelligence and Deep Learning

Artificial Intelligence is going to have a huge influence on the global economy and the University, as a nurturing place for the future economy deciders, can provide an ideally suitable environment for the AI to thrive, through its academics as well as research activities. Given that AI will impact the entire economy, the University could lay the entire foundation of making it available through education, academic and industrial research; transfer the levels of understanding and degrees of experience with building or using AI systems to the general public.

The imminent revolution in the field of AI and Deep Learning will have potential impact in every facet of our life, especially in the fields of Agriculture, Healthcare, Cyber Security & Communication, Transportation, Industrial Automation as well as Environment & Climate Studies.

Many of the academic courses and research areas in CUSAT, powered by AI, can significantly contribute to the revolution in the sectors of Biomedical Signal Processing, Genomic Signal Processing, Communication Systems, Embedded Systems, Robotics & Intelligent Machines and Ocean Acoustics & Bathymetric Studies.

Machine Learning has become a powerful tool and promises to grow well into the future. With this rapidly increasing scope of machine learning, the University, as a pillar of our country, has the responsibility to provide a platform, where the students get proper exposure for writing Deep Learning algorithms and developing effective AI solutions.

Not only should the University provide courses and promote research in AI as well as Deep Learning, it should provide sufficient facility to meet the heavy computational demands. If an AI system is going to be as intelligent as the brain, it'll need to equal the brain's raw computing capacity. So the establishment of a Research Facility for Artificial Intelligence and Deep Learning in the University assumes a significant importance.

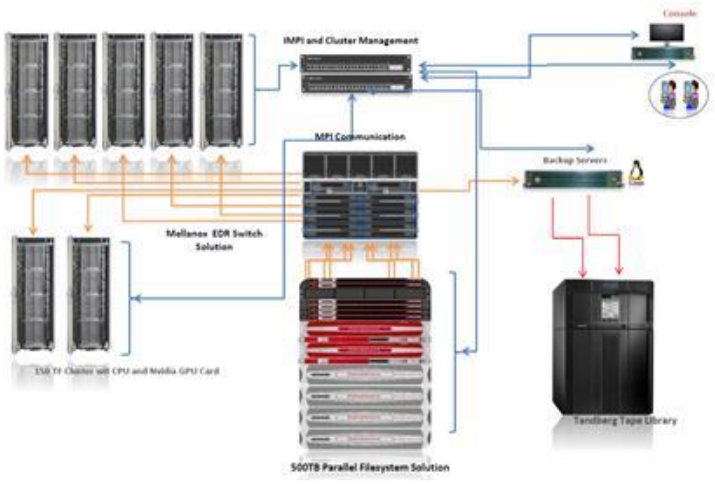
This Research Facility aims to bridge the gap between the lab and the market while nurturing a research and innovation ecosystem unbounded by national borders and corporate firewalls. The proposed facility is intended to create a major transformation in the education sector, aiming to train students suitable for the AI sector, where a lot of job opportunities are about to happen in the next few decades.

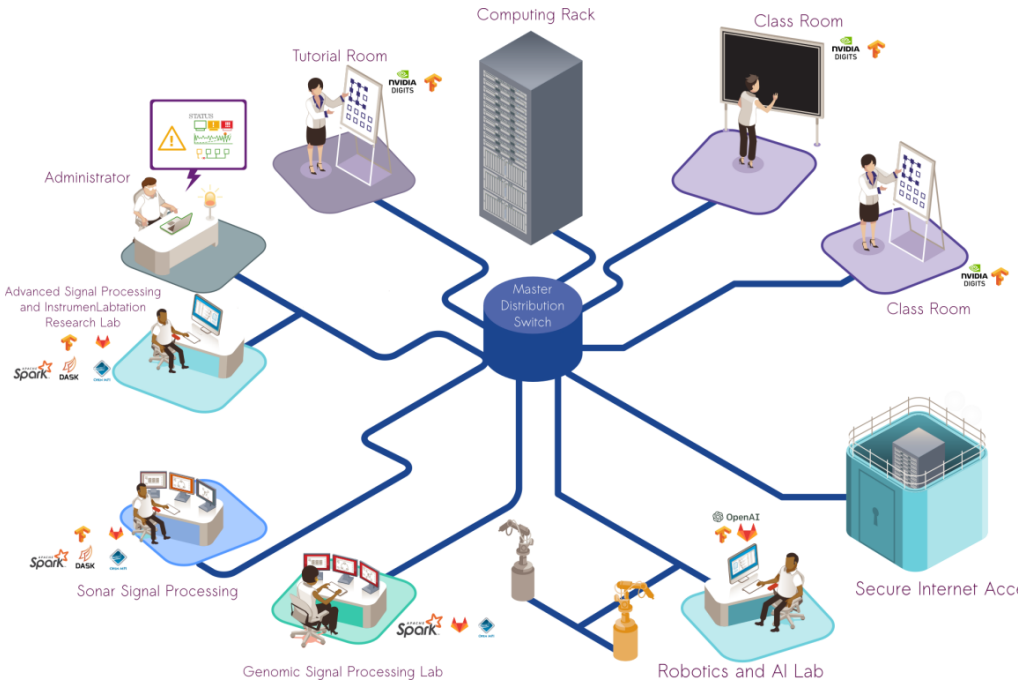
The main objectives of this facility are not limited to the following,

- To create necessary facilities to undertake strong advanced level Research & Development Activities in AI Assisted Technologies which have direct relevance to the present national context
- Start new courses relevant in AI and Deep Learning domain
- Industry-University Collaboration in this field to Promote Technology Transfer
- Implement Exchange Programmes with Foreign Universities
- Facilitate Student Internships in Leading AI Firms
- To strengthen R&D efforts by Enhancing the Talent Resources in Machine Learning Technologies
- To identify and develop systems for the societal benefits enabled by AI and ML
- To offer teaching, training/manpower development programmes in this highly specialized area of technology
- To undertake technical leadership, product development and consultancy programmes in the area
- To collaborative with user agencies for effectively utilizing the available infrastructure

The core facility for the age of AI based systems is essentially the computing power requirements, the model that uses massively parallel graphics processors to accelerate learning and inference. Scientists and researchers in the areas of interest under the facility includes Communication, Microwave Engineering, Antennas, Computational Electromagnetics, Genomic Signal Processing, Robotics & Artificial Intelligence, Underwater Acoustics, Communication & Navigation, Microwave Systems etc. needs High Performance Computing as the core Facility for conducting their research efficiently

alongside with domain specific tools. Schematic of the proposed facility and the concept Plan for Distribution of Computing Infrastructure is shown below.





In addition, high performance computing is the need of the day. In future, lot of demand will arise in India in the field of high performance parallel computing particularly in the weather and climate modelling. For meeting this goal, hands on training needs to be

conducted with HPC. CUSAT therefore proposes to establish a Centre for Scientific Computing to conduct the above research projects as well as for skilled man power development in HPC. By establishing the HPC facility development of programs, algorithms and product design for chemical, biological and material science can be achieved. Eventually, CUSAT thrive to develop a world-leading research group through active collaboration with National and International Academia and Industry, which will also facilitate knowledge and technology transfer.

Marine Science Research

The oceans are part of the thin, outer shell of the Earth and marine science is the study of this envelope, from the deep sea to shallow coastal oceans: their biology, chemistry, geology and physics together make marine science a richly inter-disciplinary science. The oceans are dynamic and vast, they contain most of the Earth's water and carbon and surface heat, and much of its biomass, but they do not operate alone. In conjunction with the atmosphere, continents etc they form a working machine, driven mostly by energy derived from the sun and the Earth's interior.

Marine Scientists focus their work on both practical or applied problems and basic scientific questions. The oceans as we know provide both bounty and peril. They provide a wealth of food, a vast water supply reservoir and are the source of most of the heat and carbon used in our climate system. They are the source of ½ the oxygen our biosphere needs. They also spawn large storms and hurricanes, and transmit energy over great distances as tsunamis, all of which endanger coastal populations, which are a significant fraction of the Earth's total population.

Today's oceans are under great stress. Pressures from a growing human population are increasing, with fishing, shipping and recreation crowding into regions of abundant shell-fish and other active fisheries. Global climate change is being felt at all scales, from the coastal oceans to major ocean basins. These changes are causing a variety of phenomena, including increases in the bleaching of corals, increases in the frequency and extents of poisonous algal blooms , increases in ocean water oxygen depletion,changes in oceanic acidity and depletion of marine resources, among many others.

The importance of the oceans to physical climate, food supplies and biological stability are being more widely recognized and appreciated nowadays. Kerala being primarily a coastal state, research of the marine life would definitely be interesting and worthwhile.

Some of the major areas which have attracted the attention of the researchers in the faculty of departments of CUSAT are Biological impacts of climate change ,drug discovery from marine organisms, the cost effective culture and mass production of biofuels from algal blooms etc. The establishment of a Research group for Ocean Biogeochemistry and Ecosystems (OBE) is a vision formed in the concept of incorporating the research under multidisciplinary fields like physics, chemistry and biology using leading modelling and instrumentation techniques to understand ocean biogeochemistry and biodiversity.

Food Safety is yet another emerging area in which safe food production, handling, processing, marketing and consumption requires utmost care and advanced technologies. The aim being food security, through production and management of nutritious food for the growing population around the world. A Research group in Food Safety & Food Security is proposed with this in mind. An overview of the proposed research areas in marine sciences is intended to be integrated into a single umbrella under the **Centre for Interdisciplinary Studies in Marine Science (CIMS).**

1. Marine Biology, Microbiology and Biochemistry

The vision of the Department of Marine Biology, Microbiology and Biochemistry is to 'Know the biology of the ocean and its interconnections with the abiotic environment'. In order to realize the vision the department is engaged in its mission which is as follows:

'Dedicated to research and education to advance understanding of the biology of the ocean and to disseminate the understanding for the benefit of society and environment'.

Department of Marine Biology, Microbiology and Biochemistry is a research intensive department with nearly 80 full time Ph.D. research scholars and several part-time research scholars. Current thrust areas of research in the Department of Marine Biology, Microbiology and Biochemistry are as follows:

- Marine biodiversity
- Harmful Algal Blooms
- Aquaculture nutrition
- Microbial oceanography
- Fish/ Shellfish pathology
- Marine Biotechnology

- Fishery biology and Aquaculture
- Marine Ecotoxicology
- Wetland biology
- Polar biology

It is envisaged in the research plan to involve all members of the department of marine biology community are engaged in creating new knowledge. It is strongly felt that advantage of being part of a highly interdisciplinary school of marine sciences is not optimally exploited. In the future research initiative, it is desired to optimize this potential by engaging in research that is highly interdisciplinary.

As of now the department has developed considerable strength in basic research and to some extent in applied aspects. Two major areas have been identified where the research could be focused.

Basic Research Areas: Marine biodiversity and its interconnections with the abiotic environment, especially in the context of changing climate and increasing human intervention in the marine environment. Biodiversity being a gift of nature, it is of paramount importance to safeguard this valuable asset for the humankind. The key areas where CUSAT would like to focus are as follows:

Mapping of the benthic fauna :along the coast of Kerala with the help of underwater photography and remotely operated robots.

Plankton ecology and food web dynamics: Between important players in the marine ecosystem as the community dynamics in the marine environment are changing abruptly due to factors that are climate-driven and unsustainable fishing practices.

Molecular bar coding of the benthic fauna: To be done along the Kerala coast as they are the signature organisms indigenous to this environment.

Ballast water-mediated invasion of new species: Study of such an invasion into our territorial waters is very important as sea commerce along the coastal belt of India is increasing rapidly and projected to rise further with the commissioning of new harbours coming across the coastal cities of India. This information could be used in policy formulations to curb ballast water-mediated invasion of new species

***Biological impacts of climate change*:** Climate change results in weather extremes and resultant impacts on organisms. Though the changes could at times be beneficial, the negative impacts on commercially important fish stocks are considerable and need to be explored in detail

***Marine Microbiology*:** The habitability of earth is a function of microorganisms, especially marine microorganisms as they drive key reactions in biogeochemical cycles and strike mutually beneficial interactions with host. However, their role as pathogens and potential spread under a warmer climate need focused research. They also act as huge reservoir of potentially dangerous antibiotic resistance genes (ARG's). Kinetics and spread of antibiotic resistance genes in an aquatic medium is an emerging area of research and demands higher end research.

Applied Research Areas

Research on the above basic science aspects could yield lot of spin-offs that could be utilized in the applied research. We have already made some progress on this; however, the upside is quite significant. The following are the areas where the department would like to focus in the coming years: -

Drug discovery from marine organisms:

Marine organisms, both micro and macro, are considered as treasure houses for the discovery of new drugs as the rigours of marine environment might trigger the organisms to produce unique molecules that could have potential use in human therapy. The vast marine environment still remains largely under explored and harbours wide range of organisms that could be screened for novel drugs. This is all the more important as emerging and remerging infections caused by multidrug resistant pathogens challenge our capabilities to successfully treat such infections. The drugs envisaged include antibacterial, antifungal, antiprotozoan, antiviral and anticancer agents. Currently the department has some leads in some of these compounds, however, would require highly interdisciplinary and higher end research to further develop and commercialize these compounds for human use. Cross-disciplinary

research with chemical sciences and clinical sciences is extremely important to realize this potential

Phytoplankton biology and algal fuels

Being the primary producer in the ocean, phytoplankton drives the energy transfer in the ocean. Many of them also contain potentially high lipid content, the cost effective culture and mass production of them could be used for biofuels. Mass culturing of algae in one hand could act as carbon sequestering mechanism, while on the other hand it could yield clean energy offsetting the negatives of fossil fuel burning.

Marine Chemical Biology and Biotechnology:

Marine organisms in general and microorganisms in particular yield many bioactive molecules and enzymes with potential use in the industry. While many of the marine microbial enzymes are already available and in use, the potential for new ones are very high. This again an area of intense cross-disciplinary research for which efforts should be made to strike collaborations with potential departments within and outside the university.

2. Food Safety & Food Security

Food Safety

Safe food for growing human population is the need of the hour. Poisoning and illness due to the consumption of polluted water/contaminated foods with natural or artificial agents are increasing day by day. Advanced research on contaminants & pathogens in food and water, quality of aquatic food products, different measures for ensuring safe food, preventive strategies etc. need to be focused on to mitigate the growing concerns in this area. The school proposes to undertake cutting-edge research on these lines to safeguard the food we eat.

Sustainable Fish Production and Food security

Fish is considered as one of the most nutritious food items on the earth. Sustainable production and utilisation of the aquatic resources both from capture and culture fisheries

need to be addressed to meet the objective of fish for all. Advanced research in this area is required, and the school proposes to research fish germplasm, production of disease resistant-high yielding aquaculture varieties and sustainable exploitation of natural aquatic resources and minimisation of food loss.

Fish waste valorization

Waste management through complete waste utilisation is one the emerging areas in science and technology. Fish processing industries produce a huge quantity of waste materials every year. Extracting innovative byproducts, application of biomolecules from the waste in different areas, full utilization of fish, food waste for value added or value yielding products through continuous cutting-edge research are some of the areas we plan to focus on.

