Science and technology on the eve of the 12th Plan

As the country is gearing up for the 12th Five Year Plan, starting April 2012, proposals for the plan are being submitted. Three science secretaries of the Government of India throw light on the expectations from the Five Year Plan.

Thirumalachari Ramasami

T. Ramasami in the Department of Science and Technology, New Delhi, on 29 November 2010.

T. Ramasami is Secretary, Department of Science and Technology (DST), Ministry of Science and Technology, Government of India, New Delhi. Before joining this position in 2006, he was the Director of the Central Leather Research Institute, Chennai, for more than a decade. As the Secretary of DST, he is keen on attracting young talent to science. He narrates to *Current Science,* DST's role in promoting science on the whole and takes no credit for his contributions to the department.

What is the new National Science and Engineering Research Board?

The National Science and Engineering Research Board has been an aspiration of the community for a long time and it is somewhat similar to the National Science Foundation (NSF) in the United States. NSF is funded by the Government but functions as an autonomous body for achieving better efficiency. This structure is helpful for serving the local science community.

Our processes today, from the technical evaluation stand point, are not very different from what NSF has been implementing in the US. The National Science and Engineering Research Board in the country will maximize the good lessons we have learnt from the existing Science and Engineering Research Council of this department over the years and try to eliminate the bottlenecks associated with the unit, functioning within the norms of the Government. Although people may think NSF is efficient, it is efficient in a different culture. One must remember that eventually the unit must operate in the culture we are placed in. So, we are going to draw tools and mechanisms, and gain from the experience of all the councils in the country (not just Science and Engineering Research Council), and then embed them in this process.

What schemes of DST support school students?

The Ministry of Science and Technology has a responsibility to promote science, not the school students! Its focus is promoting science for research purposes, as research is the upstream end of the science stream. Over the years our Ministry was focusing on funding science and researchers, giving them support systems and so on, but we did not have a pipeline. Unless we have good students being attracted to the study of science and to carry out research, this reactive response to the needs of scientists already enrolled in the science community is not enough. Therefore, DST has devised a scheme called INSPIRE (see Box 1), which is proactively going into the school level and promoting the excitement of students with science, but the focus is on research such that INSPIRE standing by its acronym is truly an 'Innovation in Science Pursuit for Inspired Research'. Thus, the focus is on inspired research, where science is a pursuit not a profession. Our entire focus with this programme is to attract people with some interest in science and excite them.

We have announced one million INSPIRE awards of Rs 5000 value in schools for the age group of 10 to 15 years (students of Class VI to Class X). We ask the students to undertake a small project and exhibit it in a project competition; the students are visited by the best scientists of the country. They interact with the students and select 5 to 10% of them. Then we bring the students to the state level and give them a prize. Next, we take them to the national level. Under the same scheme top 1% of Class X pass outs who decide to pursue a science education in class eleven, are entitled to a summer camp and a winter camp with Nobel Prize winners of the world. In the last one year about 177 camps were held and 41,000 young people participated. About 17 Nobel Prize winners were invited. Nobel Prize winners come here; of course their science is great but they do create an aura. The students compete among themselves and create an upwelling and excitement.

The top 1% from X and XII class who decide to do a science course or those who have qualified for IIT-JEE, but have joined a science course (instead of an engineering course) are given a scholarship for five years for the course. We now have 4,500 people studying science courses because of the scholarship scheme. Anybody who is the top ranker in any branch of science, be it medicine, engineering, technology, agriculture or veterinary, and decides to do a Ph D, gets a full scholarship. In 2010 there were about 1200 applications. We have also mounted on top of this an offshoot career opportunity where they will get a five-year job as a research faculty, salary commensurate with that of an Assistant Professor of IIT, under which they can go to any place in the country and get a research grant of 35 lakhs in addition to the scholarship. This way the scheme is benefitting people from age of 10 to 32 years. So the focus of INSPIRE is not really school students and INSPIRE is not the only scheme we have. There are wider programmes than INSPIRE.

