Action Plan for
Harnessing Science and Technology towards Indigenous Self-Reliance
submitted
by
Science Academies
to
The Honorable Prime Minister of India
(through Secretary, DST, Govt of India**)**

On behalf of the scientific community of India, President, Indian National Science Academy (INSA) had written a letter to The Honorable Prime Minister of India addressing the needs and ways to make India the knowledge economy and to deliver social goods by employing science (Annexure I). In response to this letter, the Prime Minister's office (through Secretary, Department of Science and Technology) has requested the Science and Engineering academies to make an Action Plan to further strengthen science and technology base in India (Annexure II). Accordingly, this document has been prepared and being sent to The Honorable Prime Minister of India through Secretary, DST, Govt of India.

Outline:

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- Develop and nurture research and innovation ecosystem for scientists to plan and pursue long term projects of national importance
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Harnessing Science and Technology
towards Indigenous Self-Reliance

Executive summary of the action plan

For India to achieve scientific 'self-sufficiency' and to assume scientific leadership in the world, there has to be a '**sustainable scientific support revolution**' akin to the white revolution in the country. India must aim to invest at least 2% of GDP in scientific education and research across Universities, Colleges, Research Institutes and Defense and Space Research Organizations. To reap the full benefits of this investment, the governing structures (financial, administrative and functional) of education and research establishments must be reformed to make them independent and self-regulating. We should confer more autonomy to Universities and research institutions. Basic science, applied science and translational research should all be given equal importance. Conditions must be created for each ministry to invest a fraction of their budget for specific challenge-driven science. A mechanism should be evolved to encourage significant participation of industry in these efforts. In parallel, the Ministry of S&T should enhance its efforts in promoting basic research in broad areas with enhanced capacity, so as to provide a constant stream of talent for grand challenge-driven research activities of various ministries. A large number of science administrators must be engaged to facilitate this process, and to ensure efficient delivery, monitoring and reviewing of the enhanced resources.

In order to achieve the above, we envisage a 15-year vision, a 7-year strategy and a 3-year action plan.

15-year Vision: Tranforming India from a Service economy to a Knowledge economy by making it a source of knowledge and innovation.
7-year Strategy: Expand S&T manpower and infrastructure to initiate large numbers of mission-mode projects of national importance, based largely on basic research carried out within the country.
3-year Action Plan: Set-up a broad-based Apex body of Scientists and Technologists drawn from Science and Engineering Academies, S&T Departments and other S&T organizations, which may be consulted by all ministries such that science would be part of all policy, planning and implementation strategies; increase funding for scientific research and ease of governance to enable promotion of intellectual pursuit; make Science and Engineering systems an integral part of international diplomacy and create an environment that will make scientific research and education an attractive career option.

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Background

India has traditionally been a knowledge-based country, as rationality and critical thinking are part of our cultural heritage. Being largely literate in science and technology, India could not only become self-sufficient in food production, but also can now export/donate food to other countries. We also have been able to make unique contributions in space research, biotechnology, development of missiles, affordable drug and vaccine development by indigenously developed technology. Because of our familiarity with science, we have been able to quickly deploy technology developed elsewhere (for example, in healthcare and telecommunication) for the benefit of the public good, particularly the poorest of the society. However, in spite of these successes, our overall performance in Science & Technology activities measured either in relation to world standards or to our population size, leaves much scope for improvement.

Science in the 21st century is not only crucial for the economic development of a nation, but also for gaining the required competitive advantage amongst nations. The globally connected world is now more aware of issues such as climate change, environment, ecology, energy, water, health and wellness and how it affects life on this planet. Breakthroughs in both basic science and technology will be necessary for seeking optimal and affordable solutions for nation's survival with increasing population, diminishing natural resources (food, fossil fuel and water), changing climate (environment), increasing energy requirements and inadequate health facilities (human, plant and veterinary). Thus, quality of life, economic prosperity, national security and the well being of a nation cannot be assured without due importance to Science. In a fast changing world, lifespan of any technology is progressively getting shorter leading to their rapid obsolescence. In such a scenario, ***a country's progress can only be ensured if we can continuously innovate and discover newer solutions. Science is the fountainhead of new technologies. Continuous high quality research in basic science is, therefore, essential.*** To secure India's

leading position in the knowledge economy of the millenium, science needs to grow exponentially and the engine for this accelerated growth should be ignited today.

