

differentiated organizations, must give way to a nonlinear model of continuous participatory learning within the larger agricultural innovation system. The latter, the innovation systems approach, based on iterative learning and building partnerships with the relevant actors/ agencies in the agricultural innovation system, demands institutional and organizational changes. There is a felt need to strengthen social science research in agricultural innovation systems, to enhance the social and ecological learning capacity of R&D organizations. Finally, the papers in the session on 'Addressing sustainability goals' were concerned with two crucial aspects of long-term sustainability in agricultural innovation systems: (a) the agricultural education system to produce dynamic manpower, and (b) the natural resources research sub-system to ensure sustainable use of and conservation of natural resources. Both the groups of papers addressed institutional and organizational issues that impede the goals of sustainability in Indian agricultural R&D.

Some of the important issues and suggestions that emerged from the technical sessions were discussed further in the last session. The main recommendations of the workshop are:

- The policy regimes of the past, which put a huge public R&D system in place, have changed. The current economy and policy will not support this R&D system whose performance has definitely declined.
- Since the productivity of crop and disciplinary subject-matter research has reached a plateau, an interdisciplinary issue-based research approach is necessary.
- Success of the green revolution should not lead to complacency in this era with pressures from WTO, emerging technologies like biotechnology, and declining international (CG system) support for agricultural R&D. New methods of funding R&D and partnerships in R&D must be sought.
- Personnel policies in the system need to undergo a change to promote innovation, with due reward to merit.
- Major changes in the conduct of R&D are needed, most crucial being an analytical framework to orient agricultural research to meet sustainability goals and specific poverty-reduction goals.
- Indian agricultural R&D must seek the processes and structures for an internal thinking mechanisms at all levels.
- While decentralization and accountability down the line to the Principal Investigators have been recommended time and again, it has always been translated to mean financial decentralization. A progressive and dynamic R&D system that caters to policy demand for agro-ecological, diversified strategies for agriculture demands decentralization of ideas and approaches in the conduct of research.
- Increasing stakeholder involvement in research decision-making and better research partnerships in technology generation and utilization demand institutional learning and organizational changes that enable these learning processes.
- Better social science research capabilities to analyse and develop R&D strategies for specific agro-ecological regions or farming systems perspectives. This will, therefore, call for greater interaction between natural sciences and social sciences.
- There is a need for emphasis within ICAR and SAUs (in the public sector) on an innovation systems approach to agricultural policy, science, and development.

It was concluded that professionals in the innovation system, policy-makers and other stakeholders have to define the socio-economic and sustainability goals in an ecoregional perspective and work towards reorienting location-specific R&D needs to meet these goals.

This workshop was a small beginning; yet, a significant one in which the need for change in R&D was discussed and analysed, openly and honestly.

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NEWS FOCUS

Science in Thiruvananthapuram

Kerala. Viewed from the skies is lush green, white surf lapping the coastline and aptly described as 'God's own country'. 'Keralam' is 'land of coconut trees'. But, can this remain so? Kerala is beset with problems; those requiring intervention of scientists. A 570 km coastline, several rivers and estuaries need scientific monitoring. A high population density means more erosion and more landslides. Improved land use, alternate building

materials, pollution checks, water budgeting, watershed development, terrain analysis, soil studies, materials development and biodiversity protection need attention. Geoscientific studies of minerals, seismology and understanding natural radioactivity occurring on the Kerala coast are necessary for Kerala's continued health. Thiruvananthapuram, Kerala's capital city has several institutions involved in scientific and medical research.

Kerala is the first state in the country to have a State Committee on Science and Technology, which now includes Environment also, and is known as STEC (Box 1).

Centre for Earth Science Studies

The Centre for Earth Science Studies (CESS) celebrates its silver jubilee in 2002–2003. For the development of

Box 1.