The Children's Science Congress is an activity we are engaged in, where we don't look at this excellence but bring an awareness of science.

What are the other major schemes of DST?

One is PURSE (Promotion of University Research and Scientific Excellence). DST has mapped the publications from institutions in the ten-year time span (1996–2006). Looking at their science contributions, we have found only 35 institutions responsible for 47% of the publications of the country, out of which 14

Box 1. INSPIRE (Innovation in Science Pursuit for Inspired Research)[1].

The INSPIRE programme was launched by the Department of Science and Technology, Government of India, in December 2008.

The INSPIRE programme has three broad schemes:

- Scheme for Early Attraction of Talents for Science (SEATS); age group: 10–15 years.
- Scholarship for Higher Education (SHE); age group: 17–22 years.
- Assured Opportunity for Research Careers (AORC); age group: 22–32 years.

Under the SEATS, two lakh school students are selected every year for the **INSPIRE Award** of Rs 5,000 each. This is a one-time award. Students whose performance is in the top 1% in class X examinations are eligible for the **INSPIRE Internship** under SEATS. Annual summer and winter camps are conducted for 50,000 class X toppers pursuing science in class XI. These camps are held at 100 locations across India. This scheme promotes interaction of youth with Nobel Laureates.

About 10,000 scholarships are offered every year as SHE for undertaking B Sc and M Sc degrees in natural sciences. This is meant for students who were top 1% rankers in XII central and state board examinations. Those who have qualified Kishore Vaigyanik Protsahan Yojana (KVPY), National Talent Search Examination and Jagadish Bose National Science Talent Search examination are also eligible for SHE. International Science Olympiad Medallists and the top 10,000 rankers of qualifying examinations such as IIT-JEE, AIEEE and AIPMT each, are eligible. Students of IISERs, NISER, IITs with science courses and DAE–CBS of the University of Mumbai are also eligible for it. Besides scholarships, mentoring is provided through summer attachment to performing researchers. Each student is given a scholarship of Rs 60,000 per annum; a mentorship cost of Rs 20,000 goes to the teaching institute.

Under the AORC scheme, **INSPIRE Fellowship** is given to 1st rank postgraduates in science and any professional course like engineering, agriculture, medicine or under-graduate in any professional course getting enrolled into a Ph D programme at any recognized university and academic institution. An **INSPIRE Faculty Scheme** under AORC is meant for carrying out post-doctoral research. The criterion of selection involves rigorous assessment of an applicant's research by an expert committee.

1. http://www.inspire-dst.gov.in/

were universities. DST has rated a scheme to give them an incentive grant based on the number of publications and *h*-index. Without their applying, we gave these 14 universities about Rs 200 crores for three years. Three years later we mapped the publications in the country again; all the 14 of them have climbed up in the *h*-index ladder. Now we have 29 universities mounting to publication response. In all we have been looking at 43 universities mounting on to publication response.

Consolidation of University Research for Innovation and Excellence (CURIE) is for women-only universities. There were six women-only universities where the infrastructure was weak, we mapped them and gave them a research infrastructure grant. We are a policy organization and policy has a promotional role and we are now trying to set up a scheme for women creating 1000 positions in the country with which an employed woman can move from place to place without having to search a job somewhere and if they can get an attachment to any institution this scholarship will provide them the support system. This is a flexible mobility scheme.

These are the kind of avenues, which are not promotional schemes, but development schemes for which the results will show over long periods of time, not in a short span of time.

What are the major projects undertaken by DST to support DST laboratories?