Climate Change Adaptability

Harvesting of natural aquatic resources is affected by natural calamities and climate change variations. The fish availability, fluctuations in landings & prizes and reducing fishing days etc are the major issues in these lines. The economic and social impact of these changes on the fishermen and their livelihood is to be studied for devising strategies and approaches for the development of the marginalised sector and the development of the country.

Food Safety is an emerging area in which safe food production, handling, processing, marketing and consumption requires utmost care and advanced technologies. Food security through production and management of nutritious food for the growing population around the world.

The proposed objectives of the centre are as follows:-

- To study the quality of various foods prepared and marketed in different channels of food production.
- To develop test kits and testing procedures for contaminants and pathogens responsible for food poisoning
- To develop and implement food safety awareness among general public and act as a nodal centre for food safety testing and training.

- To study the food loss and food loss prevention strategies.
- To develop innovative measures for increasing fish production through sustainable aquaculture.

Following are the Research collaborations in this area

1. Ongoing Collaboration in transdisciplinary research on climate change adaptations with BELMONT Forum-UVSQ, France; UBO Bay of Bres; NEFU Russia; UAA, USA; UdeM Canada and UCAD Senegal.
2. Ongoing Collaborations with PLYMOUTH University, the UK in Science communication
3. Ongoing Collaboration with LINI LATC (NGO in fisheries) Indonesia
4. Collaboration with SALENTO University, Italy (PASSA)
5. Collaboration with Wageningen University, The Netherlands.

3. Coastal and Estuarine Research

The coastal and estuarine ecosystem in India is under threat due to the abuses arising from high population density, which include dumping of industrial and household pollutants and runoff of excess fertilisers. Both lead to issues of water quality. Another threat to Indian estuaries arises from Climate Change. It is necessary to study their dynamics and ecological/biogeochemical cycles due to the growing industrialisation and urban growth. What we propose here is the setting up of a trans-disciplinary centre comprising of all branches of marine sciences (physical, biological, chemical, geological) and fisheries with the following major objectives. The first objective is to monitor the hydrodynamic, water quality and ecosystem parameters of major coastal and estuarine ecosystems. The second objective is to create an atlas of ecosystems whose health is under severe threat. The third objective will be to develop models of hydrodynamic, ecosystem and biogeochemical cycles for the ecosystems that need immediate attention due to deteriorating health. The fourth objective of the centre will be to suggest strategies based on observational and modelling experiments for the restoration of ecosystems under severe health crisis. The final objective is to set up a coastal and estuarine forecast system.

Targeted Academic programs:

This centre will supply field and model data for PhD research. Furthermore, give training to students in the proposed five-year integrated MS in Marine Science and existing MSc programs.

International Collaboration:

The centre will have research collaborations with leading scientists and professors in the field of coastal and estuarine research. Royal Belgian Institute of Natural Sciences is an existing collaborator.

National collaborators:

The proposed national level collaborators are CSIR-National Institute of Oceanography, Goa and Indian National Centre for Ocean Information Services.

Regional collaborator:

It is proposed that the centre will have regional collaborations with Cochin port authorities.

Income generation after 15 years:

The research group will have to generate its funding by obtaining consultancy projects from industries located around the coastal and estuaries. Coastal and estuarine research has been identified as a thrust area of research for the next 20 years by Ministry of Earth Science (MoES). Project funds may also be obtained from agencies such as MoES.

4. Ocean Biogeochemistry and Ecosystems (OBE) Research

OBE is a multidisciplinary area, studying ocean physics, chemistry and biology using leading modelling and instrumentation techniques to understand ocean biogeochemistry and biodiversity. Yet another focus area could be **Biological carbon pump (BCP)**.It is the biological mechanism by which carbon is stored in the ocean's

interior. It is several times larger than the annual accumulation of CO_2 in the atmosphere, and without it, atmospheric CO_2 would be significantly higher than it is today. Basic information regarding its structure, stability and functioning is needed to assist in predicting future atmosphere-ocean CO_2 partitioning.

5. Marine Natural Products Research

The UNESCO has projected that in the 21st century people will have to depend on the marine system for the sustenance of the human life on earth. Based on this revelation a greater importance was given to the studies on this system since 1990s. The Marine resources include a wide spectrum of compounds starting from the simplest and the most important, from common salt to life saving drugs, from food to poison,from sand to valuable minerals, etc. OECD definition of biotechnology is "The application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services".

The oceans can play a major role in improving human health, as it holds a wealth of natural products. Natural products have been the single most productive source for the development of drugs. Unlike the long-standing historical medical uses of terrestrial plants, marine organisms have a shorter history of utilization in the treatment and/or prevention of human disease. Lack of natural defences in marine invertebrates is cause of secondary metabolites produced by them which play a role in defence and adaptation to the extreme environmental challenges. Marine organisms remain a prolific source of promising chemo therapeutics or chemo preventive agents. Many pharmaceutical companies have initiated the development of therapeutic compounds of marine origin. Marine environment in general and coral reefs in particular possess huge biodiversity, which is greater than terrestrial rain forests. A recent census of marine life from over 80 nations has revealed the presence of 6000 potentially novel species of organisms (Schumacher et al., 2011). Marine environment thus represents an important source of unknown natural compounds whose medicinal potential to be evaluated. Only 22,000 natural products could be isolated from the marine origin, where as the terrestrial natural products are about 131000 in number. Ocean thus remains unexplored when compared to its potential.

The **Department and the Inter-University Centre for Development of Marine Biotechnology (IUCDMB)** is currently engaged in the field of marine natural products research. The research programme is mainly concentrated on extraction and isolation of bioactive metabolites from various marine organisms like sponges, alcyonarians, actinomycetes algae, micromanage etc potential in biological activities. The outcome of the present research has been credited to a good number of publications and award of Ph.Ds. and M.Phil. Degrees.

The Research Areas:

The furtherance of research work in this area includes:

- Isolation of novel marine compounds with promising therapeutic potential
- Identification of the pharmacological applications of the compounds isolated
- More compounds to the ever appending glossary of biologically active compounds.
- Database of the compounds in the organisms present in selected study areas.
- Discovering new types of composite materials, biopolymers and enzymes for industrial use
- Synthesis of possible chemical analogues of the compounds isolated
- Human resource development in the utilization of marine resources
- Economic, cost effective research.
- Impetus in the future studies on chemical taxonomy of the organisms and the chemical ecology of the study area.

6. Aquatic Analysis and Monitoring (Environmental Forensics)

Rapid development, observed in almost every field of human activity, contributes to the degradation of environment and creates ecological hazards of global scale. Modern societies release into the environment – either during production, storage, transportation, usage or ultimate disposal – much waste, including chemical products. These materials participate in natural cycles and reactions and frequently interfere with or disturb natural systems. One may ask, what role analytical chemistry plays in this context. Analytical chemistry or, in more modern and broader approach, environmental analytics, including monitoring, focuses on determination of all possible pollutants not only in such environment

components as air, waters or soils, but also in vegetation, animal and human materials (tissues or whole organisms). Monitoring is dedicated to identification, localization and assessment of ecological risks, principally using automated and autonomous instruments or their modules. Taking into account such definition, analytical chemistry plays significant role in nowadays world and occupies a special place among all the sciences in the field of environmental protection. In almost every case, analytical chemistry provides rapid and robust systems and analytical tools for the characterization of pollutants and assessment of related eco-toxicological risks.

Thus, environmental-forensics is a combination of analytical and environmental sciences, which can be usefully applied within a legal context via "field analytical studies and both data interpretation and modelling connected with the attribution of pollution events to their causes". Environmental forensics provides a common platform for scientific investigations that explore source, fate, transport and ecological effects of environmental contamination, with contamination being delineated in terms of chemical characterization, biological influence, responsible parties and legal consequences.

Thematic focus and planned growth of the centre complies with traditional fields of interests in the Department. The Department of Chemical Oceanography is devoted to both basic and applied research in a broad range of topics with a focus on micro- and macro-Analytical aspects of Aquatic Systems. Current research interest may be described as follows:

- Development of new analytical methods and procedures for trace analysis, in particular, for environmental analysis and monitoring,
- Measurements of chemical pollutants in different environmental components
- Designing, construction and testing new modules and complete automated analytical instruments, including elements of biomonitoring into current research programme of the centre.

Besides its scientific focus, the group will also promote and carries out educational activities. The centre systematically organizes trainings, courses, and seminars for all interested institutions: educational (at all levels), industrial, and governmental (including local government).

Our initiatives are ambitious and challenging for all members of the centre. The prize we are fighting for, is establishing a leading scientific unit in India in the field of Aquatic Analysis and Monitoring, especially devoted to water pollution and air-to-water/water-to-air transfer of pollutants. CEAAM is principally dedicated to proper procedures of collection of environmental samples, their pretreatment, storage and preparation (analytes pre-concentration, isolation, etc.) for analyses by using all modern techniques.

The Department has credentials of rich experience and expertise in trace chemical analyses and has already initiated steps in this direction. An Analytical Services and Training Unit (ASETT) have been set up as an extension activity of the Department to cater to the needs of researchers/industries/individual entrepreneurs etc. As an endorsement of its analytical skills and proficiency, the Department was accorded recognition as an "Environmental Laboratory", under the provisions of the Environment (Protection) Act, 1986 (Government of India). For the last decades, the Department was actively engaged in the promotion of the unit and has the acceptance among researchers/industries/individual entrepreneurs etc. Our customers include Local Self Governments, Industries like HOC, HIL and TCC, Researchers from National Institutes and Cochin Port Trust.

7. Climate, Ecology and Climate Science

Tremendous baseline information on primary characteristics of varied marine ecosystems has been generated for the period. However, a renewed thrust has evolved in our actions, since the beginning of this decade, due to the paradigm shift in our approach to tackle various issues associated atmospheric abundance of greenhouse gases and aerosols, in solar radiation and in land surface properties alter the energy balance of the climate system, species variabilities and loss, increasing pollution and anthropogenic issues and other factors. Of late, monitoring, modelling and proposing management plans on ecosystem changes, extending from coastal estuaries, lagoons, mangroves, oceans to the arctic regions has widened the perspectives of our research priorities. The basic infrastructural facilities developed since this decade were, mathematical modelling, basic microscopes, with imaging systems for community evaluation and other applications, Green House Gas analytics for elemental & carbon analysis, ecology molecular and bioanalysis lab for genetic mapping,

ecotoxicology lab, continuous flow through system for trophic level monitoring and biomarker studies, algal, zooplankton and mangrove culture facilities and marine biology wet lab for water and soil and benthic analysis.

Establishment of a monitoring group for ecological processes and status on a long term basis is crucial in developing suitable benchmark for sustainable utilization and management guidelines. Holistic approach towards ecological concepts all-encompassing various ecological realms is necessary for understanding the "Ecological footprints" or the measure of bio capacity of the system, a resource management tool. Establishment of a research centre wholly dedicated to the study of ecology, developing theories, evolutionary concepts, metacommunity studies, interlinking of behaviour, morphology and physiology of individuals and species with their environment is of utmost importance.

The ecological division of the CUSAT is now emerging with multidimensional researches which encompass wide range of species specific and process oriented analysis of varied marine ecosystems. Research works carried out by the division includes wet lands to open oceans. Polar biology has also been taken up as a major research area. All these contributions can form the framework for proposing a centre for excellence in ecology conjointly with climate sciences. In a long term vision this could cater towards the infrastructure facility for the research activities in ecology and climate change related researches in the southern part of India which is now lacking.

Humanities and Social Sciences Research

Some of the major areas which have attracted the attention of the researchers in the faculty of departments of CUSAT is cutting-edge ideas in the field of Languages,Social Sciences as well as Law. The establishment of a **Centre for Interdisciplinary studies in Humanities and Social Sciences (CIHSS)** is a vision formed in the concept of incorporating the research under multidisciplinary fields like IPR, Law, Management and Languages under one umbrella.

1. Performing Arts and Folk Literature Research

The idea, the word, 'folk' has wide range of understanding and connotations – ranging from 'natural' to 'native' to 'traditional' to 'rural' and in some cases 'from the heart.' The 'outpourings from the heart' of native or traditional people later takes the form of folklore. All folklores are oral traditions, the lore, traditional knowledge and beliefs of cultures often having no written language and they are transmitted, generally, by word of mouth. Like the written literature they contain both prose and verse narratives in addition to myths, dramas, rituals etc. All the cultures have their own folklores. In contrast and traditionally, literature is understood to mean any written work.

During the past two decades, folklore studies in India are moving in the direction of analysis. Folklore has gained respectability as a discipline on the university campus. Many institutions are busy with collection and analysis of folklore materials. Interdisciplinary approach to folklore studies is becoming a reality. Seminars, summer schools and workshops are becoming more frequent. The national and regional associations of folklore scholars seem to be more active now. All these are indicators of healthy growth of folklore studies as a discipline and the importance it has received in the country.

India due to its clustered diversity, is blessed with excellent opportunities for studies in folklore literature. Using a study or research group which concentrates on the origin of folklore literature among the regional languages following an oral tradition, we can trace back the unity amount the boiling pot of intermingled traditions in our country. The scholar

Munshi, once wrote “Throughout the history of India the process of integration comprises two simultaneous movements: one owes its origin to Aryan culture and operates by virtue of the momentum which the values of that culture possess; the other works itself upward from the way of life of the Early Dravidians and other non-Aryan cultures in the country into the framework of Aryan cultures, modifying its form and content, though not the fundamentals, weaving into a harmonious pattern continuously. The first movement provides vitality and synthesis, the second contributes vigour and variety. But it is the harmonious adjustment of both that gives to India, age after age, her strength, tenacity and sense of mission". Mandelbaum writes “Those scholars who ventured serious research on Indian culture in the beginning of the present century seem to have failed to capture this essence of harmonious pattern and therefore suffered from the lack of "general frame of understanding of the actual regularities in Indian civilization and society”.

Anthropological work on the Indian sub-continent such as origin and evolution of oral traditions, particularly the rich and fascinating folk narratives, unfortunately remained untouched to a large extent; despite the numerous research prerogative established throughout the various curriculum established in the varsities. Most of the data that were freshly sourced were not collected or subjected to the rigorous analytic tools that anthropologists had developed over the years.

While studies on Indian caste system, social structure, kinship, village organization, the struggle for independence etc., received quite a lot of attention from both the Western as well as the Indian scholars which resulted in the creation of excellent curriculum for schools as well as colleges; oral traditions and folklore where unable to capture mainstream attention to a large extent. Scholars generally seem to have failed to understand that a systematic study of oral traditions would contribute immensely to the understanding of the century old traditions imbibed in our moral as well as social, which we all seek to desperately comprehend. However, in the recent years, scholars have realized their past mistakes. The need for study of oral traditions so as to understand the realities of Indian culture in a holistic manner are felt by both Western as well as Indian scholars.

