one to the east of Sholapur (Figure 2). Killari appears as located on the western margin of this eastern block. The violent upward movement of this block appears to have caused the faulted margin of the traps and Bhima sediments bounding this uplifted block to split and rupture vertically. This could account for the devastation at Killari to be restricted within a narrow zone without spreading laterally. This aspect needs to be attended to further, as it has serious portents for future earthquakes in the other areas of uplift and subsidence indicated in the gravity map. The depth to the base of the traps as indicated seismically is of the order of 260 metres. The trap rock has high elastic coefficients and longitudinal seismic velocity (~5300 m/s) and transmits highly the earthquake energy.

The Killari–Latur–Umarga region is reported to have experienced earth tremors for more than a year prior to the earthquake. While it is difficult to predict earthquakes, especially the magnitude and the time of occurrence, adequate monitoring of these tremors and ground movements might perhaps have provided some advance warning of the disaster. The other zones of subsidence and uplift indicated in the gravity map are also apparently earthquake-prone, especially the Nasik region in the northwestern part and the neighbouring fault zones (Figure 2), with potentialities for future earthquakes. It is advisable that these zones as well as the Bombay coastal area and the Koyna region and other earthquake-prone areas in India are monitored for ground movements on a long-term basis with modern seismological equipment and techniques and the latest satellite-based Global Positioning System, which may afford a better understanding of such disastrous intra-plate earthquakes.

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OPINION

Science and technology for development

Articles on Science and Technology in India in recent issues of *Current Science* and some newspapers should be of great interest and value to the intelligentsia in general and scientists in particular. Open discussions are essential to evaluate our achievements and focus attention on the future needs. I congratulate C. N. R. Rao for taking a lead in such a discussion and compliment *Current Science* for publishing differing viewpoints on such a vital subject at a critical time when there are changes of far reaching consequences in our economic and industrial policies.

India under the enlightened Prime Ministership of Pandit Jawaharlal Nehru recognized the importance of science and technology and established appropriate agencies and infrastructure in areas of vital interest to the nation. Today the country is in a position to boast of the third largest scientific manpower in the world and a large number of institutions of higher learning and research in every field of activity. There are some notable achievements particularly in the fields of agriculture, space and defence technologies, computer sciences, etc. to our credit. The science budget has increased from about 0.3% of the GNP in 1970 to about 1.1% in 1990. There has been some reduction recently in the eighth five-year plan allocations, bringing down the figure to about 0.9% of the GNP.

We have been supporting science and technology all these years. However it appears that sufficient thought has not been given to the obvious question – 'Science and technology for whom and for what purpose?'. Science for science sake – for revealing mysteries of the Universe and for understanding principles governing the physical, chemical and biological processes is most fascinating. Some of such studies may result in technological innovations for the benefit of mankind. Whereas basic science is universal, development of technologies have to be area-specific to fulfil the needs of the people.

Basic science has been going on in the country for long, but it has hardly resulted in any significant technological innovations. The industry and the government both have been freely importing foreign know-how and technologies for practically all the industries which have been set up in the country. And in the present situation of liberalization, we may find foreign companies coming in large numbers with their technology, equipment and machinery to flood markets in India with products ranging from potato chips to modern automobiles.

The recent articles in *Current Science* have raised a number of issues which need deep introspection and discussion. The questions which come to mind are

(i) Have the achievements of Indian science and technology since independence ever been critically assessed?
(ii) Whether such achievements have been commensurate with the financial inputs?
(iii) Have these accomplishments been of help to fulfil the needs and aspirations of the people of the country?
(iv) Is it a fact that, barring a few exceptions, science has been mediocre and repetitive?
(v) Has industrial advancement been primarily based on imported technologies?
(vi) Is it not true that even appropriate adoption and innovation in imported technologies have been lacking resulting in need for repetitive imports of technology in different fields?
(vii) Isn't it a fact that by and large even imported science and technology in the country has so far helped only the 10 or 15% of the upper strata of the population leaving the vast majority in poverty and squalor?

We are in a peculiar situation in India. Whereas we have been claiming that literacy has considerably increased and percentage of people below the poverty line has been fast decreasing due to large number of various welfare schemes implemented during the past, in actuality it is found that the absolute numbers of illiterates and those below poverty line have exceeded the total population of the country in 1947 when we became independent. Even clean drinking water is not available to a large majority of our population.

Our vision of social equality and development is extremely blurred even after 45 years of independence and there is no socioeconomic blueprint for the Indian society which is visualized for the 21st century and beyond. Do we wish to catch up and compete with the West for a materialistic society with increasing demand of newer products and consumer and luxury goods? With very different socioeconomic conditions and cultural background and with all the limitations of resources and growing population will it be ever possible to achieve that? If not, shouldn't we aim at a judicious mix of our ancient culture and civilization with appropriate science and technology to provide a contented and reasonably comfortable way of life to our people? And what is the contribution of scientists and technologists towards conceptualization of various possible models of development for the future generations to come? Should the scientists leave all these questions only to the politicians and administrators and isolate ourselves to work in our own ivory towers? Our scientific and technological goals have to be intimately connected with the needs and aspirations of the people and the society comprehended.