There is no such thing as a DST laboratory. There are laboratories in this country that were established by distinguished and eminent citizens of India like C. V. Raman, J. C. Bose, S. P. Agharkar and D. N. Wadia. These people had set up private research institutions. Those institutions have now become Centres of Excellence and are hotspots of knowledge. We fund them but we don't run them; we do not prescribe the research agenda for these institutions. So, each one of these is an autonomous society; they have their own governance. DST goes by the advice of the governance system of that particular society and provides them funds for doing what the society recommends to the extent our budget permits. Therefore, our engagement in these institutions is to ensure that the funds that we provide them are deployed correctly for doing what the society or the governing body of the institution permits them to do. Therefore, these are unlike CSIR labs, where the agenda is fixed by the institution. The agenda here is fixed by the individuals working for science.

What areas in science and technology do you see as problematic areas?

I consider them as opportunity areas. Energy is a requirement for the world at large. We have mounted a solar energy research initiative, which is a pan-IIT initiative, it is a challenge for all IITs to come together and address technology solutions for solar energy issues, driving the cost of solar energy down to technological innovations. We have started similar initiatives for fertilizers, homeland security and water.

Potash-based fertilizers are important for Indian agriculture. We are reliant completely on import currently. This import dependence coupled with fertilizer subsidy needs make indigenous techno-

logies for potash fertilizers critical. The Central Salt and Marine Chemicals Research Institute (CSMCRI) has developed a technology for potash fertilizers from sea water. If the technical and financial viability of the indigenous technology from CSMCRI could be established through a test bed, India stands to gain significantly. This would enable a proper and scientifically assessed pricing and subsidy policy for potash fertilizers. DST and the Ministry of fertilizers together have promoted a research–industry partnership for establishing a test bed for potash-based fertilizers in the factory premises.

The Indian Institute of Science has been tasked to create a National Network on Homeland Security. This is a security technology initiative, front-end science not a product.

What areas of science and technology is DST planning to enter in the future?

DST is not an output-driven organization. There are other departments which use the top–down driving mechanism. DST has to function as a gentle body that nudges the science community towards a scientific approach and solutions rather than drive them down. When we talk about the future of India, do we have enough challenges in this country to address? Every challenge is interesting and important whether it is water, agriculture, biotechnology, healthcare, affordable healthcare, biomedical devices and technology, renewable energy, protection of environment, etc. DST is trying to create an ambience and a framework for addressing some of these important challenges.

We have been working as a system that funded only individual investigators to do what they want to do – bottom-up approach – that will continue. The National Science and Engineering Research Board will operate in this direction. Now we are trying to define the nationally challenging problems and create an ambience for knowledge network frameworks, groups to come together and those groups are not just scientific groups alone, there will be industry, society and so on, and then provide them the sufficient resources and the governance to ensure that they convert money into knowledge or a product.

DST is like air, the essentiality of which is felt only by its absence. DST is an organization laying the foundation of science even if it is in select areas; India requires science in every possible area and dimension but the superstructure is not what DST is associated with; CSIR, space and atomic energy departments are the superstructures. DST includes certain areas, does not exclude others whereas other bodies strategize. The future of this department therefore will change the way we work rather than what we work upon. If you want to connect government to people, you have so many of the several vertical silos – space, atomic energy, coal, steel and so on but these do not go with each other so well. Thus, DST is scientifically horizontal, connecting various functions; it connects the fertilizer industry to science, and solves the problem, connects the steel ministry and the institutions working on steel to address an issue, etc. So it changes the process. This is the new method of working of DST. We are now a technologically agnostic body.

DST has mapped from the open source data changing trends in per capita incomes at district levels using 1993–94 as the base year. The idea is to map the growth trends of per-capita incomes with districts as units and examine through socio and techno-economic studies as to whether there were any technology and innovation based reasons for high growth trends in low income base districts. If there were any situation where technology diffusion had made the difference to per-capita incomes, the department in association with other ministries and respective state governments plans systematic technology interventions, sourcing technologies from public funded institutions under centre–state technology partnership. The motivation of this effort is to make technologies deliver socio-economic values to people through planned technology interventions.

What is expected in the 12th Five Year Plan?