Some scholars have made some modest attempts to trace the growth of folklore studies in India. However, all such basic studies, academically highly useful and informative, lack coherence and can distort the very picture they claim to draw. Moreover, these studies, because of the vastness of the area they try to enquire into, and also because of the lack of a sound theoretical approach, seem to fail utterly in joining the missing links and establishing regularities.

Of equal importance are the contributions of British civil servants of the same period in the collection and study of Indian folklore materials meant "primarily to aid in the colonial administration". Despite the fact that a good number of British civil servants had been actively collecting the folk materials, very few had ventured into the uncomfortable and often hostile tribal areas, particularly in the north-east and central provinces. Verrier Elwin's works on the tribes of North-East Frontier Agency (now consisting of the State of Arunachal Pradesh, etc.) did not only bring into light the hitherto undiscovered treasures of tribal folklore, but also attracted the attention of British Policy makers towards the welfare of these neglected people.

The Cochin University of Science and Technology plans to use the resources at the Department of Hindi to dive into this promising area of research, so that a knowledge base can be created. Such a discovery of the folk arts can lead to better understanding of our diverse culture. They may even provide a gateway into better integration of our society. Some of the ways in which the research can be subdivided are as follows:-

Special study on Kerala folk forms and literature

India, as is well known, occupies a special place in the history of world folklore. The marvellous Indic tale has contributed in shaping the theoretical growth of folkloristic itself. For instance, Max Muller's works on Indian myths and Theodore Benfey's translation of the famous ***Panchatantra*** gave rise to the theory of Indian origin of the fairy tale. Whether these and similar theories were sustained later or not is not the issue here. The issue is that the richness and variety of Indian folktales has the potential of inspiring such theories. This also reminds us of the importance of oral traditions that still flourish on this sub-continent.

Folklore studies in modern India began with the coming of the British. All kinds of cultural studies including Sanskritic and ethnographic accounts formed then an important part of a discipline known as Indology. However, folklore, more especially the written materials, did form a part of these studies. Such being the affiliations, it is no wonder to find folklore materials treated in volumes which strictly speaking belonged to history or Sanskrit literature.

Kerala folk literature and forms can provide tremendous insight into the formation of our Culture. Like the rest of the country Kerala too is a treasure trove cultural diversity. We can utilise the locally available resources like the history of Jew settlements in the Cochin area, The history of integration of the Christian Community in the Travancore Cochin Coastal Belt area, the various scattered histories of temples, churches and many other historical aspects which can provide us the clue towards the formation of or rather the beginning of the cradle of civilisation. The collection of such data such data certainly must not be limited to the erstwhile kingdoms and royal families. The research plan will certainly include all aspects of society may it be the working class or the royal lords. Each aspect of our history, determined the way in which we look at the world. Most of the Kerala folk literature is scattered in its presentation. A through research into integrating the whole raw data and forming a consolidated final picture can certainly provide the basis for a new outlook into the history of Kerala as well as our country.

In the first stage the study of Kerala folk forms and literature in detail can be done. Second the whole literature can be translated to Hindi as well as other regional languages. Thus, the Indian society can understand the impact of the literary culture of Kerala on the Indian culture as a whole. In the third stage documentation and digitalization of Kerala folk forms and literature can be done. By which the research group would become an excellence research group for the study of Kerala folk literature.

Eco-consciousness and literature

Eco-consciousness is an inevitable part of present world. Because of many reasons the nature not only in India but all over the world is polluted. So a new genre developed in the field

of philosophy and literature i.e, Eco-consciousness. First phase we can study in detail the theory of Eco-criticism. Second phase Eco-criticism and Hindi literature can be taken into account. During the third phase Eco-consciousness and world literature in general can be done.

Subaltern literature in India

Subaltern literature is the literature of the marginalized. India is a caste oriented country in which people are divided and marginalized according to their caste. Women is also marginalized. So the literature of marginalized denotes the voice of marginalized. In the first phase we can study what is subaltern and also the socio-cultural and economic situations prevailed in India and reformation of the oppressed and the literature of the marginalized. Second phase is an in-depth study of the literature of the marginalized can be done. Third phase is the study of the Indian subaltern and their literature.

Hindi Language and Information Technology

Hindi is being forwarded to world language, especially in the field of business. So the form and impact of Hindi language is being changed. In the first phase we can study the Hindi language and its changes. Business Hindi is entirely different from the origin one. In the second phase we can study the changed form of Hindi language and its development as a web language. In the third phase we can study the global form of Hindi language and its role in the field of information technology and world market.

Comparative Literature

Hindi is becoming a world language. So the impact of world language and literature will be quite natural. More over that will provide vast outlook and new sensibilities to Hindi literature. In the first stage we can study the theory of comparative literature and also comparative study of Hindi and Malayalam literature can be done. In the second phase Indian literature can be studied in the comparative way and in the last five years a comparative literature study can be done in the world level. The research group can be developed into a research group of excellence for comparative studies.

2. Performance Studies

India is a boiling pot of intermingled and versatile forms of performing arts. Kerala has a rich tradition of performing arts since ages; most of the ancient art forms are said to have had their origin and development here. Besides, it has acquired a rich educational legacy, and its 100% literacy rate could be the cause for the development and preservation of ancient art forms irrespective of globalisation or the influence of westernization. There are classical, martial art and dance drama forms.

The southern state of Kerala can claim an ancient theatrical heritage, even though the dramatic literature in Malayalam (the language spoken there) is of recent origin. Its oldest extant genre, Kutiyattam1, was fully established by the ninth century and it may well represent the longest-surviving continuous theatrical tradition in the world. It is a system of staging classical Sanskrit plays, but not entirely Sanskrit theatre in the strict sense because the enactment contains elaborate oral elucidation in Malayalam. Still, it was Kerala's first performing art based on written texts, and evidently served as a basic model of creative expression for all later forms in Malayalam. Yet it also differs significantly from them in being conventionally presented on raised stages within auditoriums known as kuttampalam, which used to be built within the premises of the major temples in Central Kerala.

As it is well known, no other state has pioneered and preserved the traditional forms than Kerala; as it has been practicing classical art forms despite the globalization. Though it is paradoxical, Kerala has retained its status quo of classical art forms. The contribution of art forms is noteworthy in the context of evolution of performing arts; as the foundation was so strong that they could entertain and amuse the audience since ages. The contribution of folk arts to theatre art form is integral in the evolution of the many later art forms. Hence, without studying and understanding the folk art forms, it would be difficult to analyse the theatre art form objectively. Especially, some of the art forms like kodiyattam and kalariya pattu have influenced the theatre art form in a commendable way, as they have become the part of training the actors even today.

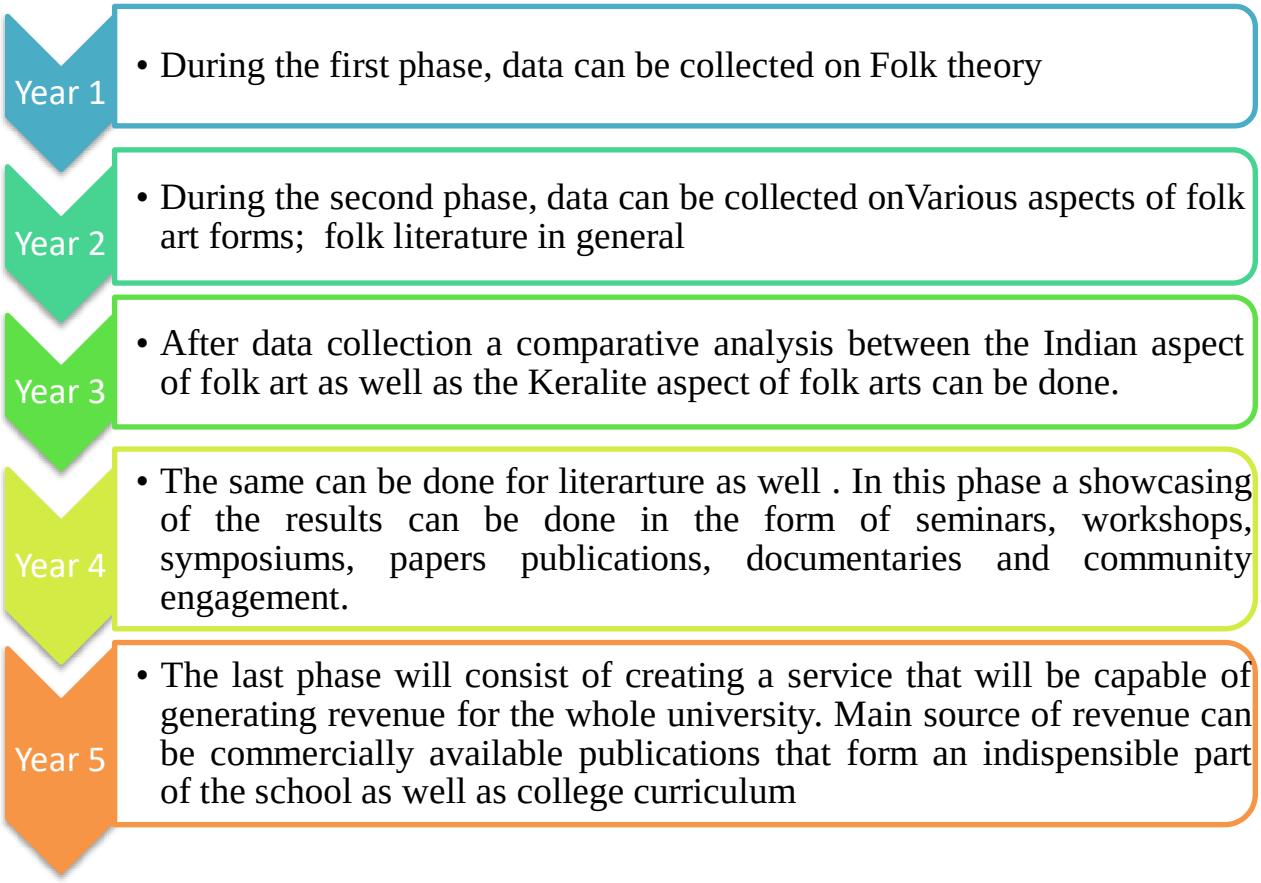
Even though some of the art forms are flourishing like never before viz. Kathakali, Kalaripayattu etc., due to the interest shown by the western world in preserving these art forms, some other art forms which are practiced only in certain echelons of the society like the Sopana sangeetham and edakka based kottu vadyam, they should be considered as dying art forms. Also, many folk based tribal art forms have not seen the light of day in a very long time. Except for a few documentaries here and there touting its significance in the local media outlets, most of these art forms are known only to a minority. Preservation and showcasing their importance in our culture must be of utmost priority.

With the help of multiple departments at the Cochin University an imminence research group can be created which can deal with the study, preservation and showcasing of the rich and brilliant aspects of the traditional, tribal, and ethnic as well as the modern culture of Kerala.

In the first phase we can study in detail, the different types of performance art forms throughout the state. Second phase performing arts of Hindi and Malayalam can be studied. In the third phase various performing arts of the whole country can be studied and a comparative analysis can be done. In this manner the advanced study research group for performing arts can help in showcasing and preserving the heritage of the state as well as the whole country.

By and large the whole research plan will be dedicated to the study of culture and it multiple aspects on our present day scenario. We can study and evaluate our traditional culture in the context of the present scenario and identify the degrading elements that have entered our society through the passage of time. Programs in the manner of community outreach programmes can be created in collaboration with the other departments of the university in order to forewarn the society. Corrective measures can be adopted and a system for preservation and enrichment of our diverse performing arts and folk literature can be accomplished by setting up the research group, which will become a research group for excellence in due course of time.

TIMELINE : FOLK THEORY



3. Entrepreneurship & Rural Management

Rural Management is the study of planning, organising, directing, and controlling of co-operatives, agribusiness and allied fields. It merges the knowledge of management studies and applying it in the rural context. Most of the courses are designed in such a way that the concepts that are taught in the class are applied in the real life through training in the rural areas through case-studies and interaction with the rural people.

Entrepreneurship is usually defined as "the process of designing, launching, and running a new business often initially small business ventures." While some others describe Entrepreneurship "as capacity and willingness to develop, organize and manage a business venture along with any of its risks in order to make a profit." While definitions of entrepreneurship typically focus on the launching and running of businesses, due to the high risks involved in launching a start-up, a significant proportion of new ventures end up closing shop, due to "lack of funding, bad business decisions, an economic crisis, lack of market demand" – or a combination of all of these factors.

The best education that anyone can receive is by working with people in the community on a **grassroots basis**. Ordinary people, when they are working together can do extraordinary things. We can develop the rural areas by identifying rural specific problems like lack of transportation, lack of clean drinking water, lack of proper educational resources, lack of revenue sources etc., and we can suggest need based and expertise based solutions, that can help towards a prosperous future for the rural areas.

Out target audience will be the rural people. Special need based attention will be given to the vulnerable sections of society like the unemployed youth, women and socially and economically weaker sections of the society.

Cochin University along with the School of Management Studies plans on creating an excellence research group which caters to the needs of budding entrepreneurs in rural areas. Rather a development of a facilitation research group for the promotion of micro business enterprises. The research group aims at providing knowledge and skill

enhancement of the newly budding entrepreneurs in the rural area by creating solutions linked to common problems which hindering the growth of micro business enterprises. Many new entrepreneurs jump into building start-ups without proper business models and without any knowledge of business practices. They may even lack or have limited access to commercial technologies available for sale with research and development centres. The proposed facilitation research group is an initiative in this direction to serve as a livelihood business incubation research group where any man or women will be provided knowledge base about business opportunities. They will be also provided with post training assistance until and unless they are able to create successful business models that can create considerable revenue.

Challenges Faced

The main challenges that are going to be faced by the research group are the creation and strengthening of infrastructure and facilities. They should be such that the research group for business facilitation must meet the demands of budding entrepreneurs. The research group must be equipped with facilities for mentoring support to incubate in enterprise establishment. Infrastructure for in-house training and portable equipment for facilitating outdoor trainings in selected localities is also a major concern.

Main Goals and Objectives

The research group would take up need based research studies on problems with respect to rural areas. They will invite planners and policy maker's attention to issues regarding the challenges faced by our target audience. The research group will identify potential entrepreneurs and establish micro business enterprises offering handholding support. The research group will conduct Entrepreneurial Development Programmes (EDPs) for target groups such as individuals, women groups, co-operatives, NGO's and students with a view to identify potential entrepreneurs and develop managerial competencies in them to initiate and manage business. Also they will conduct Entrepreneurial Motivation Campaign's (EMCs) for attracting younger generation towards entrepreneurial avenues.

The research group will offer incubation space for registered entrepreneurial units. They will also facilitate mentoring and handholding/turnkey project support to selected business models.

Students will be encouraged to register micro enterprises. Also students will be encourages to ask for handholding assistance from external sources other than the research group so that practical exposure for establishing a venture may be gained along with earnings.

