PLANNING COMMISSION WORKING GROUP

REPORT ON

PAN INDIA S&T MISSIONS

PAN INDIA S&T MISSIONS

Executive Summary

The role of Science, Technology and innovation has gained high significance in recent times in economic development processes of countries. Pursuit of science for discoveries continues to fascinate individual scientists. Science departments, agencies and institutions, while supporting discovery science are also engaged in applications of science for development of technologies. However, it is becoming increasingly evident that design of solutions to national challenges like food and nutrition security, energy and environment security, affordable health care and water security would call for large nationally coordinated mission mode programmes involving inter-departmental and inter-ministerial collaborations. Approach paper for the 12th plan programmes called for launching PAN-India S&T missions in four of five select areas.

Working Group constituted under the Chair of Professor P. Rama Rao, formerly Secretary, Department of Science & Technology, has deliberated on the priorities for PAN-India R&D missions. Four areas for launching such missions have been identified. They are a) Affordable Health Care, b) Energy and Environment, c) R&D for Water and d) Food and Nutrition.

Under National Mission on R&D for Affordable Health Care total of six sub-missions have been proposed. They are 1) diabetes, 2) biomedical instrumentation and diagnostic tools, 3) non-conventional health delivery systems, 4) biomaterials for health care,, 5) affordable and diagnostic kits and 6) human capacity building for biomedical R&D. Total of Rs 1550 crores has been proposed.

Under National R&D mission on energy and environment, total of five sub-missions have been proposed. They include 1) Hydrogen generation, storage and transportation,2) Sustainable Transportation, 3) Biofuels co-operatives in rural areas, 4) Development of energy efficient technology and 5) Hybrid technology approaches for off-grid energy supply for decentralized applications. Total investment of Rs 1700 crores is proposed.

Under National Mission on R&D for water, further strengthening of solution design dimensions of Winninng Augmentation and Renovation (WAR) for water has been proposed at an investment of Rs 350 crores.

Under National Mission on R&D for Food and Nutrition total of five submissions has been proposed. They include 1) Remunerative agriculture for low land holdings, 2) More

crop for drop schemes, 3) technologies for restoring soil health 4) avoidance of food wastage, 5) climate resilient agriculture through modern bio-technology. Total investment of Rs 1850 crores is suggested.

The working group has suggested two parallel approaches for designing and implementation of PAN-India missions. It is quite likely that various departments and agencies have independently proposed R&D programmes and activities with overlapping goals and objectives. A special task force may be constituted under the Chair of member Science planning commission for building programme synergies and avoiding duplications that merit avoidance. Sharing objectives and goals and co-investments of resources by the S&T departments and agencies may be promoted through this mode of implementation of the mission.

The working group has recommended a creation of separate PAN-India mission fund to the tune of Rs 5375 crores to be allocated over and above the allocations for individual departments. PAN-India mission has stipulated the mission goals and objectives of the sub-mission areas. For implementation of the missions under the top-down planning models, specific and time bound goals expected from each sub-mission and mission may be specified and proposals may be invited from PAN-India networks. The proposal may include also the structure and organizational arrangements proposed for implementation and monitoring. These proposals could focus on national platforms involving the participation of all the stakeholders including industry and user agencies.

The programme monitoring and oversight for the implementation could be assigned to a task force under the chair of Member Science, planning commission and department to service each sub-missions.

INTRODUCTION

During the 7th Five Year Plan period, Government of India had constituted six technology missions in the areas of telecommunication, literacy, dairy, water, immunization and oilseeds with the aim of using technology for the benefit and betterment of society. These missions paved the way for redefining the role of technology in a society like India by linking it to better methods of implementation and delivery of objectives and services for the underprivileged in the country. All these missions were focused on carefully selected projects insightfully managed and regularly monitored to assess the achievements.

Indian Science Vision has recognized the need for relating R&D outputs to solving national problems of food and nutrition security, energy and environment security, health security and water security. Several science departments and agencies through their institutional network have been engaged in Research and Development activities relating to technological solutions for national challenges. The need for better coordination and synergy among the various agencies and departments has been recognized by the steering group constituted for the development of approach plan for the 12th plan programmes in the science sector. A PAN India mission on important and selected themes on which all the science departments in the central sector has been proposed by the steering group.

Technology mission programmes implemented during the 7th plan provide a useful backdrop of experience for the PAN-India S&T Missions proposed to be launched during the 12th plan period.

APPROACH

The Pan India Science and Technology Missions have been conceived at this juncture to address cohesively science and technology issues related to major and emerging challenges that India will be needing to contend with during the next 5 years and build synergies among all the arms of the central sector addressing the R&D needs for technology solutions to national challenges

Priority Areas for the PAN-India missions have been identified and selected in consultation with groups and agencies who are engaged in one aspect or the other related to the mission programmes. Inevitably more than one agency will be required to be engaged in the related projects so that the programme, which necessarily encompasses a number of projects, can be appropriately driven. Since the groups

belonging to different institutions have to come together it has become necessary to build mechanisms and strategies for efficient deployment of funds and barrier-less utilization of expertise to implement the programmes and to ensure fruitful outcomes. A consortium mode embracing the relevant Departments and Ministries is suggested as a possible model for executing the selected missions of considerable national interest.

Working Group of the Planning Commission on PAN-India Missions discussed at length the types of structures necessary for designing, developing and implementation of PAN-India missions on the one hand the requirement for positioning a suitable oversight and monitoring mechanism. The basis approach of the PAN-India mission should be based on sharing of objectives, co-investments and co-generation of values for R&D outputs for applications in addressing national problems. Priority areas for mounting PAN India missions were identified on the basis of National needs. PAN-India S&T mission programmes selected for implementation during the 12th Plan period are a) Affordable Health Care, b) Energy and Environment, c) Food and Nutrition and d) Water.

Several agencies, departments and autonomous institutions under the administrative control of Central Government are engaged in R&D on projects and programmes relating to the themes for the four selected PAN-India Missions. Two parallel tracks for implementation of PAN-India S&T missions with internal connectivities may be necessary.

Planning Commission could set apart a finite level of resources for PAN-India mission and make a call from agencies and institutions to compete for viable PAN-India mission mode programmmes complete with resource requirements, details of time bound delivery of targets and goals, and appropriate implementation and monitoring mechanisms. The Planning Commission could set up competitive fund for PAN-India S&T mission as well as a suitable expert group to select the PAN India mission mode programmes for implementation based on the expected social outcomes as the main criteria for selection of the PAN India mission for implementation.

The second approach for the design and development of PAN-India mission is to synthesize mission goals and objectives from the 12th plan programmes submitted by various agencies and departments and connect internally the programmes earmarked for implementation under each agency. This is based on a bottom-up approach of planning. A suitable oversight and monitoring mechanism may be formed for such mission programmes. Such measures are necessary, particularly because the mere development of technologies and technology solutions are not adequate to solve any major national problem. The delivery of R&D outputs and linkages with user community is essential. End-to-End solutions based on technologies will call for strong internal

linkages among the Indian Science Sector as well as with relevant socio-economic ministries of both state and Government of India. PAN-India S&T mission should therefore focus on innovative ways of delivering convergent technology solutions to the people of India.

The PAN-India mission should call for participation of a) state Governments, b) private sector, c) NGO sector and community based organizations, d) knowledge R&D institutions and their network and d) the ultimate user communities. Overall coordination may need to rest with agencies outside the Science and Technology departments. The selection of leadership models for the implementation of PAN-India mission is extremely important.