In this context, we, the practicing scientists of this country express deep concern at the sub-optimal level of science education and research in our institutions. Support to science and scientists has always been at best incremental, if not reaching a stagnation, despite the huge increase in the number of institutes of higher education and research. We believe that unless the current level of funding and the management of our Universities and scientific establishments are dramatically improved, we may not achieve the levels of competence in research and innovation required to meet the needs of the coming decades. Absence of adequate levels of expertise in diverse domains of S&T within the country may make India vulnerable in multiple ways as we would become dependent on other countries for food and energy requirement, defence and other vital needs. Even to negotiate import of any technology developed elsewhere and to take full benefit of its deployment for social good, India will be in a disadvantaged position.

While we are concerned, we are also confident that if necessary measures are put in place now, and implemented in a mission mode, we would be securing a leading position in the intellectual and scientific landscape of the world. It is in this spirit that the following recommendations/suggestions are made to improve the quality of education and research in science in India. We sincerely request the government and policy makers to consider these proposals.

I. Science to be part of policy, planning and implementation strategies of all projects of all ministries

There is at present no regular platform for various ministries, other than S&T ministry, to consult scientists and technologists on various topics related to policy and project planning and implementation. Indian Science and Engineering academies, with over 75 years of history, represent the best in science and technology, at par with intellectual levels of any country in the world. These academies have not been effectively utilized in India by the Governments, the way other countries such as USA, UK, Australia and China engage similar bodies in drafting various policies and programs across the entire spectrum of the society.

Action Plan: In this context, we request the government to

a) Set up an **Apex body of scientists and technocrats,** drawn largely from Science and Engineering academies, S&T departments of Govt of India and other S&T organizations, which may be consulted by Finance (particularly during pre-budget deliberations) and all other ministries and the Niti Ayog.

b) Periodically commission, through Science and Engineering academies, policy/white papers on S&T solutions to various issues affecting the nation.
c) Funding of S & T activities in India needs to be augmented substantially, since in spite of its potential to be at par with global quality, the grossly sub-critical funding seriously limits the achievable goals and often demoralizes young scientists. An immediate substantially enhanced funding, beyond the minimal critical threshold, and its uninterrupted release would enable the S&T efforts in India in realization of the full potential and thereby contribute significantly to nation building and public welfare.

   In parallel, both administrative and financial mechanisms should be streamlined and made more conducive for S&T activities.

II. Develop and nurture research and innovation ecosystem for scientists to plan and pursue long term projects of national importance

Future challenges in science (gravity, particle physics, astrophysics, planetary science, cognitive neuroscience, energy, water, climate science and environment, genomics, big data analysis, nutrition, diseases, health-care etc.) are interdisciplinary in nature and it is not always possible that experts in all required fields will be available in one institution. This calls for assembling academic and R&D consortia in different areas to answer grant calls for grand challenge projects both in India (mission oriented projects) and internationally. India must take part in big international science projects through appropriate contributions. Setting up of Indian Neutrino Observatory (INO), Laser In Gravitational Observatory (LIGO) and such similar large projects would be a major boost to science activity that is needed for national development. Support from the highest offices of government is needed to ensure the timely execution of such projects.

Action plan:

a) ***Special purpose vehicle to identify and fund mission-mode projects:*** A special purpose vehicle must be set up, with funds pooled from various ministries, to identify and fund mission-mode projects of national importance and meeting societal developmental goals.
   1. This cell would conduct brainstorming sessions, workshops, give out open calls etc. to identify grand challenges in major unanswered questions in basic science and also to provide S&T solutions to problems of the society such as water, energy, food and nutrition, environment, health-care etc. and call for inter-institutional projects for competitive funding.
   2. Provision should be made for international collaboration in selected projects without compromising national security.