Consultancy/ assistance to registered enterprises for selection of business venture, availing commercialized technology will be given by establishing liaison with concerned division of the University or with the any other relevant institutions providing technology service. Assistance will also be given for conducting of market surveys and preparation of business plans for beneficiaries. The research group will also help in establishing linkages with funding agencies, private investors etc., for availing financial assistance for the start-ups. Branding of the product, marketing assistance and formalities for establishing the enterprise will also be taken up and issues will be face head on.

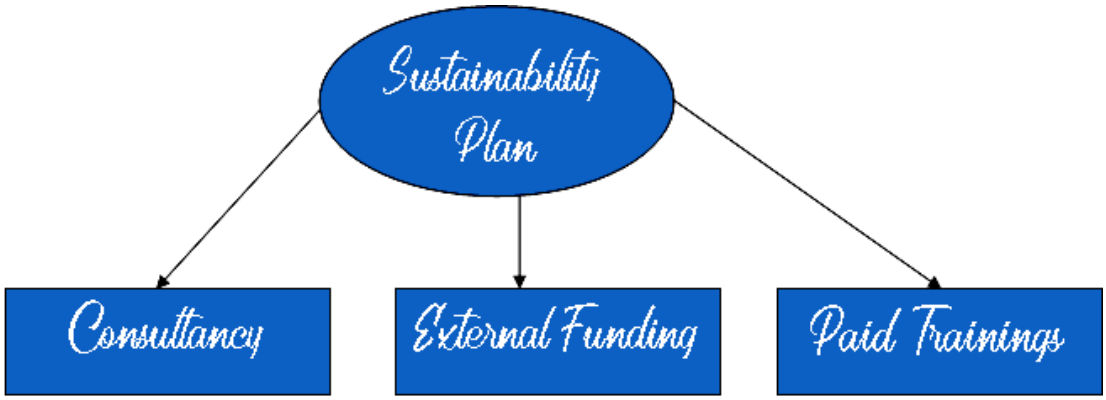
Training & Development

- EDP modules/EMCs: - Will be conducted for stakeholders to facilitate enterprise development. Modules will contain general aspects of enterprise development along with available commercially viable technology developed by Universities/R&D Institutions].
- Post training (handholding) assistance to interested stakeholders registered with the research group will be given so that they can establish their own business models.

Mentoring/Consultancy

- Liaisons with other technical as well as non technical institutions will be established in order to facilitate enterprise registration and knowledge transfer.

- Assistance for selection of available commercialised technologies will also be given so that an apt resource can be select for the initiation of the project.
- Mentoring in development of business plans will also be given, so that the stakeholder can avail financial assistances from funding agencies.
- Mentoring would be given through all the stages of the enterprise building from the nascent stages through to the end stages, unless and until a commercially viable product can be delivered to the market.



4. Urban and Regional Studies

The major areas of the proposed research group is on macroeconomic issues of the Indian economy with special focus on areas relating to urban, regional economics, public finance, industrial and labour issues, planning and development and public policy, and urban infrastructure. The focus of research in these areas is diversified in contents and coverage by including policy issues and reforms at the state level, inter-state level, national level and global level. Research on industrial economics focuses on empirical estimation of the impact of economic policy agreements and incentives on industrial development in general and on small-scale industries in particular, and industrial sector reforms as they are related to public sector enterprise reforms; research on economic infrastructure focuses on higher education, health and telecom services with special reference to financing and subsidies, and estimation of consumer demand; research on public economics focuses on policy research on fiscal federalism and decentralisation, and tax reforms with special

reference to sales taxation and value added taxes; research on labour economics emphasis on socio-economic analysis of labour markets with special reference to determination of minimum wages, valuation of life and injury risks, impact of trade unions on the compensation of job risks, and social security for unorganised labour, research on environmental economics deals with nexus between environment, poverty and human development, water and regional development and economic behaviour of the stakeholders and environmental policy.

The group seeks to understand the impact of social and economic disadvantage on places and people, and assess critically the policies and interventions targeted at these issues. Clients include government departments and agencies, local authorities, charities and foundations, international organisations, and the private sector. We offer research expertise covering a wide range of qualitative and quantitative methods, evaluation, policy advice and guidance, and consultancy.

Objectives

The main objectives of the group summarily stated are to:

- Undertake pure and applied research in urban and regional issues compassing all aspects of a developing society in an inter-disciplinary framework;
- Assist central, state and local governments by providing advice based on policy-related studies;
- Undertake regular training of doctoral students and teachers in universities and colleges, and for the officials and political functionaries, particularly at local levels;
- Maintain a documentation and data research group in urban and regional studies;
- Collaborate with universities, research institutions and the nongovernmental organisations (NGO) in the region in improving the quality of research and training.

Focus Areas

- Welfare reforms and labour markets
- Regeneration and Economic development
- Sustainability
- Measuring outcomes and impact

Clients

Research group for Urban and Regional Studies planning to undertake research and consultancy for a wide range of clients. We work with central and local government, development agencies, regeneration partnerships, charitable trusts and research councils to deliver high quality and cost-effective research, advice and consultation. Research group for Urban and Regional Studies often works in collaboration with other research and consultancy bodies.

Goals and Mission

The Research group for Urban and Regional Studies proposes to focus on important policy issues in Urban and Rural Development. Research carried out will help to bridge the gap between field level understanding and the policy initiatives undertaken at the implementation level. Participatory approach towards research and grounding the research in the public policy will be the goal of the Research group .

Activities

Research:

Strategic spatial planning: We provide analytical research and support for the development of strategic spatial planning resources at a variety of scales from the neighbourhood to the region. We undertake this through socio-economic, environmental and policy analysis, and subsequently strategic site planning and the development of the approaches and techniques of wide-area spatial analysis. Through this research, and our long standing connections to local, regional and national policy making and professional planning communities, we seek to critique current planning practice and provide a set of analytical tools that will which present issues and options for decision making.

Economic development

We aim to enhance understanding of the development and re-organisation economic activity at different spatial scales. Though a focus on; the role of knowledge networks around businesses, universities and governmental agencies in promoting economic change; the evolution of sectors and clusters of strategic importance for local and regional economies; and the development and evaluation of policies responding to economic changes affecting cities and regions.

Urban regeneration and resilience:

Economic restructuring in recent years has resulted in profound changes in our urban environment. Our work analyses the critical success factors for sustainable regeneration, housing policy and addresses the governance structures required to facilitate its management and effective community engagement in these processes.

- **Training:** Research group plan to undertake training programmes on various aspects of Urban and Rural policy related issues. Participants of these training programmes include government officials, university and college teachers, researchers and students. The training programmes are specially tailored to the needs of the participants and deal with specific themes.
- **Policy support**: It extends its support to public policy formulation not only through research, but also through representation of members of the research group in various committees.

5. Corporate Law

The research group is proposed to develop human resource in niche area of Corporate Law and related subjects. It is proposed to offer specialised courses on Corporate Governance, Banking Law, Corporate Re-organization, Securities Law and Corporate Finance to the LLM and LL.B. students. Training programme for corporate law teachers is proposed with help of resource persons from Securities and Exchange Board of India (SEBI),

National Institute for Securities Markets (NISM), Stock Exchanges, Chartered Accountants, management experts and academic experts.

Objectives

- To offer research programmes in Corporate Law
- To conduct training programmes for Corporate Law teachers.
- To offer specialised courses on Corporate Law for students
- To conduct seminars and colloquium to identify grey areas and call for views from experts.
- Introduce working paper series and publish papers
- Facilitate interaction among researchers of different Universities

6. Consumer and Competition Law

Modern society, being a market society, depends on goods available in the market for satisfying his basic needs. He no longer depends on nature for the same. Due to industrialization and globalization the market-system also developed and finished goods and various services were available in the markets for buying and selling. Thus every human being came to known as a 'consumer'. Availability of goods and services in the markets made it easy and convenient for the consumers to select and choose the appropriate goods and services as per their needs and for improving their quality of life. It is to be noted that the market system also led to exploitation of consumers due to various practices such as price hikes, production and supply of substandard and hazardous goods, use of false weights and measures, adulteration, false and misleading advertisements, misbranding, black marketing and hoarding etc. It is the duty of the State to see that the consumers are not being exploited in the market by the manufacturers and sellers. Legislative intervention is seen to have made by various countries to protect the rights of the consumers. India is not an exception to this. Various policies and legislations have been adopted to ensure the interests of the consumers and to prevent any practices which have an adverse effect on consumer welfare.

The Consumer Protection Act, 1986 is a milestone in this area. Globalization and liberalization and the development of markets in India, brought stiff competition among the different market-players and stakeholders. Unhealthy competition led to the adoption of anti-competitive practices and thus leads to exploitation of the consumers. The Competition Act, 2002 addresses this issue. It would curb anti-competitive practices with a view to promote effective competition in the market and thus lead to maximization of consumer welfare. The Consumer Protection Act, 1986 and the Competition Act, 2002 have a common goal of protection of consumers. The former sets minimum quality and safety standards for both goods and services along with grievance redressal mechanism. The latter ensures effective competition through preventing anti-competitive agreements, abusive practices and combinations having anti-competitive effects. However in spite of these legislative efforts, it is argued that, though these legislations are there, the slogans 'Consumer is Sovereign' and 'Customer is the King' are nothing more than myths in the present day scenario where the market is ever-growing and so complicated with newer and newer products. In this context, it is proposed to establish a Center for Consumer and Competition Law (CCCL)to promote understanding, research, and enforcement of consumer and competition law in India.

The research group for Consumer and Competition Law (CCCL)aims at promoting cutting-edge research in consumer and competition laws. It will provide a platform for scholars and practitioners to exchange views and do intensive research on various issues related to consumer and competition laws. The Research group intends to offers training programmes for various stakeholders of consumer and competition law.

Purposes

- To actively engage in consumer and competition advocacy
- To provide short term courses and training to meet the needs and expectations of students, academics, practitioners, consumers and other stakeholders.
- To conduct legal and empirical research in the field of consumer and competition law
- To conduct research in collaboration with other stake holders of consumer and competition law

- To offer specialised LLM in consumer and competition law in collaboration with foreign Universities and National institutions of repute.
- To offer Ph. D in consumer and competition law with Research guides who are expert in this filed.

7. Research Ethics And Protocols

The spirit of inquiry within man is inherent and incessant, which leads him to undertake impertinent ways of investigation and findings which ultimately leads to emancipation of mankind. This process mostly takes place in institutions of higher learning especially universities. Institutions of higher learning should necessarily undertake systematic studies to increase the existing knowledge on a discipline, establish or confirm facts, reaffirm the results of previous work, solve new or existing problems, support theorems, or develop new theories. These examinations and experimentations to derive new knowledge and thereby effectuate practical application of this knowledge is generally given the connotation, "research".

Thus, "Research "is not only critical to the economic and social development of society but it is also critical to the mission of any University or institution of learning. It is this research which is the foundation for knowledge that makes possible so much of the innovation and application that provides wider benefit. Academic research is significant in the sense that, it is intended for research and education while non-academic involves economic benefit alone. Universities are often regarded as hubs of knowledge, which favour multi-disciplinary collaborative research projects and in multi-disciplinary fields. In today's knowledge society, collaboration emerges to meet professional, political, economic and social demands. The growing importance of interdisciplinary fields and various external forces have given rise to intra-institutional and even inter-sectoral collaborations that allow knowledge to be pooled and transferred. Inter-sector collaborations can exist with or without explicit agreements. There is a complementary relationship between academic and non-academic institutions, which can be attributed to the different nature of research in these two sectors. Universities conduct basic research, whereas technological and product research is

undertaken outside academia. University research continues to pursue truth, whereas non-academic institutions can use these research discoveries for product production, policy making, etc. . Thus research is important to the existence of any university.

Integrity, accountability and responsibility in conducting academic research form the cornerstone of any academic enterprise and violations of widely-recognized academic research standards represent serious offences to the entire academic community and are considered injurious for its credibility and authority as an institution that promotes excellence in academic research

Academic integrity mandates that academic research follows elevated professional standards, including appropriate research design and frameworks, adheres to high levels of research ethics and abides by the requirements set out by professional and regulatory research guidance and research ethics frameworks issued in appropriate areas.

Academic integrity is understood in terms of the commitment to the values of honesty, trust, fairness, respect, responsibility, legality and dissemination. Different schools of learning in different disciplines should ensure that all researchers undertake appropriate training in research design, methodology, regulatory and ethical approvals and consents, equipment use, confidentiality, data management, record keeping, data protection and publication, the appropriate use of licensed research resources and respect for the intellectual property rights of third parties .This is more so in universities engaged in active scientific research where there needs to be ethical reviewing and codes of conduct with regard to conduct of experimentations and storage of specimens and data available for the same.

The quest for truth, knowledge and scholarship should begin within the institution. Such institution should necessarily incorporate norms and values which need to be pursued with regard to different areas of research especially with regard to scientific research. Norms or protocols for conduct of research should necessarily stem from the schools of law as different kind of research mandates different set rules and protocols while pursuing research. Hence the relevance of establishing an interdisciplinary research group for research ethics and protocols by the School of Legal Studies.

The School of Legal Studies is the pioneer in the legal education in India especially in the area of postgraduate learning and research. The School has been offering courses on diverse areas of law such as the Constitutional and Administrative Law, Human Rights Law, Maritime Law, Environment Law, Intellectual Property Laws etc. Apart from this, BB.A. LL.B & B.Com .LL.B and 3 year LL.B programmes. Seminars and Workshops are very often conducted on Research Ethics, rules and practices. The school had produced several Ph.D's in different areas of law.

This research group , if established would be the first of its own kind, in the State of Kerala. It would set to be as a role model for the entire state and probably for the entire country with regard to academic research. The research group would focus in both scientific and non-scientific research alike. It would facilitate interdisciplinary research and help in accentuating ethical research and standards. The research group would be a genre of its own kind in providing assistance not only schools under the university but all other state owned research institutions and industrial houses/institutions engaged in research.

Objectives

- To draw up Code of Conduct of Research for different disciplines and inter disciplinary studies
- To articulate and frame different norms and research protocols for different schools under the university as well as for other institutions of research and development.
- To lay down general and specific standards necessary for different types of scientific experimentations, storage of specimens, data etc.
- To provide technical advice to institutions of research especially those engaged in industrial and biotechnological research.
- To lay down different standards of law for scientific and non-scientific research
- To render advisory role to different schools with regard to pursuing research schools of thought on ethics and protocols.

- To provide assistance to the university with regard to norms of procedure to be adopted within its regulatory framework as to research
- 8To sensitize the newer modes of tools in different research and the legal and ethical imperatives associated with it.
- To conduct workshops, seminars on the relevant protocols and ethical standards to be adopted in different disciplines with the change of time.
- To conduct field visits to experimental labs and study what are the required laws to address safety concerns
- To undertake activities to those related to therein.