I. National Mission on Affordable Health Care

India's success story of economic growth is in striking contrast to its increasingly crumbling public health infrastructure. While there are continuous efforts towards increasing investments in science and technology to help India to become a major S&T super power (like putting a man in moon by 2015), there is an unmet research and development need for delivering affordable health care to nearly 70% of Indian public. Globally R&D for health care systems driven by Private sector investments are focused on overly on delivering products and services tom people with higher purchasing power. Hence most talented researchers are focusing on problems suffered by well-to-do people. Both availability and access to new health products (that include diagnostics, drugs, vaccines and other biological and medical devises and other equipment to be used at the periphery) have never been on the top of research and development agenda of most R&D systems; while the disease burden continues to be alarming. India has a huge burden of patients with tuberculosis, malaria, HIV/AIDS, viral infections as the Japanese encephalitis, dengue. What is more, there are emerging and reemerging infections like swine flue and lately Crimean Congo hemorrhagic fever. Even for many of the disease prevalent for decades like TB, malaria etc., diagnostics, drugs and vaccines are either decade old or inadequate. There is little interest in such products by the market-driven global (and Indian) pharma industry since market forces do not favour investments into R&D for diseases of the poor due to limited market. So, while the disease burden is on rise, absence of effective disease control tools has made very difficult for India to meet the Millennium Development. Whereas high, and middle income countries the health care infrastructure provides 7.4 beds, 1.88 physicians and 5 nurses and 4.7 beds, 1.8 physicians and 1.9 nurses for 1000 people, respectively, Indian infrastructure is more comparable to those of poor nations namely 1.5 beds, 1.2 physicians and 0,9 nurses for 1000 people, respectively. In some sense, the level of

nursing support at 0.9 per 1000 is lower than in many other poor countries at 1.6 per 1000 people. Further health care spending is primarily from the families in the country. S&T system of the country needs to dovetail its objective on medical research to include cost reduction of quality health care to match the paying capacity of many. Research priorities for Affordable Health Care in India have been identified as a) uniting (engineering) technology and medical sciences into a single window, b) rendering the cost of quality health care system affordable to many through research and development and c) Research and development for redressing the health burden from neglected diseases like TB, Malaria and diseases of the poor

One reason for the lack of focused national interest could be attributed to lack of indigenous R&D and dependence on discoveries and research and development made abroad and on cheaper copies for the Indian market. But with the advent of the TRIPS regime in 2006, India is already faced with the problems of the rising costs of drugs similar to those of the developed countries like the North America and Western Europe. Drug price control regimes, anti-competitive measures, and flexibilities in global IP regimes for the countries like India can help in a limited way but in the long run strong innovation-driven R&D directed to our needs is imperative to achieve the goal of affordable health care.

Significantly, equity and access of quality health care to all the citizens are enshrined in our constitution and the Government has an obligation to provide basic essential health care to its citizens. While there is general consensus that more equitable access to life saving health products and technologies must be improved, it has remained an isolated discourse among the national S& T agencies. It is t to address this issue in its entirety and seriousness at a PAN India level as given below.

Making available affordable health products is essentially a three stage process: - discovery, development and delivery. Each one of the phases requires specific and unique specialty and expertise that is not available with anyone science and technology agency or department in India. The discovery phase requires cutting-edge basic science to identify new molecules that requires expertise in pharmacognosy, chemistry, pharmacology, biotechnology, genomics, bioinformatics etc. Molecules identified to have required biological activity, largely in *in vitro* animal models, need to be tested through a process of pre-clinical toxicity in animal models. Once the safety and efficacy of a drug candidate is established, the process of development starts. Typically, the drug lead is put through a process of Phase I and Phase II trials in human beings to confirm the claimed safety and efficacy. Once the Phase II trials are successful, Phase III trials are conducted before the drug regulatory agency is approached to introduction in the market i.e. the final phase of delivery of the health product into the market.

Concerns of Government of India about adequacy of indigenous research needs for affordable innovations for human health care could be best addressed only when several departments working independent of each other in this area synergize their efforts. There is now an effort to build synergies and symbiosis in consolidating the efforts of the GoI. A broader consortia approach may well be needed not only in funding but also in the way and manner of working. S&T for reduction of the cost of quality health care to be within the ability of large percentage of people to pay should be the focus.

The Working Group has recongnized the urgency of a PAN S&T mission towards achieving affordable health care.. Some of the important areas in which the affordable health care mission should concentrate on are listed below. For reasons of convenience and higher cohesiveness and synergy, the working group has proposed sub-mission models for the area of affordable health care. The sub-missions proposed are a) Diabetes, b) medical instrumentation and Diagnostic tools, c) Innovative Health Care Delivery systems, d) Biomaterials for health care, e) affordable health care diagnostic kits and f) Open Source Drug Discovery model of CSIR.

1. Diabetes

Diabetes in adults worldwide was estimated to be 4.0% in 1995 and to rise to 5.4% by the year 2025. It is higher in developed than in developing countries. The number of adults with diabetes in the world will rise from 135 million in 1995 to 300 million in the year 2025. The major part of this numerical increase will occur in developing countries. There will be a 42% increase, from 51 to 72 million, in the developed countries and a 170% increase, from 84 to 228 million, in the developing countries. Thus, by the year 2025, >75% of people with diabetes will reside in developing countries, as compared with 62% in 1995. The countries with the largest number of people with diabetes are, and will be in the year 2025, India, China, and the U.S. In developing countries, the majority of people with diabetes are in the age range of 45-64 years. In the developed countries, the majority of people with diabetes are aged > or =65 years. This pattern will be accentuated by the year 2025. There are more women than men with diabetes, especially in developed countries. In the future, diabetes will be increasingly concentrated in urban areas (Ref: Diabetes Care. 1998 Sep;21(9):1414-31.Global burden of diabetes, 1995-2025: prevalence, numerical estimates, and projections. King H- WHO).

The prevalence is increasing at all strata of population including the children and pregnant women whose needs and care are special and needs redressal.

There is clear need for research on control measures, creating tools for affordable diagnosis/ monitoring and treatment of the disease and its complications which encompasses multi-organ failure, adverse effect on social and behavioral status of individual as well as family and thus country as a consequence. The estimates for disease in pregnant women whose needs and care are special and needs redressal are essential and the strategies for reducing the burden and morbidity and mortality are important research agenda for helping the programme. Increasing incidence of diabetes in young adults of 20yrs and up is another area of concern.

There is a need for a coordinated PAN-India R&D mission on diabetes. Several departments and agencies are engaged in supporting R&D on diabetes. Agencies like CSIR, ICMR, and their institutions have launched R&D programmes on Diabetes. DST has mounted an initiative to promote basic research in glyco-biology relating to the chemical biology of diabetes searching for new breakthroughs. Some industrial R&D systems have discovered new molecular leads. Innovative mechanisms are necessary for converting molecular leads into drugs which involve clinical trials at high investments. Challenge Award schemes for conversion of molecular leads into drugs would form a valuable next step.

Planning commission could consider mounting a National R&D mission on diabetes with specific budgets and top down models for planning while parallel efforts are made for interconnecting R&D programmes being launched by various agencies though bottom-up planning models. Special networking and monitoring models could be designed through the constitution of a task force and serviced, perhaps by one department.

Areas of Research & Development and Budget Estimates#

S.No	Area of Research*	Fund requirement during the 12th plan period (Rs. in crores)
1.	Low cost technologies	50.00
2.	Islet Cell Transplantation	100.00
3.	Gestational Diabetes	50.00
4.	Prospective cohorts	40.00
5.	Gene environmental interaction for Diabetes	80.00
6.	Use of Technology	50.00

7.	Translational Research	30.00
8	Challenge Award* under PPP model for co-investment and sharing of IPR	200.00
	T o t a l	**600.00**

** Further details on each of these are provided in Annexure-I.*

 # PAN India mission on diabetes could involve a networking of various agencies and departments, which have made separate allocations for R&D on diabetes. A special task force may be constituted for developing synergies among various agencies

2. Medical Instrumentation & Diagnostic Tools

While the country is doing reasonably well now in pharmaceuticals, the situation with respect to medical instrumentation and diagnostic tools is far from satisfactory. Affordability of available and imported medical instrumentation is low.. Given the number of hospitals and healthcare centres in the country and, even more importantly, the numbers required for serving the ever increasing population, the demand for medical instrumentation and diagnostic tools/kits is going to be huge. This is also an area where an increasing integration of hardware and software is taking place. Given the software prowess that we have now, it only makes sense to target this area as an S& T mission and define a goal for certain areas of medical instrumentation and diagnostic tools to be completely designed and manufactured in India. There is every possibility that by doing so, we can bring the healthcare costs down and make much of medical care affordable to our masses. This is a goal that can become increasingly harder if we do not take it up now.