Research institutions under STEC

Kerala Forest Research Institute, Thrissur
 National Transportation Planning and Research Centre, Thiruvananthapuram
 Centre for Water Resource Development and Management, Kozhikode
 Centre for Earth Science Studies, Thiruvananthapuram
 Tropical Botanic Garden and Research Institute, Thiruvananthapuram
 Agency for Non-conventional Energy and Rural Technology, Thiruvananthapuram
 Rajiv Gandhi Centre for Biotechnology, Thiruvananthapuram

Institutions receiving partial support from STEC

Malabar Botanical Garden and Society, Kozhikode
 Sophisticated Test and Instrumentation Centre, Kochi
 Integrated Rural Technology Centre, Palakkad
 Kerala Statistical Institute, Thiruvananthapuram
 Centre for Mathematical Sciences, Thiruvananthapuram

Kerala, CESS scientists appear to have the right combination of expertise in earth sciences, management of land/water resources and natural and man-made hazard studies. However, CESS has had to grapple with shortage of funds and is overstaffed, with the non-plan/plan funds being insufficient even to pay salaries of regular staff. Almost the entire research and development is done using external funds, although three-fourths of the programmes taken up were for the benefit of the state.

Earth system studies at CESS comprise both earth system dynamics (geo-, hydro- and atmospheric dynamics), study of land-water-atmosphere interactions and natural hazards such as earthquakes, landslides, coastal erosion, etc. CESS is among six organizations authorized by the Ministry of Environment and Forests for demarcating the high tide line (HTL). The institute has prepared coastal zone management plan maps and land use maps for coastal panchayats, in the scale of 1 : 25,000 using satellite data or aerial photographs. Studies were conducted on coastal erosion and sediment movement in selected islands of Lakshadweep. Environmental Impact Assessment (EIA) for various schemes such as for mining, hydroelectricity, housing, tourism, etc. was performed by preparation of a coastal erosion zonation map for Kerala. There is an ongoing initiative for studying the crustal blocks found in southern India. Palaeomagnetism and geochemistry studies are under way, of the mafic dykes in the proterozoic Cuddapah basin composed of magmatic rocks. The petrological study

of granulites such as charnockite in Kodaikanal-Cardamom Hills, Sabarimala and the Palghat region has been carried out. Kerala's rich deposits of ilmenite and rutile at Chavara have been investigated for their interesting magnetism and chemical properties.

Earth sciences contribute towards understanding of natural hazards and identifying potential areas. The group researching earthquakes is studying the Rann of Kutch for its seismotectonics and correlating this to the history of earthquakes in that region. Palaeoseismicity studies in peninsular India are also being carried out. Terrain evaluation for landslide mitigation studies has been conducted in Kollam District using Geographic Information Systems and understanding the increased incidence of lightning strikes in this district. The identification of radiogenic sources known for high natural background radiation is of interest to scientists in western Kanyakumari District and the Kerala coast. With the support of the Department of Ocean Development, the Coastal Ocean Monitoring and Prediction Systems (COMAPS) for monitoring marine pollution is under way. Levels of dissolved oxygen, suspended particulate matter, nitrogen concentration, zooplankton biomass density, etc. are being recorded along the Kerala coast.

Monitoring effluents dumped by industries off the Kerala coast, their environmental impact, mercury pollution in the river waters of Nilambur, determination of water quality in the school wells of Pazhayakunnummel panchayat, Thiruvananthapuram District are some activities

undertaken by CESS. Water would be the next world crisis. Towards water budgeting, CESS has taken up the conservation of Vellayani Lake as a drinking water source for Thiruvananthapuram District. Rain-fall intensity measurements are important to the highland areas of Kerala. Hence a watershed atlas of Kannur District was made. Soil erosion and terrain analysis have been taken up in Peppara, and the Idukki Wildlife Sanctuary and the Shola forests in Idukki and Wynad districts respectively. As an input for district plan preparations, a digitized road map for Thiruvananthapuram District and assessment of road transport facilities in Idukki, Kottayam and Alappuzha districts were made, and carrying capacity studies of the Greater Kochi region were conducted.