3. Once approved, mission-mode projects should be protected from budget-cuts until they reach a logical conclusion.

b) **Interdisciplinary/multi-institutional research*:***

1. Provide special funding to Universities, research institutes, hospitals, industry etc. to jointly start graduate schools in interdisciplinary topics such as water, energy, environment, genomics, neuroscience, nano-science, translational health science, etc.
2. Make provisions for international collaborations for both teaching and research in graduate schools to generate the required qualified human resources to take up mission-mode projects in the coming decades. Several cities in India have clusters of academic organizations, often with good industrial R&D in their vicinity. Graduate schools may help to bring them together and work for a common cause.

c) ***Mega research facilities:***

Set up large infrastructural centres on the lines of Grenoble in France or Beijing Genome Centre in China, with adequate funding for large projects (Neutrino observatory, LIGO, Synchrotrons, sequencing the genomes of diverse indigenous crops, Indian human genome, cancer genome, biodiversity mapping and conservation etc.). This would develop large-scale facilities for in-house research as well as for their utilization by researchers across the country and would also generate spin-off technologies and industries.

d) ***Translational research:***

Inter-academy panel may work with concerned ministries and department to suggest modifications to the guidelines for field trials of important technologies and clinical trials that enable immediate translational value to research in these areas, without compromising on biosafety. While actual release for agricultural purposes and human and livestock health require stringent quality control and evaluation for safety, current guidelines are too sweeping and actually have a crippling effect on research in these vital areas.

III. Governance of S&T organizations

The governing structure in our academic and research institutes need to be made innovatively autonomous and accountable so that the academic and research efforts reach newer heights, which would enable them to connect to the society and take up projects of national importance on a mission mode in collaboration with other organizations and industry.

Action Plan:

a) ***Autonomy:*** Good governance depends on the structure and composition of governing bodies, which should be empowered by the government with functional autonomy, associated with strict accountability.

1. Academic community should be given full autonomy in selection of Directors and Vice-Chancellors in a manner similar to that in the proposed bills for conferring autonomy in the selection of Directors at IIMs in the country.
2. All Central and State Universities should have empowered Governing bodies similar to IITs and IISERs.
3. All colleges which are older than 25 years and have a NAAC rating of 3 and above should automatically be made autonomous colleges to ease the burden on universities. For effective academic governance, number of colleges affiliated to any University should not be more than 50.
4. A system of accountability and audit of academic outputs should be put in place. Periodic review of all research organizations by eminent scientists from India and overseas to be made mandatory.

b) ***Finance rules:***

1. Set up a mechanism to formulate General Finance Rules that are more research and innovation-friendly.
2. The Science and Engineering academies along with representatives of Finance ministries may be asked to formulate finance rules to be implemented in Universities, IITs, IISERs, NITs, research institutes etc.

c) ***Management practices:***

1. Accomplished scientists with good management experience should be selected as heads of Universities, scientific institutions and other S&T organizations. Professional senior scientists may be appointed as advisors.
2. All Directors, Vice Chancellors and Principals of colleges are to be given orientation in financial and administrative principles and procedures and in understanding that policies, guidelines and rules and regulations are distinct entities. IIMs should offer customised courses/workshops aimed at Directors, Vice Chancellors and Principals of colleges.
3. Each University/Institute should have highly qualified academic administrators trained in managing academic organizations, who would be given responsibility of all administrative and financial matters. Directors and vice-Chancellors would then be able to focus on policy, planning, research directions, faculty recruitment etc.
4. In addition, we need focused programs to impart training to mid-career teachers and researchers from various colleges, universities and research institutes in India in academic leaderships, governance and management.

A few centres for such training in selected academic institutes of high reputation need to be set up.