S.No	**Area of Research**	**Fund requirement during the 12th plan period (Rs. in crores)**
1.	Development of Instrumentation	100.00
2.	Development of Diagnostic Tools	100.00
	T o t a l	**200.00**

2. Non-Conventional Healthcare Delivery Systems

Technology platforms for health systems offer alternative approach to avoid discretionary decisions and human errors. In a country where the ratio of physicians per

1000 population is as low as those in poor economies, innovations are required for leveraging the relatively poor ratio of physicians per 1000 population by resorting to technology assisted methods. A PAN-India R&D mission on non-conventional health care delivery systems will be a timely next best step forward.

a) Electronic Health Records: Electronic health records which capture key patient characteristics, allow for documentation of results of physical examination and investigations, and mention treatment prescribed, will enable creation of a centralized repository of that individual's information. Information acquired at any level of health care can be accessed by other health care providers at the same levels (different specialists in a district hospital) and also at different levels (information generated at the medical college or district hospital level, can be available to the primary health care provider who did not have the resource or expertise to generate that information required for the individual's care especially critical for chronic / non-communicable diseases. With the availability of the UID number an individual's entire health record can be available in a consolidated fashion, instead of the fragmented records available and that too dependent on whether the patient or the hospital has kept these carefully.

b) Decision support software: Coupled with the electronic health records, is the option of integrating standard treatment guidelines and algorithms which will aim towards objectivizing patient management - both at initial presentation and on assessing response to therapy. The arbitrariness of decision making will thereby get reduced. This software can also help make decisions regarding the need for referrals and also arrange appropriate referral consultations - not only at the same health care institution but also at the next level of care. This will address one major lacuna of the current system - in which the process for adjudging the need for referral and establishing the process for this referral will get resolved. Currently patients seek help at myriad levels of health care - which are either over- or under-equipped to meet their requirements. For example there is no need for a tertiary care facility to be seeing individuals with coughs and colds - but it happens on a regular basis in urban India. The chanelizing of such patients through facilities / institutions at the appropriate level will be achieved - rather than the current process which is chaotic.

c) Use of mobile phones for health care: For a country with near 100% penetration of mobile phones it could be a major component for screening, communication and monitoring. Identification of individuals at high risk for non-communicable disease such as high blood pressure and diabetes, can be done through risk

scores and algorithms which are mobile phone based. Individuals identified through this process can be then referred for formal testing and treatment - again using cell phone based applications. This can enable use of less trained health care workers to identify and refer individuals, instead of utilizing already overburdened physicians for the initial phase of disease identification and diagnosis. Follow up of such patients can also be based on mobile phone based alerts and reminders, and also to help create and foster linkage between the patient and different components of the health care delivery system.

In summary, identifying areas for the appropriate use of information technology and networks to create and support health care delivery systems and creation of such systems would be a worthwhile goal for the next 5 year plan.

S.No	Area of Research	Fund requirement during the 12th plan period (Rs. in crores)
1.	Electronic Health Records	50.00
2.	Decision support software	100.00
3.	Use of mobile phones for health care	100.00
	T o t a l	**250.00**

4. Biomaterials for Health Care

Biomaterials incorporated into medical devices have had at least as great an impact on health care in the twentieth century as have pharmaceuticals. Virtually all types of material systems have been used in health care applications, including metals and alloys, ceramics, polymers, composites, and biologically derived biomaterials. Developing materials that can be implanted in the body and remain for many years without adverse effects requires understanding of the biological processes that occur around the material and reactions that may occur once implanted in the body, especially if they can have harmful consequences. Today these implantable materials are largely passive and provide structural integrity, such as a hip replacement. In addition to these implantable materials, materials chemistry and engineering has also had a significant impact on separations technologies used in medicine. Examples of these applications include hemodialyzers, blood oxygenators, leukofilters, intravenous filters, apheresis filters, and diagnostic assays. Recent developments in materials chemistry have led to

significant improvements in drug delivery systems. Biocompatible polymeric materials have been developed that allow for the controlled delivery of drugs, proteins, and genes. Copolymer networks are being developed that form a mesh-like structure and are potential delivery systems for drugs. By varying the monomers that make up these copolymers, it may be possible to tailor the dosage and time over which these drugs are delivered to the body. Materials research in the biomedical field has also included extensive work on new materials for medical diagnostics, particularly medical sensors. Thus the interface between materials chemistry, engineering, biology, and medicine presents a number of challenges that still have to be overcome. One overarching issue is the integration of biocompatible materials into living systems. This includes areas such as bone scaffolding, artificial organs, and tissue engineering. Other challenges are materials which sense and respond to stimuli such as that required for synthetic muscles, in situ drug production, nanocellular systems, and human integrated computing. It is also almost certain that as research in the biomedical field advances, better sensors that take advantage of the latest developments in new materials will be essential. Success in any of these areas will require detailed understanding of the interactions between the material and the human body, knowledge of the chemistry between the various constituents of the heterogeneous material, and understanding of how to control the properties of the material to produce the desired response and would thus require a multidisciplinary, multi-organizational effort to achieve its goals.

A brainstorming meeting was organized jointly by DBT, DHR and DST at AIIMS and held intense discussions on R&D for human health care. Major recommendations emanating from the inter-departmental consultation are presented in **Figure 1.**

Brainstorming at AIIMS for S&T in health care

Suggestion	Decision	Action
Structured programme for biomedical research with career path	To design an "INSPIRE" like programme for biomedical area	DST to study creation of window within INSPIRE or develop a new program Three member committee will meet DST secretary
Strengthen physical infrastructure for medical research	To establish an inter-agency initiative to identify 10-12 institutions based on transparent criteria and provide infrastructure grant	ICMR, DBT and DST to work together to develop a suitable scheme with well designed governance for partnerships and collaborations and decentralized decisions
Create of an innovation infrastructure in biomedical area complete with TBI and Technology service infrastructure	To mount a national mission for innovations in Biomedical research with focus on leadership and best global models	To design and develop a national mission for implementation during the 12th plan period

A strong case for PAN-India R&D mission on biomedical instruments and devices has been made at the inter-ministerial brainstorming. The mission should include also a establishment of Biomedical Devices Regulatory Authority to ensure that quality of the devices meets global standards. DST has already drafted a bill which needs to be further processed as a National activity.

DST and DBT are already engaged in supporting R&D in the area. DST proposes to focus R&D effort on Biomedical Instrumentation, Technology and Devices as a part of the Drug and Pharmaceutical Research Programme or launch a new initiative in place or DPRP with a budget outlay of Rs 400 crores. Similar programmes may be planned by other agencies as well. Therefore a special task force may be assigned to develop a coordinated R&D Mission However, Planning Commission may also mount a well articulated mission to be serviced by some Science Department with a budget outlay of Rs 200 crores..

A sub-mission on biomaterials, instrumentation and Devices is a necessary component of PAN India S&T Mission Programme in the 12th Plan.

S.No	Area of Research	Fund requirement during the 12th plan period (Rs. in crores)
1.	Research programs in development of biomaterials for body implants	50.00
2.	Biomaterials for separation technologies used in medicine	50.00
3.	Improved drug delivery systems	50.00
4.	Development of medical sensors	25.00
5.	Study of interaction between biomaterial and human body	25.00
	T o t a l	**200.00**

5. Development of Affordable and Rapid Diagnostic Kits

Simple, quick and affordable diagnostic kits which can be used by Primary Health Centres, without extensive training, are not available in the market. Hospitals are not adequate to treat even the most common and regular outbreaks of Cholera, Typhoid,

Dengue, chikungunya, JE besides several others.

To improve the healthcare, especially in a developing country like ours with limited resources, we need to focus on the development of simple, cost effective and rapid diagnostic kits.

S.No	Area of Research	Fund requirement during the 12th plan period (Rs. in crores)
1.	Development of cost effective and rapid diagnostic kits	**100.00**

6 Human Capacity Building for Medical and Biomedical Research

One of the serious limitations of the current R&D space in medical and biomedical areas is the lack of adequate number and type of R&D professionals. This would require a correction on mission mode and PAN-India actions. Some agencies like DST and DBT could take the lead and develop in consultation with ICMR and Ministry of Health suitable packages and programmes for developing Human capacity for R&D on mission mode in partnership with private sector.

