Directed basic research or science for sustainable development

I. P. Abrol

Science in India needs to undergo a paradigm change whereby it is viewed to have an explicit and a more direct relationship to building a knowledge economy for sustainable development. Progress in solving complex sustainability problems will be increasingly demanding on both basic understanding and learning as to how to apply existing knowledge in problem-solving mode – bridging the artificial and unending divide between basic and applied research. Building a shared vision, amongst the S&T community of the critical role that science can play, and developing and promoting a science agenda for sustainable development is a challenge, where the science academies and similar institutions have a role to play.

Chidambaram[1] suggests the term 'directed basic research' in selected areas determined in the national perspective as a way to generate knowledge which would benefit the society in the long term. He distinguishes 'directed basic research' from what he calls 'self-directed basic research' in that, while in the case of former, results of research would have the potential to benefit societal interests in the long term, in the latter case there would be no other deliverables than knowledge generation. In an earlier communication, Chidambaram[2] had suggested classification of R&D work in India into different categories which included basic research, mission-oriented applied research and technology development, country-specific applied research and industry-oriented research. These suggestions coming as they do, from the Principal Scientific Advisor to the Government of India on the occasion of the Platinum Jubilee Celebrations of National Academy of Sciences, Allahabad, need to be viewed in the context of debate and discussions in recent years on the state of science in India. There appears a general consensus that both quantity and quality of science has been declining and that the country's standing, vis-à-vis others, has greatly diminished[3,4] and that India's scientific community had little to offer by way of a coherent strategy based on appropriate short, medium and long-term goals formulated collectively[5]. These concerns have been now expressed at the highest level. Speaking at the meeting of the National Development Council[6] to deliberate on issues related to the food and agriculture sector, the Prime Minister observed 'one feature that stands out is the lack of any breakthroughs in agricultural production technology in recent years. There is a technology fatigue which we need to address'.

Earlier speaking at the Indian Science Congress, the Prime Minister observed that he is 'deeply concerned about declining enrolment in basic sciences and that the decaying university system needs upgrading in a massive way' and that 'while our government will do its utmost to invest in science, I call upon the scientific community to also invest its time and intellectual energy in the revitalization of our science institutions'. The reasons for the decline in Indian science are complex and so are likely to be any solutions aimed at revival of science. One thing, however, is clear – India's future growth and development are intimately linked to creation of a knowledge economy – an economy that creates, disseminates and uses knowledge to enhance growth and development and that scientific institutions/endeavours have a critical role in contributing to the emerging knowledge economy which presents the most attractive opportunity for lifting Indians out of poverty by enhancing overall productivity and per capita income[7,8].

Basic–applied research dichotomy

Any discussion on the definition and the need for relative emphasis on different types (applied, mission-oriented, technology development, basic, etc. and now, directed vs self-directed basic) of research is unlikely to be conclusive since, as Chidambaram points out, the borders between different types of research are fuzzy and they are often the result of human tendency to oversimplify issues which are inherently complex. Yet discussions on basic–applied dichotomy although unending, have been contributing to improved understanding of the scientific process and interrelationships between the apparently disconnected components[9]. Thus, a US administration report 'Science in national interest' released in 1994, observes that there is 'need to acknowledge the intimate relationship among and interdependence of basic research, applied research and technology and appreciate that progress in any one depends on advances in others'. Another report from the US House Committee on Science 'Unlocking our future: Toward a new national science policy' in 1998, observes 'far from being separate and distinct, the seemingly initially unrelated pursuits of basic knowledge, technology or instrument-oriented developments were now understood to be a weaving of a single, tightly woven fabric of one seamless web'.

This, then, brings me to the second and more important but somewhat less emphasized point in Chidambaram's paper, that is, the need to identify areas keeping in view India's national perspective and which have a built-in societal interest. I should like to elaborate on this through an example.

Nearly four and half decades ago, I had an opportunity to visit Israel and interact with scientists in my area of scientific research, i.e. soil science/agriculture. Invariably the preamble to their activities/or scientific agenda would be 'Here in Israel our water resources are limited: with increasing and competing demands we must increase agricultural productivity using 30% less water over the next two decades'. Farmers would tell how they were trying to economize on water use by, say, operating sprinklers in the night when evaporative losses were minimal; technologists were busy designing sprinkler and drip irrigation systems for greater control and uniformity of application of water and nutrients; engineers were perfecting ways for long-distance water

transport with minimal losses; plant physiologists trying to understand basic processes underlying water economy of plants, crop improvement specialists trying to design plant types to match reduced water supply, soil scientists and agronomists trying to improve soil, water and crop management techniques for higher efficiency. On the more basic front, scientists were at the cutting edge of research to understand membrane transport processes, aimed at desalinization using reverse osmosis technologies, etc. The results of those efforts are for anybody to see – a country where farmers are most knowledgeable and use water most efficiently; the scientific community is respected and is in demand for its expertise and knowledge, not to say of the record number of publications in leading scientific journals and industry and business houses are in the forefront of marketing technologies globally. What I have said about water would also be true of other areas, e.g. energy, defence, etc.

The moral of the story and which is somewhat in tune with Chidambaram's suggestions is that science in India must undergo a paradigm change – from one where science must be promoted for the sake of science; because it has possible spin-offs in terms of societal benefits and that it is a cultural necessity to one which views a more direct and explicit relationship between science and development, between science and the solution of emerging problems facing the society in the short, medium and long term. Depending on the societal goals that we define for ourselves, different types of research then become a seamless continuum and basic research a necessity and not a luxury.