Biodiversity research is important to Kerala. CESS scientists carried out various soil, geological, hydrological, climatological and geomorphological surveys necessary for data collection. The biodiversity threat in Kerala arises from encroachment, pollution of wetland and siltation. CESS has made an integrated study of the Vamampuram River basin, Neyyar catchment area, Sacred Groves of Kerala and the fast-disappearing mangroves in the Vembanad Estuary. These studies have been aided using GIS and remote sensing data.

Rajiv Gandhi Centre for Biotechnology

It is just over a decade since the Rajiv Gandhi Centre for Biotechnology (RGCB) was created under STEC, catering to the development of the state through biotechnology. The massive 110,000 sq. ft main building complex is about to be completed for a total staff strength of about 100, including 16 scientists. The Department of Biotechnology has already pumped in a research project grant of nearly rupees 18 crore for 1999-2001. RGCB does have the latest equipment for performing biotechnological research, but a walk through some laboratories indicated a paucity of simple but essential pH meters, water-baths and stirrers. The philosophy behind RGCB is 'having research groups around individuals'. There are seven major divisions: infectious diseases, plant molecular biology, environmental biotechnology, molecular human genetics, neurobiology, cancer biology and molecular endocrinology.

Infectious diseases: Studies on the biochemical nature of the Hepatitis C virus (HCV) infection, immune response and host-pathogen interactions have led RGCB to develop a diagnostic kit based on ELISA for detecting Indian strains of HCV. This kit is undergoing multicentric evaluation. The laboratory extends its services to the public referred by local hospitals, for confirmatory diagnosis of HBV and HCV infection using PCR methods. The *Mycobacterium tuberculosis* group is looking at the molecular aspects of the causative organism of TB. They are building up a repository of *M. tuberculosis* in the state by isolating TB bacilli from patients. The group uses Alamar Blue dye reduction assay for screening the strains and fingerprinting the isolates. Drug resistance profile and new drug candidates against *M. tuberculosis* are the other interests of the group. The research activity on *Vibrio cholerae* includes molecular ecology, epidemiology and pathogenesis of *V. cholerae* strains. *V. cholerae* strains from Kottayam, Alleppey and Thiruvananthapuram, numbering about 25, were tested for differential drug susceptibility. These were found to be multi-drug resistant, with differences in antibiotic susceptibility varying with the geographical location in Kerala. Hereditary deafness, the genetics and causative features are the interests of the animal biotechnology group. They have screened 57 families in Kerala for mutations.

Plant molecular biology: The ethnopharmacology group is trying to isolate the active hepatoprotective principles from 'Phyllanthus' and other medicinal pteridophytes of the Western Ghats region in Kerala. A rice variety, *Oryza malampuzhaensis* endemic to the same region is little understood in terms of genetic diversity, population structure, etc. The laboratory has found through their studies that this species is under threat of becoming extinct. Experiments are under way to make black pepper (*Piper nigrum*) vine resistant to diseases by genetic transformation.

Environmental biotechnology: Safe drinking water is a prerequisite for good health. The use of modern PCR-based water quality monitoring in Thiruvananthapuram city area revealed in a few samples, the presence of wild type polio and rota virus contamination. Untreated hospital

waste disposed into the domestic sewage system and sewage samples indicated a higher incidence of blood-borne viruses (HCV, HBV and HIV) than that of water-borne viruses (entero, rota, etc.). The group has developed the multiplex RT-PCR-based RFLP analysis for monitoring water quality. Another area of research is the hunt for bacteria as non-toxic natural antifoulants. Marine foulers cause damage to shipping, offshore structures, etc. Bacterial strains from marine algae, off the Mandapam and the Shanguugam coast, have been isolated for their potential as antifoulants.

Molecular biology of genetic diseases: Kerala's tribal population and other ethnic communities are being studied for their genetic diversity and predisposition to diseases. Methods such as DNA fingerprinting, immunogenetic and pharmacogenetic profiling are used in diseases like schizophrenia, spondyloarthritis and cancer.