S.No	Area of PAN-India Mission	Fund Requirement during the 12th plan period (Rs in crores)
1	Human Capacity building for R&D on medical and biomedical research	Rs 200 crores

II. National Mission on Energy and Environment

Government of India needs to emphasize that sustainable energy, energy efficient technologies for fossil fuels and environment will be one the major missions. Social context of India under the current development phase demands a diversity of approaches to address the energy related problems. Technologies for decentralized and off-grid energy solutions based hybrid models for generation are as important as the gird based MW based energy generation approaches. PAN-India mission should address R&D requirements of both ends of the energy generation spectrum. The programs envisaged under this national mission are as follows

1. Hydrogen generation, storage and transportation
2. Sustainable Transportation
3. Biofuels co-operatives in rural areas
4. Development of energy efficient technology

5. Hybrid technology approaches for off-grid energy supply for decentralized applications

1. Hydrogen Generation

Hydrogen has been proposed as a means to reduce greenhouse gases and other harmful emissions, satisfying the need of efficient, sustainable, non-polluting source of energy. Hydrogen has a potential as a clean energy fuel and an ideal energy carrier that helps to increase energy diversity and security by reducing dependence on hydrocarbon based fuels.

Hydrogen production, storage, and distribution are globally pursued as challenging areas of research and development. Hydrogen production is a large and growing industry. Globally, 50 million metric tons of hydrogen equal to about 300 million tons of oil equivalent was produced in 2010. About half of all the hydrogen as currently produced is obtained by using natural gas as a starting material, heavy oils and naphtha make up the next largest source, followed by coal. Current total annual worldwide hydrogen consumption is in the range of 400-500 billion Nm3. Present utilization of hydrogen is equivalent to 3% of the energy consumption and with a growth rate estimated at 5-10% per year. Only a fraction of this hydrogen is currently used for energy purposes; the bulk serves as a chemical feedstock for petrochemical, food, electronics, and metallurgical processing industries.

Hydrogen could be produced from a very diverse base of primary energy feed-stocks including natural gas, coal, biomass, bio-wastes, solar, wind, hydro, geothermal or nuclear power, enabling a more diverse primary supply for fuels. A variety of process technologies can be used for hydrogen production including chemical, biological, electrolytic, photolytic, and thermochemical. All involve splitting of compounds that contain hydrogen and capturing the resulting hydrogen gas. Except the electrolytic processes of splitting water, the commercial successes of the remaining processes are yet to be proven and are at different stages of research investigations. Significant progress is being made towards the development of cost effective, efficient, clean systems. Interest in water splitting using high temperature heat, as much as possible directly in the decomposition process, started in a relatively recent period.

Hydrogen storage is the main problem to be conquered for the successful implementation of fuel cell technology in transport applications and it represents a major materials science challenge. The methods of storage currently under consideration include high pressure gas, liquid hydrogen and adsorption on porous materials, hydrides (metal/complex and chemical hydrides), zeolites, glass spheres, and activated carbons. Gas-on-solid adsorption is an inherently safe and potentially high energy density hydrogen storage method that could be more energy efficient than chemical or metal hydrides and compressed gas storage.

Scattered and disparate R&D programmes on hydrogen based fuels are undertaken in the country. Hydrogen offers a clean fuel. Globally intense R&D activities are promoted by the various Governments. A PAN-India R&D mission through a well structured and monitored mission mode programme is of national interest. Planning Commission could commission the preparation of such a mission document and establish a national task force to monitor the implementation of the multi agency mission on hydrogen based fuels.

Areas for Research & Development

S.No	Area of Research	Fund requirement during the 12th plan period (Rs. in crores)
1.	R and D on increasing the efficiency of hydrogen generation from water splitting inorganic cycles	100.00
2.	Pilot scale and mini-plant demonstrations for closing the hydrogen loop	150.00
3.	Hydrogen storage materials and devices for fuel cell and other applications	100.00
	T o t a l	**350.00**

2. Sustainable Transportation

Indian automobile industry which includes the OEMs of two-wheelers, three-wheelers, passenger vehicles, LCVs, trucks and also the auto-component manufacturers, is the second largest industrial sector of India in terms of sales turnover if we exclude financial, service and agricultural sectors. In addition, the Indian automobile sector is expanding rapidly and India is likely to become the third largest automobile market after China and USA in a few decades time.

However, such a rosy scenario hides the fact that all forms of transportation in India is largely based on the inefficient and polluting Internal Combustion Engine (ICE) and that ICE requires petrol/diesel/natural gas as the input fuel and they have to be largely imported at ever increasing cost due to dwindling world-wide resources of such fuels. Thus, there is a clear case for India moving towards non-ICE based transportation technologies like hybrid vehicles in the first stage and electric vehicles and fuel cell vehicles in the second phase.

Transition to hybrid and electric/fuel cell vehicles leading to sustainable transportation is essential if India is to achieve energy independence and security, reduce emissions and pollution in general, mitigate greenhouse effects and lastly conserve energy through the use of highly efficient motive power like electric and fuel cell based vehicles.

There is a clear need for Government of India to initiate a National Mission Programme on Hybrid, Electric & Fuel Cell vehicles (NMPHEFC) during the 12th Plan period. The NMPHEFC will encourage various types of activities related to hybrid, electric and fuel cell vehicle technologies as follows:

Areas for Research & Development

(a) Directed basic R&D with the direction provided by the industry.

(b) Technology demonstration through academia/R&D lab – industry collaborations.

(c) Technology deployment with the help of industry and industry associations.

(d) Encouragement to industries to start the commercial production of various sub-technologies essential for hybrid / electric / fuel cell vehicles.

(e) Human resource development (B.Tech., M.Tech., Ph.D.) in the areas of hybrid/electric/fuel cell vehicle technologies. Also upgrade and enhance the skills of industry engineers/managers so that they contribute fully to non-ICE based technologies.

(f) Public education/awareness programme regarding the advantages and sustainability of hybrid / electric / fuel cell vehicles based transportation system.

(g) Consolidate the efforts / activities mentioned above by creating a green field institute during the middle of the 12th plan dedicated to automotive research. This institute will carry out pre-competitive research in the areas of relevance to auto sector with government funds and also contract research with individual auto companies with funding largely from the industry.

Budget Estimates

Sl. No.	Project Type	Fund requirement during the 12th plan period (Rs. in crores)
1	Battery system for EV/ hybrid vehicles	30.00
2	Fuel cells for EV/ hybrid vehicles	25.00
3	Controlers, power electric components for EV/hybrid/ fuel cell vehicles	25.00
4	AC motors, ultracapacitor, etc. for EVs/ hybrid	20.00
5	Light weighting EV/ hybrid/ Fuel Cell vehicles	30.00
6	Deployment of EV/ hybrid/ Fuel Cell vehicles	20.00
7	Establish green field R&D institute for dealing with all aspects of EV/ hybrid/ Fuel Cell vehicles including human resources development	250.00
	T o t a l	**400.00**

3. Bio-fuels Cooperatives in Rural Areas

Current biofuels used across the world only comprise first generation biofuels ethanol and biodiesel i.e. fuels derived from resources that also find uses as food. In 2010 worldwide biofuel production reached 105 billion liters (28 billion gallons US), up 17% from 2009. In 2010 biofuels provided 2.7% of the world's fuels for road transport. Global ethanol fuel production reached 86 billion liters (23 billion gallons US) in 2010, with the United States and Brazil as the world's top producers, accounting together for 90% of global production. The world's largest biodiesel producer is the European Union, accounting for 53% of all biodiesel production in 2010. As of 2011, mandates for blending biofuels exist in 31 countries at the national level and in 29 states/provinces. According to the International Energy Agency, biofuels have the potential to meet more than a quarter of world demand for transportation fuels by 2050.

India formulated its National Biofuel Policy through Ministry of New and Renewable Energy. The mandate was to start with blending 5% ethanol in gasoline and was expected to go up to 10% by 2008, and to 20% by 2017. As on today India uses less than 0.5% of fuel as biofuel which incidentally is the first generation biofuel. Substantial efforts in production of *Jatropha* oil as non-edible fatty oil resource for biodiesel production has not met with success.