I don't believe in expectations. There are three ways of investment – one is investment into hope, second is into expected returns, and third into calculated returns. The institutions that are intramural research bodies can talk about commitment to an expected return or a calculated return. I don't work with scientists there. I work with India. Therefore, when you are working with India, the scientists do not have the administrative control, even if they want to, we don't want them. Therefore, we are investing into hope, and when we are investing into hope, we don't talk about expectations, we talk about aspirations.

What have been your key contributions as the Secretary of DST?

Nothing. I am here to develop a system, to develop something that outlasts me. If I am going to work on something which is my contribution, what will happen when I go away? Science of India requires a continuum, it does not require a plural leader and this department requires a serving government employee.

What are the plus points of being in this position?

Plenty! I am able to serve the country better. Most scientists focus on success. As a Secretary I focus on service. All my life as a scientist I focused on discovery; most discoveries do not provide solutions to people. Technology is not a solution; it is an input to a solution. I have been looking at solutions and that can happen only as a Secretary. I tried to reduce the tensions between bureaucracy and technocracy in this department.

Scientists are in the nonlinear world; they work on growth and nonlinear processes. Bureaucrats and civil servants work on a linear processes; they have to maintain stability, not growth. They have to ensure that jurisprudence provides the same rights for the same conditions for all people. Therefore, they maintain stagnancy. Scientists on the other hand, work on a nonlinear path; they don't think the same day twice and that is the cultural dichotomy. So what the DST should do and what we are trying to do is to work at the interface of the linear and nonlinear processes. We try to reduce the interfacial tension, make the scientists recognize the site of the bureaucracy and make the bureaucrats appreciate the sentiments of scientists; generally bureaucrats focus on processes and scientists are supposed to focus on the purpose and the connection between the process and the purpose is what we are trying to create.

Maharaj Kishan Bhan

M. K. Bhan outside the guest house of the National Institute of Immunology, New Delhi, on 28 November 2010.

M. K. Bhan is Secretary, Department of Biotechnology (DBT), Ministry of Science and Technology, Government of India, New Delhi. An M D in Paediatrics, Bhan contributed to the development of rotavirus vaccine based on neonatal strain; the vaccine is undergoing clinical trials. His research interest led him to identify enteroaggregative *E. coli* as a causative agent of persistent diarrhoea, and developing its treatment, now widely in use. He has served as the Chairman of the WHO Task Force on child health research and is a member of several committees in the field of medicine. He is also the advisor to the Drug Regulatory Authority of India. He talks to *Current Science* about the initiatives of DBT and his involvement.

What do you like about being the Secretary of DBT?

It is an opportunity to serve a community that creates knowledge and useful technology. The scientists do not ask for much. Those of us in the government must anticipate their needs, respond generously and efficiently. It is an opportunity to learn and share. One meets interesting people across many disciplines who think critically, impersonally, with boldness as well as wisdom. Being in government facilitates participation in a variety of knowledge circles. I also value the opportunity to study institutional ecosystems that sustain long-term excellence, an issue of concern in India. It is a vintage position to study connectivity between government, science, industry and society. In a way, the whole is more relevant to absorb than the components. As a scientist, you see only a part of it.

What are the downsides of being in this position?

It is easy to be prescriptive, and to focus on short-term gains for self-identity, at the expense of long-term development. The recent decline in tolerance for plurality and the lack of social trust limits bold initiatives. One reason why Western science does well is that it values failure.

It is also challenging to be part of a governance system that focuses on process only and less on the fulfilment of purpose. Science, innovation and science-based entrepreneurship are all critical to biotechnology but it requires different processes and support systems. 'One size fits all' does not really work.

The executive job leaves little time for reflection; the role of service delivery and making policy are difficult to handle simultaneously as work expands. The reason why government-based services do not perform well is because they are inherently non-competitive. A redesign of our governance system to strengthen policy and strategy, planning and service delivery would go a long way.