8. Climate Change

Monsoon rains in Asia are behaving ever more erratically, often with catastrophic effect, the monsoons always have the capacity to cause flooding, and often do. But when the rains strike at an odd time or in the wrong place they can be devastating. Some studies indicate that heavy single day monsoon rains in central India between 1981 and 2000 were more intense and frequent than in the 1950s and 1960s, and increased by 10 per cent since the early 1950s. Severe rain incidences doubled over the same period. It has been reported that human-induced climate change may be affecting the Asian monsoon cycle. Records show that, before 1960, warmer years were associated with stronger monsoons, and the temperature decreased when the monsoon weakened. But the study found a reversed association after this date. The rising temperature now leads to less precipitation, which is not a natural pattern, which indicates that the monsoon had started to be affected by man-made causes.

Satellite observations of convective clouds of recent 30 years have shown that equatorial rainfall has increased in response to the sst increase. It is hypothesized that increase in convective heating of the atmosphere around equatorial Indian ocean will change the strength of the tropical Hadley circulation and thus affect the jet streams. Modern atmospheric science is a field that combines meteorology, physics, mathematics, and computer science, to a lesser extent oceanography, chemistry and geophysics. Few decades

back, scientific studies of atmosphere were limited primarily to studies of the weather. Since the advent of atmospheric computer modelling, models have been applied to study, weather, climate, circulation, dynamics, physical processes, etc on local, regional and global scales.

Recent studies have shown that in the high rainfall zones of the western ghats, there is a significant decreasing trend of monsoon rainfall. This area is the catchment zone for several rivers. It is well known that deforestation of western ghats has taken place particularly acutely during the recent decades. Effect of deforestation of western ghats on rainfall has to be studied in detail using appropriate numerical models.

Changes in temperature and precipitation patterns and numerous other factors will impact both natural and human systems. Climate sensitive sectors like agriculture, forestry, water resources and coastal regions, and, human systems including human health, human settlements, industry and energy sectors will be drastically affected (IPCC 2001).

Impact of rainfall variability on land use patterns is another area of concern. Detailed analysis of rainfall over Kerala state has shown that rainfall in south Kerala has been exhibiting a decreasing trend. Rainfall in other regions also show wide inter-annual and decadal variability. Such variations in rainfall would definitely affect the cropping pattern and land use over the state. A detailed study of these aspects is envisaged so that the nature of the impact of rainfall trends and variabilities on agriculture and land use could be established. Remote sensing data of land use and crop distribution will be used to study the change over the last three decades. A variety of vegetation indices can be obtained from satellite data, as evolutions of the well-known normalised vegetation difference (sometimes - density) vegetation index (ndvi). Cumulative values of ndvi are proposed to be used to estimate cropping patterns. Conventional data would be analysed.

Tremendous baseline information on primary characteristics of varied marine ecosystems has been generated for a long period. However, a renewed thrust has evolved in our actions, since the beginning of this decade, due to the paradigm shift in our approach to tackle various issues associated atmospheric abundance of greenhouse gases and aerosols, in solar radiation and in land surface properties alter the energy balance of the climate system,

species variabilities and loss, increasing pollution and anthropogenic issues and other factors. Of late, monitoring, modelling and proposing management plans on ecosystem changes, extending from coastal estuaries, lagoons, mangroves, oceans to the arctic regions has widened the perspectives of our research priorities. The basic infrastructural facilities developed since this decade were, mathematical modelling, basic microscopes, with imaging systems for community evaluation and other applications, green house gas analytics for elemental & carbon analysis, ecology molecular and bioanalysis lab for genetic mapping, ecotoxicology lab, continuous flow through system for trophic level monitoring and biomarker studies, algal, zooplankton and mangrove culture facilities and marine biology wet lab for water and soil and benthic analysis.

Establishment of a monitoring group for climate change and its effect on geological, ecological, and biological processes on a long term basis is crucial in developing suitable benchmark for sustainable utilization and management guidelines. Holistic approach towards ecological concepts all-encompassing various ecological realms is necessary for understanding the "ecological footprints" or the measure of bio capacity of the system, a resource management tool. Establishment of a research centre wholly dedicated to the study of climate and climate change and their effects on geology, biodiversity, ecology etc to develop new theories, concepts, and interlinking of behaviour, morphology and physiology of individuals and species with their environment is of utmost importance. In a long term vision this could cater towards the infrastructure facility for the research activities in these fields under climate change scenario in the southern part of India.

9. Labour Laws

Economy is changing very fast. Though primarily agrarians, the others sectors particularly service sector is on an all time rise. This rise is not only in terms of its productivity and output but also in terms of human resources being employed. The rise of employment is evident in different industries cutting across the economic and educational strata. This has brought tremendous change in employment relations creating a huge gap in the existing law and current practices.

The change in employment relations is not something particular to India. As a consequence of this we see dynamic situation in ILO too. As India is also a member in the ILO, changes and recommendations in the international policy also has domestic impact.

The aim of this Research group shall be to understand the changing aspects of employment relations and to contribute to policy making as to ensure justice in labour relationship management.

Core Areas of Research

- Collective Bargaining and labour retaliation
- Freedom of Association and Trade Unionism
- Industrial Democracy
- Wages and related benefits
- Social Security Benefits
- Industrial Disputes & its resolution
- Issues of informal sectors
- Disability and employment
- Equality and discrimination – gender based, children, indigenous people
- Forced labour, trafficking and slavery

10.Omega of Farmers' Rights

This will be special research cum field study in Farmers' rights covering all the aspects of farmers' rights. As the protection of the farmers' rights is essential for any economy, and ecology, farmers' rights are inextricably bound with protection of environment, especially biodiversity, and food safety and security. Without farmers, a country cannot survive. But they do not get the adequate protection they deserve. This specialized programme aims at directly helping the farmers to overcome their problems in farming activities, to assist them to legally fight their cases, and also to bring out study materials in the field of farmers' right- both national and international. This will be done in association with NGOs like TERI, Greenpeace, and environment activists like

Padmabhushan Madhav Gadgil (who has already associated with the School of Legal Studies in 2017 March for a lecture series called Anukalikam. He has promised to have more assistance with the School in future.) Fund will be raised by writing a proposal to the MHRD or UGC. One of the other aims of OFR is to develop expertise in Intellectual Property rights of Farmers as against the Plant Breeders' Rights and to help the government to propose an International Convention for the Protection of Farmers' Rights, and to have adequate changes in the TRIPS agreement.

Road Map of the first five years

TIMELINE : CORPORATE LAW

Year 1

- First phase is going to deal with recruitment of staff such as Research associates and administrative staffs. During this period admission may be given to research students.

Year 2

- During this time journals and books relevant to the research plan can be identified and sourced from reliable avenues. Simultanoeuosly data collection can be done during this period. Also specialised courses can be conducted for LLB students

Year 3

- After data collection a Rigorous analysis can be done. Based on the results obtained, showcasing seminars and workshops can be conducted . This will help in knowledge transfer. Through collaboration with other peer groups more data can be collected and analysed.

Year 4

- By the end of this period a general concensus of the research plan must have formed. The ideas concieved should be beneficial to the general public. Research training programmes based on the research plan can be conducted during this period as well. Visiting Scholar programmes can also be conducted during this period as well.

Year 5

- The last phase will consist of creating a service that will be capable of generating revenue for the whole university. Main source of revenue can be commercially available publications that form an indispensible part of the school as well as college curriculum. Also consultancy services can be provided to corporates, start-ups and governmental agencies

TIMELINE: CONSUMER COMPETITION LAW

Year 1

- First phase is going to deal with the conduction and promotion of research in the area of Consumer and Competition Law Recruitment of staff such as Research associates and administrative staffs can be done. During this period admission may be given to research students.

Year 2

- During this time journals and books relevant to the research plan can be identified and sourced from reliable avenues. Simultanoeuosly data collection can be done during this period. Also specialised courses can be conducted with importance to the research plan. Select students can do working paper series. Collaboration with foreign Universities can be hammered out and courses can be conducted.

Year 3

- After data collection a Rigorous analysis can be done. Based on the results obtained, showcasing seminars and workshops can be conducted . This will help in knowledge transfer. Through collaboration with other peer groups more data can be collected and analysed. National seminar on topics relating to consumer law and competition law identified can be conducted during this period as well.

Year 4

- By the end of this period a general concensus of the research plan must have formed. The ideas concieved should be beneficial to the general public. Research training programmes based on the research plan can be conducted during this period as well. Visiting Scholar programmes can also be conducted during this period as well. An annual Journal on theme of Social Justice and Public Law to publish the research articles of scholars and students can be established . (Dr. Ambedkar Journal of Social Justice and Social Reforms)

Year 5

- The last phase will consist of creating a service that will be capable of generating revenue for the whole university. The research group for Consumer and Competition Law (CCCL) requires a working capital of 10 lakhs per year initially but subsequently it can be reduced on the basis of income raised by the Research group through financial support from other agencies.

TIMELINE: CLIMATE CHANGE

Year 1

- First phase is going to deal with the conduction of interdisciplinary course(s) in climate change. Admission may be given to research assistants for interdisciplinary research Data Collection can be done suring this period.

Year 1

- During this time journals and books relevant to the research plan can be identified and sourced from reliable avenues. Simultanoeuosly data collection can be done during this period. Select students can do working paper series. Compilation of materials and publication of articles can be done. Awareness classes to law students by environmental scientists can be given. A preliminary foundation for interdisciplinary link can be done during this period.

Year 2

- Awareness classes to environmental science students by law expers/lawyers can be given to students during this period. After data collection a Rigorous analysis can be done. Based on the results obtained, showcasing seminars and workshops can be conducted . This will help in knowledge transfer. Through collaboration with other peer groups more data can be collected and analysed.

Year 2

- By the end of this period a general concensus of the research plan must have formed. The ideas concieved should be beneficial to the general public. Research training programmes based on the research plan can be conducted during this period as well. Visiting Scholar programmes can also be conducted during this period as well. An annual Journal on theme of Social Justice and Public Law to publish the research articles of scholars and students can be established . (Dr. Ambedkar Journal of Social Justice and Social Reforms)

Year 3

- Lecture series by eminent speakers like Padmabhushan Madhav Gadgil
- Conducting seminars on the interdisciplinary topics in association with the expertise from eminent research personals from the study area.

Year 3

- After data collection a Rigorous analysis can be done. Based on the results obtained, showcasing seminars and workshops can be conducted . This will help in knowledge transfer. Through collaboration with other peer groups more data can be collected and analysed. National seminar on topics relating to consumer law and competition law identified can be conducted during this period as well.

Year 4

- Visit of the groups to places where environmental laws relating to climate change are violated-identification of reasons
- Preparing report on the visit
- Plan of action for rectification of the violation- legal as well as scientific remedies
- Preparation of Books and articles based on these aspects- publication of the same- publicity to the report-forwarding the report to government for further action
- Consultancy works, other extension activities, to act as a research group of excellence for any environment related issues

Year 5

- The last phase will consist of creating a service that will be capable of generating revenue for the whole university. Initially the fund will be found from the State Government, UGC or Central Government. Sustenance of finance will be done by offering other courses, consultancy works, and extension activities

TIMELINE: LABOUR LAWS

Year 1

- First phase is going to deal with the conduction Courses that can be offered LL.M. in Labour laws P.G. Diploma in Labour laws Online Certificate programmes in any/ all core areas of research. Sensitisation programme for various stakeholders – both in formal and informal sectors. Visits to labour settlements, factories, industries to monitor labour conditions. Start general courses on Labour law – LL.M., PG diploma, Certificate courses.

Year 2

- During this time journals and books relevant to the research plan can be identified and sourced from reliable avenues. Simultanoeuosly data collection can be done during this period. Also specialised courses can be conducted with importance to the research plan. Select students can do working paper series. Maintain Blogs and Online short articles and Newsletters

Year 3

- Through collaboration with other peer groups more data can be collected and analysed. Publish Research articles and books Provide policy support at national level.Start Specialised Courses within Labour Laws – ex. Wages, Social Security Benefits, Informal Sector, etc in PG Diploma Courses and Certificate programes

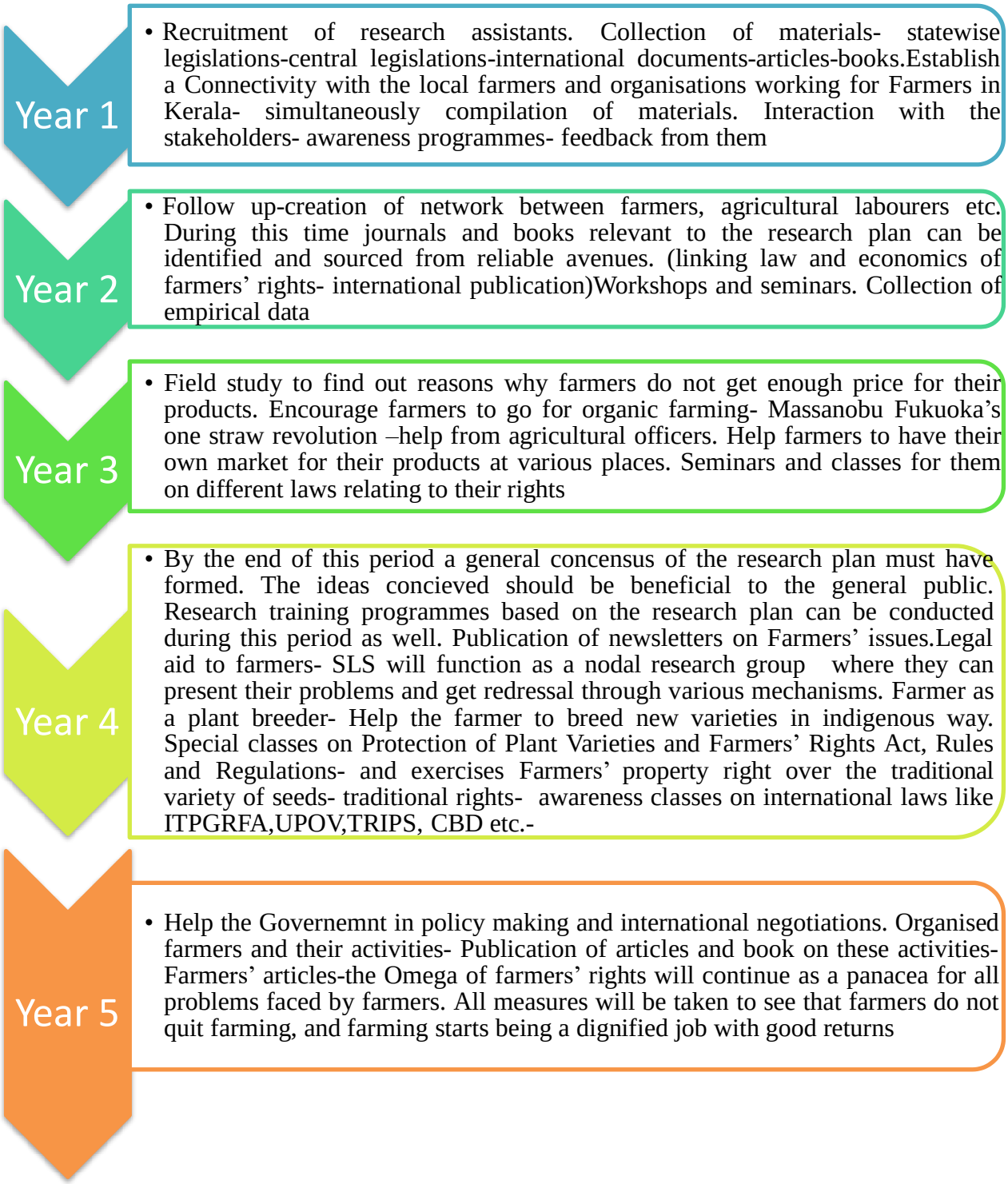
Year 4

- By the end of this period a general concensus of the research plan must have formed. The ideas concieved should be beneficial to the general public. Research training programmes based on the research plan can be conducted during this period as well. Visiting Scholar programmes can also be conducted during this period as well. Provide policy support to government at international level. Activities in co-operation with similar institutions can be conducted

Year 5

- The last phase will consist of creating a service that will be capable of generating revenue for the whole university. The Consumer and Competition Law requires a working capital of 10 lakhs per year initially but subsequently it can be reduced on the basis of income raised by the Research group through financial support from other agencies.