The immediate hope for future of biofuels is cellulosic ethanol which though despite intense research over last 20 years and more than 100 pilot plants all over the world, has not seen commercial success as yet. Nevertheless, cellulosic ethanol is expected to become reality by the year 2014. India has invested some efforts in this direction through DBT and MNRE, and may match global efforts. However, a much larger effort needs to be mounted in a very systematic manner to achieve some degree of success in biofuel technologies especially for the new emerging class of drop-in biofuels. A national effort towards R&D, setting up incubation centres and pilot plants needs to be mounted if India desires to achieve some decent degree of technology self-reliance in biofuel production and energy security by the year 2020 and beyond.

Since there is substantial quality of biomass available, cooperative factories like the sugar cooperatives can be established for collection of local agricultural biomass to reduce transportation and availability of cheap biofuel for energy, transport and refrigeration.

S.No	Area of Research	Fund requirement during the 12th plan period (Rs. in crores)
1.	Research on cellulosic ethanol and other biofuels	100.00
2.	Cheap biofuel from biomass	50.00
3.	Setting up of pilot plants and incubators for production of biofuels	250.00
	T o t a l	**400.00**

4. Development of Energy Efficient Technologies

Since crude oil will still be used along with coal for next few decades, the process efficiency of refineries and coal processing plants must be improved. An integrated gasification combined cycle (IGCC) is a technology that turns coal into gas—synthesis gas (syngas). It then removes impurities from the coal gas before it is combusted and attempts to turn any pollutants into reusable byproducts. This results in lower emissions

of sulfur dioxide, particulates, and mercury. Excess heat from the primary combustion and generation is then passed to a steam cycle, similarly to a combined cycle gas turbine. This then also results in improved efficiency compared to conventional pulverized coal. These novel catalytic technologies to reduce SOx and NOx emissions should be focused.

The modern world cannot live without refrigeration which is often required either for human comfort (air-conditioning) or for preservation (refrigeration, cold-storage) of food or other perishable goods. In India, a majority of fruits and vegetables are perishable and seasonal. The food processing industry finds it difficult to meet the challenges for want of cheap electricity in the rural areas. It is estimated that about 35% of fresh fruits and vegetables are lost due to decay for want of either immediate market or preservation facilities. The main difficulty in providing refrigerated or cold-storages is the continuous availability of primary energy. The most common technique employs electrical energy through a compressor and is known as Mechanical Vapour Compression Refrigeration (MVCR) technique. An alternative technique exists which can use heat as the primary energy source. Coupled with solar energy, it also means that the primary energy is available at higher amounts when most needed. This method is known as Vapour Absorption refrigeration (VAR) technique by which heat is used as an energy input for generating refrigeration.

The common operational difficulty in operating ammonia vapour absorption refrigeration (VAR) to produce temperature of $0^{o}C$ is that it requires heat source (steam) of at least $120^{o}C$ and results in a coefficient of performance of about 0.55. It is possible to use heat sources as low as $80^{o}C$ to provide ample cold-storage facilities even in rural locations where reliable continuous supply of electricity is not available. Thus the farm produce can be preserved immediately close to the place of production itself. The VAR system can be operated by burning any combustible agro-waste during periods when the Sun is not available or even as a regular alternative.

The main difficulty with this arrangement is that while it is carbon neutral and has low operating cost, it needs high capital investment and hence needs government assistance. Here each village can be taken as a unit and provided with these types of refrigerators.

S.No	Area of Research	Fund requirement during the 12th plan period (Rs. in crores)
1.	Solar powered refrigeration	150.00
2.	Energy efficient refinery technology	150.00
	T o t a l	**300.00**

6. Hybird Technologies for Decentralized off-grid Applications

Indian energy demands require multiple technology approaches in the social context in which the country is placed currently. Clean energy options should reach the unreached areas of country. There are several villages in which there is no regular supply of electricity. Diesel engines are used to generate power for decentralized applications. There is both cots and emission penalty with such approaches. DST has mounted an effort to develop R&D solutions for decentralized power generation using off-grid approaches focused on Diesel power parity in cost for developing solutions which could be propagated wide in the country. The currently used hybrid approaches include solar thermal and biomass from agro-wastes, micro-hydel and biomass, bio-fuel based on oil wastes with solar etc.

No	Area of Research for gaining Diesel power parity or better	**Fund requirement during the 12th plan period (Rs. in crores)**
1	Solar thermal and bio-mass from agro-wastes	Rs 100
2	Micro-hydel and bio-mass from agro-wastes	Rs 50
3	Bioifuel from oil wastes and solar	Rs 100
	Total	**250**

III. National Mission of R&D for Water

Water is a fundamental need in any civilized society. Per-capita availability of water is decreasing significantly in India. It is projected that per-capita availability of water would reach levels as low as 1180M^3 by 2025. Supreme court of India passed an order in 2009 that solutions to water challenges should be found out through R&D in a mission mode.

The Secretary, Ministry of Science and Technology has been assigned the task of mounting the R&D mission.

The Department of Science and Technology has already mounted a technology mission on Winning, Augmentation and Renovation (WAR) for water. The Department has adopted a technology agnostic approach in developing the mission. Total of 26 types of water challenges in the country have been identified and listed. As many as 89 clusters in the country where one or more of the water challenges are dominant have been identified. The WAR for water mission is planned in three phases In the first phase, nature and scope of water related problem in the selected cluster is being studied and the solution provider is expected to design convergent technical solutions for the specific location for meeting the total water requirements. In the second phase, proving on ground the technical and social viability the selected solution for a population of 10,000 to 25,000 human habitat is prioritized. In the third phase, the successful solutions will be extended to a human habitat of 100,000 for assessing the financial viability and develop a revenue model for sustainability before extending the proven and viable solutions to other regions for deployment through Ministry of Water Resources and State Governments and other line agencies.

Expression of interest from solution providers has been sought through open and global tender approach. Currently under WAR for 17 water related challenges are being addressed in different parts of the country through contracts issued to solution providers. A finding of DST through WAR for water is that there are a large number of technology assets already available with both public funded institutions and private sector. However, in the absence of ability to design solutions based on available technologies to suit the specific local problems after engaging into discussion with local community, the available technologies remain under- and un-utilized. There is a need to bridge this serious gap under PAN-India mission on water.

One of the challenges recognized by DST during the implementation of WAR for water is that there are very few solutions designers among the technical and R&D institutions in the country. While the R&D institutions are adept in technology development, they are weak in designing technology solutions to match specific needs of the cluster. Private sector enterprises seem to be engaged in deployment of technologies and products available with them rather than to design location specific solutions and prove viabilities of solutions complete with revenue model. The PAN-India mission on water should address total water needs namely a) agriculture, b) municipal including live stock and c) drinking water. Quantum and quality of water needs for the diverse requirements of water vary. Technical solutions should therefore address a) data on water needs for the habitat, b) sources of water supply and their sustainability, c) water withdrawal and recharge rates, d) rain-water harvesting, e) viable technologies for water quality

management, f) participation of the Panchayat Raj institution and public in designing and implementation of solutions and g) human capacity needs for water management.

WAR for water offers a wide scope for actions under PAN-India mission on water. Technology platform approach for addressing the water challenges has already been proposed by DST under the 12th plan. Netherlands have launched a National Water Partnership involving as many as 250 stake holders. PAN-India mission on water could plan the establishment of India Water Partnership involving many stakeholders and R&D agencies. Although many R&D agencies have earmarked significant resources for water related technological research, serious gaps are recognized in designing and implementing sustainable solutions in real life conditions. Therefore the PAN-India mission of water could be launched with the specific objective of designing and deployment of viable solutions and development of human capacity for deployment of solutions.

PAN-India sub-mission on water could focus on providing a technology platform for the R&D outputs of all agencies in the country which are engaged in development of technologies and outputs.