Molecular basis of biological functions: The study of the molecular basis of biological function includes the molecular endocrinology group, which researches the biology of estrogen receptors in mammalian uterus, the cancer biology group and the neurobiology group. The cancer biology group concentrates on the cancer of the uterine cervix, the most prevalent form of cancer among Indian women. Curcumin, the yellow pigment of turmeric (*Curcuma longa*) is a potent anti-inflammatory agent and an antioxidant. Certain cell types are resistant to apoptosis by curcumin; so understanding the reason for this is of interest to cancer biologists in the hope of developing curcumin-based anti-cancer therapies. Another study by the same group focuses on the effects of garlic on the proliferation and apoptosis of cancer cells. The neurobiology group is studying the interaction among proteins present at neuronal synapses, thought to be involved in memory and learning.

Sree Chitra Tirunal Institute for Medical Sciences and Technology

This institute (SCTIMST) was formally inaugurated in 1976 and is one of national importance (1980), with the status of a university. What makes it so unique is that one can see the best of medical sci-

ence and technology under one roof, complementing each other. In 1973, the erstwhile royal family of Travancore gifted land and the beautiful Satelmond Palace that now houses the Biomedical Engineering and Technology wing of the institute. Goals set for SCTIMST are to develop appropriate technologies to meet the health care needs of the country, initiate training and research programmes integrating biomedical technology and health sciences, and maintaining high standards of patient care in medical specialities. The institute is supported by the Department of Science and Technology.

Medical technology and biomedical research: The medical devices market is of approximately Rs 5000 crore; yet most of the country's needs are met through imports. Sadly, the medical devices industry is still in its fledgling stage, and there is surprisingly no medical device policy or legislation, even in 2002. There is urgent need for legislation or else we might be using sub-standard medical devices in life-threatening situations! Just as there is a Drug Controller, there has to be a Medical Devices Controller. SCTIMST has contributed successfully its mite to this industry with the Laboratory for Dental Products, Modelling and Prototyping and Devices Testing Laboratories (focusing on development and standardization of test methodologies for evaluation of medical devices conforming to national and international standards) and an instrumentation laboratory for development work in medical instrumentation.

The well-known successes of SCTIMST include the 'Chitra heart valve', blood bags, blood oxygenator and hydrocephalus shunt. There are presently about 5000 people walking around with the Chitra heart valve and 80 centres using the valve. About 2000 patients would be fitted with this device in 2002; and this is expected to rise to about 5000 per year, by 2005. Improvements are under way for optimizing the fluid-flow design to increase blood throughput and uniformity of flow and reduce thrombogenicity. For this, new materials and coating types are being evaluated at the laboratory stage. Among technologies recently developed are:

- **Dental composites:** Technology transfer has been effected in four dental pro-

ducts: chemical cure, light cure, radio-paque dental composite and dentine bonding agent. These are now undergoing multi-centric evaluation in selected dental hospitals.

- Technology for fibrin glue and haemostatic fibrin sheet developed by the Thrombosis unit is also transferred and their evaluation begun.
- The Bioceramics laboratory has transferred to industry bioactive glass composite and porous hydroxy apatite granules for ceramic surgical implant and bone regenerations which are biocompatible and serve as an osteoconductive bone repair material.
- A hollow fibre membrane oxygenator is in the final series of animal experiments. It consists of a polycarbonate reservoir, connectors, polypropylene hollow fibres, anodized heat exchangers with a rotating venous inlet and an oxygenation module.
- Chitosan-based wound dressings developed by the Bio-surface Technology Division can be used in dressing chronic ulcers and is presently under clinical evaluation.
- Other developments include devices and materials suitable for application in vascular graft, haemodialysis membranes, artificial skin and biomaterial such as hydrogel microspheres for applications in embolotherapy.

Clinical research: In addition to the clinical research described below, several other departments also conduct clinical research, such as the Division of Biochemistry, Neurosurgery, Pathology and Radiology.