How has DBT or the biotechnology sector benefitted with your presence as the Secretary since 2004?

The Department of Biotechnology, as a board, undertook missions where technology was harnessed for important developmental goals. When upgraded to a department, its focus, very appropriately, was to develop a deeper base in biological science by supporting education and training, infrastructure, basic research and begin some efforts in technology innovation.

We have built on these efforts and adopted a more integrated strategy that includes basic and interdisciplinary science and an innovation system where early and mid-level translational research, product innovation targeted at affordable solutions to meet challenges in health care, agriculture, energy environment, all find their rightful place. The pillars of a good science system are people, institutional framework and governance.

Life sciences is in an explosive phase and keeping pace is a challenge. We have initiated our programmes in several areas, such as stem cell research and regenerative medicine, RNA biology, nano biotechnology and interface with medicine and agriculture, systems biology, plant molecular science and genomics, basic and clinical proteomics, molecular and applied energy science, foetal and neonatal developmental and disease biology, and application of science to better understand pregnancy and birth. In achieving success in these areas, quality people and not investment are the rate limiting step.

While our science policy is sound, we perceived a need to put in place a well-thought out strategy to leapfrog Indian engagement in addressing technology generation/access, translation/validation and eventual commercialization. This has been initiated by addressing several steps, such as strengthening translational research at mid-level and not focus only on incremental innovation; building capacity to address entire innovation value chain; working towards a new regulatory regime (Biotech Regulatory Authority); improving ethical standards in human research; creating reliable product validation capacity; new institutional mechanism for idea conceptualization such as 'bio-design'; and connecting medicine, agriculture, engineering and basic science through novel mechanisms.

We have made a transformational change in the way academia–industry (SME) interactions are enabled; supported schemes such as SBIRI, BIPP, Ignition Grants; nurturing young talent pool to meet innovation requirement; established BIRAC under DBT as an autonomous agency, Clinical Development Service Agency (CDSA) for product validation and regulatory support at THSTI, Faridabad, translational technology platform at ICRISAT to help universities and SMEs in agriculture technology development; bio processing centre at Mohali for value-added products from agriculture residue and through modern food biotechnology, C-CAMP at Bangalore as a readily accessible advanced technology platform and others.

We have renewed our commitment to strengthen science close to education. DBT is now well on its way towards spending 50% of its R&D budget in the university system. Apart from R&D projects, we are establishing interdiscipli-

nary life science centres in universities, providing programme support on a long-term basis to well performing departments. We hope to provide major support to 25 universities by the end of 2012.

DBT has initiated several new research institutes. These are centred on disease biology and translation and cover health sector, agriculture (food and nutrition science), animal science, stem cell and regenerative medicine. These are hopefully not more of the same, but a real complement to our existing good institutes focussed on cell and molecular biology.

There is now a greater diversity in the way we fund. The centres of excellence, five-year grants for leaders, programme support for universities, young investigators grants, women scientist grants, a variety of fellowships in India such as biotech innovation awards, the Stanford-India Biodesign fellowships, inter-institutional programme support, DBT partnered centres, and support for innovation service centres are some of the examples.

We have taken decisive steps to attract overseas Indian scientists back to India (DBT–Wellcome Trust Fellowships, Ramalingaswami Fellowships) and reach out to young Indians overseas. Close to a hundred scientists came back last year and more through DST's Ramanujan Fellowship. We have reached out to connect medicine, engineering and basic science through novel mechanisms; extramural centres of existing institutes (CMC-Vellore of inStem), inter-institutional centres (IIT Delhi and AIIMS), Glue Grants, graduate schools and many others. DBT has created an interesting model in BIRAC for supporting innovation with a contractual career path that is novel. This model is being adapted to CDSA, the new technology platforms and regulating test labs. DBT's international programmes have received a major boost and they are well-governed.

Are any other schemes planned?