S.No	Area of Research	Fund Requirements for 12th plan period (Rs in Crores)
1	Training of water managers	Rs 25 crores
2	R&D for solution design for 10 different water challenges in different locations	Rs 100 crores
3	Translational research for deployment under real-life conditions	Rs 200 crores
	Total	Rs 325 crores

IV National Mission on Food and Nutrition

Food and Nutrition security of India is even more critical in second decennium of 21st Century than in earlier times. Sustainable economic growth at 8-9% levels during the 12th plan period in all probability to increase the food demands of the country. Self sufficiency of food in India is partially on account of a large percentage of population not being able to afford at least two full meals a day. With decreases in the percentage of people Below Poverty Line to the targeted levels of 12th and 13th plan periods, at least 30% increase in food demand is likely. There are estimates that nearly 25% of new borns in the country may suffer from the long term ill effects of mal nutrition. If India

were to emerge truly as a major economy of the world in 2030, Food and Nutrition demands of the county should be addressed even more comprehensively than what is accomplished currently. Nutrition security of the country needs to be built on strong scientific principles. The task forces constituted by Indian National Science Academy on nutrition needs of India, have elicited clearly R&D gaps. If R&D requirements of India on Food and Nutrition were to be addressed, PAN-India programmes are essential.

R&D systems in agriculture have remained focused on extension. Main streaming of research and development activities on agriculture by engaging Extra Mural Research activities involving a large number of R&D professionals is necessary. Total funds deployed in EMR on agriculture as of 2007 were limited to only Rs 60 crores per year.

Agriculture in India is closely related to livelihood of more than 650 million people. It is not an industrial activity. Agriculture in India has remained largely a cultural practice. Challenges on Indian agricultural R&D system include a) rendering agriculture remunerative at levels of less than 0.2 hectare of per-capita land resource, b) increasing water use efficiency by at least 2.5-3 times in rain fed irrigation, c) redressing the soil health erosion in intensive production centres and d) provide new, cost effective and easy to adopt technologies for avoiding food wastage from the current levels and e) climate change resilient agriculture and soil health genomics. Main streaming R&D on agriculture through policy changes is a critical requirement. One of the critical gaps to be bridged in R&D on nutrition security is to take into account of large genetic variety and differing needs of nutritional demands of Indian population.

The currently used R&D structures do not promote adequately PAN –India approaches to address problems in food and nutrition. Therefore, 12 plan proposal of the country must include a serious effort to bring about organizational synergies in R&D on food and nutrition. Total of five sub missions on food and agriculture theme have been proposed by the working group. They are a) Remunerative agriculture for low land holdings, b) More crop for drop schemes, c) technologies for restoring soil health d) avoidance of food wastage, e) climate resilient agriculture through modern bio-technology.

1. Remunerative agriculture from low land holdings

Land holdings are small in the social context of the country. Remunerative agriculture from small land holdings is a unique challenge in Indian agriculture. Intelligent management systems for remunerative agriculture would call for inputs from tools modern biotechnology which have not been hitherto used. GPS assisted agriculture

where location specific advisories based on local soil health conditions and selection of crop form valuable paths. Marker assisted and new breakthroughs in plant breeding techniques would require a special PAN India R&D effort.

s.no	Area of Research	Fund requirement for 12th plan period Rs. In crores
1	Marker assisted and plant breeding research	150
2	Soil health genomics for high yielding crops	125
3	GPS assisted real time advisory platforms	50
	Total	**325**

2. More Crop for Drop scheme for water productivity

Current water requirements of India for irrigation are not sustainable. There is a critical technology gap in the Indian agricultural practice with respect to water usage in irrigation. Global bench marking of water usage in irrigation in Indian agriculture is an immediate need. Precision agriculture practices in Israel have been implemented with remarkable success, A bi-national R&D mission on agriculture and water with Israel is suggested by the working group.

S no	Area of Research	Fund Requirements for 12th plan Rs. In crores
1	Bench study on Global bench marking of water requirements for major crops per tonne and inter country comparison	50
2	Bi-national mission on agriculture and water with Israel	400
	Total	**450**

3. Restoring soil health

Intensive production systems and excessive use of fertilizers and pesticides lead to erosion of soil health. This has emerged already a major problem in some states in the country. Unless a PAN India R&D effort is mounted sooner than later, sustaining the food demands of the country would become challenging. A sub-mission on Restoring soil health is an area of priority. This would involve studies on soil genomics, crop selection for soil restoration, organic farming, break throughs in soil microbiology and technology policy interface research. Working group recommends a sub-mission on R&D for restoration of soil health in some select states like Punjab and Hayana.

S no	Area of Research	Fund Requirements for 12th plan Rs. In crores
1	Soil genomics in select states	100
2	Crop selection for eroded soils	50
3	Organic farming	100
4	Technology break throughs in soil micro biology	100
5	Policy research in soil restoration	25
	Total	**375**

4. Avoidance of food wastage

Current levels of food wastage in handing and management are too large for sustainability of production. There are a large number of available technologies which could be advantageously used. However, usage of such technologies in the social context of India requires R&D for social referencing. Techniques like cold storage for instance are well known, but their applications have not spread. Food processing technologies for decentralized applications for value addition by primary producer could be of great advantage. Technologies for crops with higher resistance to attacks by pests and damages by micro –organisms are an area of R&D priority.

S No	Areas of Research	Fund Requirements for 12th plan Rs. In crores
1	Storage and better handling and management technologies	100
2	Food Processing technologies for value addition to primary producers	200
3	Modern biotechnology for pest resistant crops	150
	Total	**350**

5. Climate Change resilient Agriculture

Vulnerability of certain food crops for weather and climate changes are well defined. Climate change could affect the crop yields of wheat and other essential food materials. R&D for building climate resiliency as well as salt tolerance is an essential area of activity for the country. PAN-India sub mission in this area has been strongly recommended by the working group. This task could be best accomplished only through a coordinated and Top-down planning and implementation. The working group

recommends the constitution of a task force to develop the details of the sub-mission with a fund of about Rs 400 crores.

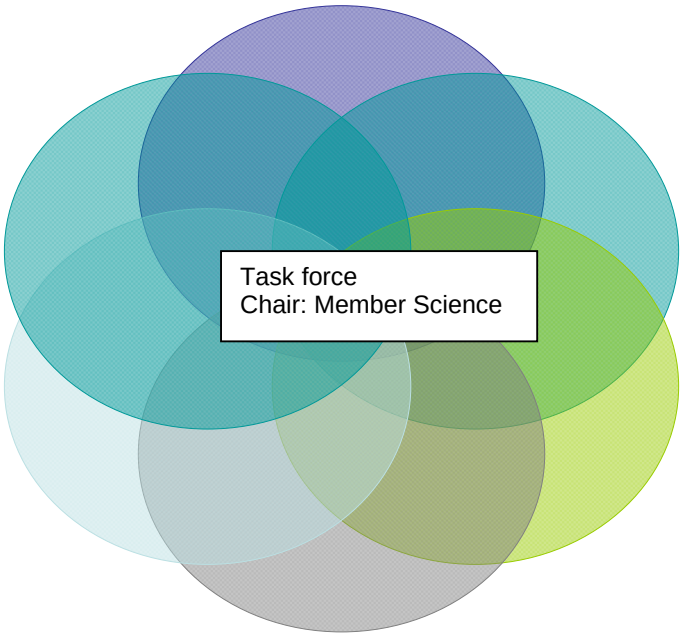
Structure, Mechanisms and Organizational Arrangements **(to be added)**

PAN-India mission of science and technology sector proposes a new beginning. Therefore, the organizational arrangement and structure required for implementation would call for innovations in R&D management. CSIR has gained experience in implementation of Network programmes. DoS, DRDO and DAE have implemented a large number of S&T mission mode programmes under Intra-mural research model in strategic sector where the goals and targets are defined *a priori.* Therefore, there is some previous experience within the S&T sector to design and implement R&D missions through intra mural programmes. Multi-agency R&D mission is newer challenge being proposed for implementation during the 12th plan.