TIME LINE FARMERS RIGHTS



RESEARCH LABORATORIES PROPOSED

Research Laboratories Proposed

Engineering Sciences and Technology

1. Industrial Engineering Lab

- To offer experiments/exercises for the proposed M.Tech programme in Industrial Engineering
- For research in appropriate areas in Industrial Engineering.

2. Computational Lab

- Development of algorithms and computer programs using C, C++, MATLAB, LINDO, LINGO, EXCEL and ARENA
- Modelling and analysis of decision problems in the areas of Production Planning and Control
- Inventory and Supply Chain Management
- Manufacturing System Design
- Performance of Manufacturing Systems
- Facilities Planning

3. Management Science Lab

- Problem formulation and solution and sensitivity analysis using LINGO, X-bar and R charts,
- Material planning and scheduling
- Design of process and Product layouts
- MRP planning
- Time Study and Motion Study

4. Cyber Physical Systems Lab

Cyber physical systems changed interaction and communication between each other. It establishes a bridge between the physical world and cyber world with the help of sensors and actuators, these systems automatically collect information to enable communication. These systems are used to collect all distributed intelligence in the environment to gain a deeper

knowledge of the environment. Now CPS is everywhere from IoT to Smart Cities, Drone to health care, volcano to aquatic monitoring.

- Smart devices with sensing and computing capabilities.
- Wireless sensor network with fibre optic sensors and Micro electrical mechanical sensors.
- Artificial Intelligent Robots for performing skilful work including search and immediate response.
- Smart cellular access points.
- Grid and cloud computing environment and its control systems.
- Base stations operating in VHF band (to reduce energy requirement and improve the network capacity).

5. Data Science and Data Analytics Lab

The Data Science and Analytics Lab have to be set up with a vision to foresee it as a data driven innovation hub. The high-performance lab will be equipped with latest distributed and parallel computing facilities that can be utilized for solving big data analytics problems of all fields including engineering, medicine, business etc.

This is an inter disciplinary lab setup to bring together engineers, physicians, computer scientists and statisticians to develop novel ways to manage, analyse and visualize very large data sets. It is also intended to accelerate applications to industry funded projects. It also assists local and regional companies with their data analytics needs.

6. Integrated Bioinformatics

In alliance with different biological scientific community data processing and visualization tool development can be developed.

Lab needed

- Animal Cell Culture Lab
- Microbiology Lab
- Bioinformatics Lab.

7. Engineering Design

- Vehicle Dynamics lab - Steering Robot with GPS, DAS, wheel force transducer, gyros, Sensors, accelerometers for a complete study of vehicle dynamics
- CAD Laboratory
- Rapid Prototyping Machine
- Mechatronics and Control Laboratory
- Laser based Gas sensing system
- 6 DOF simulator platform
- Parallel manipulator simulation system
- Geometric modelling and analysis facility

8. Polymer Processing lab:

For improving the skills in polymer processing through analysis and experiments. This will help the students to understand mixing and compounding of polymer materials such as thermoplastics, thermos sets and elastomers. The different equipment required are internal mixer, high-pressure capillary viscometer, rubber process analyser, single screw extruders, twin screw extruder, twin screw kneader, micro compounder, hydraulic press, two-roll mill, etc.

9. CAD/CAM lab:

For giving effective training to the students on the polymer product design and also for mould and die design. The software required are Auto CAD, CATIA, AUTODESK MOULD FLOW, computer workstations, etc.

10. Vibration Analysis and Condition Monitoring Lab

The internal combustion engine produces ample possibilities for excitation of the engine structure itself, the shafting, the supporting structure as well as the hull girder. Structural vibration is generally a result of the exciting force and dynamic properties of the structure. In modern engine development work, excitation, structure and vibration response can be analysed and taken into account at the design phase itself, in order to prevent resonance by moving the natural frequency of the component away from the harmful

excitation frequency. Different vibration aspects of marine propulsion systems have to be analysed in order to predict forced vibration response to machinery loads. Three main aspects should be investigated in order to find out the critical engine speeds:

- The torsional vibration of the shafting system
- Dynamic properties of the engine foundation, i.e. natural frequencies and mode shapes.
- Incompatibility of the exciting forces and moment caused by the propulsion machinery with hull.

The dynamic properties have to be determined by using the Finite Element Method (FEM) and validated by means of experimental modal analysis. Using finite element model, the evaluation of the engine exciting forces and moment and the hull/machinery incompatibility are to be studied of the foundation of a large low-speed two-stroke diesel engine which cause significant hull structural vibration when the frequency and magnitude of free moments coincides with one of the lower hull modes. The dynamic analysis of the engine supporting foundation is required in order to determine its natural frequencies and associated mode shapes.

The axial vibrations of ship power transmission systems of direct propulsion, equipped with low speed internal combustion engines, may potentially endanger the safe engine operation, and may generate excessive excitation forces leading to a high level of vibration in the ship body and superstructure. The longitudinal vibrations of the shaft line are coupled with the torsional-bending vibrations through the crankshaft, and are caused by the hydrodynamic forces generated in the ship propeller.

It is desirable to avoid engine breakdowns for reasons of safety and economy. This has led to an increasing interest in engine condition monitoring and performance modelling so as to provide useful information for maintenance decision. A computer program is to be developed to analyse this problem. Nonlinear algorithms to determine the dynamic characteristics of the thrust bearing, and of the main engine bearings are also to be researched and are to be validated with experimental result.

11.Emission Control Laboratory

I C engines pollute atmospheric air by its exhaust gases which includes unburnt hydrocarbon, sulfur oxides, Nitrogen oxides Carbon monoxide, Carbon dioxide and particulate matter. Global shipping emissions amount to 1 billion tons a year which is 3% of world's total greenhouse gas (GHG) emissions. In the 1990s, IMO, EPA and the EU concentrated their work on a reduction of NOx and SOx through Tier I. Tier II will continue the focus on lowering NOx and SOx emissions, but also such exhaust gas components as particulates, unburned hydrocarbons and CO_2 will be considered for future engine designs and development. The IMO Tier III requirements reduce nitrogen-oxide emissions (NOx) by approximately 76% in comparison to a Tier II engine. Though Tier III standards only apply to current existing Emission Control Areas (ECAs) for NOx (North American and US Caribbean Sea), it would be a global requirement soon. It poses a significant challenge to engine designers, as they need to apply NOx-reduction measures with the help of other engine technologies. In this context K M School of Marine Engineering proposes to do research in engine emission control focussing the following areas:

Exhaust Gas Recirculation (EGR): Recirculation of the exhaust gas back to the engine's combustion process in which the NOx reducing effect is achieved by reducing the local maximum combustion temperatures in the combustion chamber, and by reducing the concentration of oxygen, adding inert media with a high specific heat capacity, i.e. exhaust gas CO2 and water vapour. The NOx production only takes place at very high temperatures (2,200°K and above), and it increases exponentially with the temperature. Suitable EGR system need to be developed for large two-stroke engines and are to be optimised with regard to cross-over effects on fuel oil consumption, heat load conditions and other emission parameters.

Scavenge Air Moisturising (SAM) : Humidification of the engine intake air is another method to reduce NOx. The SAM method is partly based on reducing the oxygen content of the cylinder charge, and partly on increasing the heat capacity of the cylinder charge by the addition of water vapour. The scavenge air moisturising system controlled by

a Programmable Logic Controller (PLC) are to be developed to operate the pumps and valves automatically depending on the status of the auxiliary system and the diesel engine.

12. Acoustic Fire Fighting System for the ships.

Fire hazard is a major concern on board the ship especially in the case of oil tankers, gas tankers and LNG carriers. Presently used fire hydrants like water, foam and DCP may spoil and damage the equipment on board. Co_2 fire extinguishers are also used on board and Co_2 flooding is used for major engine room fires. If people are trapped in the engine room, the Co_2 flooding system cannot be operated. The need for filling the Co_2 bottles after usage causes inconvenience and increases overheads. In case of use of fire hydrants, there is problem of accumulation of water on board ships which will adversely affect the flexibility of ship. In the acoustic Fire Fighting System sound waves are used for extinguishing the fire. The K M School of Marine Engineering has developed the prototype of small Acoustic Fire Extinguisher by which we were able to extinguish diesel fires. The physics of mechanism of extinguishing the fire is to be further analysed and more research is needed to extend this to substitute Co_2 flooding system for the engine room fires.

Marine Sciences

1. Ocean Modelling Lab

Oceans are so vast and highly dynamic so that it is difficult and practically impossible to measure every part of the ocean to get a full description of processes occurring in the oceans. Hence modelling is inevitable in the study of oceans to understand and predict their behaviour. An application of ocean modelling is done in the field areas such as circulation, eddies and oil spill etc. Ocean models coupled with atmospheric models provide a better forecast for processes that involves strong air-sea interactions.

Research and academic exchange programs could be arranged with foreign and Indian universities/institutions for advanced training. It will take around 1-2 years for the establishment of the centre with facilities and again a 3 to 5 years for the implementation of numerical ocean models. They also need

- Computational genomics/ bioinformatics Lab
- Laboratory for chemistry and biology of ocean organic matter
- Marine pharmacology lab
- Marine bioacoustics lab

2. Stable Isotope Geochemistry Lab

Isotopes are atoms of the same element that have different numbers of neutrons. Origins of stable isotope geochemistry are closely related to modern physics in early 20^{th}centuary and along with the discovery of neutrons in 1932. The real history of stable isotope study was further expanded during the time second world war. Stable isotopic composition of terrestrial environments changes by mass dependent and independent fractionation associated with physical, chemical and biological processes. Mass dependent fractionations are usually associated with terrestrial processes, whereas mass independent isotope fractionations occur during extra-terrestrial processes.

A series of applications have been formulated by utilizing different fraction properties of stable isotopes. Isotope thermometry has become well established since the time Harold Urey (1947) on the thermodynamic properties of isotopic substances and partitioning of two stable isotopes between two mineral phases.

Isotopes record biological responses to Earth's changing environmental condition. For cases in which substances or residues accumulate in an incremental fashion, such as in tree rings, animal hair and ice cores, isotope ratios can be used as a record of system response to changing environmental conditions or a proxy record for environmental change.

The isotope ratios of plant and animal tissues and organic and inorganic compounds (including gases) in soil represent a temporal integration of significant physiological and ecological processes on the landscape.

Application of tracers especially isotope tracers have been the most useful in terms of insights into terrestrial and extra terrestrial processes. Isotopic fractionations associated with physical and biological reactions, nutrient and element pools within and among ecosystems often differ isotopically. As a result, the sources of essential elements and resources acquired by an organism are easily traced using isotope ratios.

Stable isotope compositions of specific organic molecules (biomarkers), biodiversity of microfossils, and isotope and elemental chemistries of biogenic and abiotic phases are used to study the physical and chemical character of ancient and modern oceans, atmospheres, and terrestrial environments. Stable isotope proxies from environmental and biogenic samples are being developed to study paleoenvironmental conditions and nutrient, mineral cycling in modern marine and terrestrial systems, as well as in the Precambrian oceans. Multi substituted Isotopologues were being used as a new paleotemperature proxy, and in CO2 as a new atmospheric tracer in the modern carbon cycle. Metal stable isotopes are used to help resolve elemental mass balances and provide histories of continental weathering and the evolution of orogens. These data and numerical Earth system models are used to determine the composition of ancient atmospheres, ocean

chemistry and temperatures, with a focus on the global biogeochemical cycles, the history of atmospheric oxygen, and paleoclimates.

Isotope ratios of lighter elements like C, O, H, N and S are measured using gas source isotope ratio mass spectrometer, whereas Isotope ratios of heavy elements like Zn, Cu, Fe, Cr, Mo, and Tl are measured using multiple collector ICPMS.

3. Advanced Imaging Microscopic laboratory

A miniature facility is now in the Department of Marine Biology which is still rudimentary in stage that needs upgradation for general research and open sourced works.

Framing an exclusive laboratory for advanced microscopic bioimaging units with light and electron microscopes, modern wide field and confocal microscopes, phase contrast polarization and interference microscopy, modern fluorescence microscopes etc. Ultra zoom stereomicroscopes for taxonomic studies and micro dissections can be procured. Digital imaging units with microscope adapters also need to be included.

4. Zooplankton and post larvae culture laboratory

Tanks, connections, water circulation systems, lightings, digital controls etc.

Exclusive zooplankton culture laboratory to study their growth dynamics

5. Advanced Flow through Ecotoxicology and energetics laboratory

This facility is required for analysis and quantification various contaminants and their trophic transfer rates; pollution and related problems in the environment; the energy changes and sequestration rates in the ecosystem due to various stress factors is being assessed. A miniature facility is vogue in the dept which is still rudimentary in stage that needs upgradation for general research and open sourced works.

6. Advanced Wet lab and bioanalysis facility

This common facility will have basic and advanced environmental analysis, taxonomic and biodiversity assessment of various life forms including benthic, planktonic and other megafauna state of art analysis of the organisms for the different components are required. Basic wet lab is available but with bare minimum facilities.

7. Seismic Observatory

Kochi being the industrial and urbanization hub of Kerala, it is essential to have solid information on seismological stability of Kochi and its adjacent areas. The aftershocks of recent earthquakes episodes of Nepal and Afghanistan were also felt in Kochi urban agglomeration. Monitoring of the micro level seismic activities is essential for mitigating the seismic hazards of Kerala State. The proposal is aimed to establish a broad band seismic observatory housed at CUSAT, Kochi along with this broad band micro earthquake recorders (MEQ) will be installed all along Kerala to get a very detailed seismic micro zonation data for the entire Kerala state. It will enable us to alert the possibilities of seismic hazards.

Due to the instability of the lithospheric plates owing to many reasons, a situation has now arrived to study the deep continental structure of southern India. Thus a multi-disciplinary Earth Science Research to understand the deep crustal configuration and related processes of the South Indian Lithosphere has become the need of the hour. The major prospects of the study are petrological, geochemical and isotopic evolution of the lower crust and mantle of the Southern Granulite Terrain and associated blocks, major intracontinental shear zones of South India and their role in Gondwana assembly, goechronological and geochemical constraints, structure and evolution of the South Indian Craton and mobile belts from gravity and magnetic and other geophysical studies.