We have a long list of tasks to be completed: the biotech regulatory authority, new institutes, BIRAC and the bioscience clusters. We propose to come up with improved schemes for developing research excellence in universities; promoting science and education in biology in IITs and top medical and veterinary institutes; with ICAR we aim to create a modern network for marker-assisted breeding with excellence in genomics and phenomics.

We will establish regulatory testing laboratories to address public concerns. We need better mechanisms for supporting small science meetings and for supporting star colleges and teacher training. It is planned to establish a national system for storage and use of the massive amount of biological information being generated and link it to experimental science.

Finally, we have doubled the scientist posts in DBT. The challenge is to make DBT capable of giving hassle-free services and build the capacity of young recruits.

What is the basic idea behind creating bioclusters?

Science-led innovation and techno-entrepreneurship is more effective in clusters where science education, scientific research and diverse talent pool required for innovation services related to regulation, investment, law, technology transfer, incubation and place for start-ups, are available in a functionally linked and physically close ecosystem. Clusters and knowledge centres require championship, leadership and governance over and above that of individual institutes. Success is measured in terms of social and economic impact. We are engaged in building clusters at Faridabad, Mohali and at Bangalore. Though the challenges are formidable, the experience is great.

What are the problem areas in biotechnology?

The problems are at several levels. In ensuring future food security, how do we develop and deploy technology that is safe, effective as well as farmer-friendly.

Regulatory system needs strengthening, quality people, leadership and global best practices. Our basic and interdisciplinary research is growing but not reaching world class. It is to do with quality people, and effective mentorship. The education system must produce 'educated but effective people'. Teaching and teachers need major attention. Major research resources are lacking for discovery and translation. This needs a decisive push. Science governance as a whole needs improvement through better use of technology, better presence and well-trained workforce.

Finally, measurement of performance is missing at all levels – government agencies, universities and institutions. Data is scanty; it is often not used for planning or investment decisions.

What do you think is the way forward for genetically modified food crops in India?

My reading of the literature is that genetic modification at a single gene level is safe. More complex genetic modification needs careful watch. Our experience from human vaccines suggests that a case-by-case approach is the way forward. Whether an event is safe or has the efficacies that are claimed is best judged by a team of high quality scientists and regulatory professionals without conflict of interest.

So do you think imposing a moratorium on Bt brinjal was the right move?

The process by which this conclusion was arrived at has elements that I am not comfortable with. Issues of safety and commercialization were mixed up due to lack of clarity. Community decisions should be made on the principle of listen, learn and teach. Experts should be selected among an approved list at random, not a result of prejudice on either side. As yet, we seem less prepared to handle such challenges in a mature, patient manner.

There has been a lot of criticism of biotechnology courses at the undergraduate level. What do you have to say to this?

I think undergraduate education should be broad based and develop strong basic understanding, creative thinking, experimental experience and analytical ability. Specialization is relevant only at later stages.

What is expected in the 12th Five Year Plan?

We have more or less completed implementation or at least obtained approvals for what was committed in the National Biotech Strategy. We have started a process of generating a vision and strategy for 2025, and within that we will have, with help from peers, crafted out the 12th Plan. I do not want to push my own ideas prior to group thinking by peers.

Shailesh Nayak

Shailesh Nayak in the office of the Ministry of Earth Sciences on 29 November 2010.

Shailesh Nayak is Secretary, Ministry of Earth Sciences, Government of India, New Delhi. He joined the position in August 2008, before which he served as the Director of the Indian National Centre for Ocean Information Services (INCOIS), Hyderabad. He talks to *Current Science* about initiatives taken by the Ministry and recognizes the dearth of human resource in the field of earth sciences.

What are the objectives of the Ministry of Earth Sciences?