There has been no dearth of seminars, symposia, conferences and discussions on science, technology and development. Every formulation of 5-Year Plans has had components of science and technology. New faith in science and technology was kindled with the formation of Department of Science and Technology in 1969 and the National Committee on Science and Technology (NCST) in 1971. During the period from 1971 to 1973 a large number of scientists, engineers, technologists and persons from user ministries and industries were involved in the formulation of the science and technology plans to be incorporated in the economic plans of the Planning Commission. NCST prepared status papers in different fields of scientific activity, prepared research programmes to meet the future needs, identified institutions, worked out financial requirements and projected time frame for their completion A good beginning was made in some fields of activity and identified institutions but with the political changes in the country and scientists in key positions changing their loyalties, most of the programmes were forgotten and research priorities of the institutions and individual scientists got reoriented. No objective assessment of the accomplishments and failures of the NCST was ever made nor of the five-year plans of science and technology.

More recently a Science Advisory Council to the former Prime Minister Shri Rajeev Gandhi was constituted and a number of recommendations were made from time to time. I wonder if any factual assessment of the fulfilment of those recommendations is available anywhere. High power committees were set up one of which was chaired by the Prime Minister himself for research in high-T_c superconductivity and adequate funding was provided. But nothing has been heard of the accomplishments. The present Prime Minister has had two scientific advisors. Their contributions to science and technology policies have been unclear.

During the NCST exercise, the Sector of Natural Resources recognized the interdependence of all the elements such as land, soil, water, forests, wild life, minerals including petroleum and natural gas and the environment. A Commission for Natural Resources was proposed to the then Prime Minister Mrs Indira Gandhi by Sri C. Subramaniam, the then Chairman of NCST and Minister for Science & Technology. Unfortunately nothing moved due to vested interests at high levels. The various elements of natural resources still remain under the charge of different ministries and agencies which have been often working at cross purposes.

Our scientific institutions and science academies have produced self-glorifying annual reports and nebulous future plans all along but these were only to justify the budget demands. There is never a critical appraisal of their performance and never a presentation of their contribution in totality to the developmental efforts for the society. *Nature* (vol. 308 of April '84) came out with an article on Science in India by its editor John Maddox. While appreciating developments in agricultural sciences and green revolution, the article is critical of scientific efforts in many fields. It states 'India has set ambitious goals for science and technology, self reliance and relief of poverty. Some great things have been accomplished but much effort is frustrated'. In one of his visits to India as guest of the Indian National Science Academy (INSA) Nobel Laureate Prof. Abdus Salam had observed that not a 'drop' has been added by India and other developing countries to the 'pool of world knowledge'. Recently Hyung Sup Choi of Korea on his visit to India stated that 'India's science plans exist only on paper and its vast scientific man-power will remain useless unless its capabilities are organized for a specific purpose'. Choi has been primarily responsible for his country to become a technological power in the

South-East. He built Korea's first steel plant, was head of the Atomic Energy Research Institute and a Minister for Science and Technology. Choi said Korea followed the Japanese approach of 'imitation, adoption and improvement of technologies'. Korea was able to catch up with Japan in several areas in a short period of 30 years. He recommended India to consider following such an approach.

Comments of Maddox, Abdus Salam and Choi and other foreign scientists are often based on their own perceptions and of scientists whom they meet during their visits. I am wondering whether any in-depth and all-pervasive study has ever been made by our own scientists and institutions to show us what we have achieved and what we have not, where we stand today and where the future scientific and technological efforts should be concentrated Financial inputs alone do not provide any indication of the health of science and technology in India.

Under the prevailing conditions whom do we blame – the government, the scientific advisors and advisory committees to the Prime Minister, the heads of the various scientific agencies who have been deciding the fate of Indian science over the years? Of course the major failings could be ascribed to those scientists who were close to the seat of power. It is a vicious circle and most of these persons and the politicians, planners and administrators responsible for science, technology and development have to share the blame for the situations in which we find ourselves today.

Scientists should not take a narrow view of S&T to safeguard their own interests. A holistic view of the national development in all its totality has to be taken and one has, then, to find the part what science and technology can and should play and how different institutions and individuals could fit in to achieve the pre-determined goals. Broadly three major components of science and technology are needed to fulfil our national objectives towards eradication of poverty, employment generation, all-round economic growth, defense security and excellence in fields of creative scientific activity.

First:
Application of known and proven science and technology on massive scale to the basic needs of large number of people in our rural and slum areas on a time-bound basis; interactive research from land to laboratory and vice-versa will be required. Such activities would include land, soil, water management, agriculture, post-harvest technology, storage and distribution of food grains, etc., health, hygiene, sanitation, family welfare, small- and medium-scale technologies for appropriate cottage and rural industries, housing, roads, communication and building of necessary infrastructure. Problems such as recurring droughts and floods need the attention of scientists and technologists. Education for our rural masses plays an extremely important part in all these areas of activity and known technologies and innovations in the field of education need to be used on a very wide scale to remove illiteracy and develop scientific temper.