The south Indian plate which was earlier considered as stable has now become active, inducing micro seismic triggers which is detrimental to the life and property of people. The long term effect has to be studied to delineate its various impacts on land. It may also be

noted that the Kerala is quite frequently experiencing minor tremors/micro-earthquakes of lower scale which so far has not been precisely analysed.

The investigations on storm surges, tsunamis, unusual sea level changes and the monitoring of day to day tide levels are also a complimentary part of the observatory.

8. Deep Continental Studies Facilities

Deep Continental Studies of southern India aims to a multi-disciplinary research to understand the deep crustal configuration and related processes of the South Indian Lithosphere. The study includes integrated geological and geophysical studies along selected transects of southern India. The major prospects of the study are

- Petrological, geochemical and isotopic Investigations to understand the evolution of the lower crust and mantle of the Southern Granulite Terrain and associated blocks.
- Major intracontinental shear zones of South India and their role in Gondwana assembly: Geochronological and geochemical constraints
- Structure and evolution of the South Indian Craton & mobile belts from integrated geophysical studies.
- Geological and geophysical investigations to understand the role and significance of novel lineament concept of Central Kerala.

9. Facilities on Hydrogeological and Saline Water Influx

Ground water exploitation in an illogical manner has led to scarcity of portable water and saline water intrusion particularly along the coast. A systematic study on the above will evolve suitable and ideal measures to be taken to avoid over exploitation of groundwater and thereafter to prevent salt water intrusion. The study will help to evolve a sustainable utilization of the groundwater and there upon potable water availability. The acute shortage of drinking water is the present crisis that the society is addressing.

10. Facilities on Sedimentological and geochemical characterization of Coastal sediments

Value added products of beach Placers

Placer deposit or placer is an accumulation of valuable minerals formed by gravity separation during sedimentary processes. India, gifted with a coastline of over 7000 km, hosts some of the largest and richest shoreline placers. The beach and dune sands in India contain heavy minerals like ilmenite, rutile, garnet, zircon, monazite and sillimanite. A combination of favorable factors like network of drainage, aided by wind and coastal processes like waves and currents, have influenced the formation of the beach and adjoining dune sands The State of Kerala enjoys a pride place in the world mineral map by virtue of its top class black sand deposits occurring along the coastal belt. According to AMD (200), the total reserves of black sands upto a deposit of 15m contain 12.7 m of ilmenite, 1m of rutile, 1.9 m of ilmenite, 6 m of sillimanite and 0.4 m of monazite which altogether value more than 10,000 crores. These black sand deposits have been a topic of controversies in recent time because of their proposed mining by private agencies and the probable EI it is going to make on the fragile coastal belt of Kerala.

The proposed investigation will facilitate a detailed and in depth study on the mineralo-chemical aspects, beneficiation and value addition, mining and its EI etc. The department which lays much emphasis in marine resources studies can act as a nodal agency in the state for the black sand mineral development.

Coastal Vulnerability Studies

Coastal environments are the most dynamic interfaces on the earth. These are transition areas between land and sea which supports the most diverse and productive habitats. The modern scientific community considers them as the triple interface comprising of the land, the sea and the atmosphere. In modern time, coastal areas become the focus of intensive urbanization and tourism and are subjected to hazardous natural environmental modifications. Coastal vulnerability is defined as the degree to which geophysical, biological and socio economic systems are susceptible to and unable to cope with the adverse impact

of climate change. Thus costal vulnerability studies are the need of the hour for a country like India especially for Kerala being one of the coastal states. Thus proper planning and protection strategies for Indian coast must be taken seriously by coastal management and policy makers.

Mud Bank Prominences

The Kerala mud banks have socio-economic significance since their high biological productivity provides rich fishery grounds and their impact on wave energy minimizes coastal erosion that prevails elsewhere on the southwest Indian coast. Despite its importance, it is not clear why the mud bank regime is so seasonally persistent. It is clear that the regime is triggered by the southwest monsoon, but the origin and source of the fine sediments that constitute the mud bank regime remain speculative.

In this context the proposed project looks into the various aspects of mud banks such as to sources of fine sediments of mud banks, causes of homogeneity of sediments, clay mineralogy, migratory characters , occurrences of mud banks , isotopic studies of water and shell fragments, heavy mineral studies, geomorphology and tectonic controls. Integrated Geophysical studies will also be carried out to identify submarine groundwater discharge seepages and associated phenomena.

Geochemical characterization of sediments

Geochemical characterization factor of the heavy metal sediments is most essential tool to bring out the Geo-accumulation Index of metals, pollution load index, Environmental factor of the heavy metals to categorize natural and anthropogenic means of heavy metal loading, bioavailability of sediments that serve as receptacles as sink for the pollutants. The absorption, desorption and adsorption of pollutants to a considerable extent depend on the nature of the substratum. The geochemical characterization of sediments serves as the basis for echo and environmental friendly activities

11.Geoinfomatics Laboratory

For the preparation of geo data base.

12.Facilities for Multi proxy plaeoclimatological studies

Ocean acidification is an emerging global problem. Over the last decade, there has been much focus in the ocean science community on studying the potential impacts of ocean acidification. Since sustained efforts to monitor ocean acidification worldwide are only beginning, it is currently impossible to predict exactly how ocean acidification impacts will cascade throughout the marine food chain and affect the overall structure of marine ecosystems. It is the quiet tsunami of environmental degradation. The ocean acidification studies of the biota of the Arabian Sea are in infancy. In this context a research with a multiproxy approach to document the effect of ocean acidification on microfuanal records of the Arabian Sea will through light into the paleoecological and paloclimatological records of the Arabian Sea.

13.Ocean [Wave] Simulation Laboratory

This laboratory is planned for multi purpose applications - 1.Facility to keep the ocean technological instruments in operational conditions 2. A set of simulation test facility to carry out oceanographic experiments. 3. Maintenance facility for oceanographic instruments. 4. Infra-structural test facilities for scientists / engineers to carry out R& D in marine instruments. 5.National calibration facility for marine instruments (and also some water resources instruments) for which similar facilities do not exist in the country. 6. A permanent exhibition of oceanographic instruments in operational conditions, to educate the students and public. 7. The facility will directly benefit many other Departments in the university such as: Environmental Sciences, Marine Geology, Atmospheric Sciences, Industrial Fisheries, Chemical Oceanography of this University, where measurements are needed from the open marine field. 8. Facility to carry out Dissertation works of students at M.Sc., M.Tech and also at Ph.D. levels on such subjects where field data are needed for

systems analysis. And 9. Offer facilities to Sister Institutions in and around Cochin and to those outside the state.

Laboratory facilities projected are :

1. Physical simulation / test facilities
to keep oceanographic instruments in operational conditions, so that they are always kept ready for expensive and elaborate field trips and continuously used for educational and training purposes.

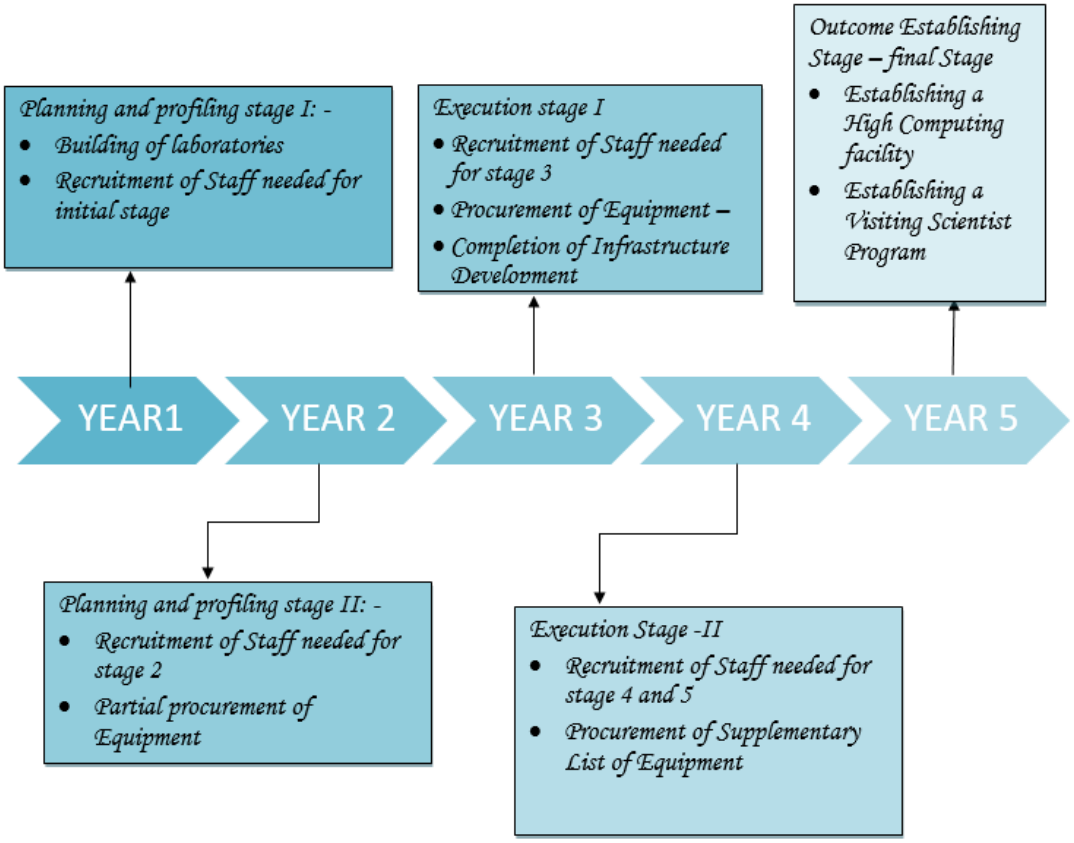
2. Establishment of a wave simulation set up
for studies on wave energy and wave bottom interaction. Mechanical Wave Simulation Facility for generating different operational conditions for testing sensors / instruments based on acceleration and attached with simulated wave recording system.

3. Establishment of test and calibration facilities
Establishment of new Test/Simulation Facilities for the set of oceanographic instruments (18), for which the required facilities do not exist in the country.

INFRASTRUCTURE PLANS

Infrastructure Plans

1. Centre for Interdisciplinary studies in Basic Sciences (CIBS)



Detailed Layout: - Utilisation of funds and essential timeframe.

Year 1

During the first year, the centre will kick off the infrastructure development plan. During this year the fund amounting to 4000 lakhs or 40 crore rupees will be utilised to setup a laboratory building which will house cutting edge equipment required for enumerating on the proposed research plans. During this stage initial recruitment can be carried out as well. Selection of research assistants can be carried out. Around 100 lakhs can be utilised for the research support of faculties and students in the first year

Year 2

During the second year the infrastructure will be complete. The equipment can be procured from here on and the laboratories set up can be fleshed out in their functionalities. During this stage a second recruitment can be done in terms of research associates and faculty essential for the realisation of research plans. The rest of the infrastructure development can be utilised during this period

Year 3

During the third year the infrastructure will be equipped with the complete list of equipment as shown below in the budgetary requirements.

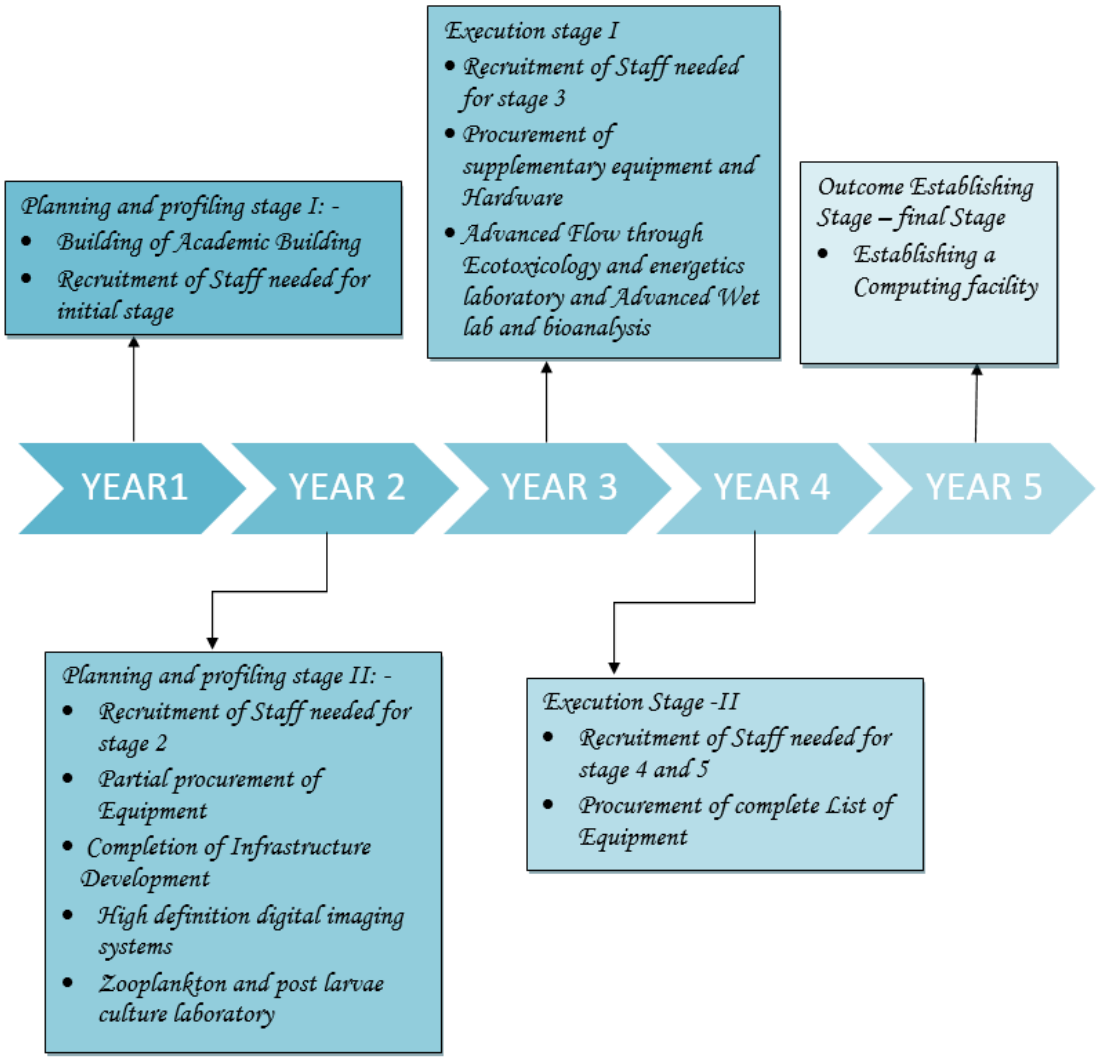
Year 4

This year can be dedicated to the supplementary list of equipment required. Establishment of a high computing facility can be started during this period.