Division of Cellular and Molecular Cardiology: Cardiac care and growth of cardiology in Kerala can be traced back to its origins at the Medical College, Thiruvananthapuram. A multidimensional approach to the field of cardiology is evident at SCTIMST which has four major areas, namely clinical and educational cardiology, biomedical practices, basic cardiac research and cardiac epidemiology.

The molecular basis of endomyocardial fibrosis (EMF) and the origin of the pathogenesis of the disease investigated by the group at SCTIMST have led to the culprit, cerium which forms the basis of the geochemical hypothesis of tropical EMF. Cerium (constituting 30% by weight) occurs in the monazite sands off the

Kerala coast, which in combination with magnesium deficiency could be the cause of EMF. It is a disease that is specific, has a geographical distribution around the equator, with the poor who easily succumb to malnutrition and diarrhoeal diseases falling prey to EMF. Other research areas are molecular mechanisms in cardiac fibrosis, free radical stress in cardiac ailments and the effect of vitamin D and its relationship to coronary artery disease (CAD) in the tropics. The Achutha Menon Centre for Health Sciences under SCTIMST has, along with other organizations, undertaken a cardiac epidemiological study of Kerala.

Department of Neurology: Clinical research is ongoing in the area of epilepsy. A study of the prevalence, knowledge, attitude and practice of epilepsy in Kerala revealed that the pattern does not differ from that of developed countries. Although awareness was comparable, the attitudes of the people were negative. A significant factor in reducing the effect of this disorder in the daily activities of the patient is to provide the family with enough information to dispel misconceptions associated with the disease. An epilepsy counselling and training module is available at the R. Madhavan Nayar Centre for Comprehensive Epilepsy Care, Department of Neurology. The centre also coordinates the activities of the registry of epilepsy and pregnancy on a national level. Since 1995, the centre has performed about four hundred medically refractory epilepsy surgeries. An *Epilepsy News* is brought out by the centre to disseminate current status of epilepsy research.

The Health Sciences wing of SCTIMST is the Achutha Menon Centre (AMC). Its main objective is to train health professionals in health research and the formulation and implementation of health policies. It conducts an international Master of Public Health (MPH) programme, short courses and Ph D programme for all South Asian countries. The centre is also the secretariat for the Public Health Schools without Walls Networking Initiative in Asia and Africa. The research programme covers epidemiology with projects such as detection and monitoring of hypertension in Kumarakom, Kerala, diarrhoea morbidity in under-five children in selected villages of Kerala and Tamil Nadu, and surveillance of cardiovascular diseases (CVD) risk factors.

Other projects are gender and social issues in reproductive health research and health sector reform.

A high standard of patient care at the hospital (corroborated through locals) with medical records that can be easily retrieved on demand puts SCTIMST on track to successfully meet global challenges.

Regional Research Laboratory

The Regional Research Laboratory (RRL) is part of the Team CSIR laboratories nestled in Pappanamcode, Thiruvananthapuram. Research activities at RRL are divided into nine areas, namely agro-processing, photochemistry, speciality polymers, mineral processing, structural and electronic ceramics, alloys and composites, waste water technology, and organic synthesis.

Agro-processing: In India, this particular area of technology development is of significance. For example, this Unit has established palm oil mills in Goa, Gujarat, Orissa and Tamil Nadu. A process has been developed to retain in red palmolein more than 60% of the original carotene and about 80% of the tocopherols. Oleoresins and flavours from fresh spices have been developed from turmeric, ginger and pepper. A fresh-ginger processing plant has been commissioned at Manipur for obtaining ginger oil.