Second:
Applied research and development in areas of relevance to the needs of the people and growth of industry; industrial research and development of appropriate technologies suitable to the natural resources and indigenous skills need to be vigorously pursued. Labour-intensive and energy-saving technologies need to be given importance when the country is energy starved and has large unemployed population. In case of imported technologies parallel research and development would be required to assimilate, adapt and improve them to avoid repeated imports. Fields such as communication, energy, biotechnology and a host of other areas of applied research fall under this category.

Third:
Fundamental research by its nature is universal and in India this needs to be encouraged only in institutions where capabilities and facilities exist or can be created. Through process of rigid elimination this should be promoted only in selected areas among selected scientists at selected places. Fundamental research schools can be built only around established scientists and it needs to be supported only where talent exists By the very nature of basic research and limitation of funds it can be supported only on a limited scale. Some scientists have voiced their anguish and frustration which results obviously from their commitment and dedication to science. But then scientists themselves have to draw some line somewhere rather than an amorphous body like Indian government to do so. Considerable amount of work in diverse fields is going on in the advanced countries which can afford the 'luxury' of basic research. India must make full use of their findings in development of technologies of relevance to us.

The country has people and infrastructure for the type of research and developmental activities under three categories indicated above. The first and the third category of scientific efforts will have to be supported principally by the State. Applied and industrial research should have a major financial component from the industry. Organizations such as ICAR, ICMR, CSIR, GSI, Survey of India and some others should be able to provide sufficient number of scientists and technologists for extension work in 400 and odd districts to work along with the state government scientists, technologists, engineers, medical health workers and others They can take science and technology to grassroot level and bring their problems to the laboratories.

In most of the Western countries hiring and firing of personnel is very common depending on one's capabilities and performance. There, a large number of scientists work on projects which they submit and peers in the field critically review them prior to their acceptance by funding agencies. Their job is finished when the project is over and they have to seek funding again for their continuation. In India scientists have secure positions without fear of being thrown out for non-performance. And not everyone in an organization could be suited to quality research. It is generally found that most of the organizations have personnel who would fall in one of the three categories. About 15–20 per cent of scientists/technologists are devoted to their work and make worthwhile contributions to science and technology. There is another 10–15 per cent of people who constitute the dead-wood. This leaves nearly 50–70 per cent scientists/technologists in these organizations who are sincere and willing workers but need direction. These persons can be motivated to take up applied research and developmental activities pertaining to needs of the industry and the people and undertake intensive extension programmes to take science and technology to the rural areas.

Once our broad concepts of development and approach are clear and the tasks broadly defined it should not be difficult to develop an appropriate structural framework for countrywide developmental activities through science and technology. Social realities and the needs of the people will have to be constantly kept in mind and appropriate scientific efforts will have to be mounted towards eradication of poverty and squalor.

Scientific pursuit in different fields of activity should be rated at par. Scientific effort of various nature is involved in every activity. Scientists involved in fundamental research need not necessarily be considered a better breed than those involved in extension programmes for solving the problems of the people. Some scientists have often stated that tasks such as provision of drinking water is not the work of the scientists and there is no science involved in digging wells and providing water. These are notions far removed from the actual realities. Provision and management of water resources involve as much science as in any other field of activity. It requires integration of disciplines of geology, geophysics, hydrology, rock matrics, isotope tracer technologies, mathematical modelling and inputs from chemistry and bacteriology. Detailed studies of the watershed areas, river basins or sub-basins are required to obtain a dynamic water balance between take off and recharge to provide adequate water for the present needs and future requirements. Similarly definite technological and scientific inputs are required in all the developmental activities of human existence and his interaction with the environment. Unless we shed off ideas of high-brow research and judge scientific effort objectively on its own merit it will be obviously difficult to inspire scientists and technologists to take up extension programmes and laboratory to land and land to laboratory scientific approach for the good of the common man And this has to be done by scientists and technologists in the first place to inspire confidence in science and technology and obtain national recognition.

The reduction in the budget allocation for science and technology in the 8th plan from 1.1% of GNP to 0.9% has been resented by many scientists perhaps with valid reasons. However, during the enhanced allocations for S&T in the eighties a considerable amount of money was spent in purchase of sophisticated foreign equipment, establishment of a few new institutions and extension of existing laboratories, foreign trips, salaries, daily and travelling allowances. It is doubtful whether all the money was judiciously used in pursuit of science. There is no noticeable visibility of the scientific accomplishments during the eighties to establish a relationship between financial inputs and scientific and technological output in our system. Perhaps the entire culture of scientific research needs to be improved considerably to optimize the input–output ratio and make science and technology in reality the greatest tool of economic and industrial development and a security for improved quality of life to our people.

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