Year 5

The final year will be dedicated to showcasing of the research outcomes. By this time a visiting scientist program can be setup. The centre should fulfil its goals that were embarked upon during the beginning of the period.

2. Centre for Interdisciplinary studies in Engineering Sciences and Technology (CIEST)



Detailed Layout: - Utilisation of funds and essential timeframe.

Year 1

During the first year, the centre will kick off the infrastructure development plan. During this stage initial recruitment can be carried out as well. Selection of research assistants can be carried out. Around 100 lakhs can be utilised for the research support of

faculties and students in the first year. In the budgetary requirements the partial amount in will be utilised.

Year 2

During the second year the infrastructure should be complete. The rest of the infrastructure development can be utilised during this period. Laboratories like High definition digital imaging systems and Zooplankton and post larvae culture laboratory can be setup during this year. Equipment can be procured during this period. This stage should see the completion of infrastructure in the sense of equipment as well as buildings.

Year 3

During the third year laboratories such as Advanced Flow through Ecotoxicology and energetics laboratory and Advanced Wet lab and bio-analysis can be setup. Setting up of Campus [Digital] Library in the realm of Earth, Marine and Allied subjects can also be done during this period. Procurement of ocean research vessel, Procurement of coastal research vessel and other remaining list of equipment must be done.

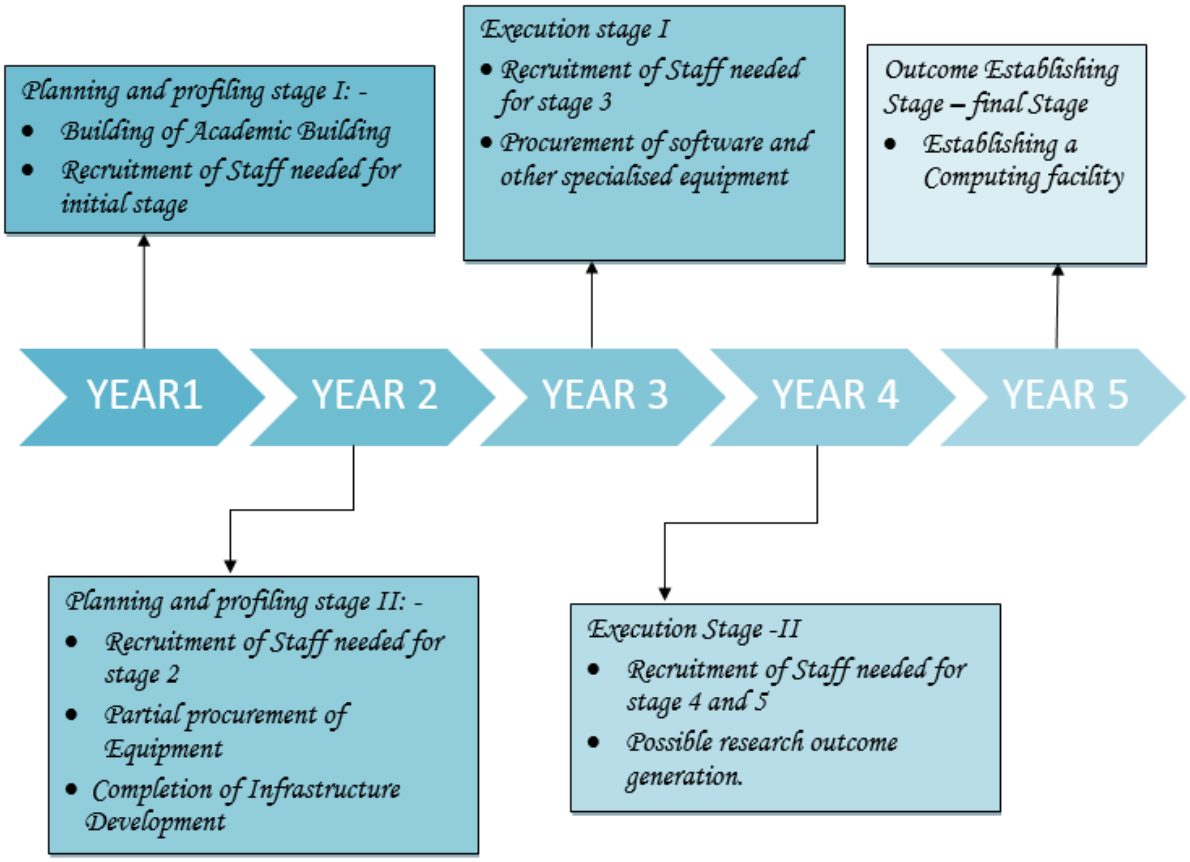
Year 4

This year can be dedicated to possible research outcome generation. Establishment of a computing facility can be started during this period.

Year 5

The final year will be dedicated to showcasing of the research outcomes. The centre should fulfil its goals that were embarked upon during the beginning of the period.

3. Centre for Interdisciplinary studies in Scientific Computing(CISC)



Detailed Layout: - Utilisation of funds and essential timeframe.

Year 1

During the first year, the centre will kick off the infrastructure development plan. During this year the fund amounting to 4000 lakhs or 40 crore rupees will be utilised to setup a laboratory building which will house cutting edge equipment required for enumerating on the proposed research plans. During this stage initial recruitment can be carried out as well. Selection of research assistants can be carried out.

Year 2

During the second year the infrastructure should be complete. The rest of the infrastructure development can be utilised during this period. Partial procurement of equipment can be done.

Year 3

During the third-year procurement of software and other specialised equipment can be done.

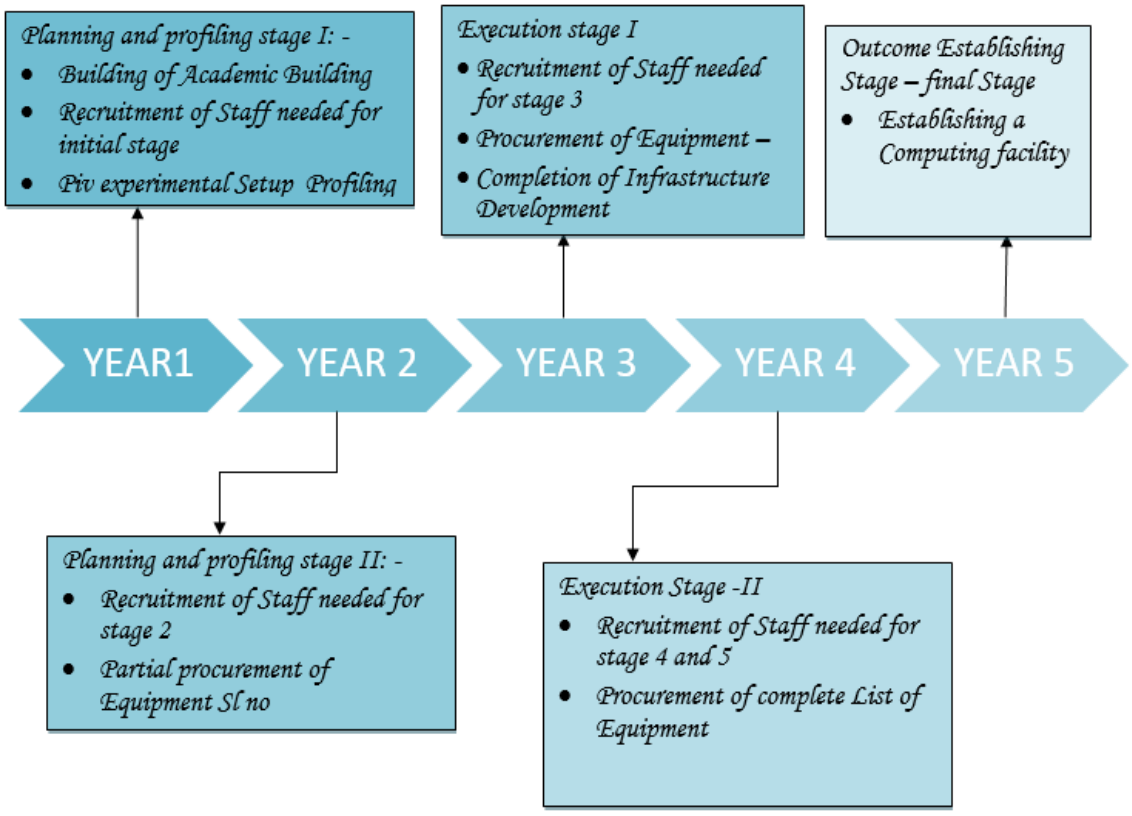
Year 4

This year can be dedicated to possible research outcome generation. Establishment of a computing facility can be started during this period.

Year 5

The final year will be dedicated to showcasing of the research outcomes. The centre should fulfil its goals that were embarked upon during the beginning of the period.

4. Centre for Interdisciplinary Studies in Marine Science(CIMS)



Detailed Layout: - Utilisation of funds and essential timeframe.

Year 1

During the first year, the centre will kick off the infrastructure development plan. During this year the fund amounting to 4000 lakhs or 40 crore rupees will be utilised to setup a laboratory building which will house cutting edge equipment required for enumerating on the proposed research plans. During this stage initial recruitment can be carried out as well. Selection of research assistants can be carried out. Around 100 lakhs can be utilised for the research support of faculties and students in the first year.

Year 2

During the second year the infrastructure should be complete. The rest of the infrastructure development can be utilised during this period. . The rest of the equipment can be procured in this stage.

Year 3

During the third year the infrastructure will be equipped with the equipment list from 3 to 56 as shown below in the budgetary requirements. This stage should see the completion of infrastructure in the sense of equipment as well as buildings.

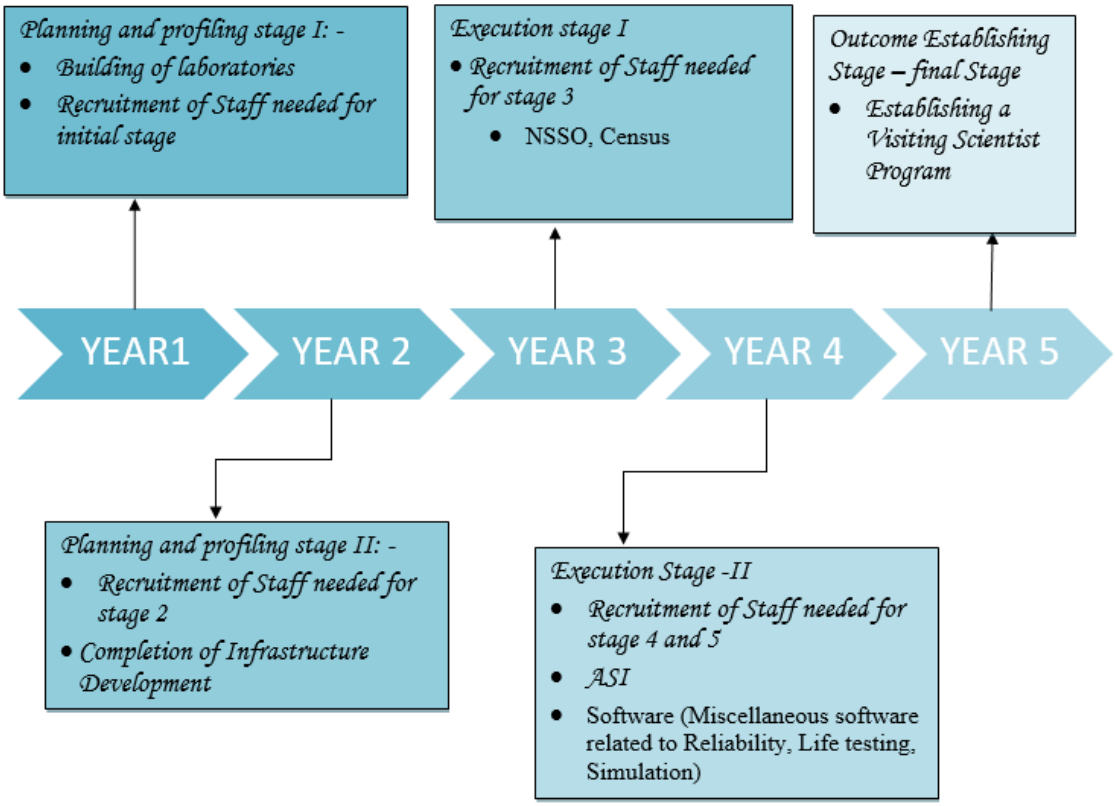
Year 4

This year can be dedicated to possible research outcome generation. Establishment of a computing facility can be started during this period.

Year 5

The final year will be dedicated to showcasing of the research outcomes. The centre should fulfil its goals that were embarked upon during the beginning of the period.

5. Centre for Interdisciplinary studies in Humanities and Social Sciences (CIHSS)



Year 1

During the first year, the centre will kick off the infrastructure development plan. During this year the fund amounting to 4000 lakhs or 40 crore rupees will be utilised to setup a academic building which will house cutting edge equipment required for enumerating on the proposed research plans. During this stage initial recruitment can be carried out as well. Selection of research assistants can be carried out. Around 100 lakhs can be utilised for the research support of faculties and students in the first year.

Year 2

During the second year the infrastructure will be complete. During this stage a second recruitment can be done in terms of research associates and faculty essential for the

realisation of research plans. The rest of the infrastructure development can be utilised during this period. The beginning of Census can be started here.

Year 3

During the third year the infrastructure will be equipped with the complete list of equipment as shown below in the budgetary requirements.

Year 4

Purchase of software and recruitment of staff

Year 5

The final year will be dedicated to showcasing of the research outcomes. By this time a visiting scientist program can be setup. The centre should be able to fulfil its goals that were embarked upon during the beginning of the period.

MEMBERS OF THE MASTER PLAN COMMITTEE

1. Dr. J. Letha, Vice Chancellor **- Chairman**
2. Dr. V.N Rajasekharan Pillai, Former Chairman of UGC and Former Chairman of NAAC
3. Dr, Damodar Acharya, Former Director, IIT Kharakhpur and Former Chairman AICTE
4. Dr. P. G. Sankaran, Pro Vice Chancellor
5. Dr. M.K Jayaraj, Professor, Department of Physics
6. Dr. G. Madhu, Professor, School of Engineering
7. Dr. M. Bhasi, Professor, School of Management Studies
8. Dr. N. Chandramohanakumar, Professor, Department of Chemical Oceanography
9. Dr. Supriya M.H, Professor, Department of Electronics
10. Dr. A.N Balachand, Professor, Department of Physical Oceanography
11. Dr. Sunil K. Narayanankutty, Professor, Department of Polymer Science and Rubber Technology
12. Dr. James Varghese, Assistant Professor, School of Engineering
13. Dr. K. Satheesan, Associate Professor, Department of Atmospheric Science
14. Dr. K. Girish Kumar, Director, IQAC **- Convenor**

INTERNAL QUALITY ASSURANCE CELL

CUSAT, KOCHI 682 022