The purpose of the Ministry of Earth Sciences is to understand various components of the earth system – atmosphere, ocean, sea, snow and ice, and geosphere; how they interact with each other; how the energy and material transfer from one component to another and this essentially will help to have a better forecasting capability for weather, monsoon, climate or some of the hazards. Earlier what we had was sectoral – India Meteorological Department (IMD), Indian Institute of Tropical Meteorology (IITM) and the National Centre for Medium Range Weather Forecasting (NCMRWF) were essentially looking at some of the atmosphere-related issues; the Netherlands Indian Ocean Programme (NIOP), National Institute of Oceanography (NIO) and INCOIS were studying oceanography; the National Centre for Antarctic and Ocean Research (NCOAR) was studying snow and ice, essentially Arctic and Antarctic (not Himalayan). They were working in individual sectors, not how interactions between these components are taking place.

The first current objective is that we need to put them into areas where the interaction takes place, of the people first, and to evolve programmes which are of that nature. Now, fortunately there are climate change-related programmes and some of the programmes related to monsoon that allowed us to do this. We are trying to build the integration of work, people, institutes, so that everything works together. This was never done earlier. Unless we try to do this, we will not be able to model, predict or forecast correctly.

What have been your key contributions to the Ministry?

We are trying to improve forecasting. To achieve this we have taken certain steps – one major step was installing the observing systems; you need a certain density of observations, not only in the atmosphere but also on the ocean and other fields. That is now on. Some initiatives were taken on the atmosphere side before I joined; I have taken up some on the oceans side because that is equally important. We are in the process of building the ocean observing capability.

The second important thing we did is building the computing infrastructure, which was not there earlier and to model you need high performance computing (HPC) systems. Now we have been able to place HPC systems in four institutes – NCMRWF, IMD, IITM and INCOIS – which put together may account to around 100 teraflops (floating-point operations per second; used to measure the computing capacity). But this is not enough, this is only the beginning because we need to learn also how to do HPC. Our requirement is about 800 teraflops, which we will be building in next 2–3 years.

We have been using the models developed in USA, UK and other places. We need to develop a model suited for Indian conditions. We have installed coupled ocean–atmospheric model for weather and climate forecast. We need to improve and customize this model and ultimately develop our own model.

Another initiative is the assimilation of satellite data, weather data and other data. That activity has started mainly in NCMRW. So a lot of progress has been made. We have been able to assimilate some of the satellite data and observed data. We also need to understand the processes which are interacting like ocean and atmosphere, or land and atmosphere. This work has been taken up mainly at IITM, NCOAR and INCOIS. For understanding of the processes we are also involving other academic institutes like IISc, IITs, NIO and NGRI. We have a programme by which we can get their inputs. Once the understanding of the process will be there, we will put that information into the models; programmes have been formulated. We are also planning to have a monsoon mission.

But ultimately to do all this we need human resource. We have not invested earlier in human resources especially in this area. We have now formed an advanced training school for earth system and climate in Pune. We will offer guaranteed employment, i.e. participants will not be taken as trainees but as employees of our Ministry. They will be getting a stipend during that period which will be substantially higher than Junior Research Fellowship. They will be trained in different fields related to climate change, which again involves all the fields – ocean, atmosphere, snow and ice. They will be trained at different levels for about one year or less, which can then lead to M Tech or Ph D degree. Once this is over they can join one of the institutes and continue there.

Are there any other schemes for the young other than the training school you mentioned of?

There are many other schemes. We support universities and have a programme 'Ocean Atmospheric Cell' in the universities. We provide grants to the universities and in turn they recruit research fellows. We have separate schemes for the IITs, particularly for building human resources in IIT-D, IIT-K, IIT-KGP and IIT-M. We are discussing with IIT-Powai, IIT-Gandhinagar and IIT-Bhubaneswar about how we can further interact within this area. We have received a proposal from IISER-Kolkata. We are interacting with IISER-Bhopal. Our units also have their own projects that in turn support the students.

What are the new areas that your Ministry is planning to enter?