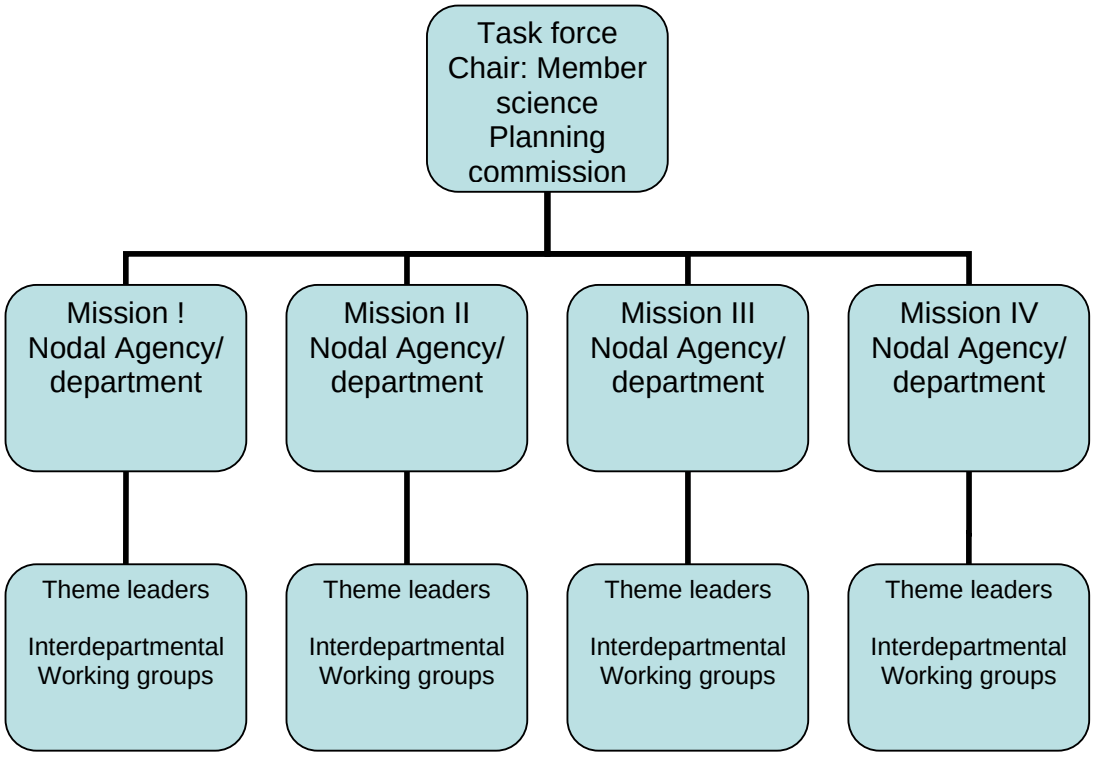
The working group has suggested two parallel approaches for designing and implementation of PAN-India missions. Four missions have already been identified and selected by the working group. It is quite likely that various departments and agencies have independently proposed R&D programmes and activities with overlapping goals and objectives. It should be possible to study the various proposals of the science departments and synthesize a common technology mission plat form by incorporating some the objectives proposed in this PAN-India mission proposal in the programmes of the individual departments and agencies for implementing the mission activities within the budgetary allocations of each department and agency. A special task force may be constituted under the Chair of member Science planning commission for building programme synergies and avoiding duplications that merit avoidance. Sharing objectives and goals and co-investments of resources by the S&T departments and agencies may be promoted through this mode of implementation of the mission.

The working group has recommended a creation of separate PAN-India mission fund to be allocated over and above the allocations for individual departments. PAN-India mission has stipulated the mission goals and objectives of the sub-mission areas. For implementation of the missions under the top-down planning models, specific and time bound goals expected from each sub-mission and mission may be specified and proposals may be invited from PAN-India networks. The proposal may include also the structure and organizational arrangements proposed for implementation and monitoring. These proposals could focus on national platforms involving the participation of all the stakeholders including industry and user agencies. The programme monitoring and

oversight for the implementation could be assigned to a task force under the chair of member science planning commission and department to service each sub-missions.



Bottom-up mode of development of PAN Indian missions


Task force
Chair: Member science
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Mission III
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Mission IV
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Theme leaders
Interdepartmental Working groups
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Theme leaders
Interdepartmental Working groups

Consolidated Budget Requirement

Area	Total Fund requirement during the 12th plan period (Rs. in crores)
I. Affordable Health Care	1550
II. Energy and Environment	1700
III. Water	325
IV. Food and Nutrition	1850
TOTAL	5375

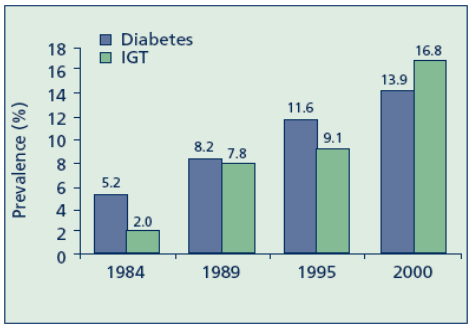
Annexure - I

Affordable Health care in Diabetes: Areas of research

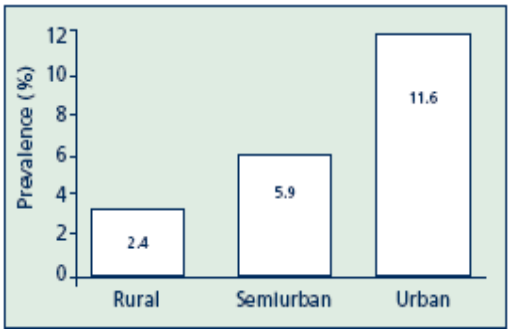
Diabetes in adults worldwide was estimated to be 4.0% in 1995 and to rise to 5.4% by the year 2025. It is higher in developed than in developing countries. The number of adults with diabetes in the world will rise from 135 million in 1995 to 300 million in the year 2025. The major part of this numerical increase will occur in developing countries. There will be a 42% increase, from 51 to 72 million, in the developed countries and a 170% increase, from 84 to 228 million, in the developing countries. Thus, by the year 2025, >75% of people with diabetes will reside in developing countries, as compared with 62% in 1995. The countries with the largest number of people with diabetes are, and will be in the year 2025, India, China, and the U.S. In developing countries, the majority of people with diabetes are in the age range of 45-64 years. In the developed countries, the majority of people with diabetes are aged > or =65 years. This pattern will be accentuated by the year 2025. There are more women than men with diabetes, especially in developed countries. In the future, diabetes will be increasingly concentrated in urban areas.(Ref: Diabetes Care. 1998 Sep;21(9):1414-31.Global burden of diabetes, 1995-2025: prevalence, numerical estimates, and projections. King H- WHO).

The prevalence is increasing at all strata of population including the children and pregnant women whose needs and care are special and needs redressal.

Rising trend in the prevalence of type 2 diabetes in urban India.



Diabetes prevalence in rural and semi-urban areas



Projections:

Year	Estimated that the global burden of diabetes
1994, McCarty et al	110 million in 1994, 239 million by 2010
1997, Amos et al	124 million people, 221 million by 2010.
WHO report, 2004,King H	135 million in 1995, 299 million by 2025
WHO 2004	171 million in 2000 to 366 million in 2030
WHO 2004	171 million in 2000 to 366 million in 2030

It is estimated that India now has 39 million diabetics.- CBHI-2010.

There is clear need for research on control measures, creating tools for affordable diagnosis/ monitoring and treatment of the disease and its complications which encompasses multi-organ failure, adverse effect on social and behavioral status of individual as well as family and thus country as a consequence. The estimates for disease in pregnant women whose needs and care are special and needs redressal are essential and the strategies for reducing the burden and morbidity and mortality are important research agenda for helping the programme.

ICMR as an apex research body of the country intends to play contributing partner in this war against epidemic of Diabetes.

Low cost technologies Rs 50 crores

Development of low cost technologies that can help in screening, diagnosis, monitoring and management of Diabetes and its complications is a critical need in our country.

Due to the enormous burden of diabetes, mass screening of populations at risk has become an important public health strategy. As glucometers and glucose strips that are imported are quite expensive, this limits the feasibility of such screening strategies. In this context, there is an urgent need to develop indigenous glucometers, sensors and glucose strips that can be made available at a low, affordable cost.

Similarly, development of low cost technologies for devices that continuously monitor glucose and insulin pumps which would make them affordable tools in management of Diabetes is also the need of the hour.