Photochemistry: At the Photochemistry Research Unit the areas of active interest are molecular/nanomaterials, macromolecular/supramolecular materials, photobiology and photoinduced electron transfer. This is one of the three laboratories identified to coordinate the CSIR programme on Photonics under the Tenth Five Year Plan. Research at this Unit has potential for applications such as photovoltaic devices, organic light-emitting diodes, photoswitchable liquid crystals, low-band conducting polymers and photodynamic therapy for cancer. In photoinduced electron transfer, the main focus is to understand important photoprocesses. Other interesting research projects are the design and study of photophysical properties of squaraine and ruthenium-based dyes coated on large band gap semiconductors, storage of light in the form of chemical energy using fullerene-based dyads that are tuned with different donors

and acceptor pairs, and light-harvesting devices in the form of nanoparticles of transition metals. The Unit also has research interests in the development of organic material for electrooptic applications, with the design of inherently active liquid crystalline materials and development of sensitizers for biological applications.

Speciality polymers: A successful development of a commercial process for manufacture of panelling material and veneers of banana fibre composites, uses a device that cleaves the leaf-sheath without splitting in banana plantations. Other projects are melt processable liquid crystalline polymers and thermochemical processing for value addition of China clay. Systematic studies have been undertaken on the structure, physical and mechanical properties of plant fibres of Kerala such as coconut, banana, sisal, pineapple, palmyrah and talipot for development of plant fibre-reinforced polymer composites and preparation of useful products made from cashew nut shell liquid, a by-product of the cashew industry.

Mineral processing: China clay and heavy mineral sand like ilmenite are abundantly found in Kerala. In collaboration with industries beneficiation technologies have been developed that give value addition to the minerals. In the case of China clay, this has helped upgrade sub-premium quality clay raw material to paper-coating-grade products. Similarly, an environment-friendly process for the manufacture of high-grade synthetic rutile has been developed. From waste and industrial by-products like glass, flyash with aluminium, clay or polymer are used as matrices for wear

resistance and building material applications.

Structural and electronic ceramics: The range of research varies from high density ceramics for use at low temperatures, to helping the Kerala tile industry scientifically modernize, with evaluation of raw materials and use of optimum blends. Ten-metre long multifilamentary superconducting tapes in helical coil form have also been fabricated. The electronic ceramics group concentrates mainly on work associated with high T_c superconductors. Other ongoing projects are in the area of sol-gel self-cleaning coatings, ultra and nano filtration catalytic ceramic membranes, monazite ceramics, dielectric resonators and microwave resonators for communication.

Alloy and composites group: An Al-Si alloy sand casting has been developed, which can be used at different temperatures and components fabricated for use in space applications and aluminium metal matrix composites for nuclear and automotive applications.

Organic and natural product synthesis: There is a programme to isolate, modify and evaluate biologically active compounds from plant sources under a CSIR inter-laboratory programme. Some of the plants currently under scrutiny are from the Zingiberaceae, Lamiaceae and Mimoidaceae families that grow abundantly in Kerala. The organic synthesis group is interested in carbon-carbon and carbon-heteroatom chemistry through novel methods using ecofriendly reagents and catalysts. The resultant synthetic products have potential use in drugs and pest control. The method frequently employed with success is a multicompo-

nent reaction in which at least three chemical functionalities join through covalent bonds, giving enhanced speed, efficiency and are environment-friendly.

Waste water technology programme: This provides service to industry in environmental technology. Among the projects undertaken are: a hydrogen sulphide inhibition control system for the effluent treatment of a penicillin G plant, anaerobic filter in a milk-chilling plant, biofilter for deodourization of off-gas from chemical factories, anaerobic digester for biosolids containing waste water and a process to selectively remove iron and silica from process water for reuse in clay refining. The above projects were done for industries both in Kerala and those of neighbouring states. These technologies can be of benefit to greening existing industries that deal with a variety of products, ranging from sewage-treatment plants, chemicals and petrochemicals, agro-based industries to ice-cream factories.

Centre for Marine Analytical Reference and Standards: This centre is trying to achieve quality in measurement of the marine environment in the Coastal Ocean Monitoring and Predictive Systems Programme of the Department of Ocean Development, involving ten national laboratories and a state unit.

The RRL, Thiruvananthapuram is currently in the process of augmenting its strengths by a process of internal reorganization with an accent on more focused projects under a new Director, Javed Iqbal, an organic chemist with experience in both academia and industry.

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