We will be taking up 2–3 major programmes. One is the earthquake research; we are at present not able to predict earthquakes. We have started precursor

studies including all the precursors. There are different views – that radon gas comes out, some say ground water goes up or goes down; like these various precursors are there. We are now trying to put labs having all the precursors at one place where earthquakes are likely to occur. One lab is already functioning in Central Himalayas, in Guttu, which is near to the main earthquake-prone area. Similar labs are planned in the North East, Jabalpur, Andaman and Pooch. So we cover all the areas; in Koyna we have been able to predict some of the earthquakes with a reasonable accuracy. Last year we had done this for Koyna earthquake. Harsh Gupta and his team did that in National Geophysical Research Institute, Hyderabad and it was pretty close to the prediction. We are planning to dig two more holes, 6–8 km deep, to study the various processes that happen during the earthquake, before and after the earthquake, and the various aspects of earthquake. This is one major programme we are conceptualizing.

The second major initiative is a similar deep core hole in the ocean bed; we are planning to have a deep core hole in Lakshadweep Islands in the Arabian Sea. There are two problems; one is to understand how the crust has evolved, when we separated from Antarctica and second is a huge sediment sequence; we can know what happened in the past, especially what happened in the last 40 million years or so. Then there are questions like how monsoons originate, what are the other paleoclimates, etc. We have submitted the science plan to IOBP (International Ocean Building Programme). We may get a ship in 2012 to dig a deep core hole. We are also considering a similar borehole in the Bay of Bengal.

What are the problematic areas in Earth Sciences?

We have not invested in the past in research, and because of that we do not have sufficient people to take up these tasks. Building human resource required to do all this I mentioned, is the major issue today. You can buy equipments and buy computers, when there is money, it doesn't take much time, but building the capacity to use the HPCs, or models, cannot be done overnight. It takes its own time. That I think is the major issue we are facing. I don't think we have any problem of getting sufficient funds.

Earth sciences is not perceived as a very popular, lucrative career option by the young...

It is because students were not made aware of the kind of excitement it could have to study the earth sciences. We have to design our programmes such that they excite them. We have taken some actions to excite them. For instance, we took expedition to the South Pole.

We also have a plan to make a submersible which can take you to the bottom of the sea. Programmes of the kind where they can think and imagine have also been taken up, e.g. sea bed is not mapped yet. These are similar to satellites but at the ocean bottom. I think we have not done sufficient to excite them in something which is unknown. We need to do that and hopefully these kinds of programmes will excite them and make them come back to the earth sciences. I don't think passion is always where you get larger money or larger benefit.

What is expected in the 12th Five Year Plan?

Earthquake research, monsoon mission and deep ocean drilling are important. We are also going to build ice glass vessels. We have planned a huge programme in understanding the biogeochemistry of the ocean. In the ocean, we have an area which is low-gravity anomaly in Southern Indian Ocean. It is the largest negative anomaly on Earth and has not been studied yet.

We need to study two areas, Himalayas and Andaman and Nicobar islands, from the tectonics angle; how they affect the earthquake in the subduction zone. On observation side we would like to cover the entire India by weather radars, so anything happening does not go unnoticed. We may have to put about 60 weather radars. We have already put on the coast some high frequency radars to measure the ocean currents. We would like to cover the entire coastal area with such radars. A lot of improvement in the observing system is planned. We have to build a computing facility of up to 1 petaflop. Another major programme we have launched is on the Earth system models.

Apart from the routine services which we have been providing we are going to have 8–10 major missions of this kind, which will fill into building capacities, infrastructure, and some of the research to understand the various processes.

Message for the young...

I would like to tell them that Earth Sciences is also a very exciting subject. The major satisfaction that you can get by working in Earth Sciences is serving the society, different communities of farmers, fishermen and a variety of masses.

We have to build on the resources which we have and explore new resources and phenomena, the understanding of those phenomena, and then apply that knowledge to improving the quality of life.

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