5. Provide short-term deputation opportunities for scientists and academic personnel in administrative positions in science ministries.

d) ***Role of private Universities:***

1. With increase in gross enrolment ratio, it is imperative to expand and diversify educational institutes. A role for private universities is very critical in this context as a larger proportion of future citizens would be educated in these organizations. We need to set up an ecosystem that helps emergence of high-quality private universities in India (on the lines of Princeton, Yale etc.).

2. A stringent regulatory system should be established to protect the students (and their parents) from financial and academic exploitation.

3. Research component in private universities must be strengthened.

IV. Strengthening and expanding individual scientist-driven research

Research in Universities and Institutes of higher learning has 3 main objectives: (i) research as an integral part of education, (ii) research to advance the frontiers of knowledge, and (iii) research as a means to develop novel resources (intellectual, physical, material etc.) for societal/public good. Indian Universities and research institutes play an important role in generating human resource required for various science related sectors. If India has succeeded in certain mission-mode projects (such as Agriculture, Vaccination, Space, Atomic Energy etc.), it is because the nation had produced quality human resources in sufficient numbers in those sectors. As the S&T enterprise expands, it will be imperative that we expand and continue to nurture the support system at higher education centres to provide trained human resources. Therefore, it is important to perpetually support science practiced in small groups within Colleges, Universities and research institutes.

Action Plan:

a) Increase funding for individual PI research projects and those driven by a small group of PIs-. The maximum limit per grant be enhanced by 2 fold at the review-committee level.
b) Increase the flexibility in grant utilization to allow PIs to utilise the funds as per the demands of the research project.
c) Total quantum of funds available for each category/topic/discipline needs to be at least quadrupled.

d) We need a mechanism for continuous support to researchers with periodic review instead of asking them to write new research project proposals every 3 years to 5 years. Thus while the initial funding is proposal based, subsequent funding should be based on past achievements. Funding should be released in time bound manner and provision should be built into the schemes to increase funding every year to account for inflation.
e) In order to promote research atmosphere at the large number of colleges in the country, special more liberal funding schemes be strengthened to support research projects submitted by college teachers.
f) There has to be a better co-ordination between funding agencies and simplified/transparent bureaucratic procedures for timely release of sanctioned funds
g) Need to develop separate financial auditing procedures and norms for scientific projects with a fair consideration of the inherent uncertainties and risks in scientific research enterprises.

V. Nurturing Universities and Institutes to reach global standards in S&T quality and output

We need to set up well-defined goals and mechanisms to nurture Universities and institutes to reach higher levels of quality which would attract the best minds from all over the world to work on cutting edge science and its application to solve societal problems.

Action Plan:

a) ***Sustained and guaranteed funding:*** While underperforming institutes need to be provided mentorship and funding to improve, consistently high performing Universities/institutes should be protected from uncertainties of budget cuts besides being provided additional support to sustain their higher performance. Each University/institute should be provided a guaranteed 10-15% increase in annual budget to account for inflation, while additional funds should be provided as per the performance and future projections.
b) ***Recruiting best faculty:*** Set up transparent mechanisms to attract and appoint outstanding faculty based only on merit and competiveness with flexibility in providing salary and start-up grants.
c) ***Mentoring young faculty:*** Once a young faculty is recruited, he/she needs experienced mentoring in starting a research/teaching career, growing to be good participant in departmental and institutional progress. They should be nurtured as future leaders by providing ample opportunities to develop interpersonal skills and learning administrative skills in the management of resources etc. Connect them to an accomplished scientist of their choice from anywhere in the world and facilitate continuous interactions.

d) ***Improve Gender equality and inclusiveness:*** Women constitute half of the human resource; without active engagement of women scientists and technologists, we cannot accomplish envisioned growth of Science and Technology in the country. It is necessary that a conducive environment is created for them and a conscious decision to include them into the main stream of activities. A slew of measures should be put in place to attract more women to science, ensure equal opportunities for women researchers in jobs, awards, funding and in leadership.