Ramans and Ramanujans

While it is absolutely important for Indian science not to miss out on the potential Ramans and Ramanujans, equally and perhaps more important is to motivate and meaningfully engage the large mass of scientific community in pursuit of goals that we together set for ourselves. One of the biggest problems of a working scientist is that we are not part of any mission, which will continually guide our efforts. Individual scientists are left on their own to define what they wish to do and how they wish to do the same. Most researchers from India do extremely well working in Western laboratories for doctoral and postdoctoral work, because often they are a part of a team/project aimed at contributing to a larger objective or goal. Fortunately we have good examples in the Departments of Atomic Energy and Space where R&D programmes were organized around well-defined goals and the results are before us. What is now required is to align our overall science agenda around well-defined thematic areas which will contribute to achieving overall development goals and benefit the society, i.e. we need science in the national interest. And this agenda must be lead to building a coherent strategy aimed at achieving appropriate short, medium and long-term goals formulated collectively[5].

Sustainable development – the new context for science

Ever since the concept of 'sustainable development' emerged as a global development paradigm at the UN Conference on Environment and Development 1992, The Earth Summit, there has been a continuing debate on the ways of achieving goals of sustainable development and the role that science can play in achieving these.

Traditionally science has largely been pursued in a disciplinary mode and as a result our views of development issues have been always bounded by our specialized disciplinary knowledge, and many of our serious environmental problems are the direct result of applying narrow, specialized knowledge to complex systems. In particular, there has been little effort to understand how social and natural systems (society and nature) interact and drive towards unsustainability. It is in recognition of these shifts in thinking that several initiatives worldwide are engaged in a debate as to in what way science must reorient to respond to societal concerns (e.g. Friiberg Workshop on Sustainability Science[10]). One thing that emerges clearly from these discussions is that science aimed at contributing to sustainable development, sustainability science, has to be fundamentally different from the way we have planned and executed science in the past, and that this will call for new patterns of institutional organization which foster and support interdisciplinary research over a long term, capacity building for such research and contribute to a coherent system of research planning, assessment and decision support. There appears a fair degree of agreement on the broad characteristics of effective research systems for sustainable development[11] and these include:

- Systems will have to be structured in a manner that they are driven by the most pressing problem of sustainable development as defined by stakeholders in these problems. This will certainly result in a science agenda which is much different than one which is the outcome of scientists' perception of the 'most interesting problem' in science and technology that needs solution. While the definition of the 'most pressing problem' would need to come from assessments at the national, regional and local levels, there is emerging consensus that these will invariably call for discovering and inventing ways which simultaneously seek to address human needs, particularly giving attention to reducing hunger and poverty while protecting the earth's essential life-support systems and biodiversity.
- Research for development systems will have to be highly integrative, not only to permit synthesis across disciplines, but also to enable to take on broad concerns of both economic development and sustainable resource use and environment. Particularly important will be to view production of scientific and technological knowledge through research as only one element of the larger 'innovation system', which is essentially the result of an interactive process between many actors which may include government and non-government organizations, universities, private companies, etc. Individual organizations rarely possess all the knowledge necessary for the whole process of innovation, and therefore the need to bring together many actors. Particularly challenging will be to find ways to identifying, utilizing and respecting the vast knowledge base and informal expertise of communities derived from practical experience in grappling with a particular sustainability problem in a particular social and ecological setting[12]. This will call for structuring, which facilitates 'vertical' connection between best research anywhere in the world and practical expertise in a particular situation. At the same time, the institutional set up will need to foster horizontal communication that enables greater learning from any regional experiences.
- Science for sustainable development will have to be more policy relevant (In-

ternational Council for Science, 2002)[13]. This will require science to deliver useable knowledge which is in the form of conceptual frameworks that provide insights for sustainability analysis; indicators and measures for monitoring development and environmental change; specific forms of analysis, e.g. cost-benefit, risk analysis, etc. and carefully constructed assessment that can provide policy inputs. And this knowledge has to reflect a geographic and regionally based focus rather than being generic in nature.

- Finally, research for sustainable development systems will contribute to the much needed bridging of the artificial but pernicious divide between 'basic' and 'applied' research. Progress in solving some of the urgent problems of sustainability will increasingly call for the much needed, both depth and breadth of knowledge – demanding on both basic understanding as also learning how to apply existing knowledge in a problem-solving mode.

Funding for science

Low level of funding is frequently cited as one of the major factors for the declining state of science in India. While there would appear no two opinions that increased level of funding is a sine qua non for improving the health of Indian science, in a democratic set-up such as ours, where funding comes largely from public exchequer, it must contribute to public goods – goods which are of value locally, nationally or globally. It is in this context that a more explicit relationship between science and sustainable development can provide a basis for sustained funding. If science is for society, society will be for science. The onus for building a new image of science as one which directly addresses societal concerns, rests with the S&T community.

In conclusion, creating a shared vision of the critical role that science must play in building a knowledge economy for sustainable development, and developing and pursuing a science agenda towards this is then a challenge and an opportunity for a new role for the science academies and similar institutions.

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I. P. Abrol is in the Centre for Advancement of Sustainable Agriculture, NASC Complex, DPS Marg, Pusa, New Delhi 110 012, India.
e-mail: iabrol@gmail.com