Other technologies that would help in early diagnosis of diabetes and its complications including development of suitable biomarkers at low cost are also required.

These areas of research are likely to make Diabetes prevention & Care affordable and would go a long way in containing the growing diabetes epidemic in our country.

Islet Cell Transplantation Rs 100 crores

Creation of an Islet cell transplantation facility in a few premier institutions for service as well as for research in this area is another thrust area that would pioneer this novel approach as an important tool to tackle Diabetes with a promise for cure.

Collaboration with University of Minnesota (UOM) under the MOU of ICMR-UOM for this would provide a unique opportunity to develop these centers. UOM are world leaders in Islet Cell Transplantation and have the most advanced protocols and centers for the same. Transfer of technology and expertise in this area would go a long way in establishment of these facilities that can help realize the true potential and promise of this novel approach.

The centers can not only pioneer research is various facets of islet cell biology and islet cell transplantation, but can also develop into advanced centers offering islet cell transplantation with the most effective protocols for treatment of diabetes. Research has shown that this approach, which has traditionally been used in Type 1 DM can also be

used in Type 2 DM. If explored appropriately, this can evolve as an important approach for type 2 DM also.

In the context of the Diabetes epidemic, creation of islet cell transplantation centers would be a timely and important investment for the treatment at cost which is affordable.

Gestational Diabetes Rs 50 crores

In women, gestational diabetes mellitus (GDM), defined as any degree of glucose intolerance identified for the first time in pregnancy, is an indicator of underlying metabolic dysfunction. In parallel with the rising prevalence of T2DM, the incidence of GDM has been increasing worldwide. In India, the incidence of GDM has risen from 1-2% in the 1980s and 90s to current levels of 5-17%. While most cases of GDM resolve with delivery, these individuals are at increased risk of subsequently developing T2DM. This has resulted in the recommendation of screening for diabetes 6-12 weeks postpartum using non-pregnant oral glucose tolerance test (OGTT) criteria. Such early postpartum screening will help differentiate women who probably had pre-gestational diabetes (5-15%) from those with dysglycemia unmasked only by the stress of pregnancy. The latter show a progression to diabetes over time varying from 2-5% at 1 year to 20-40% at 10-15 years depending on ethnicity, the diagnostic criteria used and other factors. While there are studies on the incidence of gestational diabetes from tertiary care centres across India there is limited information from across all regions – urban and rural. Perhaps even more importantly, there is virtually no information on the rate of conversion of gestational diabetes to type 2 diabetes in our country, nor is there information on the characteristics which influence this conversion. Hence, a pan India study on gestational diabetes prevalence, and factors influencing its conversion along with intervention strategies to retard or prevent this conversion would be a high priority area.

Prospective cohorts Rs 40 crores

The issue about a prospective cohort is very useful. A cohort to be followed longitudinally will be of exceptional utility in understanding not only disease natural history but also as you pointed out markers for disease progression and complications. Further such a cohort need not be restricted to diabetes – information about all chronic non-communicable diseases can be acquired. Finally, data on health service utilization can also be got from such a study. With the allotment of the UID – a cohort will be eminently more doable than in the past – since hopefully with the UID one should be able to track individuals better even if they migrate.

Gene environmental interaction for Diabetes Rs 80 crores

In complex disorders like diabetes, the genetics at best will provide us information on pathogenesis and thereby suggest new sites for intervention. Genomics will not be useful for disease prediction – may predict complications to some extent. The gene environment interaction studies are critical and can be ideally combined with the cohort being suggested; as also with appropriate utilization of GIS strategies to more objectively define the environment. The dynamic nature of a cohort study will lend itself better to a gene environment interaction study as compared with a cross sectional study.

Use of Technology Rs 50 crores

Use of mobile phones for health care: For a country with near 100% penetration of mobile phones it could be a major component for screening, communication and monitoring. Identification of individuals at high risk for non-communicable disease such as high blood pressure and diabetes, can be done through risk scores and algorithms which are mobile phone based. Individuals identified through this process can be then referred for formal testing and treatment – again using cell phone based applications. This can enable use of less trained health care workers to identify and refer individuals, instead of utilizing already overburdened physicians for the initial phase of disease identification and diagnosis. Follow up of such patients can also be based on mobile phone based alerts and reminders, and also to help create and foster linkage between the patient and different components of the health care delivery system.

Another area which will be of use is the appropriate use of technology platform for health system. Conventional health care delivery pattern are based on patient evaluation and referral are dependent on physician knowledge and discretion as well as the available facilities. The present model of the primary health centre is being the first contact and based on the medical condition the patient are either treated there or refer to the appropriate level of care. This model has not been successful because of inadequate both in terms of manpower and infrastructure as well as absence of adequate referral linkages. Few things that can help are as follows:-

Electronic Health Records and decision support software – would be useful as a tool for proper recording interpretation and treatment of a patient by making its use at different level of care. Knowledge management strategy for proper referral and treatment should be a priority.

Translational Research Rs 30 crores

This involves research into how to effectively translate the lessons learnt from research in the lab and clinic into directly improving outcomes with respect to Diabetes for the patient, for those at risk and for the community as a whole. In other words, it is about how we could use small, cost effective interventions / strategies to bring about major reductions in the burden of Diabetes and its complications.

India is already in the midst of the epidemic of Diabetes and Cardiovascular disease. The impact of the rising burden of Diabetes in terms of its physically and economically disabling complications such as CVD, Stroke, CKD and blindness which is already being felt will be come enormous over the next few decades.

There is an urgent need to focus on Translational Research in diabetes and make it a national priority. To apply the knowledge gained from earlier research to plan cost effective interventions / strategies would help decrease the burden of Diabetes Mellitus and its complications.

Annexure – II

A national committee comprising of experts, Government officials and industry needs to be created so that specific programmes in the areas mentioned above can be formulated, funded and monitored. A partial list of projects important to the mission programme shall be:

(i) Development of Li-ion and other batteries for electric/hybrid vehicles of all types with a target of progressive reduction in battery weight and cost and an increase in expected life time of the battery.
(ii) Large-scale synthesis of electrode and electrolyte materials suitable for various batteries having the potential to be used in EV/hybrid vehicles.
(iii) Facility to assemble and test batteries and subsequently manufacture them as per international standards in sufficient quantities.
(iv) Design and deployment of battery management system.
(v) Development of electric car / fuel cell vehicle controllers.
(vi) Development of software standards for small EV/Fuel Cell vehicles.
(vii) Development of new generation magnetic materials for stator and rotor of AC motors for EV/hybrids.
(viii) Design and development of robust AC motors for EV/hybrids and their manufacture.
(ix) Development of other power-electronic components for Electric / Fuel Cell vehicles like invertors, DC/DC voltage boost converters, invertors for air compressor in fuel cell vehicle etc.
(x) Development of alternate membranes and non-noble catalysts for fuel cells.
(xi) Production/generation of H_2 from sunlight using photocatalytic effect and at improved efficiencies.
(xii) Development of exfoliated graphite and metal based bi-polar plates for fuel cells.
(xiii) Establish production/pilot-plant facility for production of fuel cells suitable for vehicles and achieve continuous reduction in cost and weight and at the same time increase energy/power density.
(xiv) Development of ultracapacitors to be used in conjunction with fuel cell/battery.
(xv) Develop regenerative braking system for electric/hybrid vehicles.
(xvi) Light weighting of the vehicle itself by the use of ultra-high strength steel, AI and Mg alloys and polymer composites, but without compromising the crashworthiness, structural integrity and recyclability.
(xvii) Demonstration of at least 10,000 grid connected vehicles in 5 different cities with the establishment of a large number of charging stations in residential, commercial and public locations.
(xviii) Encourage the use of electric/fuel cell buses for intra city travel.
(xix) Encourage taxis/autorickshaws to transition to EV/hybrid systems.
(xx) Fund various universities to initiate electric/hybrid/fuel cell vehicle specific education programme for undergraduates and graduates.

Many of the above projects can be in public-private partnership (PPP) mode. While project proposals can be solicited on the basis of "call for proposals" in the case of Directed Basic Research proposals, a top-down approach needs to be adopted in the case of technology demonstration and deployment programmes.