e) ***Innovative post-doctoral fellowship and assured career path for young researchers:*** Promoting a strong postdoctoral culture in the country which can also attract international fellows. Set up new fellowships schemes, equivalent to Early Career fellowship of the DBT-Wellcome-Trust India Alliance, in which a fellow contributes to research in India. All such new schemes and the existing schemes like the INSPIRE Faculty Fellowship, Ramanujan Fellowship, Faculty Recharge Programmes etc. be dovetailed to various faculty recruitment schemes to ensure smooth transition of a highly qualified post-doctoral fellow to a regular faculty position.

f) ***Industry-Academia relationship:*** Fundamental research and scholarship should coexist with applied, industry and society-relevant research. To facilitate academia-industry collaborations on campuses, we should establish innovation hubs that connect Universities, IITs, IISERs, NITs, National laboratories etc in different parts of the country. These hubs will have central facilities for joint projects with industry. They should also run customized courses on business, finance, IP, law, company, start-ups etc. These courses should be part of doctoral/post-doctoral programs of all the participating Universities and institutes. We need to establish appropriate incentives to facilitate and increase participation of Industry in basic science research.

g) ***Instrument design and fabrication:*** In contrast to the era of science leading to technology, it is now a bi-directional process. Modern science is now highly driven by, and dependent on, advanced technology. Across the world, most high-tech instruments have originated from university research that provided the basic principles for prototypes, which were then elaborated on by companies. Designing and building instruments in Indian labs has to be encouraged and recognized. Creation of such environment and the infrastructure needs assured funding for Universities and institutes and timely flow of sanctioned funds.

h) ***Internationalization of faculty and students:*** To be world class, Indian Universities and research institutes should be globally competitive and competent. For this, (i) we should internationalise profiles of faculty and students (UG, PhD and postdoctoral) on campuses of Indian universities and research institutes and (ii) set up special programs to attract students from SAARC and African countries to transfer our experience of

transforming the country from developing to modern economic superpower and (iii) provide adequate funding for organizing international conferences in India and for participation of Indian Scientists, faculty and students in international conferences abroad.

VI. Science and Technology Education

There is an urgent need to i) change and revamp the curriculum to prepare students who have a comprehensive understanding, ii) improve the quality of teaching, and iii) make S&T part of solving societal problems at all levels.

Action Plan:

a) ***Measures to improve quality of Higher Education in Science:*** Each district should have a centre of excellence in post-school education in science. That centre should take the responsibility of training teachers of nearby colleges. It should have adequate funding for inhouse mentors, good laboratories, to invite reputed scientists from Universities and research institutes etc. such that it can organize high-quality training for teachers.

b) ***Innovation in Curriculum and Pedagogy:*** Commission academies to develop better curriculum for school and post-school education in science and for training teachers in pedagogy. The aim of the new curriculum is to inculcate rationality, analytical skills and reasoning so that future citizens would be better prepared for mission-mode projects, citizen science programs, translational research, connecting science with society, awareness in climate change and its impact on living earth, sustainable and equitable development and life.

c) ***Science Outreach:*** All major research institutes and Universities should have Science Outreach centres with professional expertise in science communication. Each centre will have hands-on activities/workshops for teachers and students and organize stimulating talks by experts from academia and industry. These centres may also be used for organizing INSPIRE science camps, science exhibitions etc.

d) ***Science Communication and popularization of science:*** Special measures to improve public perception of science by setting up of a mechanism for continuous interactions between scientific community and media.

Conclusion: Most of the action points listed here are immediately implementable within the current framework of the Constitution and operating rules/regulations of the country. With these changes in place, confidence level of S&T practitioners will increase, leading them to take up challenging projects in basic science and its applications to the national welfare. With more confident and successful (and visible) S&T enterprise, more and more bright students too get attracted to research, thereby, furthering increasing S&T output

and its applications. Increase in quality and the scale of S&T enterprise, will eventually help economical, sustainable and equitable development. What is required are positive changes and strengthening of the S&T system, which will enable the S&T ecosystem to give total confidence to the people of the country in indigenous self-reliance for the nation.